urbantech west

APPENDIX A
BACKGROUND DOCUMENTS

A-1 Fruitland-Winona Block Servicing Strategy Terms of Reference
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APPENDIX A-1
Fruitland-Winona Block Servicing Strategy Terms of Reference

Hamilton

Terms of Reference for:

Fruitland-Winona Block Servicing Strategy

October 15, 2013 - FINAL

Introduction

The Fruitland-Winona Secondary Plan area is characterized by a relatively flat topography which requires specific grading and detailed servicing provisions to adequately service the future development area so development proceeds in a coordinated and comprehensive manner. The purpose of this study is to develop a Block Servicing Strategy (BSS) for areas identified in the Fruitland-Winona Secondary Plan – Block Servicing Strategy Area Delineation is shown in **Appendix A.**

The Fruitland-Winona Block Servicing Strategy shall be carried out in accordance with the Fruitland-Winona Secondary Plan policies in Section 13.2.19. Review Section 13.2.19 of the Fruitland-Winona Secondary Plan when developing work plan. This Terms of Reference provides an overview of the requirements of the Block Servicing Strategy.

There are three (3) blocks included in the Fruitland-Winona Secondary Plan which require a Block Servicing Strategy:

Block 1: Generally located by Barton Street to the north, Highway 8 to the south, Fruitland Road to the west and east of Jones Road to Stoney Creek numbered watercourse 6.

Block 2: Generally located by Barton Street to the north, Highway 8 to the south, watercourse 6 at the west, and Glover Road to the east.

Block 3: Generally located north of Barton Street, Highway 8 to the south, McNeilly Road at the west and east of Lewis Road.

The Fruitland-Winona Subwatershed Studies shall form the basis of all Block Servicing Strategies. It shall conform to the vision, objectives and policies of the approved Fruitland-Winona Secondary Plan and shall identify the land use designations, densities and natural heritage features, including Vegetation Protection Zones and Restoration Areas, in accordance with the Secondary Plan. Where it can be achieved, the Block Servicing Strategy shall comply with the Fruitland-Winona Secondary Plan Urban Design Guidelines.

The Block Servicing Strategy shall have regard for existing development in accordance with the Fruitland-Winona Secondary Plan by reflecting the general scale and character of the established development pattern in the surrounding area by taking into consideration lot frontages and areas, building height, coverage, mass, setbacks, privacy and overview. All development within the lands identified as the "Servicing Strategies Area" as identified in the Fruitland-Winona Secondary Plan – Block Servicing Strategy Area Delineation shall conform to the Block Servicing Strategies.

The Block Servicing Strategy will be used in assessing priorities among proposals for development. The preliminary grading plan, layout of local roads, sanitary sewers, storm sewers and stormwater management facilities, watermains shall be defined, together with the phasing of servicing proposed to ensure development is achieved in an efficient and systematic manner within each block area.

The Block Servicing Strategy shall follow the Municipal Class Environmental Assessment Planning process for Phases 1 and 2. A public consultation plan shall be developed including the number of meetings to be held with the public and stakeholders.

Key Tasks & Deliverables

This study is intended to outline the concepts for the servicing of the Fruitland-Winona lands located south of Barton Street, east of Fruitland Road, west of Fifty Road, and north of Highway No. 8.

The Block Servicing Strategy shall include an integration of a Functional Stormwater Management and Environmental Management Plan, and a Functional Servicing Plan forming one comprehensive document. The Environmental Management Plan shall build on the findings of the final sub-watershed study for SCUBE watercourses.

The Block Servicing Strategy shall include the following tasks:

1. Functional Stormwater Management and Environmental Management Plan; and a
2. Functional Servicing Plan

1. Functional Stormwater Management and Environmental Management Plan

The Functional Stormwater Management and Environmental Management Plan is intended to build upon the baseline information contained in the subwatershed study and shall be implemented in support of the secondary plan. This study shall address any gaps identified in the subwatershed plan related to servicing, stormwater management and natural heritage features (meander belt assessment). The level of study would focus on integrating servicing and stormwater management to a greater level of detail than is normally achieved through the subwatershed study.

Stormwater management facilities shall comply with the City's Criteria and Guidelines for Stormwater Infrastructure Design and Policies, the Fruitland-Winona Sub-watershed Studies and the Block Servicing Strategy. In addition, stormwater management facilities:

- shall be located and designed to maintain ecological functions of the Natural Heritage features;
- shall be located adjacent to the Barton Street Pedestrian Promenade and other Open Space Designations where possible;
- shall be designed along the Barton Street Pedestrian Promenade; and,
- shall be designed to provide visual attraction and passive recreation where possible.

The principle objectives and tasks required for a Functional Stormwater Management and Environmental Management Plan include but not limited to:

a. Review final sub-watershed study for SCUBE watercourses. Re-running of the models from the sub-watershed study using the proposed level of impervious coverage and stormwater controls to confirm the existing targets are sufficiently robust to control the increased impervious arrears without causing an increase in downstream flooding and erosion and water quality compliance in accordance with MOE guidelines.
b. Establish basic sub-watershed conditions (peak flows, runoff volumes, and erosion threshold assessment)
c. Determine the preliminary design of the stormwater management systems including the stormwater management design at each location.
d. Functional stormwater management pond design (approximate size and configuration)
e. Capacity assessment of the receiving system for the proposed storm outlet
f. Identify drainage constraints relating to existing and post-development flows
g. Screen various stormwater management strategies and techniques and evaluate a reasonable range of alternatives.

h. Recommend stormwater management solutions based on sound evaluations of the natural, social and economic environments of various feasible alternatives.
i. Prepare general drainage plans, outlining both the major and minor systems along with detailed flow limits at critical points.
j. Identify opportunities to integrate passive recreation opportunities with stormwater management strategy.
k. Identify opportunities for Phasing of construction of stormwater facilities.
l. Functional design of proposed realignment of watercourses.

The Functional Stormwater Management and Environmental Management Plan shall have regard to ecological, hydrological, air drainage and road geometry assessments.

Ecological Assessment
The components of the ecological studies shall include:

a. Meander Belt Width Assessments for all watercourses;
b. The identification and consideration of all areas regulated by the Conservation Authority's Development, Interference with Wetlands; Alterations to Shorelines and Watercourses Regulation or its successor; and,
c. Scoped EIS including evaluation of natural areas (Core Areas).
d. Topographic survey of the lands including the staked limit of wetlands and top of bank of watercourses.
e. Determination of top of stable slope of watercourses
f. Determine limits of buffers to watercourses and wetlands based on HCA/City criteria
g. Hydraulic study of watercourses and determination/verification of flood plain limits.
h. Geotechnical assessment to determine stable slope of the watercourse.

Hydrological Assessment
The stormwater management finding/recommendations from the SCUBE sub-watershed study shall be reviewed and incorporated in the Block Servicing Strategy. In addition, the hydrological investigation shall include:

a. Water balance study.
b. Groundwater levels and flow path.
c. Significant recharge and discharge zones.
d. An assessment of the impacts of development on the functions of b & c above.

e. The foundation drain flow rate based on groundwater and severe wet weather conditions.
f. Recommendation for an appropriate sump pump design.
g. A contingency plan to ensure that an appropriate mitigation strategy can be implemented where:
   - An aquifer is breached during construction;
   - Groundwater is encountered during construction;
   - Continuous running of sump pump occurs; and,
   - Negative impacts occur on the water supply and sewage disposal system or any surface and groundwater related infrastructure.

Air Drainage Analysis

The Air Drainage Analysis Brief shall include:

a. A review of the existing conditions, including air photos, topography, thermal conditions, climate and air movement down the Niagara Escarpment and towards Lake Ontario, to evaluate the effects of the proposed Secondary Plan land use on the existing microclimate and airflow; and,
b. Where appropriate, propose a road layout and development patterns that maximize air drainage in a north/south alignment to minimize potential negative impacts on the tender fruit area to the south.

Road Geometry

The Block Servicing Strategy shall include the development of a transportation network for local roads in consideration of the existing and proposed collector roadways identified in the Secondary Plan.

The following shall apply to new road crossings:

- Where possible, road crossings shall avoid significant and/or sensitive natural features;
- Where it is not possible for road crossings to avoid significant and/or sensitive natural features, road crossings may be located in previously disturbed watercourse reaches or in locations where the disturbance or removal of riparian vegetation can be minimized. All watercourses will need to recognize inputs from meander belt analyses, flood plain analyses and fisheries at a minimum;
- New roadway culverts and bridges shall have sufficient conveyance capacity to pass 100 year event to avoid adverse backwater effects. In addition, under Hurricane Hazel event the maximum flooding depth on road shall be in accordance with MNR's technical guidelines;

- Where new roadway culverts and bridges cannot meet the requirements set out above, Regulatory flooding depths on roadways shall be based on the standards within the Ontario Ministry of Natural Resources Natural Hazards Technical Guides, latest version or its successor guideline; and,
- If a minor realignment of the stream channel is necessary to achieve the desired crossing configuration, the new channel should be established using natural channel design principles.

2. Functional Servicing Plan

The Functional Servicing Plan is intended to identify the manner in which water, sanitary and storm servicing is to be provided for. The plan generally includes, but is not limited to

a. Defining the sanitary and storm drainage area boundaries and confirming capacity of the outlets
b. Finalizing the land-use plan through the establishment of local and collector road locations
c. Functional design of all existing collector roadways within the Block
d. Location and preliminary sizing of sanitary sewers
e. Location and preliminary sizing of storm sewers
f. Location and preliminary sizing of watermains
g. Preliminary grading plan based on the proposed road pattern
h. Location and functional design of stormwater management facilities
i. Location and preliminary sizing of hydraulic structures (i.e. Bridges and culverts)
j. Preliminary channel grading plans and supporting analyses
k. Watermain Analysis of Block Plan using City-wide WaterCad Model.
l. Proposed phasing scheme

Notes:
The findings and solutions identified in the individual drainage and flooding assessments shall be integrated into the Block Servicing Strategies and subsequent Draft Plan of Subdivision.

<u>Block 1</u>
- Include functional design for Jones Road
- Determine the floodplains for:

    - Along Watercourse 5.0, immediately downstream of Fruitland Road (between sections 2221 and 2150); and
    - Along Watercourse 5.0, halfway between Highway No. 8 and Barton Street (between sections 1693.967 and 1537.457)
- Through the Schedule C Class Environmental Assessment process, determine the alignment for the north/south (new Fruitland Road) road between highway No. 8 and Barton Street.
- Local flooding issue remediation required:
    - Local flooding at 688 Barton Street (private property drainage issue).
    - Local flooding at 728 Barton Street (private property drainage).
- Specific natural heritage requirements for the Block Servicing Strategy:
    - Ecological Land Classification and Vegetation Surveys
        - Update SCUBE West Subwatershed Study Phase 1 & 2.
    - Fisheries and Watercourse Assessments on Watercourses 5, 6 & 7
        - Re-alignment of watercourse 5 may require additional studies.
    - Re-alignment and re-construction of Watercourse 5.0 upstream of Barton Street would identify design measures to avoid/mitigate the potential negative effects of the proposed stream relocation on existing natural heritage features and functions; avoid/mitigate the potential negative impacts to wetlands 1 and 4.
    - Define limits of natural heritage feature boundaries.
    - Review the widths of the preliminary vegetation protection zone (VPZ) that have been established within the Subwatershed Study.
    - Drainage and infrastructure improvement works:
        - Identification of design measures to avoid/mitigate the potential negative effects of the proposed channel improvements on existing natural heritage features and functions.

<u>Block 2</u>

- Include functional design for Glover Road
- Determine the floodplains along Watercourse 6.0, downstream of Highway No. 8 (between sections 2232.182 and 1785.033).

- Local flooding issue remediation required:
    - Local flooding at 808 Barton Street.
- Specific natural heritage requirements for the Block Servicing Strategy:
    - Ecological Land Classification and Vegetation Surveys
        - Update SCUBE West Subwatershed Study Phase 1 & 2.
    - Define limits of natural heritage feature boundaries.
    - Review the widths of the preliminary vegetation protection zone (VPZ) that have been established within the Subwatershed Study.
    - Drainage and infrastructure improvement works:
        - Identification of design measures to avoid/mitigate the potential negative effects of the proposed channel improvements on existing natural heritage features and functions.

<u>Block 3</u>

- Include functional design of McNeilly Road and Lewis Road
- Local flooding issue remediation required:
    - Local flooding at 1028 Barton Street (groundwater issue).
- Specific natural heritage requirements for the Block Servicing Strategy:
    - Ecological Land Classification and Vegetation Surveys
        - Update SCUBE East Subwatershed Study Phase 1 & 2.
    - Define limits of natural heritage feature boundaries.
    - Review the widths of the preliminary vegetation protection zone (VPZ) that have been established within the Subwatershed Study.
    - Drainage and infrastructure improvement works:
        - Identification of design measures to avoid/mitigate the potential negative effects of the proposed channel improvements on existing natural heritage features and functions.

Appendices

Appendix 'A'	Fruitland-Winona Secondary Plan – Block Servicing Strategy Area Delineation

APPENDIX A-2
Figure 2-1 / Map B.7.4-4 Block Servicing Strategy Area Delineation

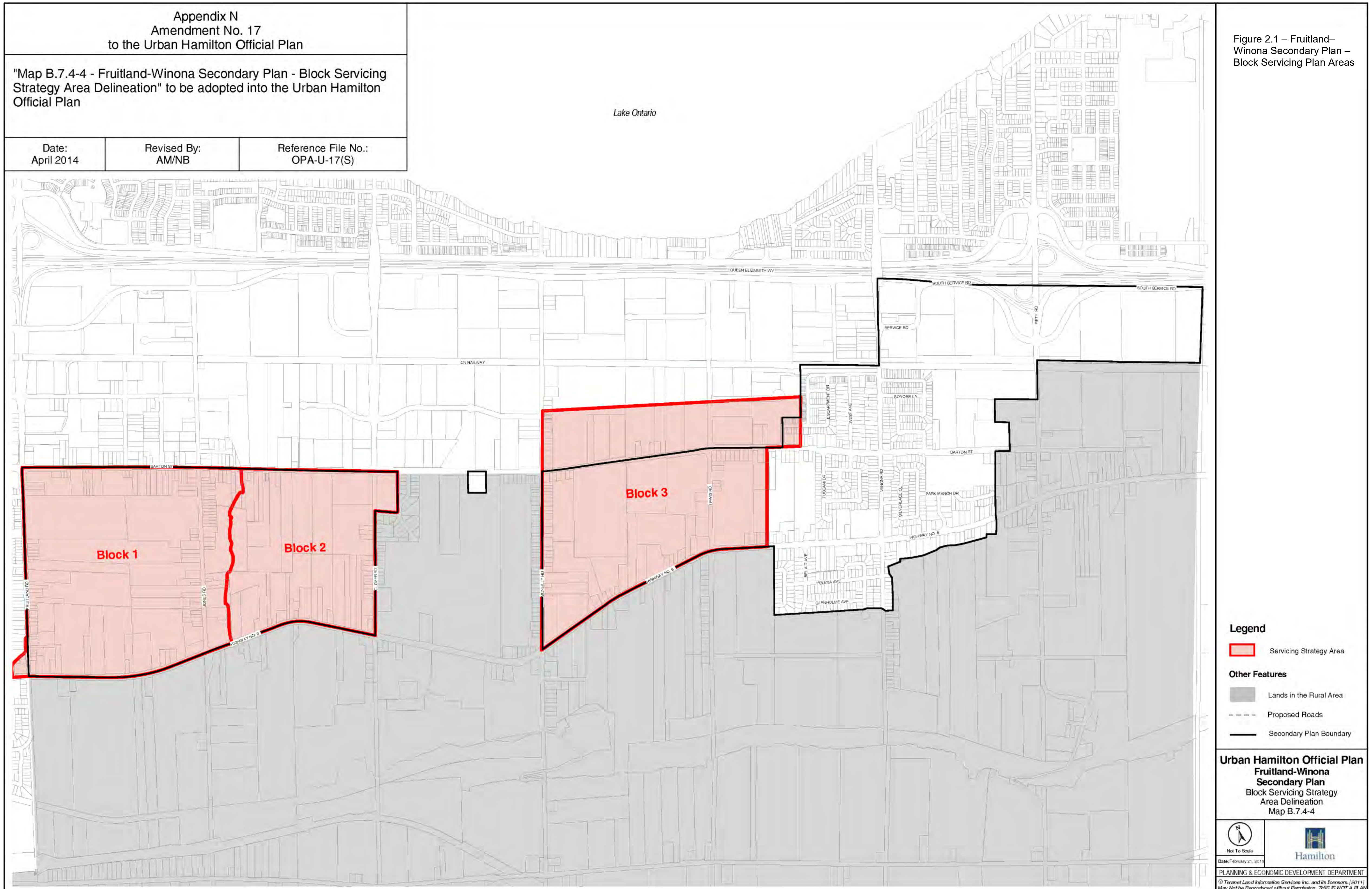

Figure 2-1 –Fruitland-Winona Secondary Plan – Block Servicing Plan Areas

APPENDIX A-3
Glen Schnarr BSS#3 – Concept Plan

BLOCK SERVICING STRATEGY AREA # 3 - CONCEPT PLAN

STONEY CREEK, CITY OF HAMILTON

Scale 1:2500
(24 x 36)
November 19, 2019

GSAI
Glen Schnarr & Associates Inc.

APPENDIX A-4
SCUBESS Figure 1.1 – Limits and Bounding Streets Parcels

KEY MAP

Legend

Study Area

SCUBE Development Lands

Streams

NOTES:

0 125 250 500 750 1,000

Meters

77 James Street North
Hamilton ON
L8R 2K3
Phone: (905) 546-2424
Fax: (905) 546-4435

Hamilton

SCUBE Subwatershed Study
Study Area

FIGURE No. 1.1

DATE: November 2010

APPENDIX A-5
HCA Regulated Features Identification Map

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Feature 1
Feature 2
Feature 3
Feature 4
WILLOW LN
CHRISTINA AV
GLOVER RD
BARTON ST
PRIVATE RD
LEWIS RD
ARVIN AV
EDENROCK DR
ESCARPMENT DR
MCNEILLY RD
HIGHWAY NO 8
TUSCANI DR
ROSEPARK CR
BEL-AIR AV
HELENA AV
GLENHOLME AV
LACOMA DR
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For information screening purposes only. This is not a plan of survey

APPENDIX A-6
SCUBESS – Table 5.2 – Conceptual SWM Pond Characteristics

TABLE 5.2:
Conceptual Stormwater Management Pond Characteristics
SCUBE Subwatershed - East and West

Pond # or Catchment	Estimated Drainage Area (ha)	Landuse	Assumed % Impervious	Water Quality Control (Level 2)				Extended Detention for Erosion Control												Total Storage Volume * (m^3)	Conceptual Pond Footprint Area ** (ha)	Pond # or Catchment
												Extended Detention for Flood (Quantity) Ctonrol										
								Erosion Control				2-Year Control				100-Year Control						
				Perament Pool Storage for Water Quality		Extended Detention for Water Quality		Release Rate		Storage Volume		Release Rate		Storage Volume		Release Rate		Storage Volume				
				(m^3/ha)	(m^3)	(m^3/ha)	(m^3)	(m^3/s)	(L/s/ha)	(m^3)	(m^3/ha)	(m^3/s)	(L/s/ha)	(m^3)	(m^3/ha)	(m^3/s)	(L/s/ha)	(m^3)	(m^3/ha)			
SCUBE East																						
12-1	11.8	employment	80%	105	1,239	40	472	0.013	1.1	2,401	203	0.087	7.4	3,430	291	0.333	28.3	7,730	655	8,969	1.2	12-1
12-2	14.5	employment	80%	105	1,523	40	580	0.016	1.1	2,947	203	0.107	7.4	4,210	290	0.410	28.3	9,490	654	11,013	1.4	12-2
9-1	14.7	residential	50%	65	956	40	588													1,544	0.6	9-1
9-2	54.0	residential	50%	65	3,510	40	2,160	0.035	0.6	7,952	147	0.231	4.3	11,360	210	0.942	17.4	30,550	566	34,060	2.8	9-2
9-3	23.1	residential	50%	65	1,502	40	924	0.015	0.6	3,409	148	0.099	4.3	4,870	211	0.403	17.4	13,090	567	14,592	1.6	9-3
9-4	16.2	employment	80%	105	1,701	40	648	0.023	1.4	3,171	196	0.151	9.3	4,530	280	0.582	35.9	9,980	616	11,681	1.4	9-4
9-5	24.8	employment	80%	105	2,604	40	992													3,596	0.9	9-5
10-1	16.4	employment	80%	105	1,722	40	656					0.208	12.7	3,580	218	0.798	48.7	8,040	490	9,762	1.2	10-1
10-2	9.6	employment	80%	105	1,008	40	384					0.128	13.3	2,050	214	0.490	51.1	4,600	479	5,608	0.9	10-2
10-3	9.3	employment	80%	105	977	40	372					0.127	13.7	1,940	209	0.489	52.6	4,360	469	5,337	0.9	10-3
7-2-1	10.3	employment	80%	105	1,082	40	412	0.027	2.7	1,659	161	0.182	17.7	2,370	230	0.707	68.6	4,890	475	5,972	1.0	7-2-1
7-2-2	4.8	employment	80%	Catchment areas may be less than minimum recommended for a SWM Pond, and other traditional source control methods may be necessary instead. Unit storage and release rates from SWM Pond catchment #7-2-1 would apply.																		7-2-2
7-2-3	4.3	employment	80%																			7-2-3
7-2-4	2.4	employment	80%																			7-2-4
SCUBE West																						
1	39.8	residential	50%	65	2,587	40	1,592	0.025	0.6	4,011	101	0.166	4.2	5,730	144	1.143	28.7	16,830	423	19,417	1.9	1
2	24.5	residential	52%	65	1,593	40	980	0.024	1.0	2,625	107	0.159	6.5	3,750	153	0.997	40.7	11,180	456	12,773	1.5	2
3	26.4	residential	48%	65	1,716	40	1,056	0.026	1.0	2,611	99	0.171	6.5	3,730	141	1.071	40.6	11,500	436	13,216	1.5	3
4	26.5	residential	52%	65	1,723	40	1,060	0.037	1.4	2,800	106	0.248	9.4	4,000	151	1.477	55.7	11,850	447	13,573	1.6	4
5	21.1	residential	50%	65	1,372	40	844	0.013	0.6	2,198	104	0.084	4.0	3,140	149	0.564	26.7	9,330	442	10,702	1.3	5

* Note - Total volume includes permanent pool storage plus the higher of extended detention storage for water quality or flood control.

** Note - Actual footprint areas will depend on physical constraints including grading / storm sewer inverts / outlet (creek) elevations, etc. For conceptual purposes, the pond footprint areas were estimated assuming a 3:1 length to width flowpath, max. water depth of 2.5m for flood control ponds, 1.5m for ponds with water quality control only, and included allowances for sideslopes, etc.

APPENDIX A-7
SCUBESS – Figure 3.1 – Existing Drainage Area Plan

SCUBE

Subwatershed Study - Phase 1

Legend

- Watercourse Catchment
- Subcatchment
- Subcatchment No. / Subcatchment Area (101 / 10 ha)
- Storm Sewer
- Watercourse
- Flow Node (12-1)
- Major System Drainage
- Minor System Drainage
- Stream Flow Gauge Location

Scale: N.T.S.

Figure 3.1

Existing Drainage Pattern

APPENDIX A-8
SCUBESS – Comparison of Flood Flow Estimates - Table 5.2

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Table 5.2: Comparison of Flood Flow Estimates

Location	Landuse Scenario	Drainage Area* (ha)	% Impervious	Design Flows (cms)						
				2-year	5-year	10-year	20-year	50-year	100-year	Regional
Watercourse 9										
Storm Outfall (9-1)	Existing	128.2	17%	0.8	1.1	1.3	1.6	1.9	2.2	10.1
	Future uncontrolled	146.7	20%	1.0	1.4	1.8	2.3	3.1	4.0	12.3
CN Railway (node 9-2)	Existing	322.4	10%	1.2	1.8	2.4	3.0	4.1	5.1	20.2
	Future uncontrolled	340.9	33%	1.7	2.8	3.8	4.9	6.7	8.4	29.8
QEW (node 9-3)	Existing	357.3	16%	1.5	2.1	2.6	3.2	4.2	5.2	23.3
	Future uncontrolled	375.8	37%	1.9	3.0	4.0	5.2	7.2	9.0	32.7
Lake Ontario (node 9-4)	Existing	371.2	16%	1.5	2.2	2.7	3.4	4.6	5.7	24.6
	Future uncontrolled	389.7	37%	2.0	3.1	4.2	5.4	7.4	9.3	34.0

APPENDIX B
GEOTECHNICAL AND HYDROGEOLOGICAL INVESTIGATIONS

B-1 Preliminary Geotechnical Investigation (AME, 2009)
B-2 Hydrogeological Investigations Fruitland-Winona BSS#3 (Landtek Limited, February 2020)
B-3 Figure 1a – Excerpt from Toronto's Wet Weather Flow Management Guidelines

APPENDIX B-1
Preliminary Geotechnical Investigation (AME, 2009)

PRELIMINARY GEOTECHNICAL INVESTIGATION
BARTON STREET PROPERTIES
BARTON STREET AND FIFTY ROAD
STONEY CREEK
HAMILTON, ONTARIO.

Prepared for:

1312773 Ontario Inc.

Prepared by:

AME - Materials Engineering

DECEMBER 2009

PROJECT NO. 40236.210

AME
Materials Engineering

AME - MATERIALS ENGINEERING
117 Ringwood Drive, Unit 6, Stouffville, Ontario, L4A 8C1
Phone (905) 640-7772 Fax (905) 640-8512

50 BEST EMPLOYERS IN CANADA 2009

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Site Location Plan	Drawing No. 1A
Borehole Location Plan	Drawing Nos. 1B

APPENDIX 2

Log of Boreholes	Drawing Nos. 2-1 to 2-12

APPENDIX 3

Laboratory Testing	Grain Size Analysis (Figure No. 3-1)
	Standard Proctor (Figure No. 3-2)
	Certificate of Analysis Corrosivity Package (Enclosure No. 3-3)
	Certificate of Analysis Ontario. Reg. 153 (Enclosure No. 3-4)

APPENDIX 4

Drainage and Backfill Details

ANSI – AWWA Corrosivity Rating System

1.0 INTRODUCTION

On behalf of 1312773 Ontario Inc. AME - Materials Engineering has been authorized to conduct a preliminary geotechnical investigation of the Barton Street Properties located on the southeast corner of Barton Street and McNeilly Road, in the City of Hamilton (Stoney Creek), Ontario. A Site Location Plan is provided as Drawing No. 1A – Appendix 1.

It is our understanding that the proposed site development plan comprises residential lots with local roads.

The purpose of this investigation was to characterize the underlying soil and groundwater conditions, to determine the relevant geotechnical properties of encountered soils for the design and construction of the project and to provide recommendations on the geotechnical aspects of the construction of municipal services, roads and houses.

2.0 SITE DESCRIPTION

The proposed residential development site, Barton Street Properties located on the southeast corner of Barton Street and McNeilly Road, in the Community of Stoney Creek, City of Hamilton, Ontario. The site is irregular in shape and is currently used for agriculture purposes. The Site consists of three (3) parcels of lands and each parcel is approximately rectangular in shape. The total area of all the three parcels is approximately 21 hectares (52 acres).

The Site is bounded by Barton Street to the north, McNeilly Road to the west, and scattered residential dwellings and vacant lands to the south and east. Developed residential lands are located west of McNeilly Road.

The existing Site terrain is generally flat to gently rolling. The existing ground surface slopes very gently from the south to the north. At the time of our visit the Site was covered a thin blanket of snow. Scattered weed and tree lines were also visible in the properties.

The Site is located within a lowland bordering Lake Ontario, in the physiographic region of Southern Ontario known as the Iroquois Plain. The Site soils (Halton Till) have largely been developed upon red clay derived from the underlying Queenston Formation. The Queenston Formation is dominantly red, hematitic, fissile and micaceous, calcareous shale. Reduction zones have a green colouration occur parallel and discordant to bedding. Thin layers of hard siltstone, sandstone, mudstone and limy bands often exist locally in the shale

3.0 FIELD WORK

The fieldwork for this project was performed on December 17, 2009, and consisted of twelve (12) exploratory boreholes. The boreholes were drilled to approximate depths of 3.9 to 6.6 m below existing grade. The borehole locations are shown on the Borehole Location Plan, Drawing No. 1B - Appendix 1. The ground surface elevations of borehole locations were inferred from the topographic plan supplied by the client (Drawing No. 30435 by A.T. McLaren Limited).

The boreholes were advanced to the sampling depths by means of continuous flight solid stem augers. Standard Penetration Tests (SPT's) were carried out at frequent intervals of depth. Representative samples of the Site soils were obtained using the SPT split barrel samplers. The results of SPT's in terms of 'N'-values have been used to infer the consistency of cohesive soils and relative density of non-cohesive soils in this report.

All soil samples were examined in the field and carefully preserved for further examination in the laboratory. Groundwater level observations were made in all boreholes during and upon completion of drilling operations. In addition, three (3) piezometers were installed in Borehole Nos. 1, 4 and 9 for subsequent water level monitoring. Examination of the soil samples obtained in the boreholes by visual and olfactory methods did not detect contamination of the site soils at the locations investigated.

The fieldwork was performed under the full-time supervision of experienced geotechnical personnel from AME.

4.0 LABORATORY TESTS

The soil samples recovered by the split barrel sampler were sealed in air tight plastic bags, labeled and transported to AME's geotechnical laboratory for detailed examination and testing. The soil samples were visually examined in the laboratory for the final classification of soil types. The moisture content of all soil samples obtained in the boreholes was determined by oven drying in the laboratory.

The natural moisture content data, soil description and Standard Penetration Test N-values are presented on the Borehole Logs, Figure Nos. 2-1 through 2-12 – Appendix 2. One soil sample (BH3 / SS3) was subjected to hydrometer grain size analysis and one bulk soil sample was submitted for Standard Proctor testing in the laboratory. The laboratory test results are presented in Appendix 3 as Figures 3-1 and 3-2, and are discussed in the following sections.

One selected soil sample (BH8 / SS4) was submitted for pH, Sulphide, Redox Potential and Resistivity tests in order to identify potential corrosion problems with regard to underground utilities. One selected soil sample (BH2 / SS2) was submitted for the determination of selected general and inorganic parameters for comparison to the *"Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act of Ontario"*, March 2004. The test results are discussed in the ensuing sections of this report. Certificate of Analyses provided by the analytical chemistry testing laboratory are contained in Appendix 3 as Enclosure Nos. 3-3 and 3-4.

5.0 SUBSOIL & GROUNDWATER CONDITIONS

Subsurface conditions, encountered at the borehole locations, are shown on Borehole Logs, Figure Nos. 2-1 to 2-12 – Appendix 2, and a brief description of the subsoil units are given in the following subsections. The boreholes were advanced to depths ranging from approximately 3.9 m to 6.6 m below existing grade.

It should be noted that the boundaries of soil types indicated on the borehole logs are inferred from non-continuous soil sampling and observations made during drilling. These boundaries are intended to reflect transition zones for the purpose of geotechnical design, and therefore, should not be construed as the exact plane of geological change.

The subsurface stratigraphy as revealed in the boreholes generally comprises surficial topsoil underlain by earth fill / disturbed native soil and which in turn is underlain by native glacial till and / or bedrock. A brief description of these materials is presented below.

5.1 TOPSOIL

Topsoil was encountered at the ground surface in all of the boreholes except Boreholes 10 and 12. The thickness of the topsoil at the borehole locations ranged from 50 mm and 300 mm, and averaged 115 mm.

It should be noted that the topsoil measurements were carried out at the borehole locations only and may vary between boreholes. Therefore, thicker topsoil than that found in the boreholes may occur in places. This renders it difficult to estimate the quantity of topsoil to be stripped. In order to prevent over-stripping, diligent control of the stripping operation will be required. A more detailed analysis (involving test pits) should be carried out to more accurately quantify the amount of topsoil to be removed for construction.

5.2 EARTH FILL / DISTURBED NATIVE SOILS

Earth fill or disturbed native soil was encountered either just below the topsoil or at the ground surface in the case of Borehole 10 and 12. The earth fill / disturbed native soils consists of brown sandy silt to clayey silt with trace gravel. The sandy silty to clayey silt was noted to be disturbed / weathered, likely due to previous crop cultivation and / or repeated seasonal freeze-thaw cycles. The composition of the soil is similar to that of the underlying undisturbed glacial till but contains traces of organic inclusions (rootlets) and possibly intermixed topsoil. In some of the boreholes, the earth fill / disturbed native soil had pockets of black sand.

The earth fill / disturbed native soil extended depths ranging from 0.3 to 0.8 m below existing grade. The thickness of the layer varied from 0.2 m to 0.6 m, with an average thickness of approximately 0.4 m.

Standard Penetration Resistance in the earth fill / disturbed native soils had 'N'-values ranging from 2 to 9 blows per 300 mm, indicating a material of soft to stiff consistency. The sandy silt to clayey silt is moist to wet, with moisture contents determined on the soil samples ranging from 18% to 34%.

5.3 GLACIAL TILL

Underlying the earth fill / disturbed native soil, each of the borehole encountered glacial till which extended to the vertical limit of investigation. The glacial till consists predominantly of a clayey silt matrix with embedded sand, gravel and occasional thin lenses of sandy silt. Cobbles and boulders are probably present but would not be representatively sampled with the equipment used in this investigation. The glacial till contains weathered shale fragments which became more numerous with increasing depth. The glacial till was moist and generally brown to grey changing to red at greater depth.

Standard Penetration Resistance in the cohesive clayey silt till had 'N'-values ranging 15 to greater than 50 blows per 300 mm, indicating a stiff to hard consistency (compact to very dense if cohesionless sandy silt). The moisture content of samples of the glacial till ranged from 4% to 21%, and averaged 12%.

A hydrometer grain size analysis was carried out on a representative sample of the clayey silt till obtained in Borehole 3 below a depth of 1.5 m (Sample SS3) and the grain size distribution curve determined is presented on Figure No. 3-1 – Appendix 3.

In order to assess the compaction characteristics of the glacial till, a Standard Proctor test was performed on a bulk sample of material which determined a maximum dry density of 1910 kg / m^3 at an optimum moisture content of 14.1%. The Standard Proctor curve for the sample tested in presented on Figure No. 3-2 – Appendix 3.

All of the boreholes were either terminated in the glacial till or upon reaching practical auger refusal in probable bedrock.

6.0 GROUNDWATER CONDITIONS

Groundwater observations were made both during and upon completion of drilling of boreholes, and subsequently in the standpipe piezometers installed in Boreholes 1, 4 and 9. Groundwater observations made on December 17, 2009 and water level measurements made in the standpipe piezometers are summarized in Table I below.

Table 1 - Summary of Groundwater Observations

Borehole No.	December 17, 2009*	December 18, 2009	December 22, 2009
BH 1	Dry to 4.45 m	Dry to 4.45 m	1.60 m
BH 2	Dry to 4.17 m	N/A	N/A
BH 3	Dry to 4.24 m	N/A	N/A
BH 4	0.10 m	0.10 m	0.50 m
BH 5	Dry to 6.15 m	N/A	N/A
BH 6	Dry to 5.03 m	N/A	N/A
BH 7	Dry to 3.84 m	N/A	N/A
BH 8	Dry to 4.60 m	N/A	N/A
BH 9	Dry to 5.03 m	Dry to 5.03 m	Dry to 5.03 m
BH 10	4.40 m	N/A	N/A
BH 11	Dry to 5.03 m	N/A	N/A
BH 12	Dry to 6.55 m	N/A	N/A

Groundwater observations were made both during and upon completion of drilling of boreholes, and subsequently in the standpipe piezometers installed in Boreholes 1, 4 and 9. In general the fine-grained glacial till deposits beneath this Site have low permeability and preclude the free flow of groundwater. Glacial till deposits typically contain preferentially permeable cohesionless sand lenses which can be in a wet state and contain stored water. It is likely that a sand lens was penetrated in Borehole 4 which contained sufficient water to fill the boring.

Complete characterization of the groundwater regime beneath the Site would require monitoring over a period of several months because of the fine grained nature of the glacial till soils and their low hydraulic conductivity. It should be noted that groundwater levels are subject to seasonal fluctuations.

7.0 DISCUSSION AND RECOMMENDATIONS

The following discussion and recommendations are based on the factual data obtained from this investigation and are intended for use by the client's design engineers only.

Contractors bidding on this project or conducting work associated with this project should make their own interpretation of the factual data and / or carry out their own investigations.

This investigation has revealed that the site is covered by a surface layer of topsoil which is underlain by a layer of earth fill / disturbed native soil, which in turn is underlain by a thick stratum of glacial till. On the basis of our fieldwork, laboratory tests and other pertinent information supplied by the client, the following comments and recommendations are made.

7.1 PAVEMENT DESIGN

Based on the existing topography of the subject site, assumed proposed grades and the data collected during the field investigation, it is anticipated that the sub-grade material for the subdivision roads will generally comprise clayey silt till or similar compacted fill. Given the frost susceptibility and drainage characteristics of the subgrade soils, and the City of Hamilton's minimum requirements for rural residential roads, the following pavement structure designs are recommended:

Pavement Structure Layer	Compaction Requirements	Minimum Component Thickness	
		Rural Local Road	Rural Minor Collector Road
Surface Course HM-3 Asphaltic Concrete	OPSS 310	40 mm	50 mm
Binder Course HL-8 Asphaltic Concrete	OPSS 310	50 mm	90 mm
Granular Base: Granular A (OPSS 1010)	100% SPMDD*	150 mm	150 mm
Granular Subbase: Granular B (OPSS 1010)	100% SPMDD*	350 mm	400 mm

*Denotes Standard Proctor Maximum Dry Density, ASTM-D698

The granular pavement structure materials should be placed in lifts that are 150 mm thick or less and be compacted to a minimum of 100% and 98% for granular base and subbase, respectively. Asphaltic concrete materials should be rolled and compacted as per OPSS 310. The granular and asphaltic concrete pavement materials and their placement should conform to OPSS 310, 501, 1010 and 150, and the pertinent Municipality specifications. Further, it is recommended that the Municipality's specifications should be referred to for use of higher grades of asphalt cement for asphaltic concrete where applicable, particularly in the areas of expected heavy truck traffic.

The above pavement structure designs meet the minimum requirements for The City of Hamilton. If alternative pavement designs are desired, AME should be contacted and approval obtained from the City of Hamilton. Other road types, parking lots, etc. should be constructed in accordance with The City of Hamilton's standards.

The subgrade must be compacted to 98% of SPMDD for at least the upper 1000 mm and 95% of SPMDD below this level.

The long-term performance of the proposed pavement structure is highly dependent upon the subgrade support conditions. Stringent construction control procedures should be maintained to ensure that uniform subgrade moisture and density conditions are achieved. In addition, the need for adequate drainage cannot be over-emphasized. The finished pavement surface and underlying subgrade should be free of depressions and should be crowned and sloped (at a crossfall of 3% for both the pavement surface and the subgrade) to provide effective drainage. Surface water should not be allowed to pond adjacent to the outside edges of pavement areas. Sub-drains or drainage ditches must be provided to facilitate effective and assured drainage of the pavement structures as required to intercept excess subsurface moisture and minimize subgrade softening. The invert of sub-drains and ditches should maintained at least 0.3 m and 0.5 m below subgrade level, respectively

Additional comments on the construction of pavement areas are as follows;

- As part of the subgrade preparation, proposed pavement areas should be stripped of topsoil, unsuitable fill and other obvious objectionable material. Fill required to raise the grades to design elevations should be free of organic material and at a moisture content which will permit compaction to the specified densities. The subgrade should be properly shaped, crowned, and then proof-rolled. Soft or spongy subgrade areas should be sub-excavated and properly replaced with suitable approved backfill compacted to 98% SPMDD.

- The most severe loading conditions on pavement areas and the subgrade may occur during construction during wet and un-drained conditions. Consequently, special provisions such as restricted lanes, half-loads during paving etc., may be required, especially if construction is carried out during unfavorable weather.

- For fine-grained soils, as encountered at the site, the degree of compaction specification alone cannot ensure distress free subgrade. Proof-rolling must be carried out and witnessed by AME personnel for final recommendations of sub-base thicknesses.

7.2 EXCAVATION AND GROUNDWATER CONTROL

Based on the field results, temporary shallow excavations for sewers, trenches, basements and utilities are not expected to pose any difficulty. Excavation of the soils and completely weathered shale bedrock at this site can be carried out with heavy hydraulic backhoes. It is likely that heavy backhoes with ripping teeth can also excavate the upper bedrock zones that are moderately to highly weathered. However, provision must be made to use hydraulic rock breakers or other suitable percussion equipment to break up the sound, unweathered shale bedrock and hard interbeds where necessary. It should be noted that the contact between the weathered bedrock and sound bedrock is not well defined and Contractors must make their own assessment of the degree of difficulty in excavating these materials. The ability to excavate the bedrock without blasting depends on the type of equipment and excavation methods used. Therefore, contractors undertaking the project should carry out their own test pits to determine their ability to excavate bedrock without blasting.

All excavations must be carried out in accordance with Occupational Health and Safety Act (OHSA). With respect to OHSA, the undisturbed, native very stiff/dense glacial till are classified as Type 2 soils and the undisturbed, native hard/very dense glacial till are classified as Type 1 soils. Any previously excavated soil (earth fill) and undisturbed, native stiff soils are classified as Type 3 soils.

Temporary excavation side-slopes in Type 3 soil should not exceed 1.0 horizontal to 1.0 vertical. Excavations in Type 1 and Type 2 soils may be cut with vertical side-walls within the lower 1.2 m height of excavation and 1.0 horizontal to 1.0 vertical above this height.

For excavations through multiple soil types, the side slope geometry is governed by the soil with the highest number designation. Locally, where very loose or soft soil is encountered at shallow depths or within zones of persistent seepage, it will be necessary to flatten the side slopes as necessary to achieve stable conditions. Excavation side-slopes should not be unduly left exposed to inclement weather.

Where workers must enter excavations extending deeper than 1.2 m below grade, the excavation side-walls must be suitably sloped and / or braced in accordance with the Occupational Health and Safety Act and Regulation for Construction Projects.

The borings suggest that for the anticipated excavation depths there will be no significant ground water seepage into excavations. Only limited seepage is anticipated within the undisturbed, native glacial till soils. It is anticipated that adequate control of any ground water seepage can likely be achieved by pumping from properly filtered sumps in the base of the excavation. Surface water should be directed away from the open excavations.

It should be noted that the till is non-sorted sediment and therefore may contain boulders. Provisions must be made in the excavation contract for the removal of possible boulders.

7.3 BEDDING FOR SEWERS AND WATERMAINS

Suitably prepared engineered fill, undisturbed, native stiff to hard / compact to very dense soils and bedrock at the site and will provide adequate support for watermains, sewer pipes, manholes, catchbasins and other related structures. Based on the anticipated site grades, the sewer pipes and watermains will likely be supported on the very stiff to hard clayey silt till or very dense sandy silt till or bedrock.

The type of bedding depends mainly on the quality of the subgrade immediately below the invert levels and particularly on the shear strength of the subgrade.

Normal Class 'B' bedding is recommended for the underground utilities. Granular 'A' or 19 mm Crusher Run Limestone can be used as bedding material. The bedding material should be compacted to 95% Standard Proctor Maximum Dry Density. Bedding details should follow the applicable governing design detail (i.e. City of Hamilton, OPSD). Trenches dug for these purposes should not be unduly left exposed to inclement weather. Lateral pipe to bedrock clearances (particularly for deep sanitary sewer construction) should be strictly adhered to and / or compressible materials provided where necessary in trenches that are excavated in the shale in order to avoid potential problems due to swelling of the shale bedrock.

Pipe bedding and backfill for flexible pipes should be undertaken in accordance with OPSD 802.010, 802.013, 802.014, 802.020, 802.023 and 802.024. Pipe embedment and cover for rigid pipes should be undertaken in accordance with OPSD 802.030, 802.031, 802.032, 802.033, 802.034, 802.050, 802.051, 802.052, 802.053 and 802.054.

If unsuitable bedding conditions occur, careful preparation and strengthening of the trench bases prior to sewer installation will be required. The subgrade may be strengthened by placing a thick mat consisting of 50 mm crusher-run limestone. Field conditions will determine the depth of stone required. Geotextiles and/or geogrids may be helpful and these options should be reviewed by AME on a case by case basis.

Sand cover material should be placed as backfill to at least 300 mm above the top of pipe. Placement of additional granular material (thickness dictated by the type of compaction equipment) as required or use of smaller compaction equipment for the first few lifts of native material above the pipe will probably be necessary to prevent damage to the pipe during the trench backfill compaction.

7.4 REUSE OF EXCAVATED SOIL AND BEDROCK AS COMPACTED FILL

7.4.1 Topsoil / Unsuitable Fill Materials

Topsoil and / or unsuitable fill should not be left in place or utilized in any area requiring structural integrity of founding material such as houses, roads, sidewalks, structural berms, etc.

AME should be contacted to review all proposed topsoil and/or unsuitable fill usage strategies.

7.4.2 Earth Fill / Disturbed Native Soils

As noted previously, the existing earth fill / disturbed native soils typically contain trace amounts of organics and possibly included topsoil, and exhibit a high in-situ moisture content. Consequently, these materials may not be favourable for re-use as engineered fill or backfill in settlement sensitive areas, such as trench backfill beneath floor slabs and pavement structures. Therefore, it is recommended that the selection of and sorting of the existing earth fill / native disturbed soils be supervised by the Geotechnical Engineer. Alternatively, these materials may be placed in the rear of lots, landscaped areas and outside the building envelopes building lots provided it is placed a minimum of 0.5 m above the footing elevation.

7.4.3 Glacial Till

On-site excavated native glacial till materials are considered suitable for reuse as backfill or engineered fill material, provided any topsoil, organic or otherwise unsuitable materials are excluded from the backfill, the moisture content is controlled within 2% of its optimum water content as determined by Standard Proctor test, and the materials are effectively compacted with heavy vibratory pad-type rollers. The compactors must be of sufficient size and energy to break down the lumps of till material and to knead the soil into a homogeneous mass as water and compactive effort is applied. If the equipment does not have sufficient energy to break down the till lumps, there is a tendency to bridging and post construction settlements. In situ testing may fail to identify this type of deficiency adequately because the zones of influence of testing equipment is small enough that the density of the till lumps can be erroneously measured instead of the fill mass density.

Reference to the Standard Proctor test shows that the optimum moisture content of the clayey silt till is approximately 14.1%. Measured in-situ moisture contents within the clayey silt till ranged from approximately 4% to 21%, and averaged approximately 12%, which is generally within 2% of the material's optimum moisture content. However, thorough vertical mixing of the excavated clayey silt till will be required to provide a material that can be adequately compacted throughout. During warm weather, drying of the glacial till may become acute; therefore, the lift thickness for compaction and the moisture content of the soils must be properly controlled during the backfilling. Provision for water application must be made as necessary to achieve the specified backfill compaction density.

7.4.4 Shale

On-site excavated shale bedrock will require a higher degree of mechanical effort to produce an acceptable material for re-use as backfill or engineered fill material. The excavation of the shale bedrock will require heavy hydraulic backhoes and / or bulldozers equipped with ripping teeth. Earth scrapers, if equipped with ripping teeth, could be considered for excavating the weathered shale. Alternative extraction methodologies, such as hydraulic rock breakers or blasting, should be considered if the shale becomes excessively hard or stronger interbeds are encountered.

The moisture content of the shale is normally well below its optimum value. Both the glacial till and shale bedrock tend to break-up into relatively large clods/blocks/lumps when excavated. In order for pavement structures which are constructed over service trenches backfilled with these materials to perform satisfactorily, and to construct certifiable engineered fill pads, it is essential that the materials are placed as a homogeneous amorphous mass with a minimum volume of voids. To accomplish this, the construction operations must be carefully controlled and the construction equipment employed be suitable for the type of work in order that:

1. The excavated material is thoroughly mixed; and
2. Any structure (clods/blocks/lumps) exhibited by the excavated material is destroyed and the glacial till / shale are thoroughly pulverized.

In this regard, construction procedures should be adopted during all phases of the construction including excavation, stockpiling, placement and compaction to maximize break-up and mixing of the excavated material. Excavated shale must be broken down into fragments smaller than 150 mm maximum dimension. All lumps/blocks/clods and / or shale fragments larger than 150 mm in any dimension must be broken down / pulverized before deposition in the trench. Any materials larger than 150 mm must be wasted. This is especially important around manholes and catchbasins.

Selective / local excavation at the centre of the trench and / or knocking down the sides of the excavation shall not be permitted. The trench must be wide enough to accommodate the full width of compaction equipment. A bulldozer shall be used for spreading of the backfill. Use of a front-end loader or backhoe shall not be permitted for this operation.

A bulldozer must be used in the trench to spread the engineered fill or trench backfill in lifts not exceeding 200 mm in thickness and each lift shall be compacted using heavy, self-propelled vibratory pad-foot rollers. Material should be spread and compacted in a continuous operation from manhole to manhole to avoid segregation of the material on the fill slopes at the ends of each section. Provision of continuous water application must be made in order to reduce the inter-particle friction and to reduce the voids in the compacted material. Application of water and turning (mixing) of the shale material upon excavation and stockpiling will likely be required to produce a material that can be adequately compacted.

It is recommended that the shale be mixed with the excavated glacial till in order to obtain a better overall material gradation which would minimize the void content. Furthermore, a compaction trial strip of the reworked shale material is recommended prior to conducting full scale trench backfilling or engineered fill placement in order to determine the most efficient and practical methodology.

Shale must not be placed and compacted when frozen because breakdown then requires a much greater degree of compactive effort. If the shale is placed in a frozen condition and not thoroughly broken-up / pulverized, breakdown of the shale would continue due to natural processes when the material thaws, resulting in possible excessive fill settlement.

7.4.5 General

If on-site excavated soils become excessively wetter than optimum moisture contents, the soils should be dried sufficiently in order to achieve the specified degree of compaction. If construction is carried out in inclement weather, there is a likelihood that some amount of road sub-base supplement will be required (i.e. some sub-excavation followed by granular replacement).

It is recommended that service trenches be backfilled with native on-site materials such that at least 95% of Standard Proctor Maximum Dry Density (SPMDD) is obtained in the lower zone of the trench and 98% of SPMDD for the upper 1000 mm. However, prior to building the roads, the subgrade should be thoroughly proof-rolled and recompacted to 98% of SPMDD to ensure uniformity in subgrade strength and support. This phase of the work should be scheduled for drier months. Lift thicknesses shall not exceed 200 mm in a loose state unless approved by AME and should be compacted using a heavy, vibratory pad-type rollers.

As an alternative, if suitable on-site native material is not available, the upper part of the subgrade could be improved by placing imported granular material.

In areas of narrow trenches or confined spaces such as around manholes, catchbasins, etc., imported sand or OPSS Granular 'B' should be used and compacted to the specified amount.

The soils bulking factor estimated for the average cut and fill conditions at this site should be approximately 10% for the on-site native materials. The bulking factor for excavation and subsequent disposal off site would be approximately 15% for the above material. It should be noted that the type of excavation processes may greatly affect the bulking factor of the material. The bulking factor of the shale depends on the degree of weathering and breakdown. In general, bulking factors of 10 to 15% (average of ~12.5%) can be used for the upper highly weathered shale and 15 to 25% (average of ~20%) for the sound, unweathered shale. A shrinkage factor estimate of 15% can be used for the reuse of topsoil fill.

7.5 GENERAL SITE RE-GRADING

Based on the anticipated proposed grades and the existing topography at the subject site, it is anticipated that some cut and fill operation will be required for general site re-grading. Due to the variation in the composition of the on-site native materials, it is recommended that additional Standard Proctor Density tests be performed when the construction work begins and the ground is broken. AME should be contacted in order to verify and evaluate the proposed soil types for general site re-grading.

7.6 ENGINEERED FILL

Placement of excavated site soils may be used to raise grades of the proposed lands to the desired elevations. The following recommendations regarding the construction of engineered fill should be adhered to during construction:

- All of the topsoil, any excessively organic materials and the existing earth fill/disturbed native soils must be removed to expose the underlying undisturbed, native glacial till subgrade. The exposed subgrade soils must be inspected and proof-rolled prior to any engineered fill placement.

- Engineered fill operations should be monitored and compaction testing should be performed on a full-time basis by a qualified technicians supervised by the Geotechnical Consultant.

- The boundaries of the engineered fill must be clearly and accurately laid out in the field by qualified surveyors prior to the commencement of engineered fill construction. The top of the engineered fill should extend a minimum of 2.5 m beyond the building envelope. Where the depth of engineered fill exceeds 1.5m, this horizontal distance of 2.5 m beyond the perimeter of the building should be increased by at least 1.0 m for each 1.0 m depth of fill. The edges of the engineered fill should be sloped at a maximum of 3H:1V in order to avoid weakening of the engineered fill edges due to slope movement.

- Due to the potential detrimental effects of differential settlement between the engineered fill and the native soils, any lots where footings are to be placed partly on engineered fill and partly on native soils should be reinforced with 15 M steel bars (two in the footings and two near the top of wall as a minimum).

- Soils or bedrock derive materials used as engineered fill should be free of organic and/or other unsuitable material. The engineered fill must be placed in lifts not exceeding 200 mm in thickness and compacted to 98% Standard Proctor Maximum Dry Density (SPMDD).

- Imported fill must not be used unless documentation is produced verifying that the material is suitable for residential/parkland usage (as per MOE document "Soil, Ground Water and Sediment Standards for Use under Part XV.1 of the Environmental Protection Act, March 2004").

- If fill is required adjacent to sloping cuts or hill sides (> 3:1, horizontal to vertical), it is imperative that the fill is placed in stepped planes benched in order to avoid a plane of weakness.

- The engineered fill operations should take place under favourable climatic conditions. If the work is carried out in months where freezing temperatures may occur, all frost affected material must be removed prior to the placement of frost-free fill.

- When engineered fill is left over the winter, a minimum of 1.2 m of earth cover must be provided as frost protection.

- If unusual soil conditions become apparent during construction, due to subsurface groundwater influences, our office should be contacted in order to assess the conditions and recommend appropriate remedial measures.

- The footing and underground services subgrade must be inspected by the Geotechnical Consultant that supervised the engineered fill placement. This is to ensure that the foundations are placed within the engineered fill envelope, and the integrity of the fill has not been compromised by interim construction, environmental degradation and /or disturbance by the footing excavation. Foundations placed in the engineered fill should be nominally reinforced with steel bars.

7.7 HOUSE FOUNDATION DESIGN

The existing topsoil and earth fill / native disturbed soil are considered to be unsuitable of the support of building foundations. The underlying undisturbed, native stiff to hard / compact to very dense glacial till soils (below the topsoil and earth fill / disturbed native soils) throughout the site are considered suitable for the support of house foundation on conventional spread footings. Conventional spread footings founded in the undisturbed, native stiff to hard / compact to very dense soils or on certified engineered fill may be designed using a net geotechnical bearing resistance at Serviceability Limit States (SLS) of 150 kPa and a factored geotechnical bearing resistance at Ultimate Limit States (ULS) of 225 kPa (vertical, centric).

The geotechnical bearing resistance values stated above are for vertical loads (no inclination) and no eccentricity. The total and differential settlements of spread footing foundations designed in accordance with the above recommendations should not exceed tolerable limits of 25 mm and 19 mm, respectively.

The soil bearing resistance of the founding soils for all footings should be verified by the Geotechnical Engineer prior to the placing the foundation concrete.

All exterior footings and footings in unheated areas should be provided by at least 1.2 metres of soil cover or equivalent artificial thermal insulation for frost protection purposes. Exposed soil foundation subgrades should be protected against freezing and surface water should be kept away from the foundation subgrade areas to prevent softening. If unstable subgrade conditions develop the Geotechnical Consultant should be contacted in order to assess the conditions and make appropriate recommendations.

7.8 LATERAL EARTH PRESSURE

The basement walls of the house structures should be designed to withstand lateral earth pressure, P, acting against the wall. It is good construction practice to provide a perimeter filter fabric encased tile drainage system along with free-draining granular backfill material to relieve such structures of hydrostatic or excess pore water pressures. Details of perimeter drainage are presented in Appendix C. On the basis of effective drainage of the basement wall backfill, the following equation can be used to estimate lateral earth pressure at any depth:

$$\mathbf{P} = \mathbf{K}\,(\gamma\,\mathbf{h} + \mathbf{q})$$

where,
- **K** = Coefficient of Earth Pressure, assume 0.50
- γ = Unit Weight of Soil, assume 21 kN/m^3
- **h** = Height at any point along the wall in metres
- q = Any surcharge load in kPa

This equation assumes that free-draining backfill and positive drainage is provided to ensure that there is no hydrostatic pressure acting in conjunction with the earth pressure.

7.9 SOIL CORROSIVITY

One selected soil sample (Borehole 8, Sample SS4) was submitted for pH, Sulphide, Redox Potential and Resistivity tests in order to determine their corrosive characteristics of the soils. The test results are tabulated below and the Certificate of Analysis provided AGAT Laboratories is contained in Appendix 3 as Enclosure No. 3-3:

Soil Corrosivity Testing Results

SOIL CHARACTERISTICS	Borehole No. 8, Sample No. 4
pH	8.14
Resistivity (ohm-cm)	3260
Redox Potential (mV)	244
Sulphide	< 0.001
Moisture Content (%)	13.4

The above tests are considered in evaluating the corrosivity of the soil. For each of these tests, the results are categorized and points are assigned according to their contribution to corrosivity as tabulated below:

ANSI - AWWA Rating for Corrosivity

SOIL CHARACTERISTICS	Borehole No. 8, Sample No. SS4
pH	0
Resistivity (ohm-cm)	0
Redox Potential (mV)	0
Sulphide	2.0
Moisture Content (%)	1
TOTAL POINTS	**3.5***

*Note: A value less than 10 is considered non-corrosive.

Based on the ANSI – AWWA rating system, it is concluded that the soils would be considered non-corrosive for the subject site. The criteria for the soils test evaluation is presented in Appendix 4. This data should be reviewed by the pipe manufacturer to ensure proper construction methodology and appropriate protection. All watermain construction and material specifications should follow the standards and regulations as per OPSS and The City of Hamilton specifications.

7.10 ENVIRONMENTAL CONSIDERATIONS

One selected soil sample (Borehole 2, Sample SS2) was submitted to AGAT Laboratories in Mississauga, Ontario, an accredited environmental laboratory, for the determination of selected general and inorganic parameters for comparison to the *"Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act of Ontario",* March 2004. The Certificate of Analysis provided by the analytical chemistry testing laboratory is contained in Appendix 4 as Enclosure No. 3-4.

Land use at the Site is proposed to be residential. It is not known at this time if there will be use of the ground water. For the purpose of this current assessment, the results of the analytical chemistry testing have been compared to the Site Condition Standard set out in Table 2: Full Depth Generic Condition Standards in a Potable Ground Water Condition. With the exception of Electrical Conductivity (EC), the results of the analytical chemistry testing found the soil sample to have chemical concentrations less than the generic criteria in Table 2 - Residential / Parkland / Institutional Property Use [T2 (RPI)]. The EC parameter is a somewhat less critical non-health related parameter related to the fertility of soil and is associated with road salt, commonly used to de-ice roads and parking lots.

Based on the chemical nature of the soil, there is no impediment against the proposed land use. Further, the results of the analytical chemistry testing indicate that there is no impediment to re-disposition of the soil from the Site to a site accepting fill of this quality (i.e. vegetative growth in the soil not required).

8.0 GENERAL COMMENTS

During construction, frequent inspections by geotechnical personnel from AME should be carried out, to examine and approve fill material, granular base course and asphaltic concrete for pavements, to examine foundation grades for houses and sewers, and to verify the placement of fill, compaction of subgrade, base/sub-base course and asphalt concrete by insitu density testing, using nuclear gauges.

Finally, it is essential that construction be regarded as an extension of the design phases in the sense that design assumptions are confirmed or revised to conform to actual field conditions as revealed by excavation. This report is based on borehole information from only a few locations at the site. If, during construction, excavations reveal different subsoil conditions, it should be brought to our attention so that we can assess their effects on the construction.

9.0 CLOSURE

The 'Limitations of Report' attached form an integral part of this report.

We trust this report provides sufficient information for your present requirements in accordance with our Terms of Reference.

Yours very truly,
AME MATERIALS ENGINEERING

Prepared by :

LICENSED PROFESSIONAL ENGINEER
Feb 3/10
M. L. R. SELIM
100100930
L.S.
PROVINCE OF ONTARIO

Lutfur Selim, P.Eng.
Project Engineer

Reviewed by :

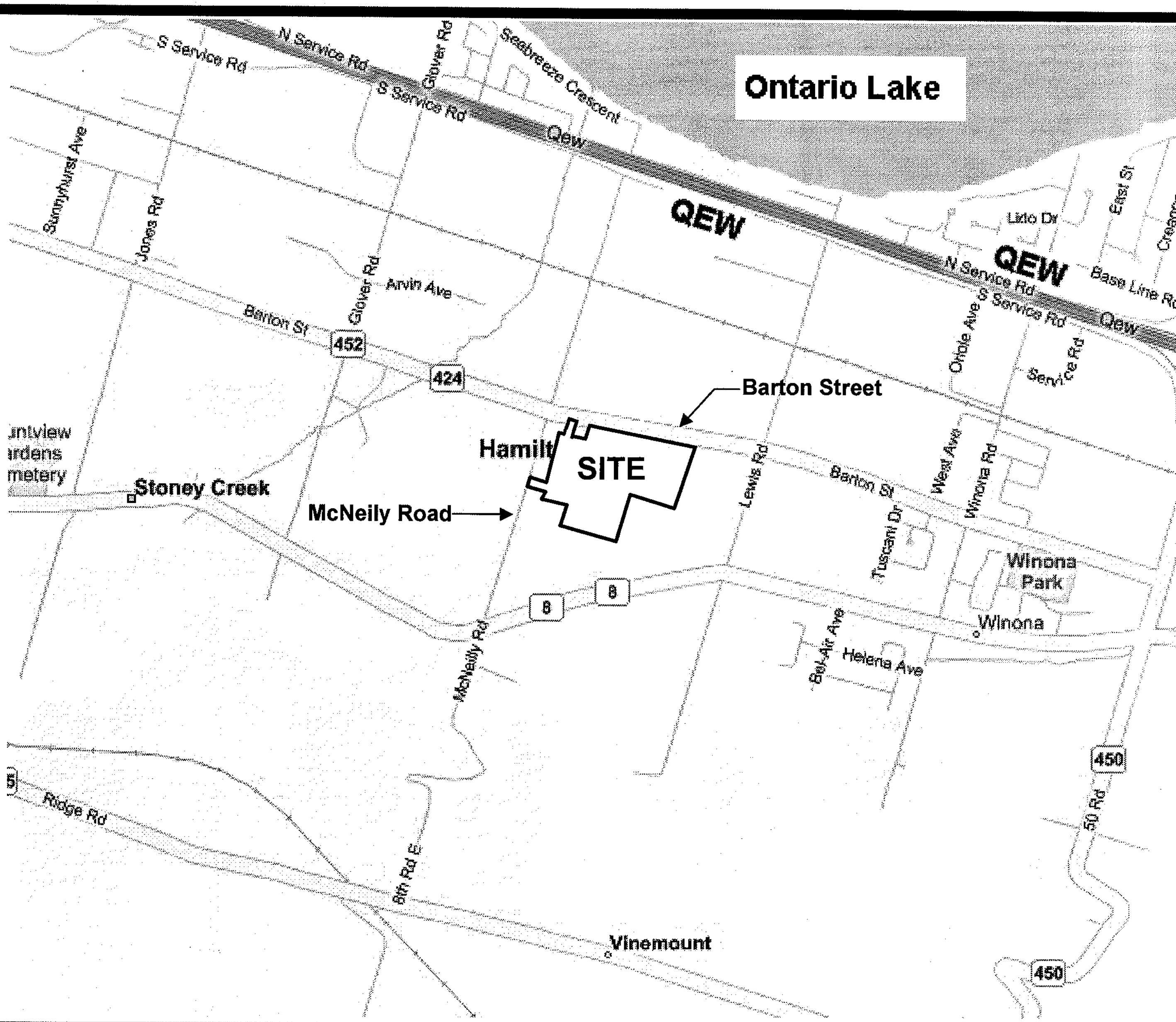
LICENSED PROFESSIONAL ENGINEER
L.C. MacARTHUR
02/03/2010
PROVINCE OF ONTARIO

Larry MacArthur, P.Eng.
Senior Geotechnical Engineer

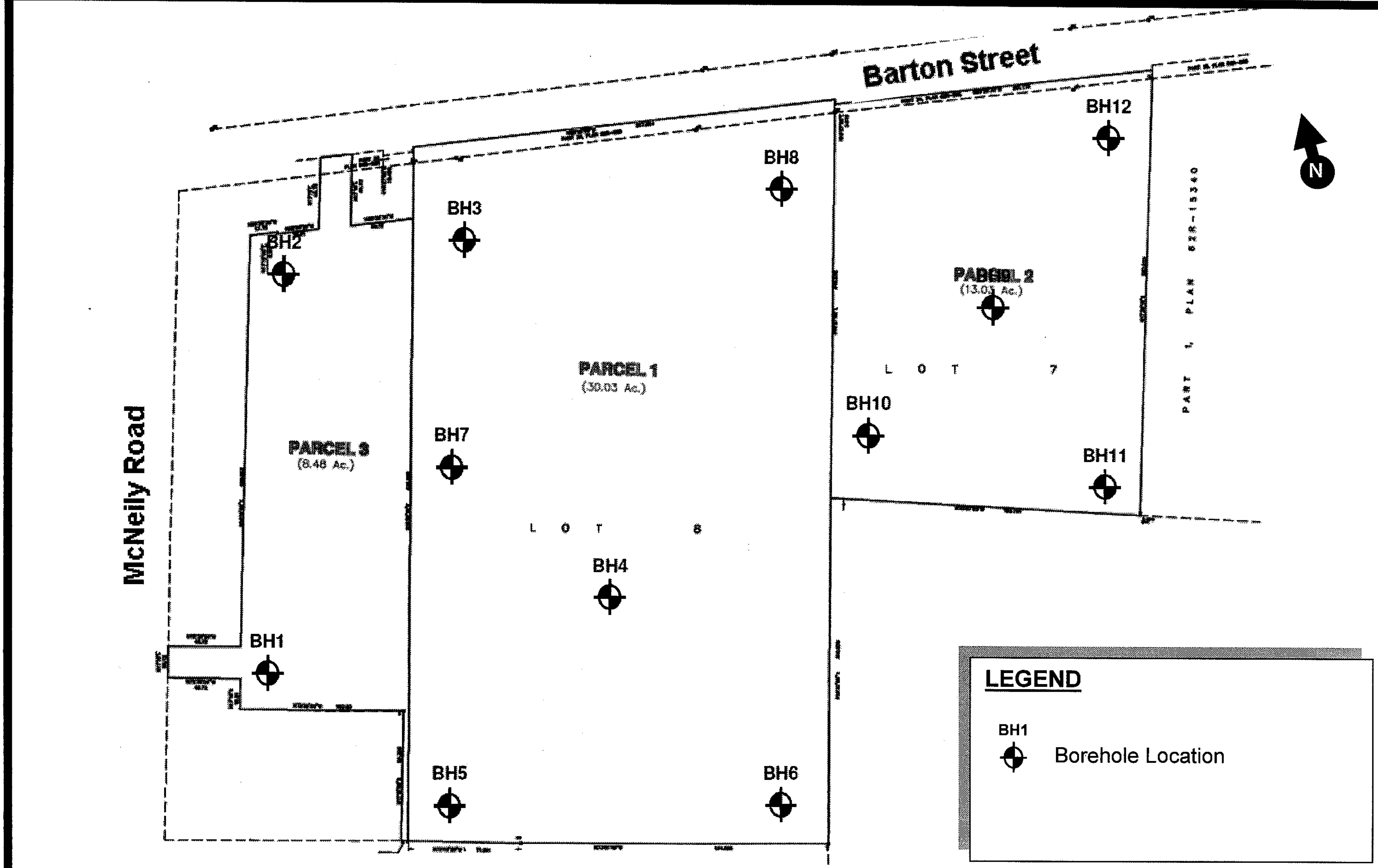
APPENDIX 1

Site Location Plan
Drawing No. 1A

Borehole Location Plan
Drawing No. 1B



AME – MATERIALS ENGINEERING 117 Ringwood Drive, Unit # 6 Stouffville, Ontario, L4A 8C1 Tel: (905) 640 7772 Fax: (905) 640 8512	SITE LOCATION PLAN Barton Street Properties Branthaven Homes Stoney Creek, Hamilton Ontario	Project No.:	40236.210
		Scale:	N.T.S.
		Date:	December 2009
		Drawing No.:	1A



AME Materials Engineering AME – MATERIALS ENGINEERING 117 Ringwood Drive, Unit # 6 Stouffville, Ontario, L4A 8C1 Tel: (905) 640 7772 Fax: (905) 640 8512	BOREHOLE LOCATION PLAN Barton Street Properties Branthaven Homes Stoney Creek, Hamilton Ontario	Project No.:	40236.210
		Scale:	N.T.S.
		Date:	December 2009
		Drawing No.:	1B

APPENDIX 2

Log of Boreholes
Figure Nos. 2-1 to 2-12

Log of Borehole 1

AME Materials Engineering

Project No.: 40236.210

Project Name: Preliminary Geotechnical Investigation for Barton Street Properties

Figure No. 2-1

Location: Barton Street and McNeilly Road, Stoney Creek, Ontario

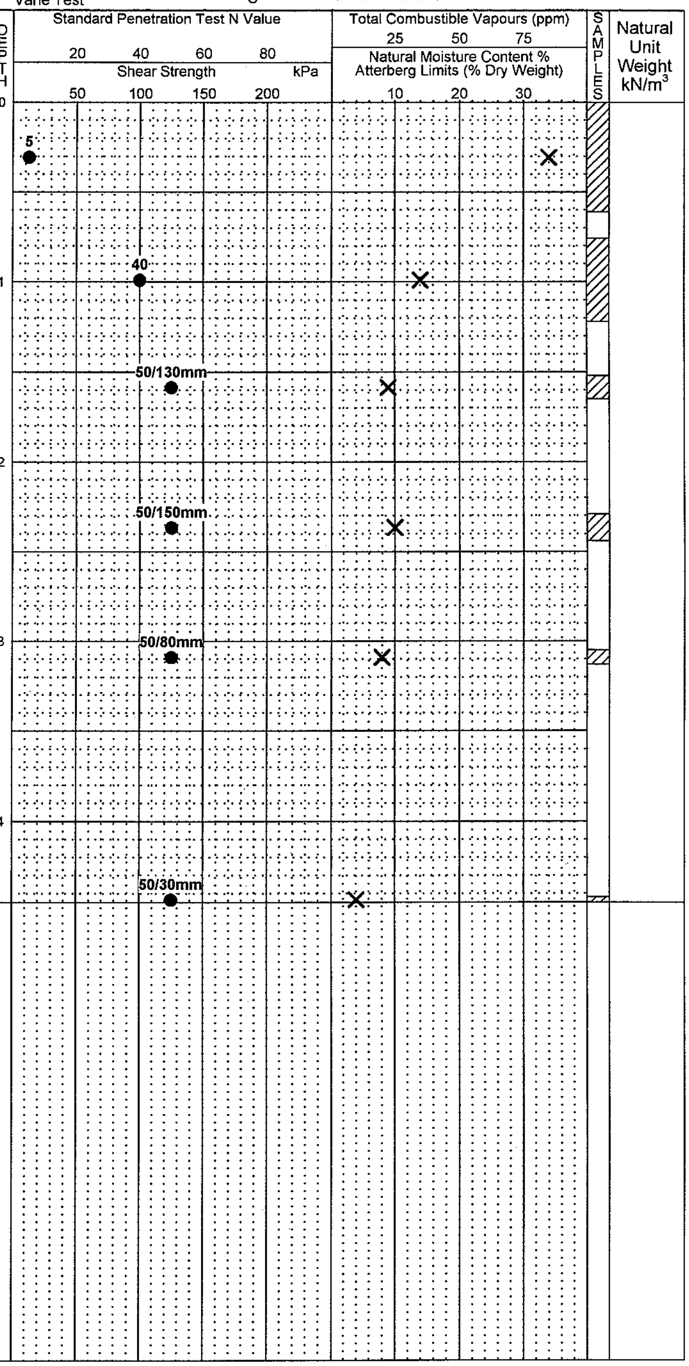
Date Drilled: 11/17/09

Drill Type: Solid Stem Auger

Datum: Geodetic

Legend		Legend	
Split Spoon Sample	▨	Combustible Vapour Reading	□
Auger Sample	▩	Natural Moisture Content	✕
SPT (N) Value	●	Atterberg Limits	⊢⊖
Dynamic Cone Test	──	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	▨		
Shear Strength by Vane Test	✚ S	Shear Strength by Penetrometer Test	▲

GWL	SYMBOL	SOIL DESCRIPTION	ELEV. m	DEPTH
			91.10	0
		~120 mm Topsoil.	90.98	
		FILL: brown clayey silt, traces of gravel and rootlets, black sand pocket, moist.	90.64	
		CLAYEY SILT TILL: some sand, traces of gravel and weathered shale fragments, brown to red, hard, moist.		1
		..........increasing red weathered shale pieces with depth.		2, 3, 4
			86.65	
		Refusal at 4.45m on probable bedrock End of borehole at 4.45 m		



Notes:

Date/Time	Water Level (m)	Depth to Cave (m)
12/17/2009	Dry	None
12/18/2009	Dry	
12/22/2009	1.60	

Sheet No. 1 of 1

Log of Borehole 2

AME Materials Engineering

Project No.: 40236.210

Project Name: Preliminary Geotechnical Investigation for Barton Street Properties

Figure No. 2-2

Location: Barton Street and McNeilly Road, Stoney Creek, Ontario

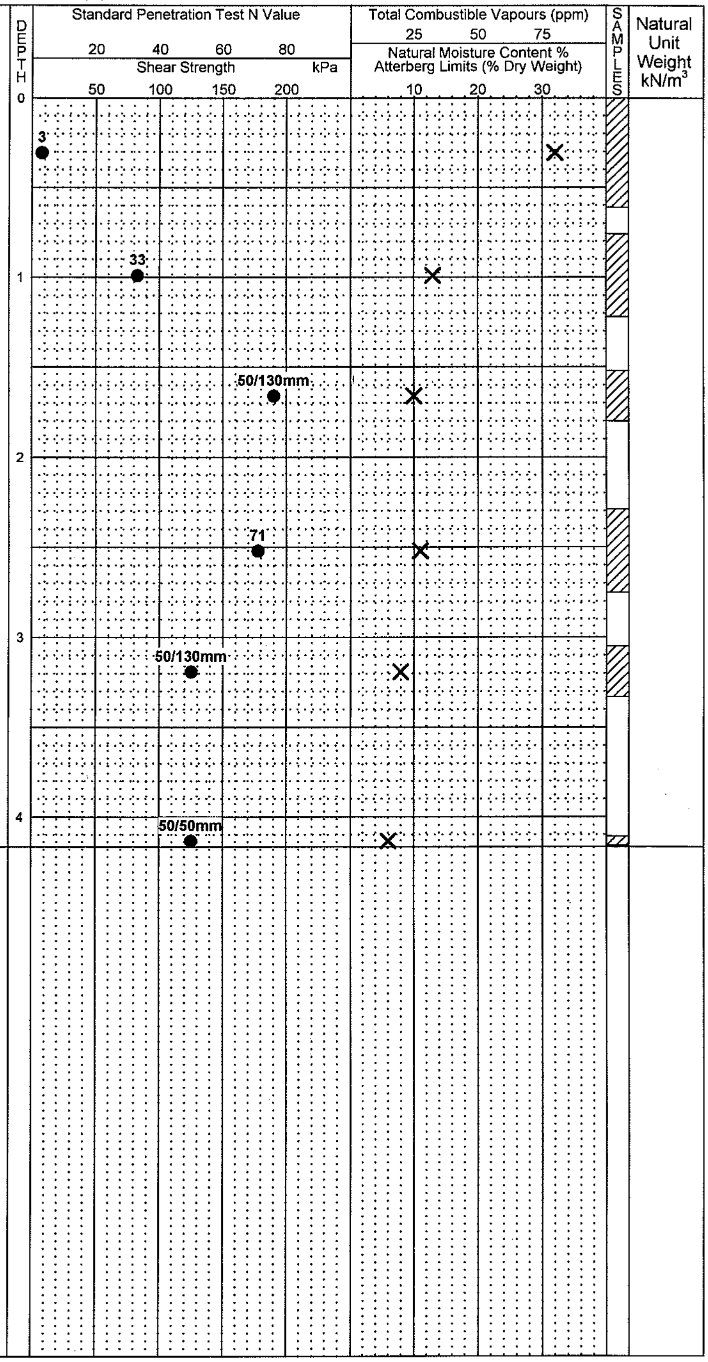
Date Drilled: 11/17/09

Drill Type: Solid Stem Auger

Datum: Geodetic

Legend	Symbol	Legend	Symbol
Split Spoon Sample	▨	Combustible Vapour Reading	□
Auger Sample	▩	Natural Moisture Content	✕
SPT (N) Value	●	Atterberg Limits	├──○
Dynamic Cone Test	——	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	▨	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	✚ S		

GWL	SYMBOL	SOIL DESCRIPTION	ELEV. m	DEPTH
			89.50	0
		~200 mm Topsoil.	89.30	
		FILL: brown sandy silt to clayey silt, traces of gravel and rootlets, moist.	88.74	
		CLAYEY SILT TILL: some sand, traces of gravel and weathered shale fragments, brown to grey to red, hard, moist.		1
		..........increasing red weathered shale fragments with depth.		2
		..........colour changes to grey		3
		..........colour changes to red		4
		Refusal at 4.17m on probable bedrock End of borehole at 4.17 m	85.33	



LOG OF BOREHOLE OLD 40236.210 - BARTON ST PROPERTIES - BRANTHAVEN.GPJ AME_ON.GDT 1/4/10

Notes:

Date/Time	Water Level (m)	Depth to Cave (m)
12/17/2009	Dry	None

Sheet No. 1 of 1

Log of Borehole 3

AME Materials Engineering

Project No.: 40236.210

Project Name: Preliminary Geotechnical Investigation for Barton Street Properties   Figure No. 2-3

Location: Barton Street and McNeilly Road, Stoney Creek, Ontario

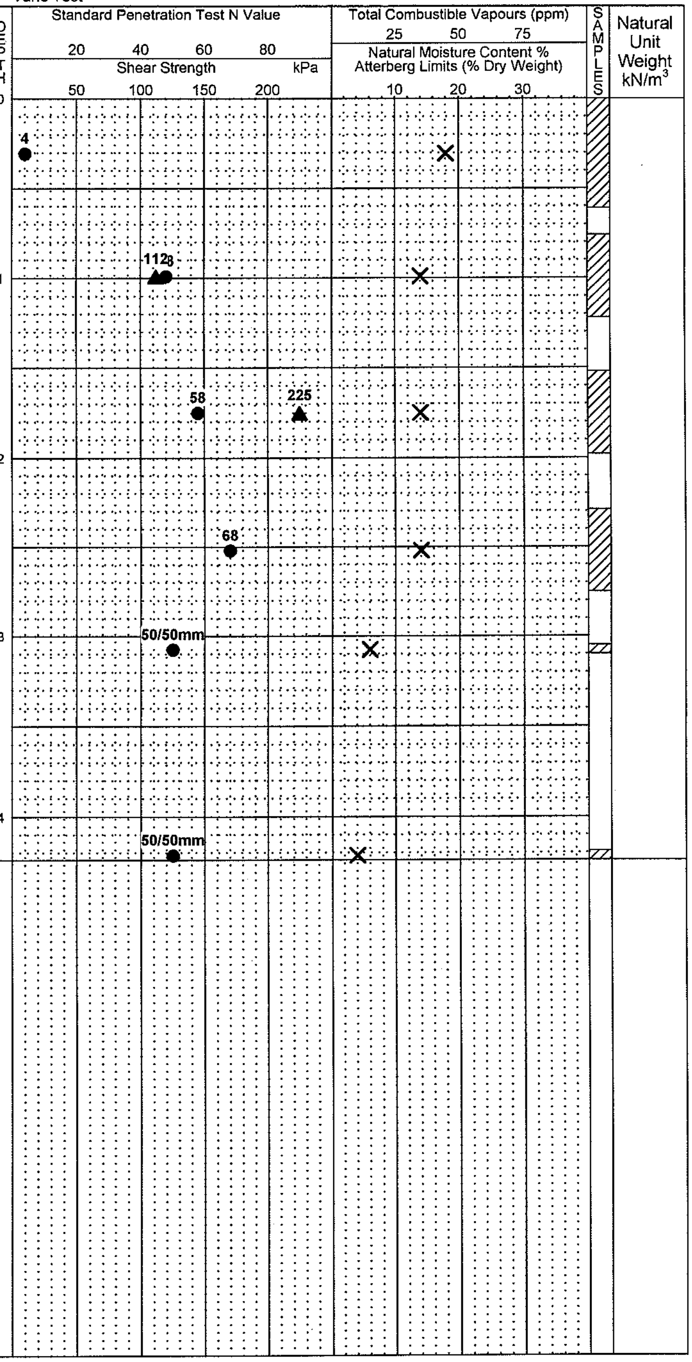
Date Drilled: 11/17/09

Drill Type: Solid Stem Auger

Datum: Geodetic

Legend		Legend	
Split Spoon Sample	▨	Combustible Vapour Reading	□
Auger Sample	▩	Natural Moisture Content	X
SPT (N) Value	●	Atterberg Limits	├─○
Dynamic Cone Test	───	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	▨	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	✚ S		

GWL	SYMBOL	SOIL DESCRIPTION	ELEV. m	DEPTH
			88.70	0
		~80 mm Topsoil.	88.62	
		FILL: brown sandy silt to clayey silt, traces of gravel and rootlets, moist.	88.24	
		CLAYEY SILT TILL: some sand, traces of gravel and weathered shale fragments, brown, hard, moist.	86.57	1–2
		SANDY SILT TILL: traces of gravel and weathered shale fragments, grey, very dense, moist.	86.19	
		CLAYEY SILT TILL: some sand, traces of gravel and weathered shale fragments, red, hard, moist. ....increasing red weathered shale fragments with depth.	84.46	3–4
		Refusal at 4.24m on probable bedrock End of borehole at 4.24 m		



Notes:

Date/Time	Water Level (m)	Depth to Cave (m)
12/17/2009	Dry	None

Sheet No. 1 of 1

Log of Borehole 4

AME Materials Engineering

Project No.: 40236.210

Project Name: Preliminary Geotechnical Investigation for Barton Street Properties

Figure No. 2-4

Location: Barton Street and McNeilly Road, Stoney Creek, Ontario

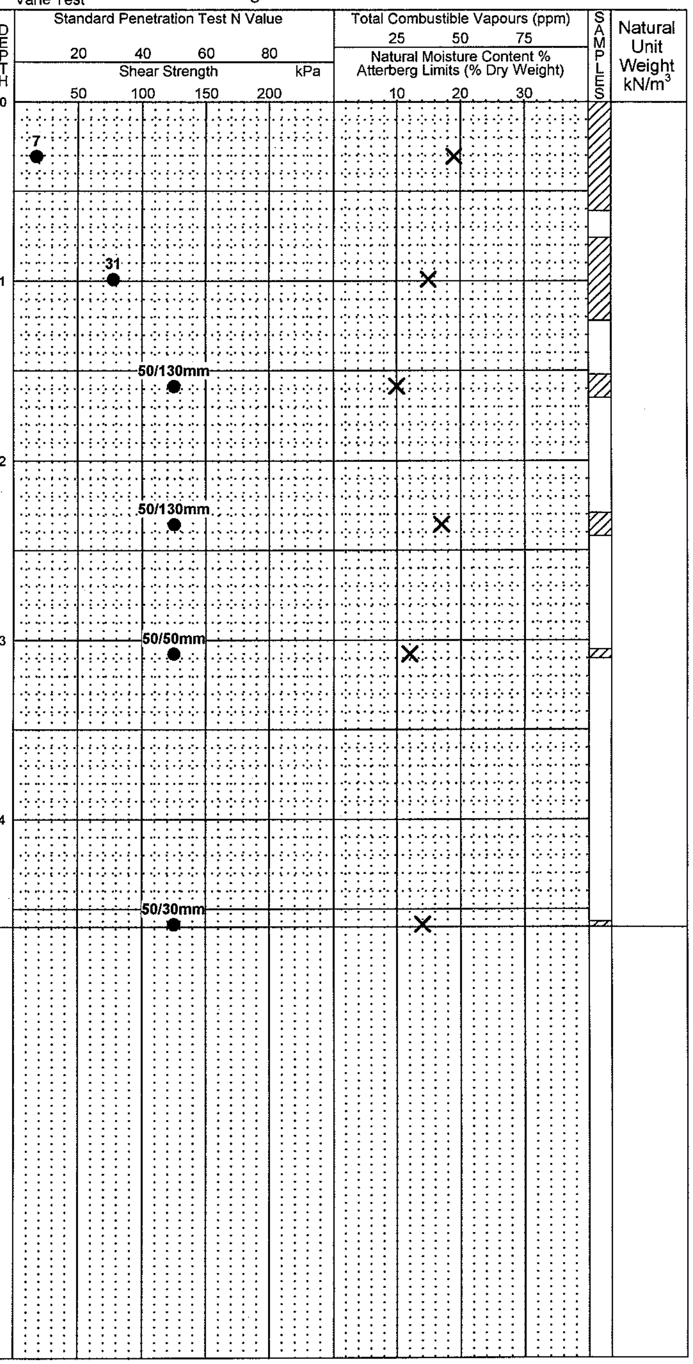
Date Drilled: 11/17/09

Drill Type: Solid Stem Auger

Datum: Geodetic

Legend		Legend	
Split Spoon Sample		Combustible Vapour Reading	
Auger Sample		Natural Moisture Content	X
SPT (N) Value	●	Atterberg Limits	
Dynamic Cone Test		Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube		Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test			

SOIL DESCRIPTION	ELEV. m	DEPTH
	91.10	0
~130 mm Topsoil.	90.97	
FILL: brown clayey silt, traces of sand, gravel and rootlets, moist to very moist.	90.64	
CLAYEY SILT TILL: some sand, traces of gravel and weathered shale fragments, brown to grey to red, very stiff to hard, moist.		1
..........colour changes to grey.		2
..........increasing red weathered shale fragments with depth.		3, 4
Refusal at 4.6m on probable bedrock End of borehole at 4.60 m	86.50	



Notes:

Date/Time	Water Level (m)	Depth to Cave (m)
12/17/2009	0.10	None
12/18/2009	0.10	
12/22/2009	0.50	

Sheet No. 1 of 1

Log of Borehole 5

AME Materials Engineering

Project No.: 40236.210

Project Name: Preliminary Geotechnical Investigation for Barton Street Properties

Figure No. 2-5

Location: Barton Street and McNeilly Road, Stoney Creek, Ontario

Date Drilled: 11/17/09

Drill Type: Solid Stem Auger

Datum: Geodetic

Legend	Symbol	Legend	Symbol
Split Spoon Sample	▨	Combustible Vapour Reading	□
Auger Sample	▩	Natural Moisture Content	×
SPT (N) Value	●	Atterberg Limits	⊢—⊖
Dynamic Cone Test	——	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	▧	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	✚ S		

Columns: GWL | SYMBOL | SOIL DESCRIPTION | ELEV. m | DEPTH | Standard Penetration Test N Value (20, 40, 60, 80); Shear Strength kPa (50, 100, 150, 200) | Total Combustible Vapours (ppm) (25, 50, 75); Natural Moisture Content %, Atterberg Limits (% Dry Weight) (10, 20, 30) | SAMPLES | Natural Unit Weight kN/m³

SOIL DESCRIPTION	ELEV. m	Printed test values
~50 mm Topsoil.	91.20 / 91.15	SPT: 3
FILL: brown clayey silt, traces of gravel and rootlets, black sand pocket, wet.	90.74	
CLAYEY SILT TILL: some sand, traces of gravel and weathered shale fragments, brown to grey to red, very stiff to hard, moist.		SPT: 30; SPT: 48
..........very stiff and grey.		SPT: 26, Penetrometer: 162.5; SPT: 26, Penetrometer: 150
.........hard		SPT: 52
..........colour changes to red	85.05	SPT: 50/50mm
End of borehole at 6.15 m		

Notes:

Date/Time	Water Level (m)	Depth to Cave (m)
12/17/2009	Dry	None

Sheet No. 1 of 1

Log of Borehole 6

AME Materials Engineering

Project No.: 40236.210

Project Name: Preliminary Geotechnical Investigation for Barton Street Properties

Figure No. 2-6

Location: Barton Street and McNeilly Road, Stoney Creek, Ontario

Date Drilled: 11/17/09

Drill Type: Solid Stem Auger

Datum: Geodetic

Legend: Split Spoon Sample; Auger Sample; SPT (N) Value (●); Dynamic Cone Test; Shelby Tube; Shear Strength by Vane Test; Combustible Vapour Reading (□); Natural Moisture Content (✕); Atterberg Limits; Undrained Triaxial at % Strain at Failure (⊕); Shear Strength by Penetrometer Test (▲)

GWL	SOIL DESCRIPTION	ELEV. m	DEPTH (m)	SPT N Value	Shear Strength (kPa)	Natural Moisture Content % (approx.)
	~200 mm Topsoil.	91.40	0			
	FILL: brown clayey silt, traces of gravel and rootlets, wet.	91.20		3		~28
	CLAYEY SILT TILL: some sand, traces of gravel and weathered shale fragments, brown to grey to red, very stiff, moist.	90.79	1	23		~18
				30		~16
	..........colour changes to grey.		2	22	125	~13
			3	30	137.5	~15
	..........hard	86.37	5	34		~14
	End of borehole at 5.03 m					

Notes:

Date/Time	Water Level (m)	Depth to Cave (m)
12/17/2009	Dry	None

Sheet No. 1 of 1

Log of Borehole 7

AME Materials Engineering

Project No.: 40236.210

Project Name: Preliminary Geotechnical Investigation for Barton Street Properties

Figure No. 2-7

Location: Barton Street and McNeilly Road, Stoney Creek, Ontario

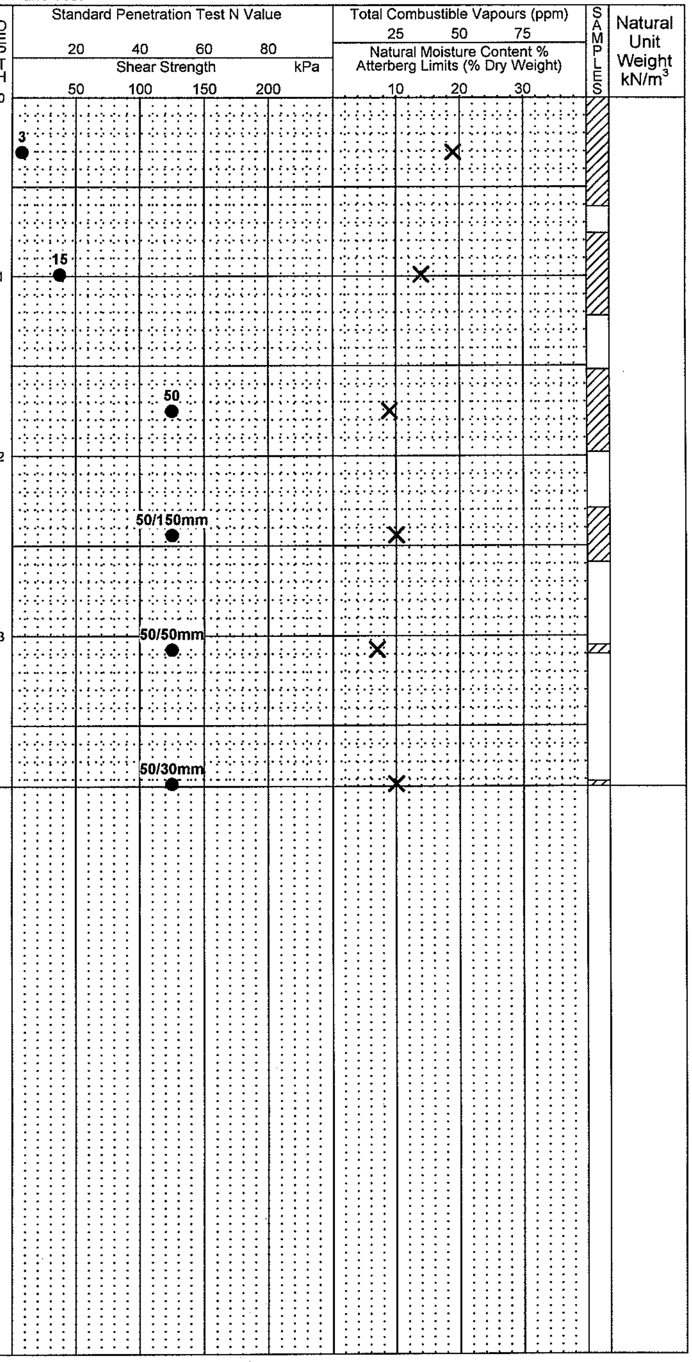
Date Drilled: 11/17/09

Drill Type: Solid Stem Auger

Datum: Geodetic

Legend	Symbol	Legend	Symbol
Split Spoon Sample	▨	Combustible Vapour Reading	□
Auger Sample	▩	Natural Moisture Content	✕
SPT (N) Value	●	Atterberg Limits	⊢—○
Dynamic Cone Test	——	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	▨	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	✚ S		

GWL	SYMBOL	SOIL DESCRIPTION	ELEV. m	DEPTH
			90.30	0
		~120 mm Topsoil.	90.18	
		FILL: brown clayey silt, traces of gravel and rootlets, very moist.	89.69	
		CLAYEY SILT TILL: some sand, traces of gravel and weathered shale fragments, brown to grey, stiff to very stiff, moist.		1
		..........hard		2
				3
			86.46	
		Refusal at 3.84m on probable bedrock End of borehole at 3.84 m		



LOG OF BOREHOLE OLD 40236.210 - BARTON ST PROPERTIES - BRANTHAVEN.GPJ AME_ON.GDT 1/4/10

Notes:

Date/Time	Water Level (m)	Depth to Cave (m)
12/17/2009	Dry	None

Sheet No. 1 of 1

Log of Borehole 8

AME
Materials Engineering

Project No.: 40236.210

Project Name: Preliminary Geotechnical Investigation for Barton Street Properties — Figure No. 2-8

Location: Barton Street and McNeilly Road, Stoney Creek, Ontario

Date Drilled: 11/17/09

Drill Type: Solid Stem Auger

Datum: Geodetic

Legend		Legend	
Split Spoon Sample	▨	Combustible Vapour Reading	□
Auger Sample	▩	Natural Moisture Content	X
SPT (N) Value	●	Atterberg Limits	├─○
Dynamic Cone Test	──	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	▧	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	✚ S		

GWL	SYMBOL	SOIL DESCRIPTION	ELEV. m	DEPTH	Standard Penetration Test N Value (20, 40, 60, 80) / Shear Strength kPa (50, 100, 150, 200)	Total Combustible Vapours (ppm) (25, 50, 75) / Natural Moisture Content % / Atterberg Limits (% Dry Weight) (10, 20, 30)	SAMPLES	Natural Unit Weight kN/m³
			88.60	0				
		~50 mm Topsoil.	88.55					
		FILL: brown clayey silt, traces of gravel and rootlets, wet.			3	X		
		CLAYEY SILT TILL: some sand, traces of gravel and weathered shale fragments, brown to grey to red, very stiff, moist.	87.99	1	22	X		
		..........hard			80/150mm	X		
				2	50/150mm	X		
		..........red shale fragments increasing with depth.		3	50/50mm	X		
				4				
			84.00		50/30mm	X		
		End of borehole at 4.60 m						

LOG OF BOREHOLE OLD 40236.210 - BARTON ST PROPERTIES - BRANTHAVEN.GPJ AME_ON.GDT 1/4/10

Notes:

Date/Time	Water Level (m)	Depth to Cave (m)
12/17/2009	Dry	None

Sheet No. 1 of 1

Log of Borehole 9

AME Materials Engineering

Project No.: 40236.210

Project Name: Preliminary Geotechnical Investigation for Barton Street Properties

Figure No. 2-9

Location: Barton Street and McNeilly Road, Stoney Creek, Ontario

Date Drilled: 11/17/09

Drill Type: Solid Stem Auger

Datum: Geodetic

Legend	Symbol	Legend	Symbol
Split Spoon Sample	▨	Combustible Vapour Reading	□
Auger Sample	▩	Natural Moisture Content	✕
SPT (N) Value	●	Atterberg Limits	├—○
Dynamic Cone Test	——	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	▨	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	✚ S		

SOIL DESCRIPTION	ELEV. m	DEPTH (m)	Standard Penetration Test N Value
	89.10	0	
~120 mm Topsoil.	88.98		
FILL: brown clayey silt, traces of sand, gravel and rootlets, wet.	88.80		9
CLAYEY SILT TILL: some sand, traces of gravel and weathered shale fragments, brown to grey, very stiff, moist.		1	18
..........hard		2	34
			38
..........colour changes to grey.		3	50/150mm
		4	
	84.07	5	50/150mm
End of borehole at 5.03 m			

Chart scales: Standard Penetration Test N Value 20, 40, 60, 80; Shear Strength 50, 100, 150, 200 kPa; Total Combustible Vapours (ppm) 25, 50, 75; Natural Moisture Content % / Atterberg Limits (% Dry Weight) 10, 20, 30; Natural Unit Weight kN/m^3.

Notes:

Date/Time	Water Level (m)	Depth to Cave (m)
12/17/2009	Dry	None
12/18/2009	Dry	
12/22/2009	Dry	

Log of Borehole 10

AME
Materials Engineering

Project No.: 40236.210

Project Name: Preliminary Geotechnical Investigation for Barton Street Properties

Figure No. 2-10

Location: Barton Street and McNeilly Road, Stoney Creek, Ontario

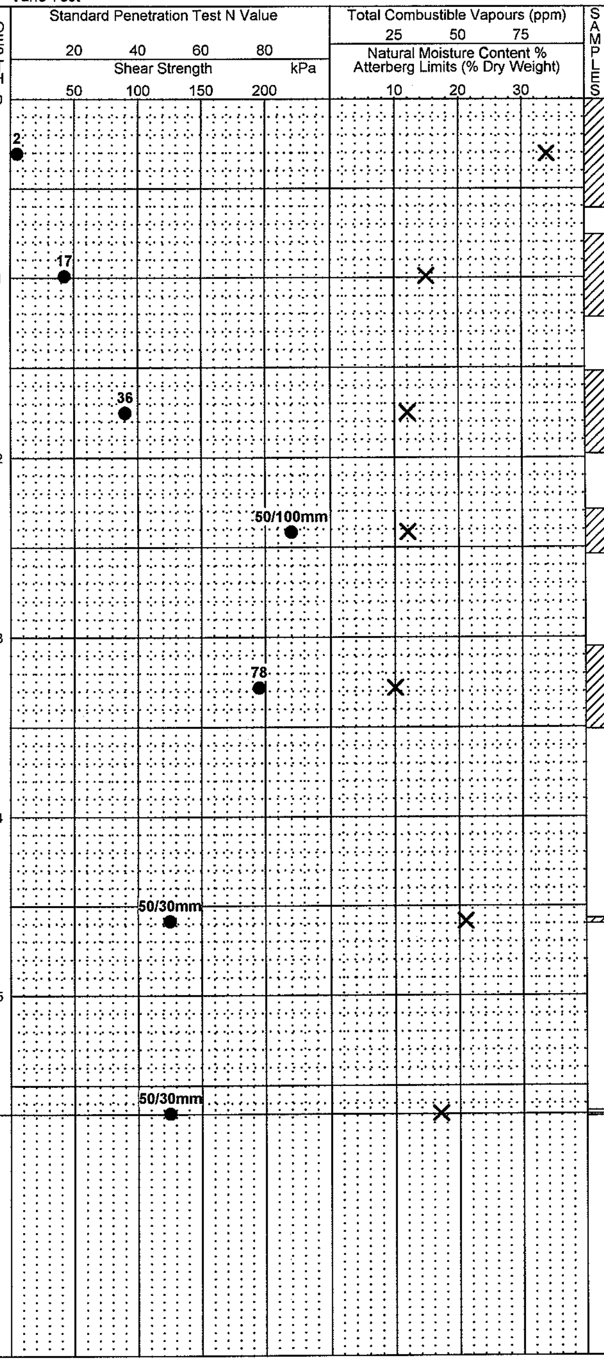
Date Drilled: 11/17/09

Drill Type: Solid Stem Auger

Datum: Geodetic

Legend		Legend	
Split Spoon Sample		Combustible Vapour Reading	□
Auger Sample		Natural Moisture Content	×
SPT (N) Value	●	Atterberg Limits	
Dynamic Cone Test		Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube		Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test			

GWL	SYMBOL	SOIL DESCRIPTION	ELEV. m	DEPTH
			89.80	0
		FILL: brown clayey silt, traces of gravel and rootlets, wet.		
			89.19	
		CLAYEY SILT TILL: some sand, traces of gravel and weathered shale fragments, brown to grey to red, very stiff, moist.		1
		..........hard		2
				3
		..........colour changes to red		
		..........weathered red shale fragments increasing with depth		4
▼			85.40	
				5
			84.14	
		Refusal at 5.66m on probable bedrock End of borehole at 5.66 m		



Natural Unit Weight kN/m^3

LOG OF BOREHOLE OLD 40236.210 - BARTON ST PROPERTIES - BRANTHAVEN.GPJ AME_ON.GDT 1/4/10

Notes:

Date/Time	Water Level (m)	Depth to Cave (m)
12/17/2009	4.40	None

Sheet No. 1 of 1

Log of Borehole 11

AME Materials Engineering

Project No.: 40236.210

Project Name: Preliminary Geotechnical Investigation for Barton Street Properties

Figure No. 2-11

Location: Barton Street and McNeilly Road, Stoney Creek, Ontario

Date Drilled: 11/17/09

Drill Type: Solid Stem Auger

Datum: Geodetic

Legend	Symbol	Legend	Symbol
Split Spoon Sample	▨	Combustible Vapour Reading	□
Auger Sample	▩	Natural Moisture Content	×
SPT (N) Value	●	Atterberg Limits	⊢—○
Dynamic Cone Test	——	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	◫	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	✚S		

GWL	SYMBOL	SOIL DESCRIPTION	ELEV. m	DEPTH (m)	SPT N Value	Natural Moisture Content (%)	SAMPLES	Natural Unit Weight kN/m³
			89.60	0				
	Topsoil	~300 mm Topsoil.	89.30		4	~19	Split spoon	
	Fill	**FILL:** brown clayey silt, traces of gravel and rootlets, very moist.	88.99					
	Till	**CLAYEY SILT TILL:** some sand, traces of gravel and weathered shale fragments, brown to grey, very stiff, moist.		1	23	~14	Split spoon	
					26	~11	Split spoon	
		.........hard		2.5	37	~14	Split spoon	
		.........colour changes to grey		3	41	~12	Split spoon	
					47	~12	Split spoon	
		End of borehole at 5.03 m	84.57	5				

Notes:

Date/Time	Water Level (m)	Depth to Cave (m)
12/17/2009	Dry	None

Sheet No. 1 of 1

Log of Borehole 12

AME Materials Engineering

Project No.: 40236.210

Project Name: Preliminary Geotechnical Investigation for Barton Street Properties — Figure No. 2-12

Location: Barton Street and McNeilly Road, Stoney Creek, Ontario

Date Drilled: 11/18/09

Drill Type: Solid Stem Auger

Datum: Geodetic

Symbol	Legend	Symbol	Legend
Split Spoon Sample	▨	Combustible Vapour Reading	□
Auger Sample	▩	Natural Moisture Content	X
SPT (N) Value	●	Atterberg Limits	⊢⊖
Dynamic Cone Test	—	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	▨	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	✚ S		

GWL	SOIL DESCRIPTION	ELEV. m	DEPTH (m)	SPT N Value	Natural Moisture Content %
	FILL: brown clayey silt, some sand, traces of gravel and rootlets, very moist.	87.60	0	8	~23
	CLAYEY SILT TILL: some sand, traces of gravel and weathered shale fragments, brown to grey, very stiff, moist.	87.07	0.53	15	~15
				29	~15
	..........hard			34	~14
				38	~14
	..........colour changes to grey			34	~13
		81.05		24	~12
	End of borehole at 6.55 m		6.55		

Chart scales: Standard Penetration Test N Value 20, 40, 60, 80; Shear Strength 50, 100, 150, 200 kPa; Total Combustible Vapours (ppm) 25, 50, 75; Natural Moisture Content % / Atterberg Limits (% Dry Weight) 10, 20, 30; Natural Unit Weight kN/m³.

LOG OF BOREHOLE OLD 40236.210 - BARTON ST PROPERTIES - BRANTHAVEN.GPJ AME_ON.GDT 1/4/10

Notes:

Date/Time	Water Level (m)	Depth to Cave (m)
12/18/2009	Dry	None

Sheet No. 1 of 1

APPENDIX 3

Laboratory Testing

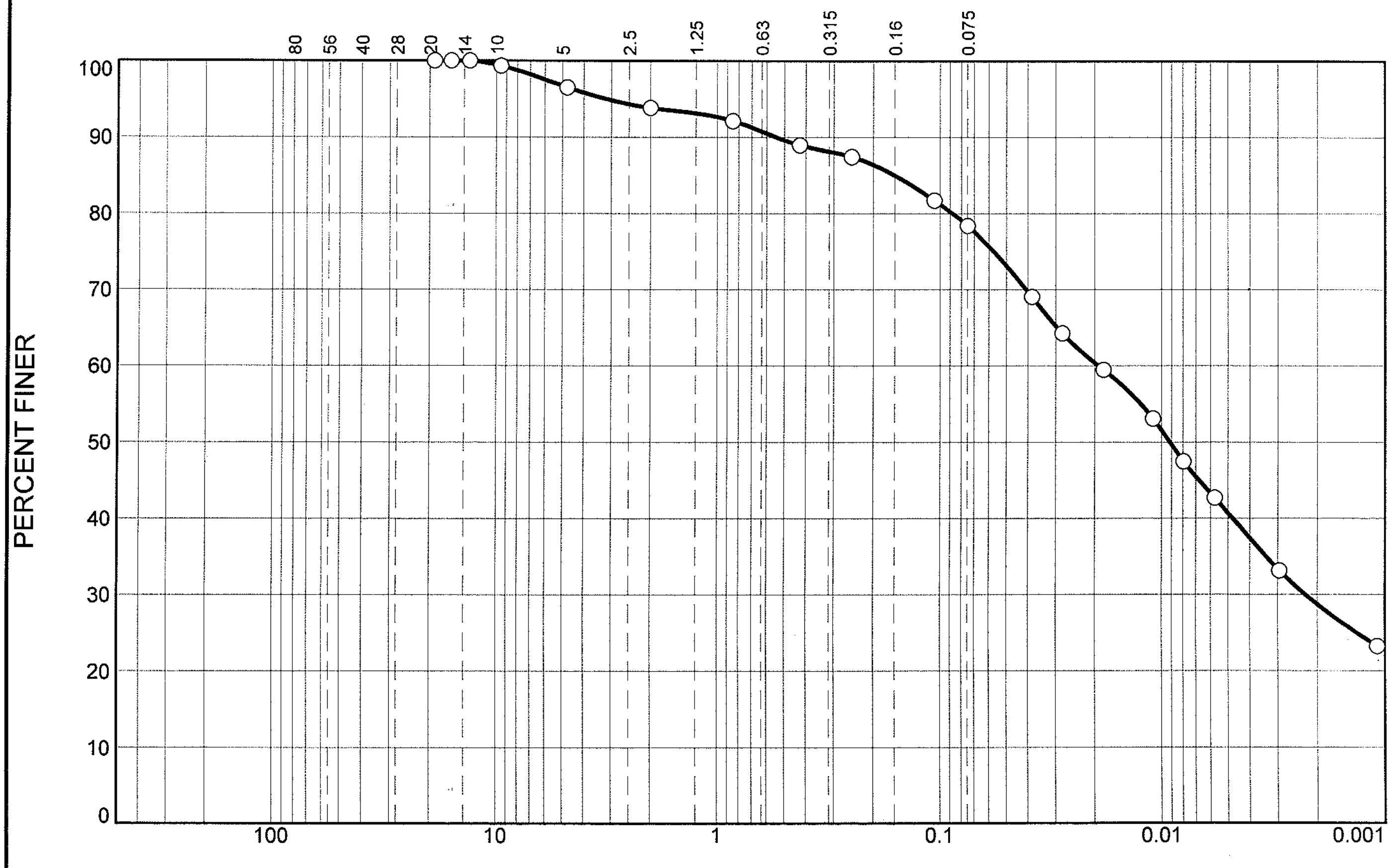
Hydrometer Grain Size Analysis (Figure 3-1)

Standard Proctor (Figure 3-2)

Corrosivity Test Results (Enclosure No. 3-3)

Metals and Inorganics Test Results (Enclosure No. 3-4)

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	3.5	2.7	4.8	10.6	49.7	28.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
19 mm	100.0		
16 mm	100.0		
13.2 mm	100.0		
9.5 mm	99.4		
4.75 mm	96.5		
2.00 mm	93.8		
0.850 mm	92.2		
0.425 mm	89.0		
0.250 mm	87.4		
0.106 mm	81.7		
0.075 mm	78.4		
0.0384 mm.	69.0		
0.0280 mm.	64.2		
0.0182 mm.	59.5		
0.0109 mm.	53.1		
0.0080 mm.	47.5		
0.0058 mm.	42.7		
0.0030 mm.	33.1		
0.0011 mm.	23.3		

* (no specification provided)

Soil Description

Reddish brown Clayey Silt, some Sand, trace Gravel

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.5394 D_{85}= 0.1597 D_{60}= 0.0192
D_{50}= 0.0092 D_{30}= 0.0023 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO=

Remarks

Location: Barton Street, BH3 SS3, Sampled by G.S. on December 17, 2009
Sample Number: E6437

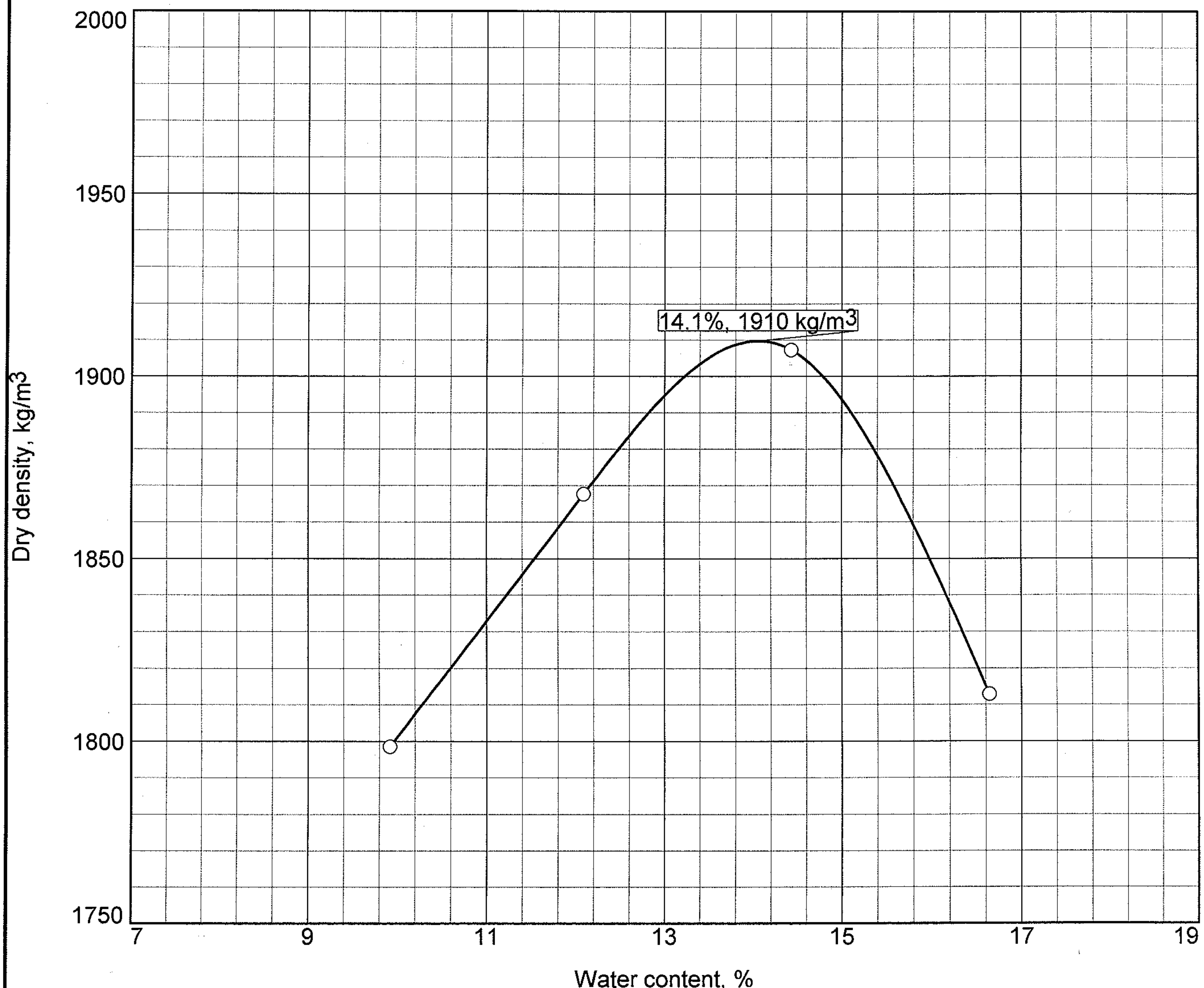
Date:

AME Materials Engineering

Client: Branthaven Development
Project: Barton Street, Stoney Creek, Hamilton

Project No: 40236.210 **Figure** 3-1

PROCTOR TEST REPORT



Test specification: ASTM D 698-07 Method A Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 1910 kg/m3 Optimum moisture = 14.1 %	Reddish brown Clayey Silt

Project No. 40236.210 **Client:** Branthaven Development

Project: Barton Street, Stoney Creek, Hamilton

○ **Loc.:** Barton Street, Bulk Sample, Sampled by G.S. on December 17, 2009

Remarks:

AME Materials Engineering

Figure 3-2

AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 09T376812

PROJECT NO: 40236.210

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: AME MATERIALS ENGINEERING

ATTENTION TO: Selim Lutfur

Corrosivity Package

DATE SAMPLED: Dec 17, 2009 **DATE RECEIVED: Dec 18, 2009** **DATE REPORTED: Dec 29, 2009** **SAMPLE TYPE: Soil**

Parameter	Unit	G / S	RDL	BH8, SS4 1617602
Sulphide*	%		0.001	<0.001
Chloride (2:1)	µg/g		2.0	12.5
Sulphate (2:1)	µg/g		2.0	170
pH (2:1)	N/A		N/A	8.14
Electrical Conductivity (2:1)	mS/cm	0.7	0.002	0.307
Resistivity (2:1)	ohm.cm		1	3260
Redox Potential (2:1)	mV		5	244

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to T2(RPI)

1617602 * Analysis was performed at AGAT's Mining Division.

EC,pH,Chloride and Sulphate were determined on the extract obtained from the 2:1 extraction procedure (2 parts DI water: 1 part soil).

Enclosure 3-3

Certified By: Elizabeth Polakowska

Results relate only to the items tested

AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 09T376812
PROJECT NO: 40236.210

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: AME MATERIALS ENGINEERING

ATTENTION TO: Selim Lutfur

O. Reg. 153 Metals & Inorganics in Soil

DATE SAMPLED: Dec 17, 2009 **DATE RECEIVED: Dec 18, 2009** **DATE REPORTED: Dec 29, 2009** **SAMPLE TYPE: Soil**

Parameter	Unit	G / S	RDL	BH2, SS2 1617601
Antimony	µg/g	13	1.6	<1.6
Arsenic	µg/g	20	0.6	5.1
Barium	µg/g	750	0.3	128
Beryllium	µg/g	1.2	0.4	0.6
Boron (Hot Water Extractable)	µg/g	1.5	0.10	1.12
Cadmium	µg/g	12	0.4	<0.4
Chromium	µg/g	750	0.6	20.9
Cobalt	µg/g	40	0.3	13.3
Copper	µg/g	225	0.3	31.4
Lead	µg/g	200	0.5	9.5
Molybdenum	µg/g	40	0.5	<0.5
Nickel	µg/g	150	0.6	28.7
Selenium	µg/g	10	0.8	<0.8
Silver	µg/g	20	0.4	<0.4
Thallium	µg/g	4.1	0.4	<0.4
Vanadium	µg/g	200	0.4	27.9
Zinc	µg/g	600	0.4	63.2
Chromium, Hexavalent	µg/g	8	0.40	<0.40
Cyanide, Free	µg/g	100	1.0	<1.0
Mercury	µg/g	10	0.011	0.015
Electrical Conductivity (2:1)	mS/cm	0.7	0.002	**2.38**
Sodium Adsorption Ratio (2:1)	N/A	5.0	N/A	0.408
pH, 2:1 CaCl2 Extraction				7.66

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to T2(RPI)

1617601 EC & SAR were determined on the DI water extract obtained from the 2:1 leaching procedure (2 parts DI water:1 part soil). pH was determined on the 0.01M CaCl2 extract prepared at 2:1 ratio.

Enclosure 3 - 4

Certified By: Elizabeth Rolakowska

Results relate only to the items tested

AGAT Laboratories

Guideline Violation

AGAT WORK ORDER: 09T376812

PROJECT NO: 40236.210

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
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http://www.agatlabs.com

CLIENT NAME: AME MATERIALS ENGINEERING

ATTENTION TO: Selim Lutfur

SAMPLEID	SAMPLE TITLE	GUIDELINE	ANALYSIS PACKAGE	PARAMETER	GUIDEVALUE	RESULT
1617601	BH2, SS2	T2(RPI)	O. Reg. 153 Metals & Inorganics in Soil	Electrical Conductivity (2:1)	0.7	2.38

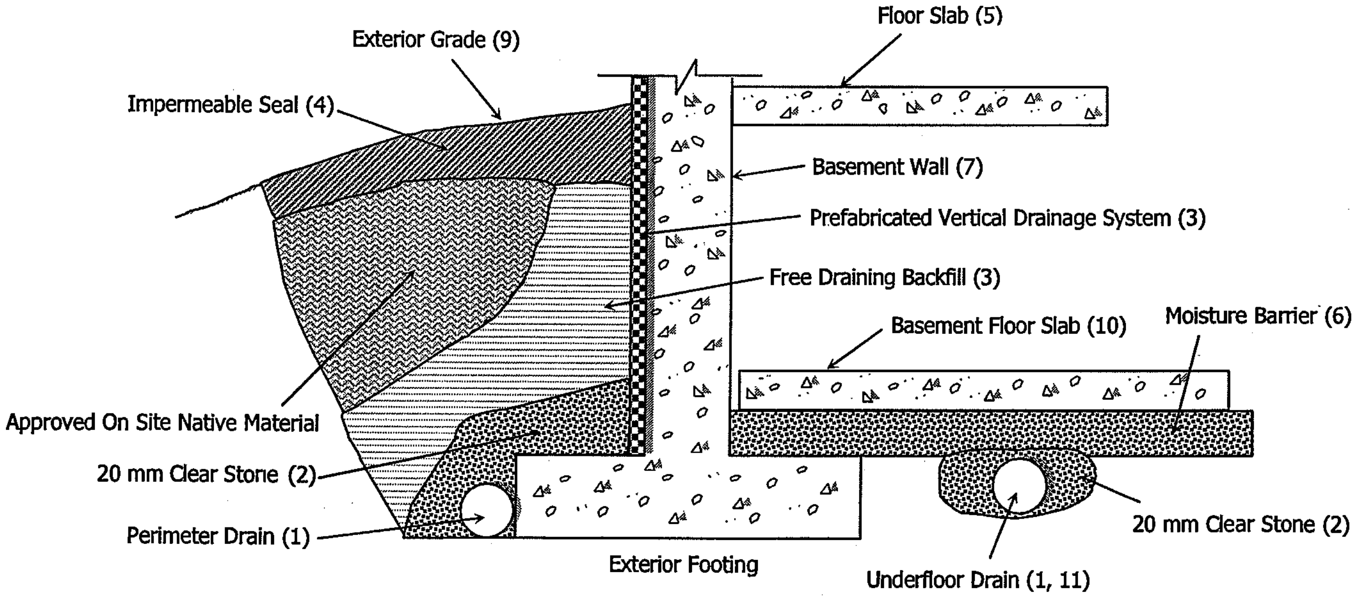
Enclosure ....

APPENDIX 4

Drainage and Backfill Details

Soil-Test Evaluation
ANSI / AWWA Corrosivity Rating System

Drainage and Backfill Details



Notes

1. Perimeter and underfloor drains (if required) shall consist of 100mm (4") diameter weeping tile or equivalent perforated pipe leading to a positive sump or outlet. Invert to be a minimum of 150mm (6") below underside of floor slab. Perimeter floor drains are not required for dwellings without basements.

2. 20 mm Clear Stone – 150mm (6") top and side of drain, surrounded by approved filter fabric (Terrafix 270R or equivalent). If drain is not on footing, place 100mm (4 inches) of clear stone below the drain. Filter fabric around the clear stone may be omitted if the drain pipe is wrapped with approved filter fabric.

3. Free Draining backfill – OPSS Granular B or equivalent compacted to the specified density. Do not use heavy compaction equipment within 450mm (18") of the wall. Use hand controlled light compaction equipment within 1.8m (6') of wall. Free draining backfill is not required if a prefabricated vertical drainage system (such as Miradrain 6000) is installed on the exterior of the basement wall.

4. Impermeable backfill seal (min. 600 mm) – relatively impervious compacted clay, silty clay or equivalent. If on-site native backfill is free draining, seal may be omitted.

5. Do not backfill until wall is supported by basement and floor slabs or adequate bracing.

6. Moisture barrier to be at least 200mm (8") of compacted 20mm (3/4") clear stone or equivalent free draining material.

7. Basement wall to be damp-proofed.

9. Exterior grade to slope away from building.

10. Basement floor slab should not be structurally connected to the wall or footing.

11. Underfloor drain invert to be at least 300mm (12") below underside of floor slab. Drainage tile placed in parallel rows at 1.83 m center to centre one way. Place drain on 100mm (4") of 20 mm (3/4") clear stone with 150mm (6") of clear stone on top and sides. Do not connect the underfloor drains to perimeter drains. Underfloor drains shall be connected to the sanitary sewer system.

DRAINAGE AND BACKFILL RECOMMENDATIONS

(Not to Scale)

SOIL-TEST EVALUATION

ANSI / AWWA Corrosivity Rating System

	Soil Characteristics	Points
1	**Resistivity (ohm-cm)**	
	<700	10
	700 to 1000	8
	1000 to 1200	5
	1200 to 1500	2
	1500 to 2000	1
	>2000	0
2	**pH**	
	0 to 2	5
	2 to 4	3
	4 to 6.5	0
	6.5 to 7.5	0+
	7.5 to 8.5	0
	>8.5	3
3	**Redox Potential**	
	> + 100 mV	0
	+ 50 to + 100 mV	3.5
	0 to + 50 mV	4
	Negative	5
4	**Sulphides**	
	Positive	3.5
	Trace	2
	Negative	0
5	**Moisture**	
	Poor Drainage, continuously wet	2
	Fair Drainage, generally moist	1
	Good Drainage, generally dry	0

* Ten points = corrosive to gray or ductile cast iron pipe; protection is indicated

+ If sulphides are present and low or negative redox potential results are obtained, three points shall be given for this range.

APPENDIX B-2
Hydrogeological Investigations Fruitland-Winona BSS#3 (Landtek Limited, February 2020)

LANDTEK LIMITED
Consulting Engineers
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Hamilton, Ontario
Canada
L8W 2E1
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engineering@landteklimited.com
www.landteklimited.com

Hydrogeological Investigations
Fruitland-Winona BSS #3
Winona, Ontario

Prepared for:

Block 3 Landowners Group.
720 Oval Court
Burlington, Ontario
L7L 6A9

File: 18270
February19, 2020

Table of Contents

Appendices:

1.0 INTRODUCTION

1.1 Background

Landtek Limited (Landtek) is pleased to submit a combined Hydrogeologic Investigation report for the proposed Block Servicing Strategy Area # 3. The site is located in the community of Winona in the City of Hamilton, south of Barton Street and east of McNeilly Road, as shown on Figure 1.

The site is irregular in shape and consists of seven (7) participating landowners. The total area of is approximately 105.70 hectares. It is currently in a general area bounded by the north limit of the row of buildings abutting Barton Street to the north, residential dwellings along McNeilly Road to the west, undeveloped land east of Winona Elementary School and west of Tuscani Drive to the east, Pettit Street to the northeast, and commercial and residential properties to the south along Highway 8.

The site is proposed to be developed primarily for community use with residential, commercial, institutional, park, and community services. The site is to be serviced by municipal water and sanitary sewer services from the City of Hamilton. The existing site diagram is as shown on Figure 2; and the proposed development site plan is shown in Figure 3, as provided by Glen Schnarr & Associates Inc.

The purpose of this study was to provide geological and hydrogeological baseline data of the proposed development site to support the Stoney Creek Urban Boundary Expansion (SCUBE) Block 3 Servicing Study (BSS) for the SCUBE Central area. The Hydrogeological Investigation is to evaluate the current conditions of the site, delineate possible post-development effects, and suggest mitigation measures to minimize the effects to the shallow groundwater system post-development. Specifically, the report provides the following:

- A description of the hydrogeologic setting of the property and a summary of the existing soil and groundwater conditions at the site.
- Identification of hydrogeologic features such as zones of significant groundwater recharge and discharge.
- Assessment of the requirement for groundwater control during construction.
- Requirements and design measures which can be used to maintain groundwater function at the site.
- A water budget for the site based on the current site development plan and recommendations for mitigation measures in order to maintain groundwater infiltration and aquifer recharge in the area.

1.2 Work Scope and Report Organization

The work program presented herein was divided into three components: 1) a desktop study to characterize the physical setting and based on available information, establish identify the Ministry of the Environment and Climate Change (MOECC) wells within 500 m radius of the Site; 2) review of meteorological data to assess the local climate and to use the information for water balance calculations, if required; and, 3) a field investigation involving drilling/well installation, hydraulic conductivity testing, and based on available information, assess water balance groundwater conditions.

The report is organized as outlined on the following page.

Section 1 contains a brief introduction to the project and the scope of work undertaken by Landtek.

Section 2 outlines the methodologies followed during completion of the desktop study and the field investigation.

Section 3 summarizes the findings of the investigation. It includes:
- a description of the physical setting
- the results of the field investigation

Section 4 provides an assessment of construction dewatering requirements and potential impacts.

Sections 5 and 6 provide recommendation for implementation of a monitoring program and mitigation measures, respectively if warranted.

Section 7 provides assessment of site development, hydrogeology, and water balance.

Section 8 provides summary and conclusions.

Section 9 provides closure.

Section 10 provides references.

Section 11 provides limitations.

2.0 METHODOLOGY

2.1 Desktop Study

A review of published works was done of available geologic and hydrogeologic information for the site including topographic and geologic maps.

Climate data for the period of 1981 to 2010 was obtained from Environment Canada publications and from the Hamilton A station (Hamilton Airport) to assess the local climate and to use the information for water balance calculations.

The MOE water well database for the local area was also accessed and the individual well records were obtained for wells that are located in the Study Area. The Study Area is defined, as an area extending 500 m outward from the edge of the excavation for the proposed basement parking levels

2.1.1 Previous Investigations

Previous studies conducted with pertinence to this hydrogeological study include a 2009 Geotechnical Investigation conducted by AME Materials Engineering (AME, 2009) and the SCUBE Subwatershed Study completed by Aquafor Beech Ltd. in 2012.

2009 Geotechnical Investigation (AME Materials Engineering)

A total of twelve (12) exploratory boreholes were drilled during this investigation to depths of 3.9 to 6.6 meters below ground surface (mbgs). The stratigraphy encountered during this investigation consisted of earth fill/disturbed native soil underlain by native glacial till followed by bedrock. The disturbed native soil was documented to consist of brown sandy silt to clayey silt with trace gravel averaging 0.4 m thick. The glacial till is described as consisting predominantly of clayey silt with trace sand and gravel. The till contains fragments of weathered shale which become more numerous with increasing depth.

All of the boreholes were either terminated in the glacial till or upon reaching practical auger refusal on probable bedrock.

SCUBE Subwatershed Study (Aquafor Beech Ltd., 2012)

A subwatershed study was completed in 2012 for The City of Hamilton on the Stoney Creek Urban Boundary Expansion Area (SCUBE), in preparation of the Fruitland-Winona Secondary Plan in support of future urban development. The existing environmental resources within the study area were defined in order to identify key features and functions, to establish baseline conditions for the assessment of potential impacts from future urban development, and to identify development constraints and potential future opportunities (Aquafor Beech Ltd., 2012).

A review of boreholes advanced in 2009 indicates a relatively low groundwater recharge potential and relatively shallow potentiometric surface (<5 m below ground surface) in the area. In particular, it is noted that the silt till and several meters of the underlying shale bedrock are noted as being dry in the 2009 borehole logs. This observation suggests that the overall recharge potential across the SCUBE area is very low.

2.2 Site Inspection to Assess Hydrogeological Features

Access was granted by the City of Hamilton and Multi-Area Development properties located adjacent to the site, to the east and south, respectively, in order to complete borehole drilling and monitoring well installations for the purposes of this study. These adjoining properties are indicated on Figure 3 and are considered part of the study site.

Detailed site inspections were conducted on November 18, 2016 and August 7, 2018 to assess the presence of features which may be significant from a hydrogeologic view point. In particular, the site was inspected to assess the following:

- The presence of closed drainage features, depressions, or sandy areas which may allow for ponding and significant or enhanced infiltration of water;
- Assessment of the presence of phreatophytic vegetation which may indicate seasonally high groundwater levels and/or groundwater discharge and seepage; and
- Identification of any zones of visible seepage or groundwater discharge.

A focus of the site assessment was to walk along the drainage features deemed regulated watercourses by the Hamilton Conservation Authority (HCA). At the time of the assessment, all of the watercourses were dry but vegetation and erosion indicated they are intermittent (seasonal) watercourses. The presence of cattails, willows, and common reeds in the meandering watercourse in the eastern portion of the site suggests a seasonally wet environment and can also be indicative of a shallow groundwater environment. All other primary vegetation on site (sumac, oak, grey dogwood, hawthorn, maple) are not necessarily indicative of a wet environment.

There was no indication of groundwater discharge or visible seepage areas on the site. All surface water runoff is directed to the watercourses and ditches lining the agricultural fields.

An area in the western portion of the site contains an abandoned vineyard, with numerous rows of abandoned grapevines.

Most areas planned for development are currently used as agricultural fields with access from two driveways along Barton Street. There is evidence of a historic concrete/foundation slab near the northeast corner of the site.

2.3 Field Investigation

2.3.1 Drilling and Well Installation

The first phase of the subsurface drilling investigation at the site was conducted from December 5 to 12, 2016, and from January 23 to 27, 2017. A total of fourteen (14) boreholes were drilled at twelve (12) locations, which were subsequently installed with monitoring wells. The second phase of the subsurface drilling investigation was conducted from August 9 to 15, 2018. A total of eight (8) boreholes were drilled at seven (7) locations, which were subsequently installed with monitoring wells.

The boreholes were advanced using a continuous flight power auger track-mounted drill rig equipped with conventional soil sampling and testing tools. The drilling was conducted by

Determination Drilling of Hamilton, Ontario and was under the full-time supervision of a member of Landtek staff who logged the borings and examined the samples as they were obtained. The results of the drilling are recorded in detail on the accompanying borehole logs, located in Appendix B of this document. The monitoring wells locations are shown on Figure 4 in Appendix A.

The monitoring wells were constructed with 50 mm inner diameter, Schedule 40 machine slotted PVC screens equipped with a bottom cap, and machine threaded riser pipe. The screen length and slot size are 1.5 m or 3.0 m, and 0.10-inch, respectively.

The annular space between the PVC riser pipes and each borehole wall was backfilled to at least 0.3 m above the top of the screen with silica sand (No. 2). A bentonite seal was placed immediately above the sand pack to a height just below grade. Each monitoring well was finished with a monumental protective steel casing, which was cemented in-place.

A.J. Clarke & Associates Ltd. conducted a survey on February 10, 2017 to determine the ground surface elevation, top of well pipe elevation, and accurate Universal Transverse Mercator (UTM) co-ordinates of the installed wells. Landtek conducted an additional elevation survey August 29, 2018 to tie-in the additional boreholes location, completed during the phase 2 drilling, to the survey conducted by A.J. Clarke and Associates ltd. Details of the monitoring wells, including survey data, and screened intervals are summarized below in Table 1 below.

Table 1: Well Construction Details

Monitoring Well ID	Easting (NAD83)	Northing (NAD83)	Ground Surface Elevation (masl)	Pipe stick up (m)	Well Depth (mbgs)	Screened Interval (m)	Screened Material
MW1	608226.2	4784919.7	95.04	0.86	5.99	3.0–6.1	Clayey Silt Till
MW2	608212.8	4784987.0	93.54	0.75	4.61	1.5–4.6	Clayey Silt Till
MW3	608237.9	4785070.9	92.74	0.68	4.58	1.5–4.6	Clayey Silt Till
MW4	608141.9	4785325.9	91.39	0.79	6.23	3.0– 6.1	Shale (Upper Weathered Shale)
MW5	608289.8	4785210.5	91.04	0.84	15.10	12.2–15.2	Contact (Till and Upper Weathered Shale)
MW6-S	608307.6	4785049.7	92.19	0.92	6.14	1.5 –6.1	Clayey Silt Till
MW6-D	608305.1	4785050.5	92.22	0.91	18.34	15.2–18.3	Shale (competent)
MW7	608382.9	4785334.4	89.87	0.65	30.5	24.4–30.5	Shale (competent)
MW8	608249.3	4785464.4	89.57	0.83	4.59	1.5–4.6	Shale (Upper Weathered Shale)

Table 1: Well Construction Details Continued

Monitoring Well ID	Easting (NAD83)	Northing (NAD83)	Ground Surface Elevation (masl)	Pipe stick up (m)	Well Depth (mbgs)	Screened Interval (m)	Screened Material
MW9	608537.1	4785266.6	89.56	0.96	17.72	13.7 – 16.8	Shale (Upper Weathered Shale)
MW10-S	608626.5	4785430.5	88.15	0.89	7.51	4.6 – 7.6	Clayey Silt Till
MW10-D	608621.6	4785431.1	88.19	0.99	20.05	18.9 – 21.9	Shale (competent)
MW11	608644.1	4785312.9	89.18	0.97	16.91	16.5 – 19.5	Shale (competent)
MW12	608715.9	4785187.8	90.12	1.01	5.53	2.1 – 5.2	Shale (Upper Weathered Shale)
MW13	607857.4	4784775.8	98.50	0.73	7.60	4.6 – 7.6	Shale
MW14	608062.6	4785233.1	99.65	0.72	7.60	4.6 – 7.6	Shale
MW15	608231.9	4785310.3	90.72	0.81	7.60	4.6 – 7.6	Shale
MW16	608453.6	4785467.8	88.55	0.80	13.7	10.7 – 13.7	Clayey Silt Till and Shale
MW17S	608455.6	4785193.0	90.59	0.79	12.20	10.7 – 12.2	Clayey Silt Till
MW17D	608455.6	4785193.0	90.59	0.75	20.0	18.5 – 20.0	Clayey Silt Till and Shale
MW18	608610.1	4785017.5	92.02	0.78	7.60	4.6 – 7.6	Shale
MW19	609102.6	4785291.1	100.99	0.90	7.60	4.6 – 7.6.5	Shale

masl = meters above sea level
m = meters
mbgs = meters below ground surface

Well Development: Each of the installed monitoring wells (MW1 through MW19) was developed to remove any sediment that may have been introduced during installation and to improve the hydraulic properties of the formation against which the wells were screened. Development employed waterra tubings with foot valves and or electric well pump. Each well was pumped until a visible decrease in turbidity was observed.

Groundwater Sampling: On September 24, 2018, samples of ground water were collected from monitoring wells MW13, MW14, MW15, MW16, MW17S, MW17D, MW18, and MW7. All collected samples were stored in coolers with freezer packs after collection and during transport to the ALS Environmental Analytical Laboratory in Mississauga, Ontario for potability analysis. ALS is accredited by the *Canadian Associations for Laboratory Accreditation Inc*. (CALA).

2.3.2 Hydraulic Conductivity Tests

Hydraulic Conductivity Testing: Eighteen of all the twenty two all the installed monitoring wells were stress tested to provide estimates of the hydraulic conductivity for the zones against which the screens for the wells were set.

Rising head tests were conducted by Landtek on February 1, 2017 for monitoring wells MW1, MW2, MW3, MW4, MW5, MW6D, MW7, MW8, MW9, MW10D, MW11, and MW12. The tests involved the extraction of a known volume to displace the water level and manual recording of recovery at pre-determined intervals to at least 90% level recovery.

The hydraulic conductivity of the screened material over the screened interval of the monitoring well was interpreted from the results using the Hvorslev formula as follows:

$$K = r^2 \ln(L/R)/2\, L\, T_o$$

Where:

- K =hydraulic conductivity
- r =radius of the well (standpipe)
- L =length of test interval
- R =borehole radius
- T_o =time for recovery to within 37% of static water level

Rising head tests were conducted by Landtek on September 12, 2018 for monitoring wells MW14, MW16, MW17S, MW17D, MW18, and MW19. The tests involved the extraction of a known volume to displace the water level. A datalogger programed at 0.5 second intervals was used to record the water level response during the tests.

The rising head test data MW14, MW16, MW17S, MW17D, MW18, and MW19 were analyzed using AqteSolve Professional Version 4.5 software package developed by Glenn M. Duffield of HydroSOLVE Inc. applying the Hvorslev analysis solutions, depending on hydrogeology.

3.0 FINDINGS

3.1 Topography, Drainage and Hydrology

The site is predominantly flat-lying with elevations increasing gradually towards the Niagara Escarpment to the south. The site ranges in elevation from approximately 88 meters above sea level (masl) in the north to 95 masl in the south of the site. A total of four (4) regulated watercourses cross the site, flowing generally south to north, directing runoff from the Niagara Escarpment to Lake Ontario (HCA, 2016). Additional manmade ditches are present throughout the site intended for local runoff from the agricultural fields. Local ponded water is intermittently present throughout the site during times of increased precipitation. The regulated areas based on Hamilton Conservation Authority Area map is as shown on Figure 5 in Appendix A

3.2 Regional Physiography

The site is located within a physiographic region known as the Haldimand Clay Plain which occupies the area from the Niagara Escarpment to Lake Erie. A glacial lake covered this area and, as a result, at some locations stratified clay and/or silt overlies fine grained till and there are also intermixed layers of till and stratified fine grained sediments. The overburden thickness increases southward from the Niagara Escarpment (City of Hamilton, 2010).

3.3 Climate

The climate in the study area is largely influenced by Lake Ontario. The general climate data presented below in Table 2 was obtained from Environment Canada publications and from the Environment Canada online database. Average climate data was taken from Hamilton A station Airport (Hamilton Airport) for the period of 1981 to 2010.

Table 2. 1981 to 2010 Climate Normals for Hamilton A Station (as averages)

	Daily Average Temperature (^oC)	Average Rainfall (mm)	Average Snowfall (cm)	Average Precipitation (mm)
January	-5.5	29.7	40.8	64.0
February	-4.6	28.2	35.1	57.8
March	-0.1	42.6	26.5	68.4
April	6.7	71.3	8.4	79.1
May	12.8	78.7	0.5	79.4
June	18.3	84.9	0.0	84.9
July	20.9	100.7	0.0	100.7
August	20.0	79.2	0.0	79.2
September	15.8	81.9	0.0	81.9
October	9.3	76.5	0.7	77.4
November	3.7	74.4	11.0	84.3
December	-2.3	43.8	33.5	73.0
Year	7.9	791.7	156.5	929.8

3.4 Regional Geology

The City of Hamilton is underlain by clastic and carbonate sedimentary rocks of Late Ordovician to Middle Silurian age, which make up parts of three major depositional sequences (Johnson et al., 1992). The oldest bedrock unit outcropping in the area, the Queenston Formation, is predominantly dark red, fissile, hematitic, calcareous shale (Liberty et al., 1976).

The Queenston Formation is found north of the Niagara Escarpment and consists in many places of up to 4 feet (1.2 m) of very weathered bedrock (red clay) which grades downward into typical brick-red shale. The Queenston shale is overlain by Halton Till in the area of the site.

The Late Wisconsinan Halton Till is a clay to clayey silt till and is exposed in the form of a till plain from Lake Ontario southward to the Niagara Escarpment. It is the youngest glacial unit in the region and has been found to be relatively thick (up to 30 m) in the buried bedrock valley between Grimsby and Grimsby Beach. The basal part of the till is red, relatively coarser textured, and consists almost entirely of Queenston shale. Proglacial Lake Iroquois clay, silt and sand is mapped as overlying the Queenston shale in the southern portion of the site. The lake terrace is mainly underlain by Queenston shale and Halton Till although a sheet of predominantly fine sand was deposited along the shoreline and is relatively thicker (up to 4.5 m) in the vicinity of Grimsby (Feenstra, 1975).

The existing surficial geology mapping of the site shows bedrock outcropping at surface in a general east-west direction throughout the centre of the site. The northern portion of the site is mapped as clay to silt-textured till (Halton Till) and the southern portion is mapped as coarse textured sand and gravel deposits.

3.5 Regional Hydrogeology

Regional hydrogeology conditions were assessed on the basis of local water well records and existing geologic reports.

The hydrostratigraphy (i.e. the vertical sequence and horizontal extent of aquifers and aquitards) in the overburden and shallow bedrock generally follows the geologic layering. Till formations in the overburden act as aquitards while the sandier units generally behave as aquifers. Shale generally acts as an aquitard with an upper weathered bedrock aquifer layer (City of Hamilton, 2010).

The Halton till has low infiltration potential due to the composition of the clay and density of the till. The groundwater recharge potential is classified as “moderate” to “low”. The coarser grained Proglacial Lake Iroquois deposits near the base of the escarpment represent a zone of high groundwater recharge potential and function as a potential contributor of baseflow to stream reaches to the north (Aquafor Beech Ltd., 2012).

3.6 MECP Water Well Records and Groundwater Resources

The site is located in the Hamilton Source Protection Area (SPA) and is classified as a located in highly vulnerable aquifer area with a Score of 6 by the Ministry of the Environment, Conservation and Park (MECP). The site location is, however, not in a wellhead protection area, is not in an intake protection zone, and is not classified as a significant groundwater recharge area. The source water protection details for the site were referenced from the MECP website on Source Water Protection for the Province of Ontario (MECP, 2019).
The MECP Water Well Information System (WWIS) is a publically available database which contains information such as groundwater well location, well construction details, static water level, geologic units encountered with depth, general water quality observations, water use, date of construction, and screened interval

The MECP records for wells located within approximately 500 meters of the site were reviewed to assess the general nature and use of the groundwater resource in the area and to characterize local hydrogeologic conditions.

Well Construction

- Wells terminated in bedrock 13
- Wells terminated in overburden 3
- No data 1
- **Total 17**

Well Uses

- Domestic 7
- Public 1
- Monitoring 8
- Unknown 1

Well Depth

- Less than 15 m 11
- Between 15 and 30 m 4
- Greater than 30 m 1
- No Data 1

The locations of all the MECP 17 wells are plotted on Figure 6 in Appendix A, and the MECP well records included in Appendix D of this report.

Based on the well records, it is evident that there are 7 domestic water wells completed in bedrock within 500 m of the site. However, the Site is situated within the City of Hamilton in an area serviced by the City water supply systems.

3.7 Results of Subsurface Investigation

The borehole information is generally consistent with the geological data, and the predominant soils comprise of an overburden of clayey silt till overlying shale bedrock.

In general, overburden was found on site ranging in thickness from approximately 0.9 m to 18.9 m. The composition of the overburden ranged from silty sand in the south to clayey silt till in the north. The overburden was found overlying Queenston Shale. The detailed stratigraphy encountered in each borehole is described in detail in the borehole logs. Note that not all of the stratigraphic units were present in all boreholes. For example, fill material was only encountered in boreholes BH11 and BH12, advanced on the City of Hamilton property.

The ground conditions encountered by the boreholes are discussed further in the following sections.

Disturbed Surficial Soil

Surficial organic soils were encountered in all boreholes drilled within the disturbed agricultural lands. These organic soils typically consisted of dark brown, silty clay, moist to wet, organic filled material.

Fill

Clayey silt fill was encountered in boreholes BH11 and BH12, located in the City of Hamilton property in the eastern portion of the site. The fill extended to approximately 1.2 m in both boreholes and generally consisted of moist, brown, clayey silt with trace coarse sand and gravel.

Halton Till

Grey to brown clayey silt till was encountered in every borehole, except BH12 (fill material overlay bedrock). The till contained trace amounts of sand, fine gravel, and shale fragments and was found to be very stiff to hard. The till was found in varying thicknesses across the site ranging from approximately 0.9 m to 18.9 m.

No water bearing zones were found in the till in the northern portion of the site, and minor water bearing lenses were observed in the south where the till was overlain by the coarser silty sand deposits.

During drilling activities, the till was found to be so hard that advancement by augering had to be replaced by triconing, which is typically reserved for advancing through bedrock.

Silty Sand/Sandy Silt

Medium grained, brown, silty sand was encountered at surface in boreholes BH1, BH3, BH6-D, BH6-S, and BH13. Slightly finer grained sandy silt was encountered in borehole location BH2. These six borehole locations are located in the Multi-Area Development property in the southern portion of the site where the pre-existing OGS maps show surficial coarse-textured glaciolacustrine deposits. These deposits ranged in thickness from approximately 1 m to 2.5 m and were found to overly the Halton Till.

Queenston Shale

The red, Queenston shale was encountered as weathered and unweathered in composition. The weathered shale was typically observed as being incorporated into the overlying overburden unit as red clay, whereas the unweathered shale was competent and was observed to have a hard, blocky texture.

The bedrock was encountered at varying depths across the site, ranging from 0.9 m in borehole BH4 to 18.9 m in borehole BH17D. The Higher bedrock elevations were observed in BH4 (0.9 m), BH8 (2.7 m), and BH12 (1.2 m). These boreholes are located in the northwest and eastern portions of the study site.

Geologic Cross Sections

Geologic cross sections were prepared using the information obtained from the drilling programs. These cross sections can be found in Figures 7 and 8 (A-A', and B-B', respectively). A plan view map showing the locations of each cross section is indicated in Figure 4.

The geologic information collected from the borehole drilling indicates some similarities with the pre-existing OGS mapping of the area, but differences were observed in the bedrock elevations found across the site in comparison to the existing maps. In comparing the OGS

surficial geology map, high bedrock elevations were observed in the northwest and eastern portions of the site, but decreases throughout the centre of the site to measured depths of approximately 18.9 m below surface. The low bedrock elevations extend from the south of the site, north to borehole location BH5, and trends in a northeast direction towards boreholes BH9, BH11 and BH17D.
Evidence of the low bedrock elevation extending to the southwest is observed in MOE well record 7122670 which logs overburden extending to depths >28 m. This well did not encounter bedrock at the final depth of drilling.

It should be noted that not all boreholes were advanced into the bedrock, so the bedrock elevations shown in the cross sections are interpreted throughout some areas.

3.7.1 Grain Size Analyses/Atterberg Limits

A total of five (5) overburden soil samples were submitted to Landtek's soil laboratory for grain size analysis using sieve and hydrometer methods (ASTM D422). The 4 samples were chosen based on the range of grain sizes encountered during drilling. Results indicate the soil types across the site range from clayey silt to silt to sand. The results of the grain size analyses are provided in Appendix E and Atterberg Limits are provided in Appendix F. The soils are classified as silty clay.

Soil samples were collected from BH13, BH14, BH15, BH16, and BH17 at depths ranging from 0.7 to 21.2 mbgs. These results are summarized below as follows:

BH13 @ 0.7-1.2 m bgs
: Classified the soil as <u>Silty Clay</u> with 1.9% gravel, 30.6% sand, 41.4% silt and 26.1% clay

BH14 @ 0.7-1.2 m bgs
: Classified the soil as <u>Silty Clay</u> with 2.0% gravel, 28.2% sand, 43.5% silt and 36.3% clay

BH15 @ 0.7-1.2 m bgs
: Classified the soil as <u>Silty Clay</u> with 1.8% gravel, 11.6% sand, 50.2% silt and 36.4% clay

BH16 @ 0.7-1.2 m bgs
: Classified the soil as <u>Silt Clay-Silt</u> with 0.5% gravel, 16.9% sand, 43.2% silt and 39.4% clay

BH17 @ 0.7-1.2 m bgs
: Classified the soil as <u>Silty Clay</u> with 1.7% gravel, 32.5% sand, 43.0% silt and 22.8% clay

3.8 Groundwater Monitoring

Water levels are measured manually in all 14 installed monitoring wells during the first phase of drilling using a Solinst Water Level Tape. Data loggers (Solinst Model 3001 LT Levelogger Junior Edge and Solinst Model 3001 LT Barologger Edge) were installed in 8 monitoring wells completed to obtain a continuous (hourly) record of groundwater levels and temperature fluctuations. Pressure data was corrected to barometric pressures recorded at the site. The 8 monitoring wells installed with Data loggers include MW1, MW2, MW4, MW5, MW7, MW10-D, MW11, and MW12. These selected monitoring wells are screened in the clayey silt till, upper weathered shale, and the deep shale.

Depth to groundwater, in all installed 14 monitoring wells, were obtained manually by Landtek staff during field events from January 2017 to August 2018. Field monitoring events were completed in order to capture the natural seasonal variability in groundwater levels at the site.

Water levels are measured manually in all 8 installed monitoring wells during the second phase of drilling using a Solinst Water Level Tape. Data loggers (Solinst Model 3001 LT Levelogger Junior Edge and Solinst Model 3001 LT Barologger Edge) were installed in 4 monitoring wells to obtain a continuous (hourly) record of groundwater levels and temperature fluctuations. Pressure data was corrected to barometric pressures recorded at the site. The 4 monitoring wells installed with Data loggers include MW13, MW16, MW18, and MW19. These selected monitoring wells are screened in the upper weathered shale.

Manual groundwater elevation measurements collected during the program are provided below in Table 4. Groundwater level elevations collected on October 15, 2018 are plotted in Figures 9 and 10 which depict the groundwater elevations and groundwater flow directions within the clayey silt till as well as the shale across the site, respectively. Depths to groundwater across the site were found to range from -0.07 mbgs (MW12 on April 27, 2017) to 11.57 mbgs (MW17-S on August 29, 2018).

Overall, the site has a relatively shallow potentiometric surface in both the overburden till and the buried shale.
Nineteen months of groundwater elevations were collected in order to present seasonal trends and variations in groundwater levels in hydrograph format. Hydrographs of groundwater elevations within each well are presented and discussed below.

It should be noted that the groundwater levels for the site will likely fluctuate seasonally depending on the amount of precipitation and surface runoff.

The groundwater monitoring data are presented below in Table 3.

Table 3. Monthly Groundwater Monitoring Data

MW ID	Screened Material	Ground Elevation (masl)	Jan. 26, 2017		Feb. 1, 2017		Feb. 22, 2017	
			WL (mbgs)	WL (masl)	WL (mbgs)	WL (masl)	WL (mbgs)	WL (masl)
MW1	Clayey Silt Till	95.04	2.38	92.66	2.52	92.52	2.03	93.01
MW2	Clayey Silt Till	93.54	0.81	92.73	1.02	92.52	0.78	92.76
MW3	Clayey Silt Till	92.74	4.42	88.32	4.36	88.38	3.02	89.72
MW4	Shale (Upper Weathered Shale)	91.39	1.56	89.83	1.79	89.60	1.27	90.12
MW5	Contact (Till and Upper Weathered Shale)	91.04	0.45	90.60	1.55	89.50	1.30	89.75
MW6-S	Clayey Silt Till	92.19	dry	dry	dry	dry	4.48	87.71
MW6-D	Shale (competent)	92.22	1.72	90.51	1.69	90.54	1.68	90.55
MW7	Shale (competent)	89.87	2.72	87.15	2.72	87.15	2.60	87.27
MW8	Shale (Upper Weathered Shale)	89.57	0.18	89.39	0.37	89.20	0.04	89.53
MW9	Shale (Upper Weathered Shale)	89.56	-	-	2.01	87.55	2.06	87.50
MW10-	Clayey Silt Till	88.15	-	-	dry	dry	7.24	80.91
MW10-	Shale (competent)	88.19	-	-	3.07	85.12	2.59	85.60
MW11	Shale (competent)	89.18	-	-	3.91	85.27	2.81	86.37

MW12	Shale (Upper Weathered Shale)	90.12	-	-	0.74	89.38	0.30	89.82

Table 3. Monthly Groundwater Monitoring Data Continued

MW ID	Screened Material	Ground Elevation (masl)	Mar. 20, 2017		Apr. 27, 2017		Jun. 06, 2017	
			WL (mbgs)	WL (masl)	WL (mbgs)	WL (masl)	WL (mbgs)	WL (masl)
MW1	Clayey Silt Till	95.04	1.31	93.73	0.69	94.35	1.10	93.94
MW2	Clayey Silt Till	93.54	0.95	92.59	0.75	92.79	1.00	92.54
MW3	Clayey Silt Till	92.74	1.06	91.68	0.34	92.40	0.84	91.90
MW4	Shale (Upper Weathered Shale)	91.39	1.19	90.20	1.13	90.26	1.52	89.87
MW5	Contact (Till and Upper Weathered Shale)	91.04	1.36	89.68	1.28	89.76	1.52	89.52
MW6-S	Clayey Silt Till	92.19	0.61	91.58	0.51	91.68	1.88	90.31
MW6-D	Shale (competent)	92.22	1.61	90.61	1.41	90.81	1.38	90.84
MW7	Shale (competent)	89.87	2.59	87.28	2.45	87.42	2.46	87.41
MW8	Shale (Upper Weathered Shale)	89.57	0.07	89.50	-0.03	89.60	0.24	89.33
MW9	Shale (Upper Weathered Shale)	89.56	1.93	87.63	1.70	87.86	1.77	87.79
MW10-S	Clayey Silt Till	88.15	6.63	MW1	Clayey	95.04	3.91	84.24
MW10-D	Shale (competent)	88.19	1.85	MW2	Clayey	93.54	2.27	85.92
MW11	Shale (competent)	89.18	1.69	86.49	1.42	86.76	1.49	86.69
MW12	Shale (Upper Weathered Shale)	90.12	0.19	89.93	-0.07	90.19	0.45	89.67

Table 3. Monthly Groundwater Monitoring Data Continued

MW ID	Screened Material	Ground Elevation (masl)	Jun. 28, 2017		Jul. 31, 2017		Sep. 09, 2017	
			WL (mbgs)	WL (masl)	WL (mbgs)	WL (masl)	WL (mbgs)	WL (masl)
MW1	Clayey Silt Till	95.04	1.59	93.45	1.83	93.21	1.84	93.20
MW2	Clayey Silt Till	93.54	1.14	92.40	1.26	92.28	1.25	92.29
MW3	Clayey Silt Till	92.74	1.37	91.37	1.67	91.07	1.64	91.10
MW4	Shale (Upper Weathered Shale)	91.39	1.83	89.56	1.97	89.42	1.96	89.43
MW5	Contact (Till and Upper Weathered Shale)	91.04	1.74	89.30	1.75	89.29	1.75	89.29
MW6-S	Clayey Silt Till	92.19	1.08	91.11	1.15	91.04	1.14	91.05
MW6-D	Shale (competent)	92.22	1.46	90.76	1.47	90.75	1.46	90.76
MW7	Shale (competent)	89.87	2.61	87.26	2.64	87.23	2.62	87.25
MW8	Shale (Upper Weathered Shale)	89.57	0.46	89.11	0.55	89.02	0.48	89.09
MW9	Shale (Upper Weathered Shale)	89.56	1.99	87.57	2.11	87.45	2.12	87.44
MW10-S	Clayey Silt Till	88.15	3.17	84.98	2.49	85.66	2.47	85.68
MW10-D	Shale (competent)	88.19	2.40	85.79	2.47	85.72	2.36	85.83
MW11	Shale (competent)	89.18	1.78	86.40	1.89	86.29	1.90	86.28
MW12	Shale (Upper Weathered Shale)	90.12	0.83	89.29	1.03	89.09	0.99	89.13

Table 3. Monthly Groundwater Monitoring Data Continued

MW ID	Screened Material	Ground Elevation (masl)	Oct. 21, 2017		Nov. 13, 2017		Dec. 12, 2017	
			WL (mbgs)	WL (masl)	WL (mbgs)	WL (masl)	WL (mbgs)	WL (masl)
MW1	Clayey Silt Till	95.04	2.29	92.75	2.25	92.79	1.65	93.39
MW2	Clayey Silt Till	93.54	1.82	91.72	1.79	91.75	1.28	92.26
MW3	Clayey Silt Till	92.74	2.13	90.61	2.09	90.65	1.83	90.91
MW4	Shale (Upper Weathered Shale)	91.39	2.25	89.14	2.22	89.17	1.84	89.55
MW5	Contact (Till and Upper Weathered Shale)	91.04	2.04	89.00	2.02	89.02	1.67	89.37
MW6-S	Clayey Silt Till	92.19	1.50	90.69	1.45	90.74	1.02	91.17
MW6-D	Shale (competent)	92.22	1.43	90.79	1.39	90.83	1.22	91.00
MW7	Shale (competent)	89.87	2.66	87.21	2.63	87.24	2.45	87.42
MW8	Shale (Upper Weathered Shale)	89.57	0.81	88.76	0.78	88.79	0.42	89.15
MW9	Shale (Upper Weathered Shale)	89.56	2.15	87.41	2.14	87.42	1.90	87.66
MW10-S	Clayey Silt Till	88.15	1.88	86.27	1.85	86.30	1.89	86.26
MW10-D	Shale (competent)	88.19	2.21	85.98	2.20	85.99	1.98	86.21
MW11	Shale (competent)	89.18	1.92	86.26	1.89	86.29	1.66	86.52
MW12	Shale (Upper Weathered Shale)	90.12	1.25	88.87	0.99	89.13	0.99	89.13

Table 3. Monthly Groundwater Monitoring Data Continued

MW ID	Screened Material	Ground Elevation (masl)	Jan. 15, 2018		Feb. 28, 2018		Apr. 25, 2018	
			WL (mbgs)	WL (masl)	WL (mbgs)	WL (masl)	WL (mbgs)	WL (masl)
MW1	Clayey Silt Till	95.04	Frozen	NA	1.62	93.42	0.73	94.31
MW2	Clayey Silt Till	93.54	0.81	92.73	0.76	92.78	0.77	92.77
MW3	Clayey Silt Till	92.74	Frozen	NA	1.80	90.94	0.32	92.42
MW4	Shale (Upper Weathered Shale)	91.39	Frozen	NA	1.77	89.62	0.21	91.18
MW5	Contact (Till and Upper Weathered Shale)	91.04	1.29	89.75	1.26	89.78	1.18	89.86
MW6-S	Clayey Silt Till	92.19	Frozen	NA	0.89	91.30	0.45	91.74
MW6-D	Shale (competent)	92.22	Frozen	NA	1.17	91.05	1.09	91.13
MW7	Shale (competent)	89.87	2.17	87.70	1.98	87.89	1.82	88.05
MW8	Shale (Upper Weathered Shale)	89.57	0.08	89.49	0.20	89.37	-0.07	89.64
MW9	Shale (Upper Weathered Shale)	89.56	1.86	87.70	1.64	87.92	1.62	87.94
MW10-S	Clayey Silt Till	88.15	1.94	86.21	1.72	86.43	2.04	86.11
MW10-D	Shale (competent)	88.19	1.88	86.31	1.55	86.64	1.91	86.28
MW11	Shale (competent)	89.18	1.55	86.63	1.50	86.68	1.39	87.79
MW12	Shale (Upper Weathered Shale)	90.12	Frozen	NA	0.75	89.37	0.29	89.83

Table 3. Monthly Groundwater Monitoring Data Continued

MW ID	Screened Material	Ground Elevation (masl)	May. 22, 2018		Jul. 3, 2018		Jul. 26, 2018	
			WL (mbgs)	WL (masl)	WL (mbgs)	WL (masl)	WL (mbgs)	WL (masl)
MW1	Clayey Silt Till	95.04	0.78	94.26	0.86	94.18	0.96	94.08
MW2	Clayey Silt Till	93.54	0.91	92.63	1.30	92.24	1.02	92.52
MW3	Clayey Silt Till	92.74	0.73	92.01	1.67	91.07	1.02	91.72
MW4	Shale (Upper Weathered Shale)	91.39	1.52	89.87	2.10	89.29	1.62	89.77
MW5	Contact (Till and Upper Weathered Shale)	91.04	1.33	89.71	2.60	88.44	1.49	89.55
MW6-S	Clayey Silt Till	92.19	0.59	91.6	1.24	90.95	1.06	91.13
MW6-D	Shale (competent)	92.22	1.21	91.01	1.42	90.8	1.38	90.84
MW7	Shale (competent)	89.87	1.90	87.97	2.52	87.85	2.12	87.75
MW8	Shale (Upper Weathered Shale)	89.57	0.48	89.09	0.67	88.90	0.71	88.86
MW9	Shale (Upper Weathered Shale)	89.56	1.70	87.86	2.17	87.39	1.87	87.69
MW10-S	Clayey Silt Till	88.15	2.24	85.91	1.34	86.81	2.48	85.67
MW10-D	Shale (competent)	88.19	2.42	85.77	2.24	85.95	2.56	85.63
MW11	Shale (competent)	89.18	1.59	87.59	2.00	87.18	1.74	87.44
MW12	Shale (Upper Weathered Shale)	90.12	0.70	89.42	1.17	88.95	0.97	89.15

Table 3. Monthly Groundwater Monitoring Data Continued

MW ID	Screened Material	Ground Elevation (masl)	Aug. 29, 2018		Sep 12, 2018		Sep 24, 2018	
			WL (mbgs)	WL (masl)	WL (mbgs)	WL (masl)	WL (mbgs)	WL (masl)
MW1	Clayey Silt Till	95.04	0.80	-	-	-	-	-
MW2	Clayey Silt Till	93.54	0.94	-	-	-	-	-
MW3	Clayey Silt Till	92.74	0.96	-	-	-	-	-
MW4	Shale (Upper Weathered Shale)	91.39	1.59	-	-	-	-	-
MW5	Contact (Till and Upper Weathered Shale)	91.04	1.43	-	-	-	-	-
MW6-S	Clayey Silt Till	92.19	0.96	-	-	-	-	-
MW6-D	Shale (competent)	92.22	1.29	-	-	-	-	-
MW7	Shale (competent)	89.87	2.05	-	-	-	-	-
MW8	Shale (Upper Weathered Shale)	89.57	0.63	-	-	-	-	-
MW9	Shale (Upper Weathered Shale)	89.56	1.76	-	-	-	-	-
MW10-S	Clayey Silt Till	88.15	2.35	-	-	-	-	-
MW10-D	Shale (competent)	88.19	2.42	-	-	-	-	-
MW11	Shale (competent)	89.18	1.70	-	-	-	-	-
MW12	Shale (Upper Weathered Shale)	90.12	0.87	-	-	-	-	-
MW13	Shale (Upper Weathered Shale	98.50	1.50	97.0	1.50	97.0	1.64	96.86
MW14	Shale (Upper Weathered Shale	99.65	2.40	97.25	2.57	97.08	2.70	96.95

MW15	Shale (Upper Weathered Shale	90.72	1.32	89.40	-	NA	1.69	89.03
MW16	Clayey Silt Till and Shale (Weathered	88.55	0.69	87.86	0.71	87.84	0.73	87.82
MW17S	Clayey Silt Till	90.59	11.57	79.02	10.48	80.11	9.81	80.78
MW17D	Clayey Silt Till and Shale (Weathered	90.59	2.82	87.77	2.87	87.72	2.91	87.68
MW18	Shale (Upper Weathered Shale	92.02	3.13	88.89	3.48	88.54	3.70	88.32
MW19	Shale (Upper Weathered Shale	100.99	3.12	97.87	3.40	97.59	3.46	97.53

Table 3. Monthly Groundwater Monitoring Data Continued

MW ID	Screened Material	Ground Elevation (masl)	Oct. 15, 2018		Nov. 16, 2018		Dec. 12, 2018	
			WL (mbgs)	WL (masl)	WL (mbgs)	WL (masl)	WL (mbgs)	WL (masl)
MW1	Clayey Silt Till	95.04	2.61	92.43	2.47	95.57	2.59	92.45
MW2	Clayey Silt Till	93.54	1.97	91.57	1.91	91.63	2.04	91.50
MW3	Clayey Silt Till	92.74	2.30	90.44	2.2	90.54	2.23	90.51
MW4	Shale (Upper Weathered Shale)	91.39	2.65	88.74	2.48	88.91	3.57	87.82
MW5	Contact (Till and Upper Weathered Shale)	91.04	2.37	88.67	2.25	88.79	2.38	88.66
MW6-S	Clayey Silt Till	92.19	1.96	90.23	1.85	90.34	1.89	90.30
MW6-D	Shale (competent)	92.22	1.58	90.64	1.40	90.82	1.53	90.69
MW7	Shale (competent)	89.87	2.75	87.12	2.68	87.19	2.75	87.12
MW8	Shale (Upper Weathered Shale)	89.57	1.23	88.34	1.17	88.40	1.28	88.29
MW9	Shale (Upper Weathered Shale)	89.56	2.37	87.19	2.29	87.27	2.41	87.15
MW10-S	Clayey Silt Till	88.15	1.65	86.50	1.52	86.63	1.60	86.55
MW10-D	Shale (competent)	88.19	2.42	85.77	2.38	85.81	2.42	85.77
MW11	Shale (competent)	89.18	2.29	86.89	2.22	86.96	2.30	86.88
MW12	Shale (Upper Weathered Shale)	90.12	1.76	89.11	1.91	88.21	1.76	88.36
MW13	Shale (Upper Weathered Shale	98.50	1.76	96.72	-	-	-	-
MW14	Shale (Upper Weathered Shale	99.65	2.86	96.79	-	-	-	-
MW15	Shale (Upper Weathered Shale	90.72	1.88	88.84	-	-	-	-
MW16	Clayey Silt Till and Shale (Weathered	88.55	0.93	87.62	-	-	-	-
MW17S	Clayey Silt Till	90.59	9.93	80.66	-	-	-	-
MW17D	Clayey Silt Till and Shale (Weathered	90.59	3.04	87.55	-	-	-	-
MW18	Shale (Upper Weathered Shale	92.02	3.77	88.25	-	-	-	-
MW19	Shale (Upper Weathered Shale	100.99	3.59	97.40	-	-	-	-

Table 3. Monthly Groundwater Monitoring Data Continued

MW ID	Screened Material	Ground Elevation (masl)	Jan 24, 2019		Feb 21, 2019		Mar 27, 2019	
			WL (mbgs)	WL (masl)	WL (mbgs)	WL (masl)	WL (mbgs)	WL (masl)
MW1	Clayey Silt Till	95.04	2.51	92.53	2.36	92.68	1.05	93.99
MW2	Clayey Silt Till	93.54	1.95	91.59	1.72	91.82	0.93	92.61
MW3	Clayey Silt Till	92.74	2.14	90.60	2.03	90.71	0.49	92.25
MW4	Shale (Upper Weathered Shale)	91.39	2.51	88.88	2.41	88.98	1.25	90.14
MW5	Contact (Till and Upper Weathered Shale)	91.04	2.36	88.68	2.21	88.83	1.21	89.83
MW6-S	Clayey Silt Till	92.19	1.39	90.80	1.72	90.47	0.37	91.82
MW6-D	Shale (competent)	92.22	1.78	90.44	1.32	90.90	1.13	91.09
MW7	Shale (competent)	89.87	2.67	87.20	2.60	87.27	1.23	88.64
MW8	Shale (Upper Weathered Shale)	89.57	1.18	88.39	1.19	88.38	0.06	89.51
MW9	Shale (Upper Weathered Shale)	89.56	2.25	87.34	2.15	87.41	1.69	87.87
MW10-S	Clayey Silt Till	88.15	1.39	86.76	1.43	86.72	1.20	86.95
MW10-D	Shale (competent)	88.19	2.30	85.89	1.33	86.86	1.72	86.47
MW11	Shale (competent)	89.18	2.23	86.95	2.13	87.05	1.49	87.69
MW12	Shale (Upper Weathered Shale)	90.12	1.64	88.48	1.46	88.66	0.59	89.53
MW13	Shale (Upper Weathered Shale	98.50	0.67	97.83	1.60	96.90	0.93	97.57
MW14	Shale (Upper Weathered Shale	99.65	-	-	-	-	-	-
MW15	Shale (Upper Weathered Shale	90.72	1.71	89.01	1.62	89.10	0.69	90.03
MW16	Clayey Silt Till and Shale (Weathered	88.55	0.72	87.83	0.87	87.68	0.70	87.85
MW17S	Clayey Silt Till	90.59	9.79	80.80	9.36	81.23	2.71	87.88
MW17D	Clayey Silt Till and Shale (Weathered	90.59	2.87	87.72	2.78	87.81	2.46	88.13
MW18	Shale (Upper Weathered Shale	92.02	3.65	88.37	3.58	88.44	1.89	90.13
MW19	Shale (Upper Weathered Shale	100.99	3.42	97.57	3.37	97.62	1.55	99.44

Table 3. Monthly Groundwater Monitoring Data Continued

MW ID	Screened Material	Ground Elevation (masl)	Apr 18, 2019		May 22, 2019		Jun 27, 2019	
			WL (mbgs)	WL (masl)	WL (mbgs)	WL (masl)	WL (mbgs)	WL (masl)
MW1	Clayey Silt Till	95.04	0.97	94.07	1.05	93.99	0.68	94.36
MW2	Clayey Silt Till	93.54	0.76	92.78	0.85	92.69	0.27	93.27
MW3	Clayey Silt Till	92.74	0.36	92.38	0.43	92.31	0.33	92.41
MW4	Shale (Upper Weathered Shale)	91.39	1.08	90.31	1.18	90.21	0.82	90.57
MW5	Contact (Till and Upper Weathered Shale)	91.04	1.05	89.99	1.13	89.91	0.69	90.35
MW6-S	Clayey Silt Till	92.19	0.23	91.96	0.30	91.89	-0.02	92.21
MW6-D	Shale (competent)	92.22	1.03	91.19	1.12	91.10	0.88	91.34

MW7	Shale (competent)	89.87	1.09	88.78	1.16	88.71	0.87	89.00
MW8	Shale (Upper Weathered Shale)	89.57	-0.05	89.62	0.24	89.33	-0.57	90.14
MW9	Shale (Upper Weathered Shale)	89.56	1.55	88.01	1.62	87.94	0.93	88.63
MW10-S	Clayey Silt Till	88.15	0.99	87.16	1.73	86.42	0.12	88.03
MW10-D	Shale (competent)	88.19	1.55	86.64	0.94	87.25	0.98	87.21
MW11	Shale (competent)	89.18	1.40	87.78	1.47	87.71	0.68	88.50
MW12	Shale (Upper Weathered Shale)	90.12	0.48	89.64	0.54	89.58	-0.25	90.37
MW13	Shale (Upper Weathered Shale	98.50	0.75	97.75	0.82	97.68	0.49	98.01
MW14	Shale (Upper Weathered Shale	99.65	-	-	-	-	-	-
MW15	Shale (Upper Weathered Shale	90.72	0.56	90.16	0.62	90.10	0.11	90.61
MW16	Clayey Silt Till and Shale (Weathered	88.55	0.61	87.94	0.70	87.85	0.10	88.45
MW17S	Clayey Silt Till	90.59	2.60	87.99	2.68	87.91	1.30	89.29
MW17D	Clayey Silt Till and Shale (Weathered	90.59	2.42	88.17	2.47	88.12	1.87	88.72
MW18	Shale (Upper Weathered Shale	92.02	1.76	90.26	1.81	90.21	1.65	90.37
MW19	Shale (Upper Weathered Shale	100.99	1.42	99.57	1.54	99.45	1.64	99.35

Notes:
WL = groundwater level
mbgs = meters below ground surface
9.79 – groundwater level appears not to have recovered
masl = meters above sea level
MW14 = Outside Property Boundary – Client requested that Monitoring should stop in November 2018.

Data loggers (Solinst Model 3001 LT Levelogger Junior Edge and Solinst Model 3001 LT Barologger Edge) were installed in February 2017 in eight monitoring wells (MW1, MW2, MW4, MW5, MW7, MW10D, MW11, and MW12) to obtain a continuous (hourly) record of groundwater levels and temperature fluctuations in order to determine seasonal groundwater level fluctuations across the Site. The hydrographs data are usually downloaded periodically and corrected for barometric pressures influences recorded at the Site.

Data from installed data logger in MW5 for December 2017 to September 2018 could not be retrieved as the logger was found to be damaged and not connecting when an attempt was made to download the data.

Hydrographs of groundwater elevations for the period of late February 2017 to early September, 2018, obtained using data loggers, and manual groundwater elevation readings are provided on Figures 1 to 8 in Appendix D.

Figures 1, 2, 3, 4, 5, 6, 7, and 8 for MW1, MW2, MW4, MW5, MW7, MW10D, MW11, and MW12, respectively, show the groundwater levels elevations readings generally increased from February to May 2017, then decreased to October 2017, with the exception of Figure 5 with lowest level in August, 2017. The groundwater levels readings then increased from August 2017 to February 2018. Figure 4 for MW5 shows the groundwater levels readings slightly increased from February to May 2017, then decreased to October 2017, and increased to December 2017 when the data logger installed in this monitoring well was damaged and and could not be downloaded. The changes in groundwater shallow wells monitoring wells completed from 5.2 to 7.6 mbgs appear to be more pronounced than in the deeper wells from 22.0 to 30.5 mbgs.

The lowest depth to groundwater below ground surface collected on Site was in MW12 on April 27, 2017 (approximately -0.07 mbgs [90.19 masl]), and the highest depth to groundwater below ground surface was in MW17S on August 29, 2018 (approximately 11.57 mbgs [79.09 masl]). It should be noted that the groundwater level in MW12 on February 27, 2017 was slightly above (-0.07 mbgs) ground but contained in the monitoring well riser pipe.

Fluctuations in the groundwater elevations on Site are interpreted to be directly affected by seasonal variations in precipitation and climatic trends.

3.9 Hydraulic Gradients and Flow

Groundwater flows from the shallow to deeper aquifers as leakage across the aquitards. The direction of vertical flow depends on the relative heads in the different aquifers. Leakage rates vary locally depending on the magnitude of the vertical gradients and on the thickness and hydraulic conductivity of the confining units (City of Hamilton, 2010).

The groundwater flow regime for the Site was determined by using the groundwater elevations recorded in monitoring wells MW1, MW3, and MW10 for the overburden; and MW6D, MW10D and MW11 for the bedrock. The water table contours lines were completed by using triangulation with linear interpolation. The horizontal hydraulic gradients within the overburden and shale aquifers were estimated from the October 15, 2018 groundwater elevation data. The horizontal hydraulic gradient within the overburden clayey silt till was estimated to be 0.015 m/m and the flow interpreted to be in a north-westerly direction. The horizontal hydraulic gradient within the competent shale across the site was estimated to be 0.011 m/m and the flow interpreted to be in a north-easterly direction. The groundwater contour diagrams, with interpreted groundwater flow directions, for the overburden and bedrock are presented on Figures 9 and 10, respectively.

For the purpose of this discussion, vertical hydraulic gradient was assessed by the difference in groundwater elevations between the shallow and deep nested monitoring wells MW6S and MW6D; MW10S and MW10D; and MW17S and MW17D. The groundwater elevations collected from February 2017 to August 2018 for the set of 3 monitoring nested wells can be referenced from Table 4 above.

A summary of the calculated vertical hydraulic gradients from the groundwater elevation readings is provided on the below in Table 4. A positive head difference represents an upward hydraulic gradient and a negative head difference represents a downward hydraulic

Table 4. Summary of Vertical Hydraulic Gradients

Monitoring Location	Vertical Hydraulic Gradients			
	Jan 26, 2017	Feb 1, 2017	Feb 22, 2017	March 20, 2017
MW6S (shallow) and MW6D (deep) head difference	NA	NA	0.214+	0.076-

MW10S (shallow) and MW10 (deep) head difference	NA	NA	0.324+	0.333+

Table 4. Summary of Vertical Hydraulic Gradients Continued

Monitoring Location	Vertical Hydraulic Gradients			
	Apr 27, 2017	Jun 6, 2017	Jun 28, 2017	Jul 31, 2017
MW6S (shallow) and MW6D (deep) head difference	0.069-	0.038+	0.029-	0.024+
MW10S (shallow) and MW10 (deep) head difference	0.251+	0.114+	0.054+	0.001+

Table 4. Summary of Vertical Hydraulic Gradients Continued

Monitoring Location	Vertical Hydraulic Gradients			
	Sep 9, 2017	Oct 21, 2017	Nov 13, 2017	Dec 12, 2017
MW6S (shallow) and MW6D (deep) head difference	0.024-	0.005+	0.005+	0.015-
MW10S (shallow) and MW10 (deep) head difference	0.008+	0.023-	0.024-	0.006-

Table 4. Summary of Vertical Hydraulic Gradients Continued

Monitoring Location	Vertical Hydraulic Gradients			
	Jan 15, 2018	Feb 28, 2018	Apr 25, 2018	May 22, 2018
MW6S (shallow) and MW6D (deep) head difference	NA	0.021-	0.058-	0.034+
MW10S (shallow) and MW10 (deep) head difference	0.004+	0.118+	0.009+	0.012-

Table 4. Summary of Vertical Hydraulic Gradients Continued

Monitoring Location	Vertical Hydraulic Gradients			
	Jul 3, 2018	Jul 26, 2018	Aug 29, 2018	Sep 12, 2018
MW6S (shallow) and MW6D (deep) head difference	0.016-	0.029-	0.030-	NA
MW10S (shallow) and MW10 (deep) head difference	0.060-	0.005-	0.005-	NA
MW17S (shallow) and MW17D (deep) head difference	NA	NA	1.046+	0.911+

Table 4. Summary of Vertical Hydraulic Gradients Continued

Monitoring Location	Vertical Hydraulic Gradients			
	Sept 24, 2018	Oct 15, 2018	Nov 16, 2018	Dec 12, 2018
MW6S (shallow) and MW6D (deep) head difference	NA	0.034+	0.037+	0.030+
MW10S (shallow) and MW10 (deep) head difference	NA	0.052-	0.060-	0.057-
MW17S (shallow) and MW17D (deep) head difference	0.826+	0.825+	-	-

Table 4. Summary of Vertical Hydraulic Gradients Continued

Monitoring Location	Vertical Hydraulic Gradients			
	Jan 24, 2019	Feb 21, 2019	Mar 27, 2019	Apr 18, 2019
MW6S (shallow) and MW6D (deep) head difference	0.032-	0.033+	0.020-	0.066-
MW10S (shallow) and MW10 (deep) head difference	0.064-	0.007+	0.036-	0.039-
MW17S (shallow) and MW17D (deep) head difference	0.706+	0.671+	0.018+-	0.018+

Table 4. Summary of Vertical Hydraulic Gradients Continued

Monitoring Location	Vertical Hydraulic Gradients			
	May 22, 2019	Jun 28, 2019		
MW6S (shallow) and MW6D (deep) head difference	0.067-	0.074-		
MW10S (shallow) and MW10 (deep) head difference	0.055+	0.060-		
MW17S (shallow) and MW17D (deep) head difference	0.021+	0.058-		

Vertical hydraulic gradients were observed at the nested well sets during the manual field measurements completed from February 2017 to June 2019 as follows:

- MW6S/MW6D
  - ❖ February, June, July, October, and November 2017; May, October, November, December 2018; February and March 2019 (upward indicating a discharge condition).

- ❖ March, April, June, September, and December 2017; February, April, July and August 2018; and January, April, May and June 2019 (downward indicating a recharge condition).

- MW10S/MW10D
  - ❖ February to September 2017, January, February 2018; and February and May 2019 (upward indicating a discharge condition)
  - ❖ October to December 2017; May, July, August, October, November, December 2018; and January, March, April and June 2019 (downward indicating a recharge condition)

- MW17S/MW17D
  - ❖ August to October 2018; January, March, April and May 2019 (upward indicating a discharge condition)
  - ❖ June 2019 (downward indicating a recharge condition)

Based on the data obtained at the nested wells MW17S/MW17D, it appears that there is no appears to readings highlighted red has not stabilized at the time they were recorded.

The vertical hydraulic conductivity values at nested wells MW16S/MW16D vary widely from 0.076- (downwards) to 0.214+ (upwards); the vertical hydraulic conductivity values at nested wells MW10S/MW10D vary widely from 0.060- (downwards) to 0.333+ (upwards); while the vertical hydraulic conductivity values at nested wells MW17S/MW17d vary widely from 0.058- (downwards) to 0.826+ (downwards).

The readings obtained at MW17S/MW17D on September 24, 2018, October 15, 2018, January 24, 2019, and February 21, 2019, as shown on Table 3, appears to indicate that groundwater levels have not recovered (stabilized). As a result, the estimated high upwards gradients on these dates should be regarded as inaccurate.

3.10 Estimated Hydraulic Conductivity

3.10.1 Hydraulic Conductivity Tests

The estimated hydraulic conductivity values are provided on the following page in Table 5, and normalized head vs. time curves for each hydraulic conductivity test is provided in Appendix G.

Table 5. Estimated Hydraulic Conductivity Values

Monitoring Well	Hydraulic Conductivity (m/s)	Well Screen Material
MW1	2.4×10^{-8}	Clayey Silt Till
MW2	1.9×10^{-8}	Clayey Silt Till
MW3	4.3×10^{-9}	Clayey Silt Till
MW4	5.3×10^{-6}	Shale (Weathered)
MW5	3.1×10^{-7}	Contact (Till and Upper Weathered Shale)
MW6-S	Dry – no results	Clayey Silt Till
MW6-D	3.9×10^{-8}	Shale (competent)
MW7	2.1×10^{-9}	Shale (competent)
MW8	1.6×10^{-5}	Shale (Weathered)
MW9	1.8×10^{-7}	Shale (Weathered))
MW10-S	Dry – no results	Clayey Silt Till
MW10-D	3.1×10^{-9}	Shale (competent)
MW11	1.1×10^{-7}	Shale (competent)
MW12	9.6×10^{-6}	Shale (Upper Weathered Shale)
MW14	6.8×10^{-6}	Shale (Weathered)
MW16	1.4×10^{-6}	Clayey Silt Till and Shale (Weathered)
MW17S	2.1×10^{-6}	Clayey Silt Till
MW17D	6.8×10^{-6}	Shale (Weathered)
MW18	9.6×10^{-6}	Shale (Weathered)
MW19	1.3×10^{-5}	Shale (Weathered)

Results indicate that the hydraulic conductivity values of the screened clayey silt till (MW1, MW2, MW3, and MW17S) have a range 4.3×10^{-9} m/s to 2.1×10^{-6} m/s. This relatively low hydraulic conductivity value is typical of a glacial till. Two additional locations screened in the clayey silt till (MW6-S and MW10-S) were found to be dry after installation. The clayey silt till overburden is of generally lower hydraulic conductivity and could preclude the free flow of water infiltrating from the surface.

The hydraulic conductivity of the upper weathered shale (MW4, MW5, MW8, MW9, MW12, MW14, MW17D, MW18 and MW19), which includes the well installed at the overburden-bedrock contact, spans two orders of magnitude from 1.8×10^{-7} m/s to 1.6×10^{-5} m/s. The upper weathered shale is the most permeable geologic unit tested on site.

Lastly, the hydraulic conductivity of the deeper, competent shale (MW6-D, MW7, MW10-D, and MW11) spans 2 orders of magnitude from 1.1×10^{-7} m/s to 2.1×10^{-9} m/s. The test results from monitoring well MW7 show it is the least permeable material tested on site. MW7 is also the deepest well installed on site with a depth of 30.5 m. Typical conductivities of shale are less than 10^{-9} m/s, as referenced from Table 2.2 in Freeze and Cherry (1979), suggesting that the higher test results obtained from MW11 may indicate a fractured zone within the shale.

3.11 Groundwater Quality

Copies of the laboratory Certificates of Analysis are provided in Appendix H.
The analyzed groundwater samples collected from monitoring wells MW1, MW3, MW5, MW6, and MW7 were compared to the following: Ontario Drinking Water Regulation (ODWQS) JAN.1,2018 = [Suite] - ON-DW-STANDARD+GUIDELINES.

The water quality results are provided in Appendix G with the parameters that exceeded the Ontario drinking water standards highlighted. The water quality results indicate that groundwater quality meets the ODWQS, and guidelines with the exception of the following parameters:

colour, Total Dissolved Solids, Colour, Turbidity, Chloride, Hardness, Nitrite, Sulphate, Aluminum, Iron, Manganese, Boron, and Sodium.

E Coli and Total Coliform were identified in the sampled monitoring wells. This could be traced to runoff and recharge of wastes from wild animals

3.12 Site Inspection to Assess Hydrogeologic Features

Significant hydrogeologic features were not identified at the site during the inspection. However, according to the Hamilton Conservation Authority Area Map there are six (6) Regulated Areas in and around the Site. One each is located along Barton Street and McNeilly Road; and four areas at the Site. The Regulated Areas are presented on Figure 5 in Appendix A.

4.0 WATER TAKING EVALUATION & IMPACT ASSESSMENT

The site is proposed to be developed primarily for community use with residential, commercial, institutional, park, and community services. The site is to be serviced by municipal water and sanitary sewer services from the City of Hamilton. The existing site diagram is as shown on Figure 2 in Appendix A; and the proposed development site plan is shown on Figure 3 in Appendix A, as provided by Glen Schnarr & Associates.

The proposed development plan has not been finalized at this time. However, the proposed site development will include Townhouses and Single Detached homes with one-level basements.

This evaluation is based on the following information provided by Branthaven Development Corp:

1. All Basements will be one level
2. Approximate Townhouse Size: Maximum of 12.95 m x 6.15 m
3. Approximate Single Detached Homes: Maximum of 16.9 m x 9.69 m

Based on the results of the subsurface investigation, shallow bedrock generally occurs in the western and eastern areas of the Site at depths as shallow as 0.9 mbgs in BH/MW4.

As a result of the uneven depths to bedrock below ground surface, the excavation for the earthworks and servicing and basements will be completed within the relatively low-permeability upper layer clayey silt, and into the underlying bedrock, depending on the location at the Site.

Maximum Invert Depths of Services

Major utilities (storm and sanitary) are proposed, with servicing branches. It is assumed that the proposed catch basins, sewers and manholes inverts will be located at depths of approximately 4.5 mbgs.

Maximum Basement Foundation Depth

It is assumed that the proposed one level basement will extend to 2.5 mbgs

Groundwater Level

Based on groundwater level monitoring completed at the Site for 30 months, seasonal high groundwater table at the Site was found to be -0.07 mbgs (above ground surface) at MW8 on April 25, 2018.

4.1 Estimating Construction Dewatering Rate

Based on the field observations made during the drilling program and groundwater level monitoring in the completed wells, it is anticipated that groundwater seepage will occur where excavations are made below the groundwater level. If groundwater levels are intercepted within the excavation, adequate pumping must be provided to prevent significant groundwater volumes from accumulating.

To evaluate the potential groundwater control requirements during construction of the proposed underground services and basements, groundwater level was conservatively assumed to be at ground surface i.e. 0.00 mbgs (seasonal highest groundwater depth recorded in April of 2018) for the entire site.

The method suitable for dewatering an area depends on the locations, type, size and depth of the dewatering needs; and the hydrogeological conditions such as stratification, thickness, and hydraulic conductivity of the foundation soils below the water table into which the excavation extends or is underlain. It is assumed that any groundwater dewatering for the Site excavations would likely be completed with standard construction sump pump/well points or equivalent, depending on conditions encountered such as water table elevation and subsurface materials.

The pumps must use appropriate techniques to prevent the pumping of fines and loss of ground during dewatering activities and the flow of water must be appropriately managed so that sediment is not pumped into the proposed discharge point.

Potential dewatering rates were calculated separately for the underground services; and Townhouse and Detached homes to represent different excavation types. For the purposes of this assessment, an open excavation was assumed. The use of trench boxes and conventional shoring could further reduce the amount of groundwater infiltration and would be determined in consultation with the selected subcontractor.

Hydraulic Conductivity Values

The geometric mean of hydraulic conductivity values obtained at four monitoring wells screened across clayey silt across the site was determined to be 4.505 x 10-8 m/s and from eight monitoring wells screened across shallow bedrock across the site was determined to be 5.0865x 10-6 m/s. These values were use in the following calculations

4.1.1 Dewatering Calculations

4.1.1.1 Equations

Underground Services

An estimate of the dewatering rate for the excavation was obtained using the method of dewatering for long narrow trench, partial penetration by a single row of well points for an unconfined aquifer (unconfined conditions) midway between two equidistant and parallel line sources (p.22 of CIRIA, by Somerville, 1986).

The calculation is expressed as:

$$Q = [(0.73 + 0.27 * H\text{-}h/H) * x*K (H^2 - h^2)/L]$$

Where: Q = pumping rate [m^3/s]
K = hydraulic conductivity [m/s]
H = distance from the static water level to the bottom of the aquifer [m]
h = height of the water table (m) (height of the bottom of excavation above the bottom of the aquifer)
x = length of trench [m]
L = distance to the line source, taken as equal to radius of influence (m), and given by:

$$L = C\,(H\text{-}h) * \sqrt{K}$$

Where C = 1750 (Source: p. 18 of CIRIA Somerville, 1986)

The following were assumed:

- Depth of Services below ground = 4.50 m
- Target dewatering water level (0.5 m below Sewers inverts) = 4.50 m + 0.50 m = 5.00 m bgs

<u>Townhouses and Detached Homes</u>

The potential groundwater flow rate to the excavation was estimated using the dewatering equation for a fully penetrated well of unconfined aquifer fed by circular source (Powers, et. al., 2007):

$$Q = \pi K\,(H^2 - h^2)/\ln(R_o/r_e)$$

Where: Q = pumping rate [m^3/s]
K = hydraulic conductivity [m/s]
H = saturated thickness of the aquifer before dewatering [m]
h = saturated thickness of the aquifer after dewatering [m]
R = radius of cone of depression or influence [m]
r_e = equivalent radius [m]

The radius of influence R can be estimated using the following equation:

$$R = Ch^*\sqrt{K}$$

Where: C = is a factor equal to 3000 for radial flow to a pumping well
h = required drawdown [m]
K = hydraulic conductivity [m/s]

Dewatering of a rectangular area can be accomplished by using an equivalent radius (re) to assess drawdown where re is given by the following equation:

$$r_e = \sqrt{(\text{length} * \text{width}/\pi)}$$

The following were assumed:

- Depth of Basement below ground surface = 2.50 m
- Target dewatering water level (0.5 m below base of excavation/basement floor) = 2.50 m + 0.50 m = 3.00 m bgs

4.1.1.2 Results

Storm/Sanitary Sewers

<u>Area with Clayey Silt (overburden thickness greater than 6.0 m)</u>

Using the dewatering equations and trench excavation lengths of 50 m, the maximum total amount required to be pumped for dewatering the excavation associated for the storm/sanitary sewer construction is approximately 3,424 L/day. Applying a safety factor of 1.2, the flow rate for dewatering the assumed excavation will be range approximately 4,109 L/day. These calculations and associated assumptions are provided in Appendix I.

Area with Shallow Bedrock (overburden thickness 0.9 m to 2. 7 m)

Using the dewatering equations and trench excavation length of 50 m, the maximum total amount required to be pumped for dewatering the excavation associated for the storm/sanitary sewer construction is approximately 46,327 L/day. Applying a safety factor of 1.2, the flow rate for dewatering the assumed excavation will be range approximately 55,592 L/day. These calculations and associated assumptions are provided in Appendix I

Townhouse and Detached Building Basement

The plans view of the proposed excavation areas are provided in the Table below.

Construction	**Length (m)**	**Width (m)**
Townhouses	12.95	6.15
Detached Homes	16.9	9.69

Areas with Clayey Silt (overburden thickness greater than 3.0 m)

Townhouses

The total amount required to be pumped for dewatering the excavation associated with townhouses basement construction is approximately 909 L/day. Applying a safety factor of 1.2, the flow rate for dewatering the assumed excavation will be approximately 1,091 L/day. These calculations and associated assumptions are provided in Appendix J.

Detached Homes

The total amount required to be pumped for dewatering the excavation associated with the townhouse construction is approximately 1,236 L/day. Applying a safety factor of 1.2, the flow rate for dewatering the assumed excavation will be approximately 1,483 L/day. These calculations and associated assumptions are provided in Appendix J.

Areas with Shallow Bedrock (overburden thickness 0.9 m to 2.7 m)

Townhouses

The total amount required to be pumped for dewatering the excavation associated with Townhouses construction is approximately 38,843 L/day. Applying a safety factor of 1.2, the flow rate for dewatering the assumed excavation will be approximately 46,612 L/day. These calculations and associated assumptions are provided in Appendix J.

Detached Homes

The total amount required to be pumped for dewatering the excavation associated with Townhouses construction is approximately 53,326 L/day. Applying a safety factor of 1.2, the flow rate for dewatering the assumed excavation will be approximately 69,991 L/day. These calculations and associated assumptions are provided in Appendix J.

4.1.2 Short Term Dewatering Volume

<u>Underground Services</u>

It was determined that the excavation dewatering rates for proposed underground services will range from 4,109 L/day to 55,592 L/day for 50 m length of excavation, depending on if excavation is completed in overburden of bedrock.

<u>Underground Parking Levels</u>

It was determined that the excavation dewatering rates for the proposed underground parking levels will range from 1,091 L/day to 79,989 L/day, depending on if excavation is completed in overburden of bedrock.

4.1.3 Long Term Dewatering (Post Construction)

The seasonal high groundwater level at the Site was determined to be above ground (~0.07 m). As a result, long-term dewatering of the Townhouses and Detached Homes will be required at the Site. The dewatering rates will range from 1,364 L/day to 69,991 L/day, depending on if excavation is completed in overburden of bedrock.

Permit to Take Water

The maximum dewatering rate for construction excavation at the site is estimated to be approximately 69,991 L/day = ~ 70 m3/day under normal condition. It should be noted that that normal condition does not include extreme weather events. An Environmental Activity and Sector Registration (EASR) is required for the Site as estimated dewatering volume is more than 50,000 L/day and less than 400,000 L/day.

4.1.4 Dewatering Procedure

Based on the results of the hydraulic conductivity tests, seepage through the overburden and bedrock the Site should be feasible to be handled by a sump/well point dewatering system.

The following general construction practices can be implemented to minimize the volume of water to be extracted:

- Schedule construction outside the spring period when the water table is typically elevated and avoid constructing during period of active precipitation.
- It is recommended that any excavations should be staged or constructed in such a manner to be able to manage dewatering volume conveniently.
- Reduce the length of time during which the open cut remains open.

4.1.5 Water Management and Discharge Plan

Water extracted during construction dewatering is required to be discharged into an approved location which could be storm, sanitary or combined sewers or surface water body near the Site.

As per the ByLaw, in order to issue a discharge approval, information relating to the quality and quantity of the discharge must be provided to City of Hamilton. It is strongly recommended that the applicant provide this information eight to twelve weeks prior to the proposed start of discharge.

It is expected that the rate and total volume of the discharge during dewatering be recorded. This would require that the discharge line be equipped with a flow meter capable of monitoring the discharge rate and a volume totalizer to record the total volume of water discharge. The discharge rate and total daily flow will need to be recorded with the records maintained on site. This can be accommodated by installing a flow meter on the discharge line.

A T-Coupling and valves should be installed downstream of the flow meter, which if necessary can be operated to divert flow for mitigation purposes.

If needed, a weir tank and filter bag can be utilized during dewatering to reduce total suspended solids (TSS) and turbidity prior to discharging of the water into either the City's Sewer Systems or water course.

4.2 Assessment of Potential Impacts and Water Management

4.2.1 Impact to Existing Groundwater Users

A search of the Ontario Ministry of the Environment Water Well Records for an area extending about 500 m outward from the edge of the excavation was completed, identifying no Water wells in the database. As a result, it is not anticipated that there will be any impact to the existing water wells.

4.2.2 Impact to Surface Water and Natural Functions of the Ecosystem

According to the HCA, there are protected areas in and around the site as Shown on Figure 5 in Appendix A. The nearest surface water to the Site Lake Ontario is located approximately 650 m southeast of the site. The groundwater dewatering activities will result in localized depression of the groundwater table, and it is anticipated that there will be impact within the estimated maximum radius of influence of approximately 20 m calculated in Appendix J.

4.2.3 Contaminants Impacts

This occurs when pre-existing ground or groundwater contamination is mobilised and transported where transmission pathways are created.

There are no known sources of contamination at the site. As a result, there is no potential for mobilization of contaminants or creation of transmission pathways during the planned groundwater dewatering activities.

4.2.4 Geotechnical Impacts

Geotechnical impacts occur where the geotechnical properties or state of the ground are changed by groundwater control activities. The most common type of impact in this category is ground settlement, with the corresponding risk of distortion and damage to structures, services and other sensitive infrastructure.

Ground settlement can be caused by two principal mechanisms:

- Increases in effective stress as a result of lowering of groundwater levels, resulting in compression and consolidation of the ground. Such settlements are an unavoidable consequence of lowering of groundwater levels
- Removal of fine particles from the ground (loss of fines) which can occur when poorly controlled sump pumping draws out soil particles with the pumped water. With good

design and implementation, loss of fines (and the associated settlement risk) can be avoided.

The Site is located in a developed area of Stoney Creek. It is anticipated that there will be no impact beyond the radius of influence of approximately 20.0 m calculated in Appendix J.

Dewatering could be handled by pumping from a sump/well point dewatering system. The well sump/point system used for lowering the water table within the excavation must be properly screened and installed to ensure that pumping will not remove sediment from the low permeability overburden aquifer. Removal of significant fines may result in the formation of voids and the loss of ground.

Base on the above, potential geotechnical impacts are anticipated during dewatering at the Site. Surrounding buildings and roads within 20 m of the Site should be monitored by geotechnical instrumentation to determine impact, if any.

The proposed monitoring and mitigation plans are presented in Sections 5 and 6, respectively

5.0 PROPOSED MONITORING PLAN

5.1 Construction Monitoring

Once construction dewatering is initiated it will be difficult to stop pumping or significantly reduce the rate of pumping without disrupting construction activities. It will however be possible to monitor the drawdown response at the construction site and to adjust the pumping rate to optimize drawdown and the associated pumping rate.

5.2 Management of Dewatering Abstraction

5.2.1 Monitoring, Trigger Levels and Management Responses

Abstraction management is critical to ensure target water levels within the construction zone are met, but that over-pumping does not occur.

Target groundwater levels in- and outside excavations will be set individually for each dewatering monitoring well based on location, aquifer and construction requirements, in-line with stated dewatering aims above.

Trigger levels for wells will typically be set 0.5 m above the dewatering target and 1.0 m below the dewatering target to give a 1.5 m target operational zone. These targets may be reviewed and adjusted to decrease size of the operational target zone and increase the factor of safety.

If monitoring indicates that dewatering zone groundwater levels exceed the upper trigger levels (i.e. required drawdown is not being achieved or maintained) management actions are available (in order of preference):

- Adjust automatic pump start and stop water levels;
- Increase pumping rates within the constraints of the system; and/or
- Install additional abstraction capacity (well points, spears or sump pumps).

If monitoring indicates that excavation zone groundwater levels are below the lower trigger levels (i.e. excessive drawdown) management actions available are (in order of preference):

- Adjust automatic pump start and stop water levels; and/or
- Decrease pumping rates; and/or
- Reduce the number of pumps operating.

5.2.2 Contingency Responses

If management responses prove to be insufficient to achieve and maintain the target levels, excavations may be slowed or suspended to enable contingencies to be implemented. Available contingency measures that will be assessed include (in order of preference):

- Construction of additional dewatering wells, spears or sumps;
- Construction of additional drains or groundwater control structures;

Excavation would resume when the required drawdown is able to be reliably obtained.

5.2.3 Settlement Monitoring

Implementation of a settlement monitoring plan is recommended to be completed within a radius of influence of approximately 20.0 m of the Site. Prior to commencing dewatering perform condition surveys of adjacent properties that could potentially be affected by dewatering considering anticipated effects and specific dewatering design.

A typical settlement monitoring system would comprise a series settlement markers sited at various distances beyond and at the site, within the zone of influence of groundwater drawdown. Monitoring points should be surveyed to an accuracy of +/-2 mm. Note that the reference benchmark must be located beyond the extent of the anticipated influence of groundwater drawdown. For very high risk projects, incorporation of piezometer standpipes will allow confirmation of the field groundwater drawdown and will enable calibration of field settlement observation with theoretical assessments.

Alert and Action settlement thresholds should be set, selected though theoretical assessment of anticipated settlements and review of sensitivity of adjacent structures and infrastructure. It is prudent to implement staged groundwater drawdown, providing hold points to allow adequate time to enable observation of the delayed settlement response of the ground.

6.0 PROPOSED MITIGATION PLAN

Mitigation would involve the reduction or elimination of the impacts induced by construction dewatering. As noted above, the potential exists for dewatering to cause ground settlement, with the corresponding risk of distortion and damage to structures, services and other sensitive infrastructure. There is also a potential for dewatering to impact the surface water system/Protected areas in and around the Site.

The groundwater dewatering activities will result in localized depression of the groundwater table, and it is anticipated that there will be no impact beyond the radius of influence of 20.0 m.

Geotechnical Impact

As noted above, the potential exists for dewatering to cause ground settlement, with the corresponding risk of distortion and damage to structures, services and other sensitive infrastructure.

Methods to limit adverse dewatering settlement are:

- Settlement associated with loss of fines can be mitigated through appropriate design of the dewatering system to control flow velocity and provide screens and/or filters matched to the grading of the in-situ soils. Entrainment of fines must be monitored during construction; actions could include analysis of Total Suspended Solids (TSS) in discharge water and/or monitoring of accumulation of sediment in sedimentation tanks.
- Drawdown-induced ground settlement is mitigated though pre-construction estimation of groundwater drawdown and settlement coefficients to identify risk prior to drawing the groundwater down, and water level monitoring in monitoring boreholes to check that larger drawdowns than anticipated at distance from the excavation are not occurring.
- Differential settlement is most problematic; this can be reduced by managing the rate of drawdown and understanding where clear changes in soil type occur. Should potentially damaging settlement be indicated, these can be mitigated by installing groundwater cutoffs to stem or restrict groundwater flow and limit drawdown beyond the site.
- Provide sufficient temporary support to excavations to maintain stability, where seeps might otherwise induce progressive collapse of the sides of the excavation.
- During dewatering implement staged drawdowns (where appropriate), and monitor field settlement and water level changes beyond the immediate site, comparing against theoretical settlements and water levels to allow warning of potential dewatering settlement issues.

Impact to Surface Water Bodies/Regulated Areas

As noted above, the potential exists for dewatering impact to surface water and regulated areas close to the Site.

All identified water bodies/regulated areas at and at close proximity to the Site should be monitored pre, during, and post- construction. Should potentially damaging impact be identified, this can be mitigated by installing groundwater cut-offs to stem or restrict groundwater flow and limit drawdown.

7.0 SITE DEVELOPMENT, HYDROGEOLOGY and WATER BALANCE

The following discussion and recommendations are based on the data gathered for the study and are presented for site planning purposes.

7.1 Site Development Concept

The Site is approximately 105.70 ha in size, including existing areas that are not planned for development, and existing residential holdout properties that are planned for development. It was assumed that including the existing areas will have a minor effect on the water balance calculations. The site is proposed to be developed primarily for community use with residential, commercial, institutional, park, and community services, parking areas, and roadways. The Site is to be serviced by municipal water and sanitary sewer services from the City of Hamilton

The following summarizes the currently proposed approximate land coverage areas for the development:

- Building roof area 21.62 ha
- Roadways, walkways, parking 22.15 ha
- Green space, SWMP, natural areas 61.93 ha
- **Total Area 105.70 ha**

The above-noted proposed land coverage at the Site is based upon information provided by the Block 3 Landowners Group and the Concept Plan of the Proposed Development presented on Figure 3 in Appendix A of this report; and does not include existing areas that are not planned for development. It includes existing residential holdout properties that are planned for development.

7.2 Principal Hydrogeologic Features and Functions

The results of the study indicate that the site hydrogeologic characteristics can be summarized as follows:

- Generally, the site stratigraphy consists of a surficial layer of disturbed soil (in the areas of the fields actively utilized for agriculture), underlain by clayey silt till (Halton Till) and Queenston red shale.
    - ❖ Slightly coarser medium grained sand was identified overlying the Halton Till in boreholes BH1, BH2, BH3, BH6-S/D, and BH13, which are all located in the southern portion of the site. This southern area has been previously identified in OGS maps as containing coarse grained glaciolacustrine deposits. Although coarse grained sands and gravels were not identified in this area, the medium grained sand was the coarsest overburden material identified on the site.
    - ❖ Shale bedrock was encountered at varying depths across the site, ranging from 0.9 m in borehole BH4 to 18.9 m in borehole BH17D. The distance between BH4 and BH17D is approximately 340 m. In referencing the OGS surficial geology maps for the area, bedrock was anticipated to be found at or immediately below surface across the central portion of the site. Instead, we found a bedrock low, extending to a measured depth of 18.9 mbgs trending in a northeast direction across the centre of the site
- Groundwater flow at the site is controlled by the surficial geology present across the area. The overburden present at surface includes the low permeability clayey silt Halton Till found in the central and northern portions of the site, and the medium

grained silty sand in the southern portion of the site. The low hydraulic conductivity (10^{-9} to 10^{-8} m/s) of the Halton Till will reduce the amount of groundwater infiltration, recharge, or flow, and as a result, water will tend to flow overland and drain along surface watercourses after rainfall or melt. The recharge rate for a clayey silt till ranges from approximately 100 to 125 mm/year (MOE, 1995). The medium grained silty sand located in the southern portion of the site was found overlying the Halton Till. Silty sand has a typical recharge rate of 150 to 200 mm/year (MOE, 1995).

- The water table present on site in the Halton Till ranges from 93.01 masl in MW1 to 80.91 masl in MW10-S. The groundwater flow within the Till is to the northwest. The water table present within the underlying Queenston shale ranges from 91.18 masl in MW4 to 85.60 masl in MW10-D. The groundwater flow within the shale was to the northeast. The groundwater directions were derived from groundwater level monitoring data recorded at the Site on October 15, 2018.
- Vertical hydraulic gradients were observed at the nested well sets during the manual field measurements completed from February 2017 to June 2019 as follows:
  - ❖ MW6S/MW6D: February, June, July, October, and November 2017; May, October, November, December 2018; February and March 2019 (upward indicating a discharge condition); and March, April, June, September, and December 2017; February, April, July and August 2018; and January, April, May and June 2019 (downward indicating a recharge condition).
  - ❖ MW10S/MW10D: February to September 2017, January, February 2018; and February and May 2019 (upward indicating a discharge condition); October to December 2017; May, July, August, October, November, December 2018; and January, March, April and June 2019 (downward indicating a recharge condition)
  - ❖ MW17S/MW17D: August to October 2018; January, March, April and May 2019 (upward indicating a discharge condition); and June 2019 (downward indicating a recharge condition).

The vertical hydraulic conductivity values at nested wells MW16S/MW16D vary widely from 0.076- (downwards) to 0.214+ (upwards); the vertical hydraulic conductivity values at nested wells MW10S/MW10D vary widely from 0.060- (downwards) to 0.333+ (upwards); while the vertical hydraulic conductivity values at nested wells MW17S/MW17D vary widely from 0.058- (downwards) to 0.826+ (downwards).

The readings obtained at MW17S/MW17D on September 24, 2018, October 15, 2018, January 24, 2019, and February 21, 2019, as shown on Table 3, appears to indicate that groundwater levels have not recovered (stabilized). As a result, the estimated high upwards gradients on these dates should be regarded as inaccurate.

- The water table present within the glaciolacustrine overburden materials at the site ranges from -0.02 (slightly artesian condition) to 7.24 meters below ground surface (mbgs); and the water table present within the shale bedrock ranges from -0.07 (slightly artesian condition) to 3.91 mbgs. It should be noted that the groundwater levels usually fluctuate seasonally depending on the amount of precipitation and surface runoff; and values will also depend if the water levels has fully recovered before readings were taken.
- During drilling activities, the surficial Halton Till was typically found to be very dense and dry. Based on the physical characteristics of the till and the low hydraulic conductivities measured, dewatering during construction activities will be minimal and may likely only be required for surface runoff and pooling in locations where construction extends only into the till. If construction activities are planned to extend into the upper weathered bedrock areas found in the northwest and eastern portions

of the site, long term dewatering will likely be required due to the shallow potentiometric surface observed in the shale.

- Once the proposed construction excavation depths have been finalized, a detailed dewatering plan should be prepared and anticipated dewatering flows estimated based.
- The majority of the surficial material on site consists of clayey silt Halton Till and would not be well suited to groundwater recharge due to the relatively low hydraulic conductivity of the glacial soils.
- The topography on the northern portion of the site gently slopes toward the northeast of the site.

The above noted hydrogeological characteristics should be considered in conjunction with the requirement for site development plans and in particular storm water management practices at the site. Further information regarding water balance at the site is presented in the following section.

Based on the above information, the following considerations should be made with respect to maintenance of hydrogeologic functions and hydrogeologic conditions at the site:

- The majority of the site consists of glaciolacustrine clayey silt material overlain by silty sand/sandy silt in the southwest area of the Site. The clayey silt was observed to be overlying shale bedrock. The clayey silt and shale bedrock would not be well suited to groundwater recharge due to the relatively low hydraulic conductivity of the these layers. Engineered infiltration methods, other Best Management Practices and low impact development methods should be implemented accordingly.

7.3 Water Balance

The Site is proposed to be developed primarily for community use with residential, commercial, institutional, park, and community services. The development plan will also consist of parking areas, and access routes. Without mitigation, this will lead to a decrease in infiltration and groundwater recharge.

The surface soils at the Site provide limited water recharge into the shallow groundwater system. This is a result of the relatively impermeable clayey silt soil encountered below surface across the Site. Based on the subsurface investigation completed for the Site, no enhanced zones of groundwater flow or transmission were identified across the Site. However, limited groundwater recharge will occur at the Site due to the coverage of most of the Site area are by buildings, parking areas, and paved access routes.

Notwithstanding the above, one of the objectives during development should be to ensure that the overall volume of groundwater recharge is not significantly impacted. A water balance for the Site was prepared to assess the distribution of precipitation, evapotranspiration, infiltration and runoff for existing (pre-development) conditions as well as post-development conditions. The water balance calculations are detailed in Appendix K.

Evapotranspiration represents the transport of water from the earth back to the atmosphere and is an important component to a water balance calculation. The Thornthwaite method was used to calculate potential evapotranspiration typical for the region. By using equations 8, 9, and 10 in Thornthwaite (1948), the potential evapotranspiration for the region was found to be 609 mm/year. The calculation is included in Appendix K.

As was presented in Table 1, the annual total precipitation was taken from the Hamilton A climate station for the period of 1981 to 2010. Total annual precipitations for the area is 930 mm/year, and mean daily temperature is 7.9 °C.

In summary, the typical shallow groundwater recharge rate for the Site is estimated to be 100 mm/year. This recharge was referenced from the MOE Table 2 and Table 3 approach in the Technical Information Requirements for Land Development Applications (MOE, 1995). The post-development water budget was calculated and is presented in Appendix K.

The water balance (pre and post-development) is summarized from data in Table 6 in Appendix K and comparison of pre and post-development water balance is summarized on the following page in Table 6.

Table 6. Comparison of Pre and Post-Development Water Balance

Development Phase	Precipitation (m^3)	Evapotranspiration (m^3)	Infiltration (m^3)	Run-Off (m^3)
Pre-Development	983,010	545,177	100,710	337,123
Post-Development	983,010	377,154	69,671	536,185

The increase in run-off from 337,123 m^3 to 536,185 m^3 is the result of developing and installing hard surfaced or impermeable areas across the Site. The post-development impermeable areas also results in the decrease of evapotranspiration and infiltration across the Site.
The above-noted values and associated calculations found in Appendix K are considered to be conservative and are based on the following assumptions:

- No infiltration will occur beneath the internal roads, public walkways, buildings or driveways.
- No evapotranspiration will occur from the internal roads, public walkways, buildings or parking areas.

7.4 Mitigating Measures to Maintain Hydrogeological Functions

7.4.1 Maintenance of Groundwater Recharge

The Site is considered not to have significant amounts of groundwater recharge due to the relatively low-permeable soils encountered beneath the Site; most of the entire surface area coverage by buildings, parking areas, and paved access routes. As a result, infiltration values are expected to decrease from 100,710 m^3/year to 69,671 m^3/year, based on the water balance calculations outlined in Appendix K. This decrease in infiltration indicates that approximately 15% of the roof runoff from the buildings must be re-directed towards overland flow or infiltration facilities in order to match the pre-development infiltration rates and surface flow to the pond.
It is recommended that development planners collaborate with storm water specialists or engineers to be able to maintain pre-development water balance and recharge at the Site through storm water management design techniques. Perhaps Low Impact Development techniques would be applicable for this Site.

7.4.2 Maintenance of Groundwater Transmission Pathways

It is understood that the earthworks and servicing will be completed within the low-permeability silty clay, clayey silt. The overall continuity of the groundwater flow at the Site should be maintained, where practical. Generally, any groundwater transmission pathways encountered can be maintained through the following means:

- The excavation of any underground services or utilities across more permeable layers may interrupt the groundwater flow. As good practice, it is recommended that trench backfilling operations be carried out with materials that are similar to the materials that have been excavated. In particular, if any more permeable sand zones are encountered, they must not be truncated by backfilling of the excavation or trench using lower permeability materials (such as the clayey silt identified across the subject Site).
- Groundwater flow may occur into the open shallow excavations if more permeable pockets of deposits, such as silty sand, are encountered; however, Based on the results of the subsurface investigation, groundwater control (such as from wells or well points) is anticipated during construction. It is recommended that any excavations should be staged or constructed in such a manner to avoid the collection of overland drainage.

8.0 SUMMARY AND CONCLUSIONS

The following summarizes the results of the investigation:

- The Site is characterized by glaciolacustrine material. Silty clayey silt, Silty sand/Sandy silt were encountered across the Site. Beneath the quaternary deposits on the Site is bedrock of the Queenstone Formation.
- Monitoring wells were installed into the overburden clayey silt Halton Till, the upper weathered Queenston shale, and the deeper competent Queenston shale.
- Shale bedrock was encountered at varying depths across the site, ranging from 0.9 m in borehole BH4 to 18.9 m in borehole BH17D. The distance between BH4 and BH17D is approximately 340 m. In referencing the OGS surficial geology maps for the area, bedrock was anticipated to be found at or immediately below surface across the central portion of the site. Instead, we found a bedrock low, extending to a measured depth of 18.9 mbgs trending in a northeast direction across the centre of the site.
- The hydraulic conductivity of the screened clayey silt till (MW1, MW2, and MW3) is relatively consistent, spanning only a single order of magnitude from 4.3 x 10^{-9} m/s to 2.4 x 10^{-8} m/s, with the exception of MW17S with a value of 2.1 x 10^{-6} m/s. This relatively low hydraulic conductivity is typical of a glacial till.
- The hydraulic conductivity of the upper weathered shale (MW4, MW5, MW8, MW9, MW12, MW14, MW17D, MW18, and MW19), which includes the well installed at the overburden-bedrock contact, spans two orders of magnitude from 1.8 x 10^{-7} m/s to 1.6 x 10^{-5} m/s. The upper weathered shale is the most permeable geologic unit tested on site.
- The hydraulic conductivity of the deeper, competent shale (MW6-D, MW7, MW10-D, and MW11) spans 2 orders of magnitude from 1.1 x 10^{-7} m/s to 2.1 x 10^{-9} m/s.
- The groundwater flow within the Till is to the northwest; and the groundwater flow within the shale is to the northeast.
- The majority of the surficial material on site consists of clayey silt Halton Till and would not be well suited to groundwater recharge due to the relatively low hydraulic conductivity of the glacial soils.
- If earthworks and servicing is planned for construction within the low-permeability upper clayey silt till, dewatering during construction activities will likely be minimal and may likely only be required for surface runoff and pooling.
- If construction activities are planned to extend into the upper weathered bedrock areas found in the northwest and eastern portions of the site, groundwater transmission pathways may be encountered and interrupted. As good practice, it is recommended that trench backfilling operations be carried out with materials that are similar to the materials that have been excavated. In particular, if any more permeable silty zones are encountered, they must not be truncated by backfilling of the excavation or trench using lower permeability materials (such as the clayey silt identified across the subject site).
- If excavation into the Queenston shale is contemplated, the water level within the shale will locally rise to its potentiometric surface/water table, which has been identified as ranging from -0.07 mbgs to 3.91 mbgs. If excavation into the glaciolacustrine overburden materials at the site is contemplated, water level within
- will locally rise to its potentiometric surface/water table ranges from -0.02 (slightly artesian condition) to 7.24 meters below ground surface (mbgs).The data presented in this report can be used by civil engineers, planners, and builders to make decisions based on residential basement construction and long term dewatering methods.

- Once the proposed construction excavation depths have been finalized and the service excavation depths confirmed, a detailed dewatering plan should be prepared and anticipated dewatering flows estimated.

9.0 CLOSURE

We trust this report is satisfactory for you purposes. If you have any questions regarding our submission, please do not hesitate to contact this office.

Yours truly,

Landtek Limited

Henry Erebor, M.Sc., P.Geo.,

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Ontario Regulation (O.Reg.) 169/03: Ontario Drinking Water Standards (ODWS). Last amendment: O.Reg. 327/08. http://www.e-laws.gov.on.ca/html/regs/english/elaws regs 030169 e.htm.

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Ontario Geological Survey, OGS Earth. Bedrock Geology of Ontario

Ontario Geological Survey, OGS Earth. Physiography of Southern Ontario

11.0 LIMITATIONS

The conclusions and recommendations given in this report are based on information determined at the borehole locations. Subsurface and ground water conditions between and beyond the boreholes may be different from those encountered at the borehole locations, and conditions may become apparent during construction that could not be detected or anticipated at the time of the geotechnical investigation. It is recommended practice that Landtek be retained during construction to confirm that the subsurface conditions throughout the site are consistent with the conditions encountered in the boreholes.

The comments made in this report on potential construction problems and possible remedial methods are intended only for the guidance of the designer. The number of boreholes may not be sufficient to determine all the factors that may influence construction methods and costs. For example, the thickness and quality of surficial topsoil or fill layers may vary markedly and unpredictably. Contractors bidding on the project, or undertaking construction on the site should make their own interpretation of the factual borehole information, and establish their own conclusions as to how the subsurface conditions may affect their work.

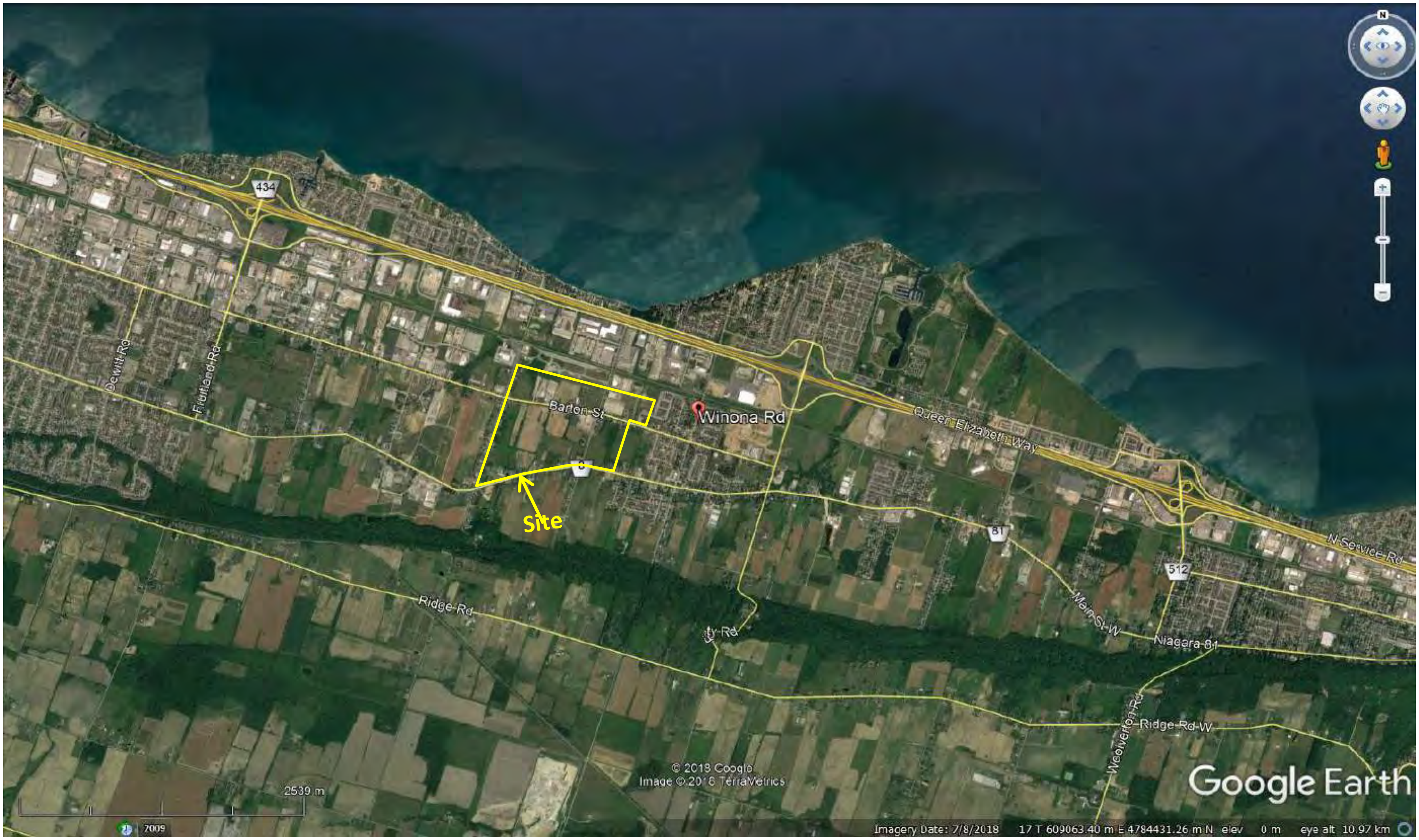
The survey elevations in the report were obtained by Landtek or others, and are strictly for use by Landtek in the preparation of the geotechnical report. The elevations should not be used by any other parties for any other purpose.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Landtek accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

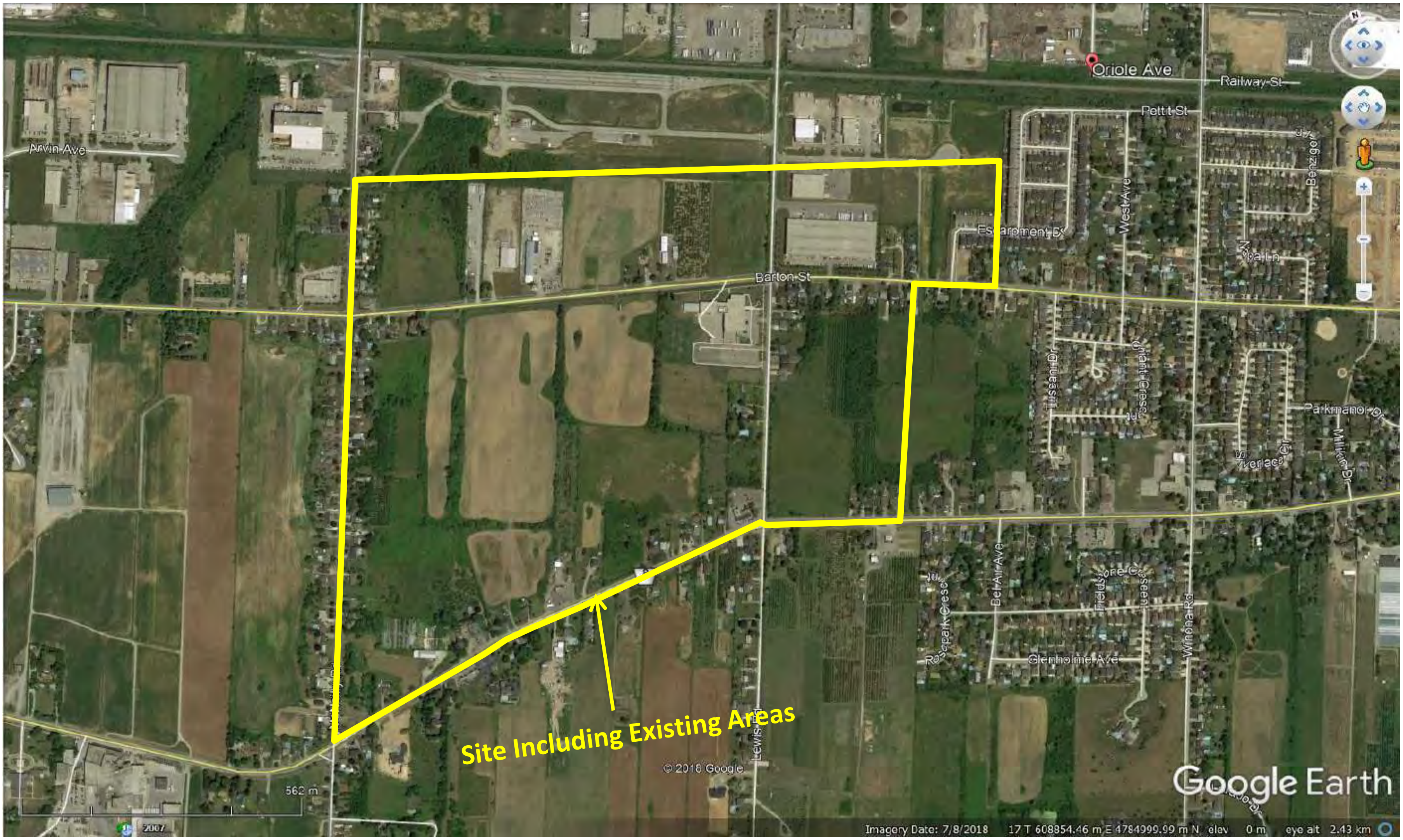
This report does not reflect environmental issues or concerns related to the property unless otherwise stated in the report. The design recommendations given in the report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report. Since all details of the design may not be known, it is recommended that Landtek be retained during the final design stage to verify that the design is consistent with the report recommendations, and that the assumptions made in the report are still valid.

APPENDIX A

FIGURES



	LANDTEK LIMITED ***CONSULTING ENGINEERS*** **205 NEBO ROAD, HAMILTON, ONTARIO, L8W 2E1**	
	Scale: See Map	Date: November 2018
Project:	Hydrogeological Investigation	
	Fruitland -Winona BSS # 3	
	Stoney Creek, Ontario	
Title:	Figure 1: Site Location	
Project No.	18270	



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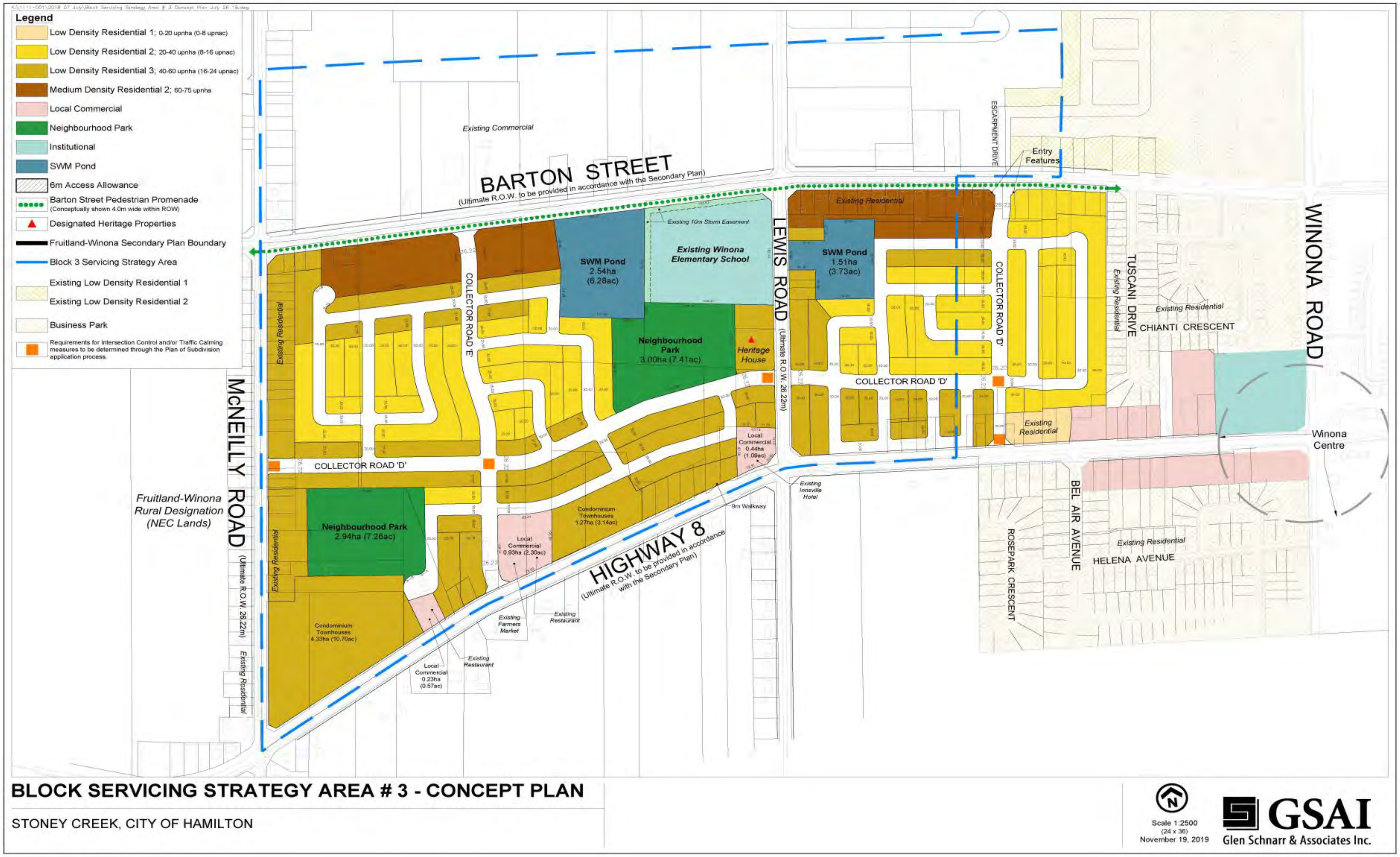
205 NEBO ROAD, HAMILTON, ONTARIO, L8W 2E1

	Scale: On Plan	Date: November 2018
Project:	Hydrogeological Investigation	
	Fruitland-Winona BSS #3	
	Stoney Creek, Ontario	
Title:	Figure 2: Existing Site Plan	
Project No.	18270	



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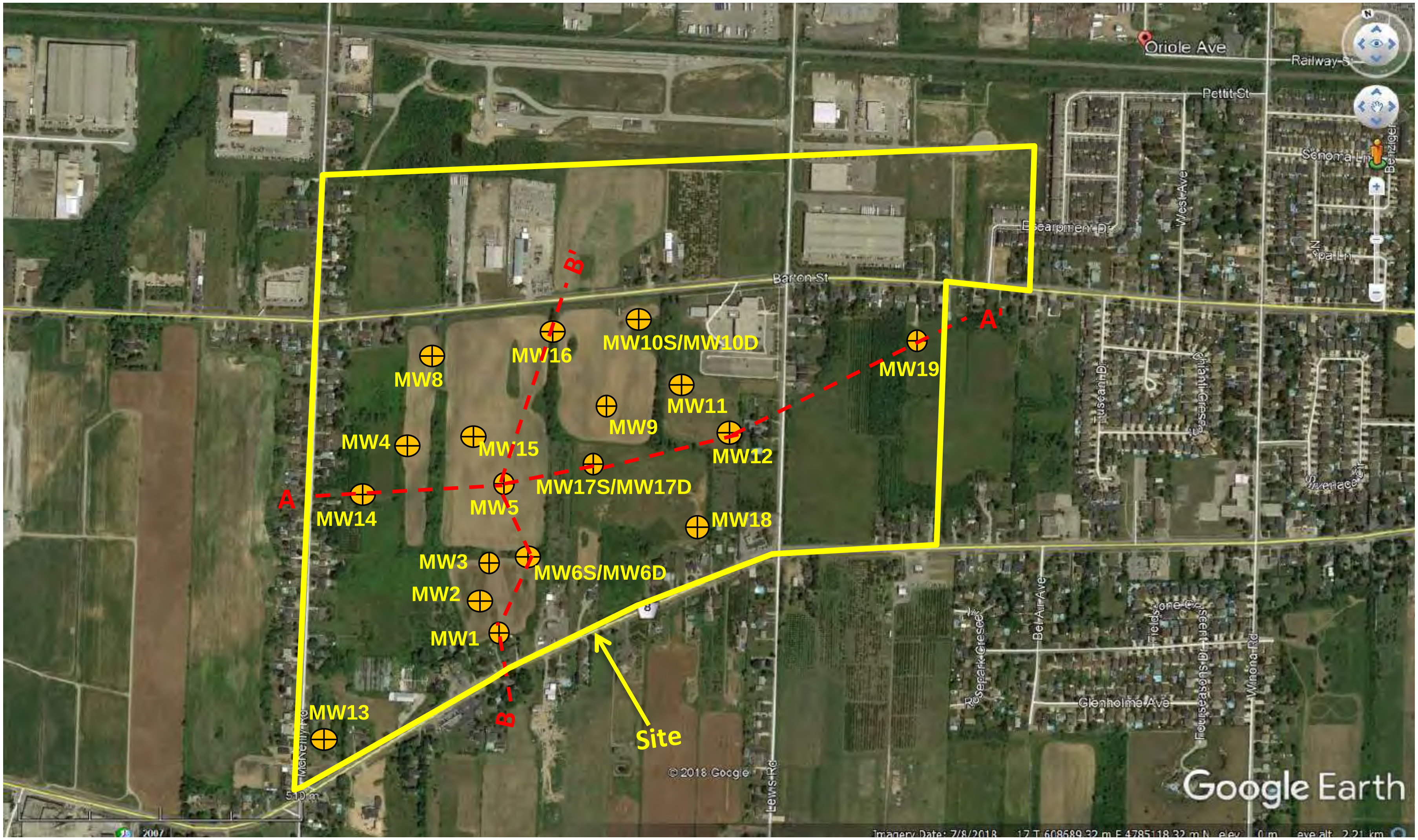
	Scale: NA — Date: January 2020
Project:	Hydrogeological Investigation Fruitland -Winona BSS #3 Stoney Creek, Ontario
Title:	Figure 3: Proposed Site Concept Plan
Project No.	18270



Legend

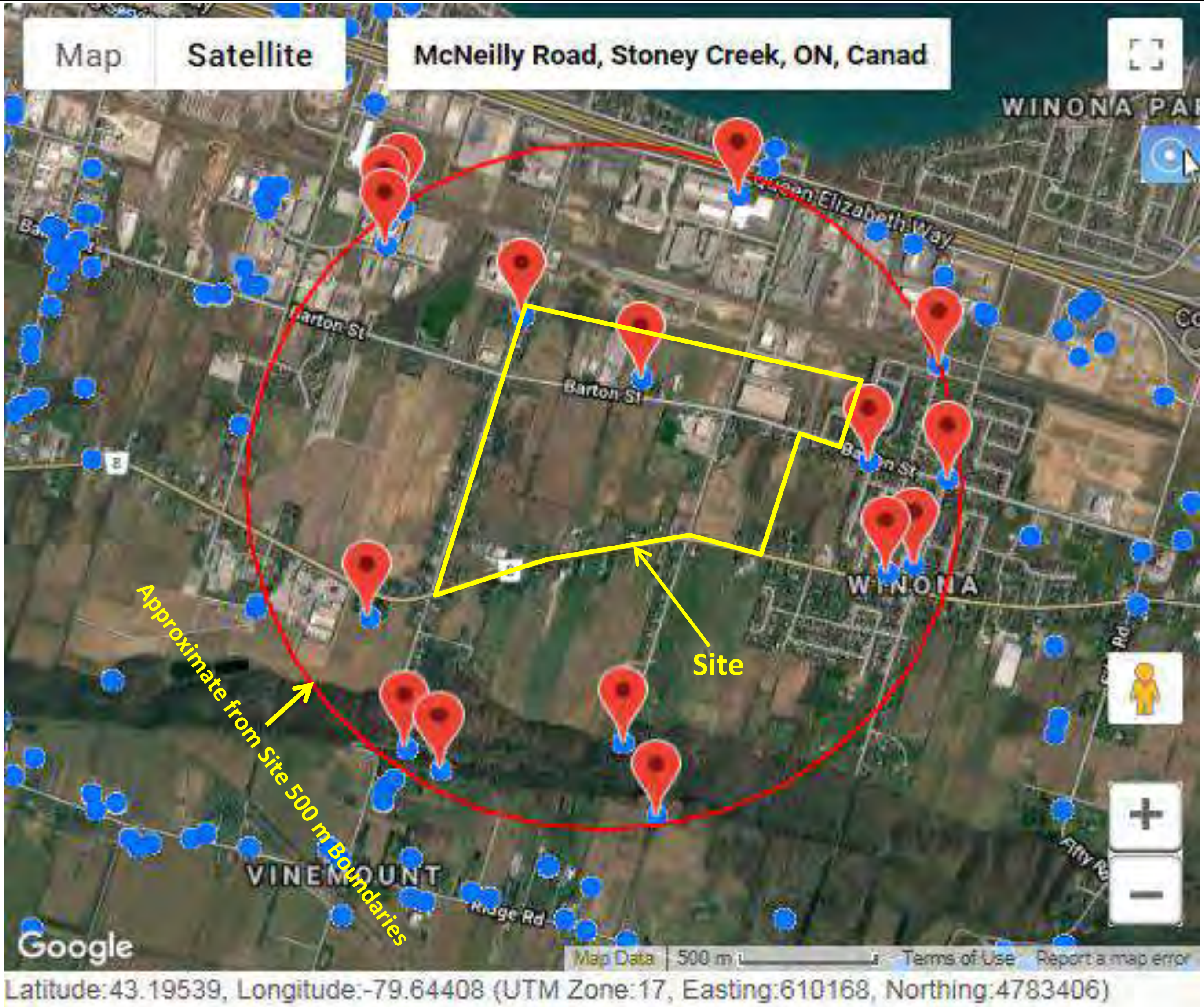
Cross-Sections

	LANDTEK LIMITED ***CONSULTING ENGINEERS*** **205 NEBO ROAD, HAMILTON, ONTARIO, L8W 2E1**
	Scale: 1:1096 / Date: November 2018
Project:	Hydrogeological Investigation Fruitland-Winona BSS #3 Stoney Creek, Ontario
Title:	Figure 4: Monitoring Wells Locations Plan
Project No.	18270

Legend

- HRCA MAP LAYERS
  - HRCA BOUNDARY
  - ROAD LABEL
  - WATERCOURSE / STORM SEWER
  - WATER BODY
  - PROPERTY BOUNDARY
  - REGULATED AREA

	LANDTEK LIMITED *CONSULTING ENGINEERS* **205 NEBO ROAD, HAMILTON, ONTARIO, L8W 2E1**	
	Scale: 1:1096	Date: November 2018
Project:	Hydrogeological Investigation	
	Fruitland-Winona BSS #3	
	Stoney Creek, Ontario	
Title:	Figure 5: Regulated Areas	
Project No.	18270	



MOE Water Well Locations

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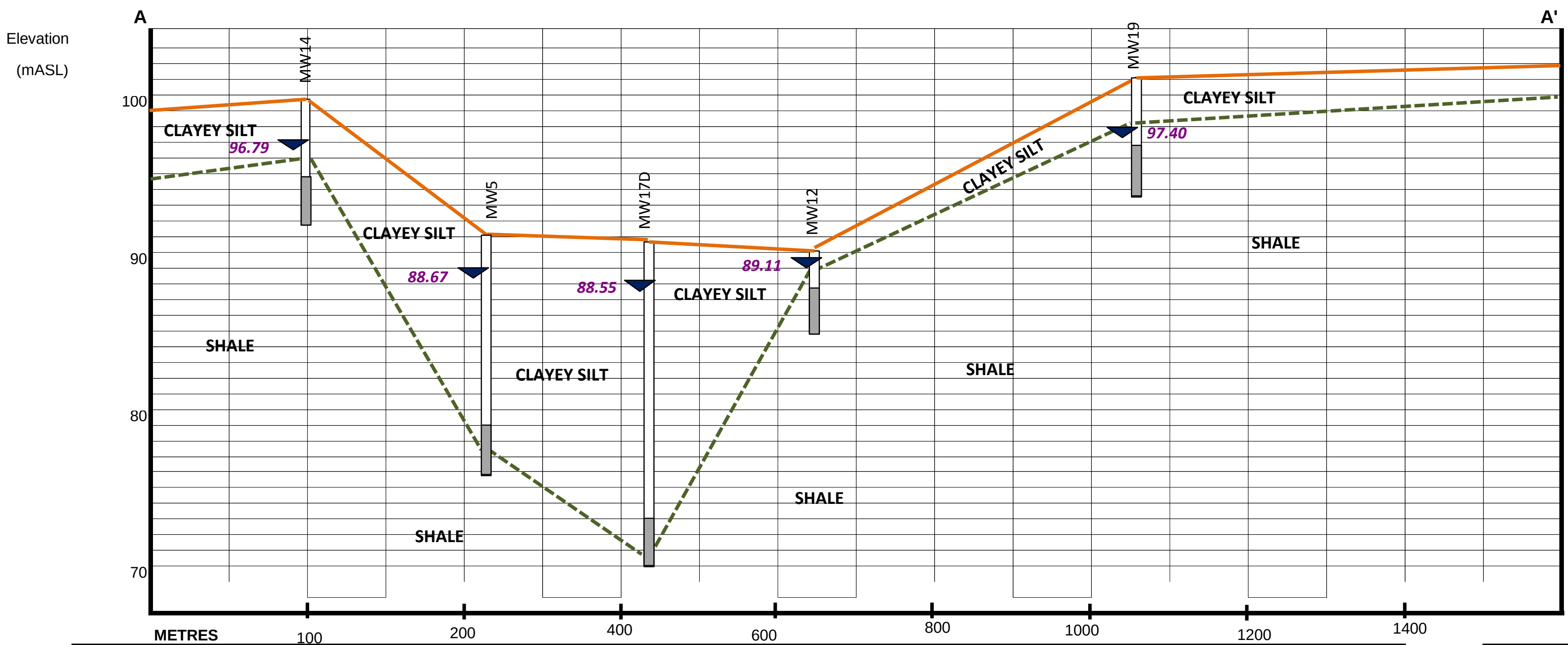
205 NEBO ROAD, HAMILTON, ONTARIO, L8W 2E1

	Scale: See Map	Date: November 2018
Project:	Hydrogeological Investigation	
	Fruitland-Winona BSS #3	
	Stoney Creek, Ontario	
Title:	Figure 6: MOECC Water Wells Locations	
Project No.	18270	



Legend

Ground Surface inferred between test locations

Stratigraphy inferred between test locations

Groundwater elevation (October 15, 2018)

Screen

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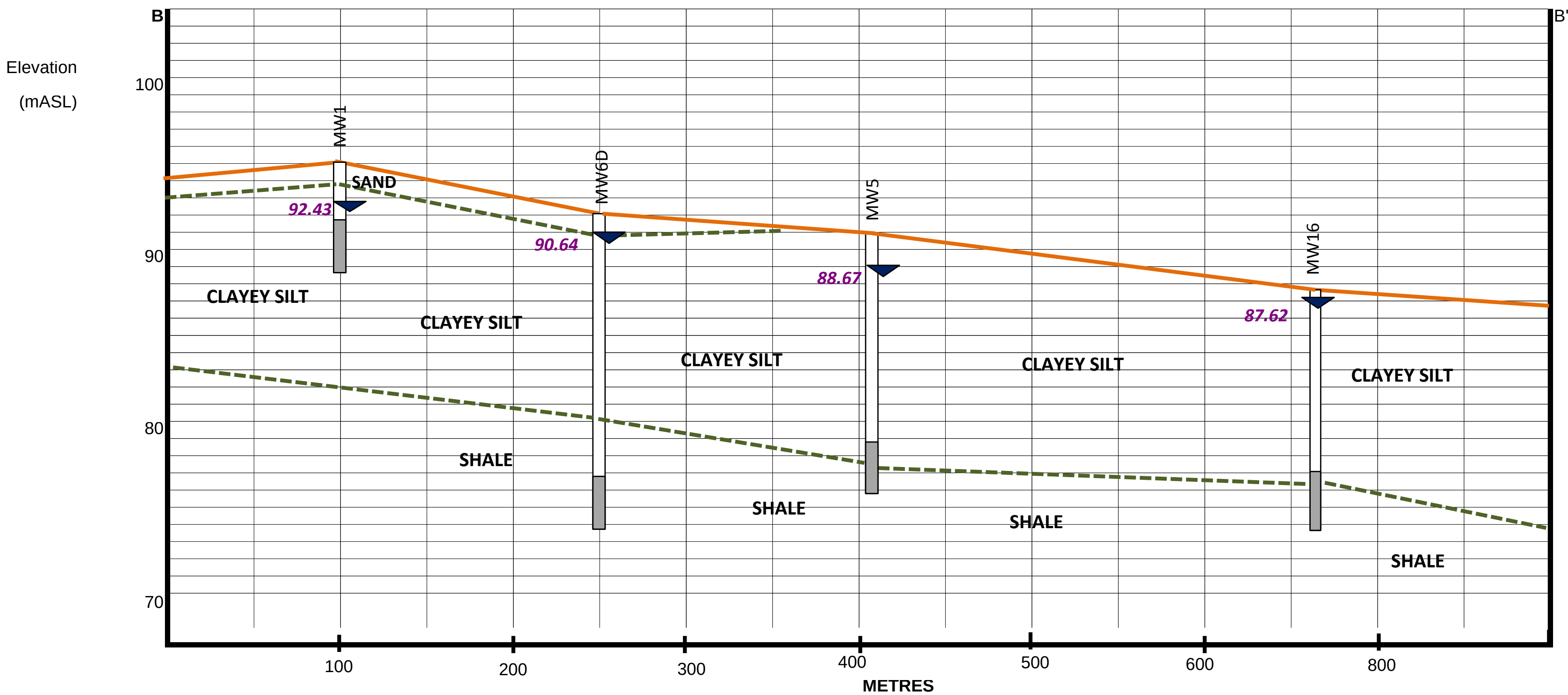
Scale:	As shown	Date: November 2018
Project:	Hydrogeological Assessment Fruitland-Winona BSS #3 Stoney Creek, Ontario	
Title:	Figure 7 -Cross-Section A-A'	
Project No.	18270	



Legend

Ground Surface inferred between test locations

Stratigraphy inferred between test locations

Groundwater elevation (October 15, 2018)

Screen

300

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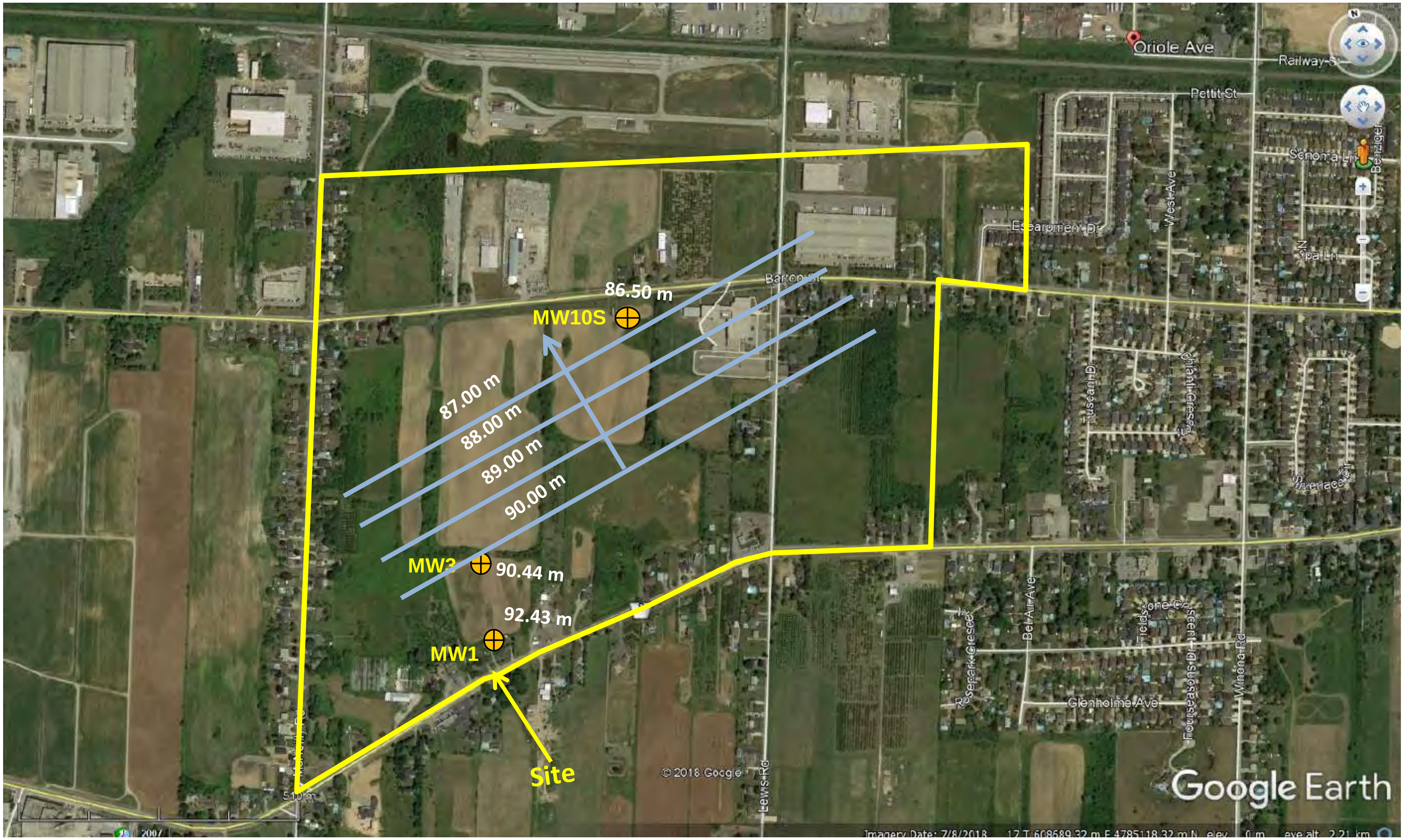
Scale:	As shown	Date: November 2018
Project:	Hydrogeological Assessment Fruitland-Winona BSS #3 Stoney Creek, Ontario	
Title:	Figure 8 -Cross-Section B-B'	
Project No.	18270	



LEGEND

Borehole/Monitoring Well

Groundwater Flow Direction

Groundwater Level Contour

88.00 m Groundwater Elevation

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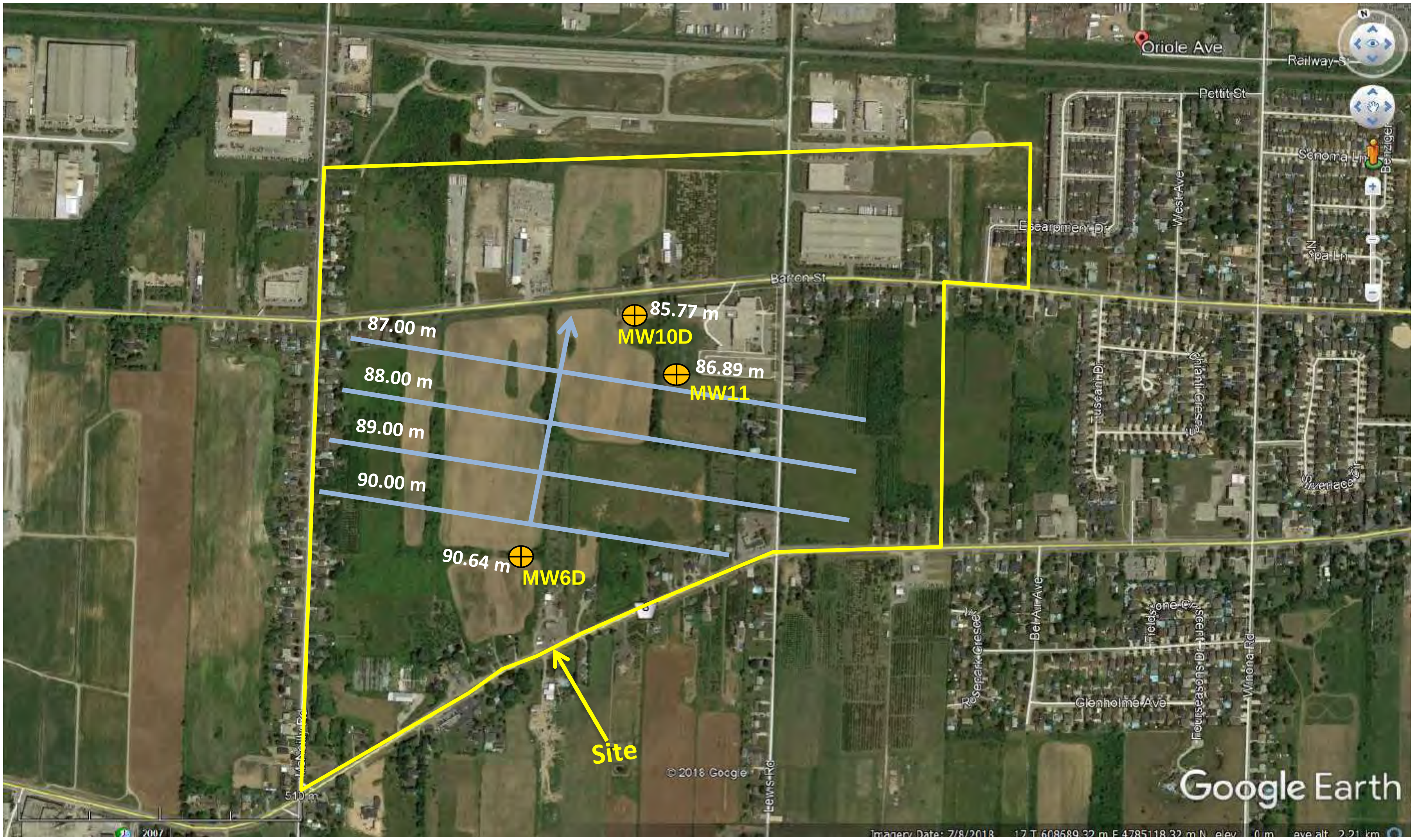
	Scale: 1:1096	Date: November 2018
Project:	Hydrogeological Investigation	
	Fruitland-Winona BSS #3	
	Stoney Creek, Ontario	
Title:	Figure 9: Groundwater Contour - Overburden	
Project No.	18270	



LEGEND

Borehole/Monitoring Well

Groundwater Flow Direction

Groundwater Level Contour

88.00 m Groundwater Elevation

	LANDTEK LIMITED *CONSULTING ENGINEERS* **205 NEBO ROAD, HAMILTON, ONTARIO, L8W 2E1**	
	Scale: 1:1096	Date: November 2018
Project:	Hydrogeological Investigation	
	Fruitland-Winona BSS #3	
	Stoney Creek, Ontario	
Title:	Figure 10: Groundwater Contour-Bedrock	
Project No.	18270	

APPENDIX B

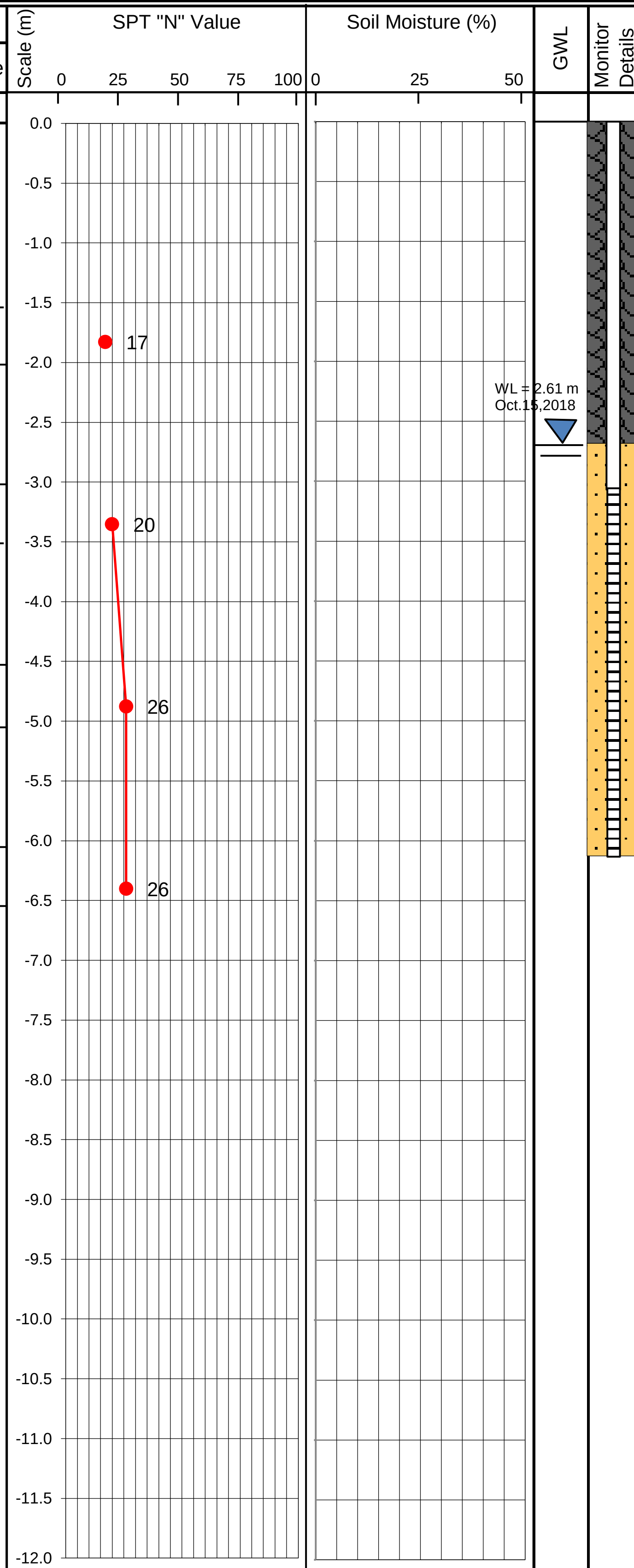
MONITORING WELL LOGS

LANDTEK LIMITED

LOG OF BOREHOLE NO. MW1

Project No.:	16381	Drill Date:	December 8, 2016
Project:	Fruitland - Winona Block 3 Servicing Strategy	Drill Method:	[ ] solid stem [x] hollow stem [ ] vibratory
Location:	Barton Street, Winona	Datum:	Geodetic

Material Description	Elev. / Depth	Sample No.	Type	SPT "N" Value
Ground Surface	95.0			
±250 mm organic soil thickness				
SILTY SAND medium grained, moist, brown	93.2	1	SS	17
CLAYEY SILT TILL trace gravel and shale, moist	1.8	2	SS	20
		3	SS	26
	88.49	4	SS	26
BOREHOLE TERMINATED	6.55			



Test Data:
- bentonite backfill
- sand backfill to 2.7 m
- 3.05 m
- 3.0 m of slotted 50 mm dia. PVC pipe
- 6.1 m

Notes:
1. Monitoring well installed with 2" PVC pipe
2. Water level reading: WL at 2.38 m below ground surface on Jan. 26, 2017.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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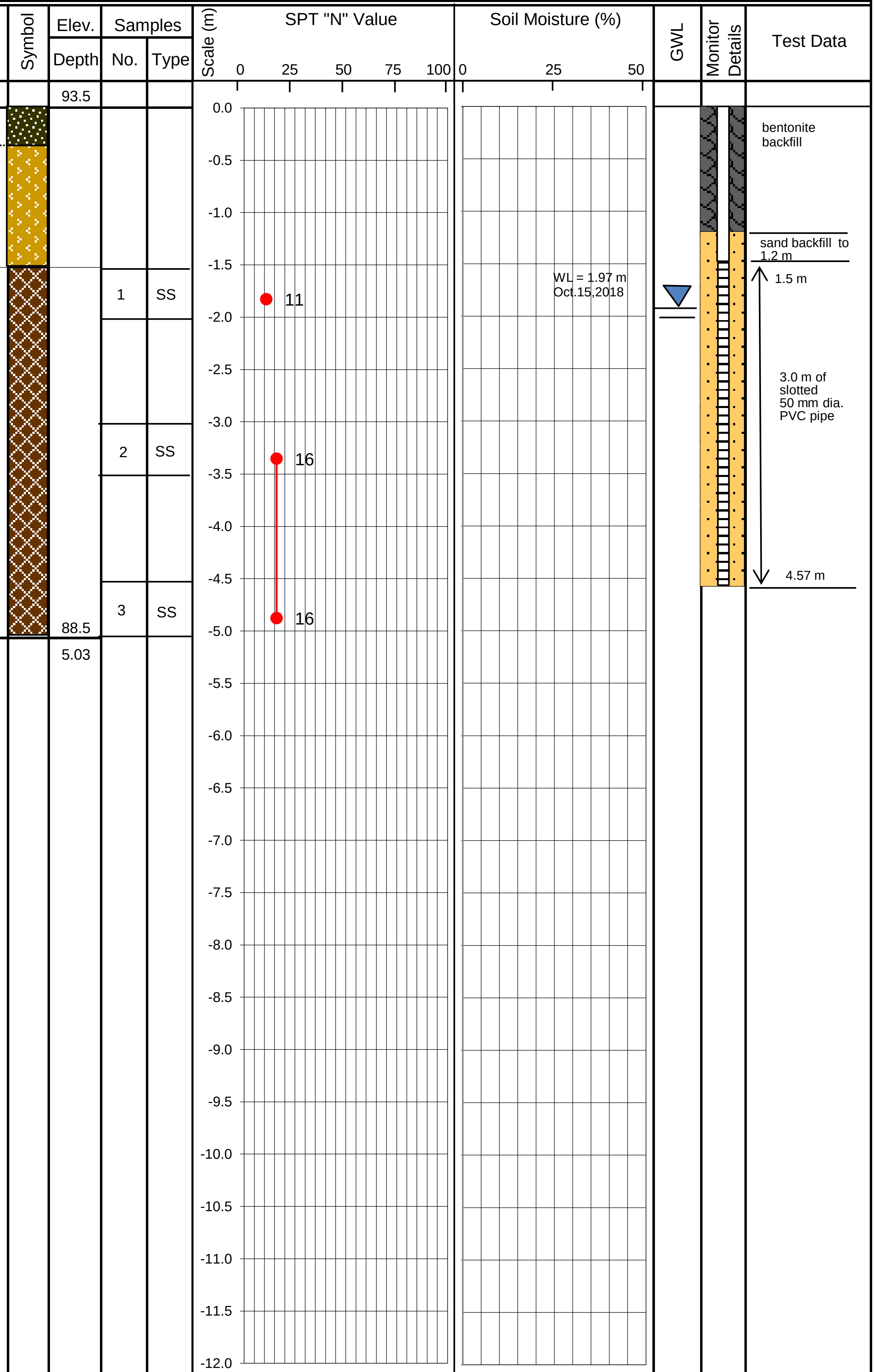
LOG OF BOREHOLE NO. MW2

Project No.:	16381	Drill Date:	December 8, 2016
Project:	Fruitland - Winona Block 3 Servicing Strategy	Drill Method:	[ ] solid stem [x] hollow stem [ ] vibratory
Location:	Barton Street, Winona	Datum:	Geodetic

Material Description	Elev. / Depth	Sample No.	Sample Type
Ground Surface	93.5		
±350 mm organic soil thickness			
SANDY SILT very moist to wet			
CLAYEY SILT TILL trace gravel and shale, moist, brown-grey		1	SS
		2	SS
	88.5	3	SS
BOREHOLE TERMINATED	5.03		



Notes: 1. Monitoring well installed with 2" PVC pipe
2. Water level reading: WL at 0.81 m below ground surface on Jan. 26, 2017.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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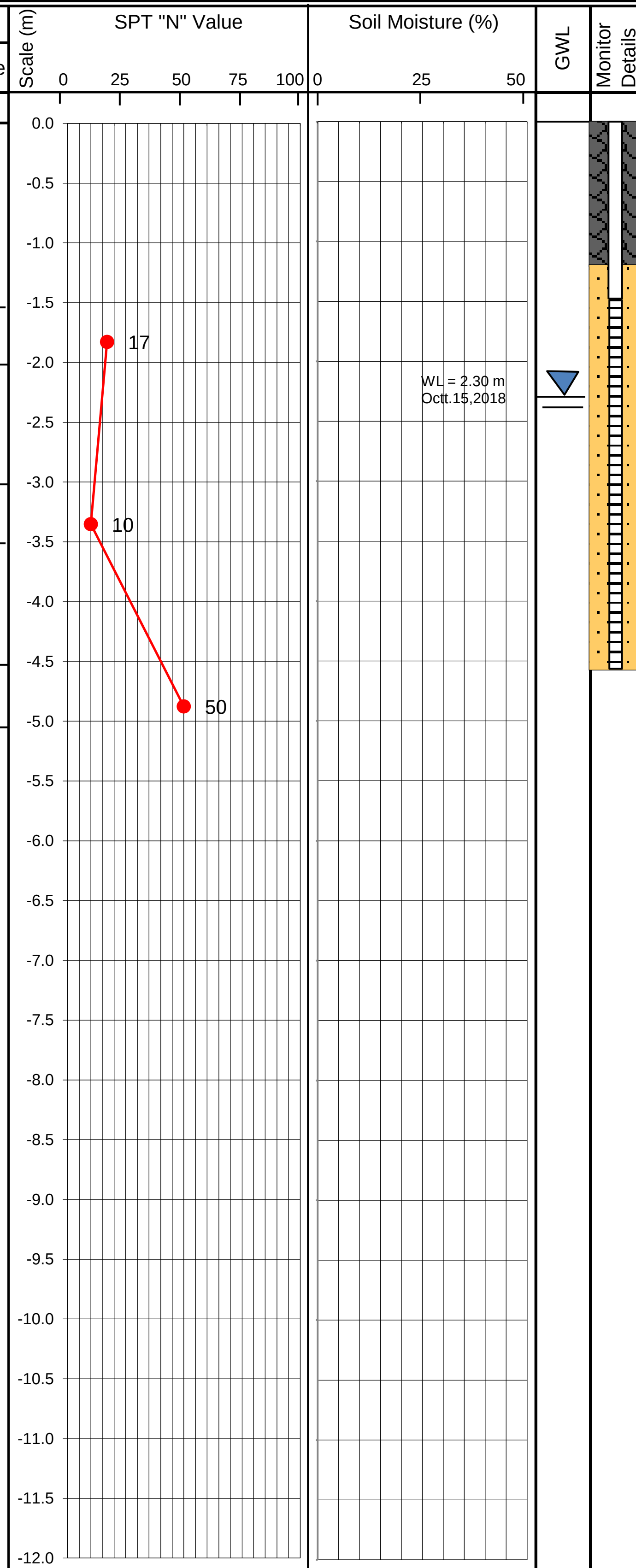
LOG OF BOREHOLE NO. MW3

Project No.:	16381	Drill Date:	December 8, 2016
Project:	Fruitland - Winona Block 3 Servicing Strategy	Drill Method:	[ ] solid stem [x] hollow stem [ ] vibratory
Location:	Barton Street, Winona	Datum:	Geodetic

Material Description	Elev. / Depth	Sample No.	Sample Type	SPT "N" Value	Test Data
Ground Surface	92.7				
±350 mm organic soil thickness					bentonite backfill
SILTY SAND medium grained, trace clay, moist					sand backfill to 1.2 m
		1	SS	17	1.5 m
wet seam found at 2.3 m					3.0 m of slotted 50 mm dia. PVC pipe
	90.0 / 2.74				
CLAYEY SILT TILL trace gravel and shale, moist		2	SS	10	
	88.1 / 4.64	3	SS	50	4.57 m

BOREHOLE TERMINATED ON POSSIBLE BEDROCK REFUSAL



Notes:
1. Monitoring well installed with 2" PVC pipe
2. Water level reading: WL at 4.42 m below ground surface on Jan. 26, 2017.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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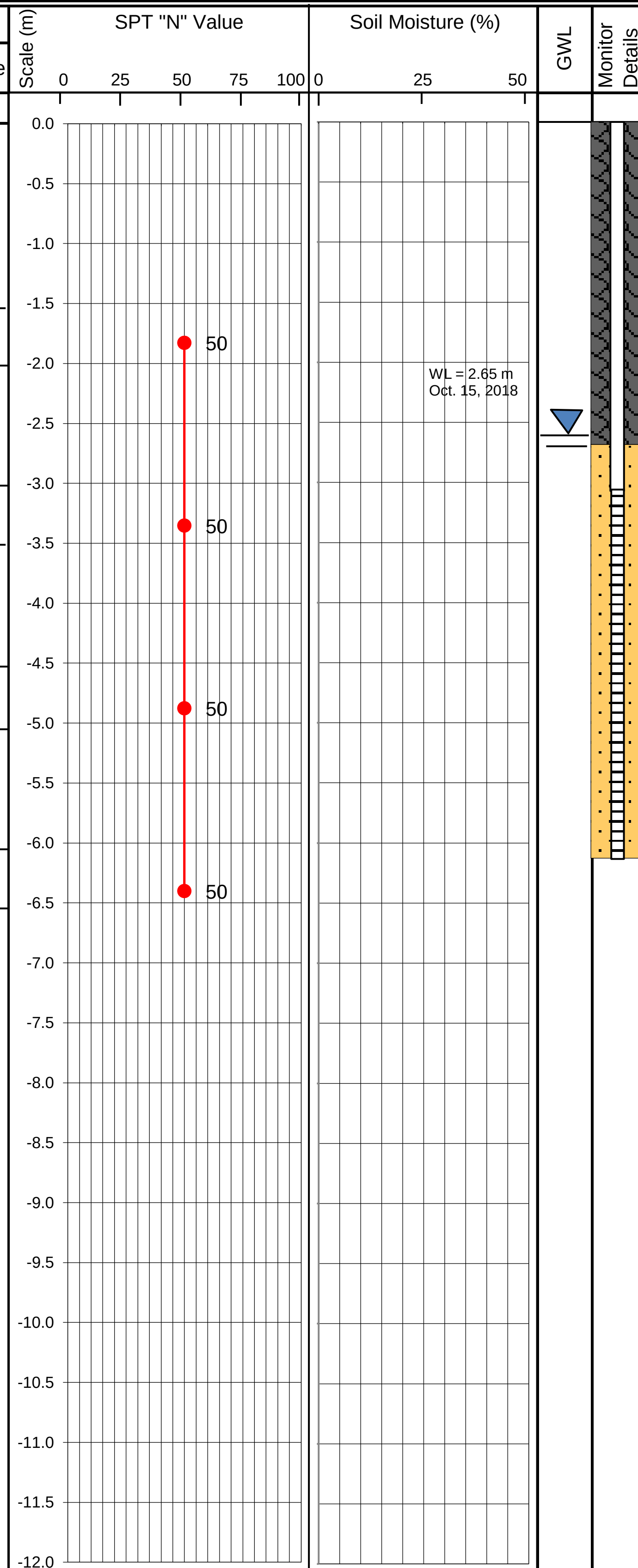
LOG OF BOREHOLE NO. MW4

Project No.:	16381	Drill Date:	December 5, 2016
Project:	Fruitland - Winona Block 3 Servicing Strategy	Drill Method:	[ ] solid stem [x] hollow stem [ ] vibratory
Location:	Barton Street, Winona	Datum:	Geodetic

Material Description	Elev. / Depth	Samples No.	Type	SPT "N" Value	Test Data
Ground Surface	91.4				
±350 mm organic soil thickness	0.0				
CLAYEY SILT TILL	90.5				bentonite backfill
SHALE red, weathered, moist	0.9				
		1	SS	50	
		2	SS	50	sand backfill to 2.7 m 3.05 m
		3	SS	50	3.0 m of slotted 50 mm dia. PVC pipe
water encountered at 5.5 m					6.1 m
	84.8	4	SS	50	
BOREHOLE TERMINATED	6.55				



Notes: 1. Monitoring well installed with 2" PVC pipe
2. Water level reading: WL at 1.56 m below ground surface on Jan. 26, 2017.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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LOG OF BOREHOLE NO. MW5

Project No.:	16381	Drill Date:	December 7, 2016
Project:	Fruitland - Winona Block 3 Servicing Strategy	Drill Method:	[ ] solid stem [x] hollow stem [ ] vibratory
Location:	Barton Street, Winona	Datum:	Geodetic

Material Description	Elev. / Depth	Samples No.	Type	SPT "N" Value	Monitor Details / Test Data
Ground Surface	91.0				
±350 mm organic soil thickness					
CLAYEY SILT TILL trace fine gravel, trace shale, moist grey		1	SS	19	bentonite backfill
		2	SS	25	
		3	SS	19	
		4	SS	17	
	77.3 / 13.7				sand backfill to 11.6 m
SHALE red, weathered, moist water encountered at 14.3 m	75.8 / 15.2				12.2 m – 15.2 m: 3.0 m of slotted 50 mm dia. PVC pipe
BOREHOLE TERMINATED					

Scale (m): 0.0 to -20.0

GWL: WL = 2.37 m Oct. 15, 2018

Soil Moisture (%): 0 – 50

Notes:
1. Switched from augering to triconing after sample 4 due to dense till conditions
2. Water level reading: WL at 0.45 m below ground surface on Jan. 26, 2017.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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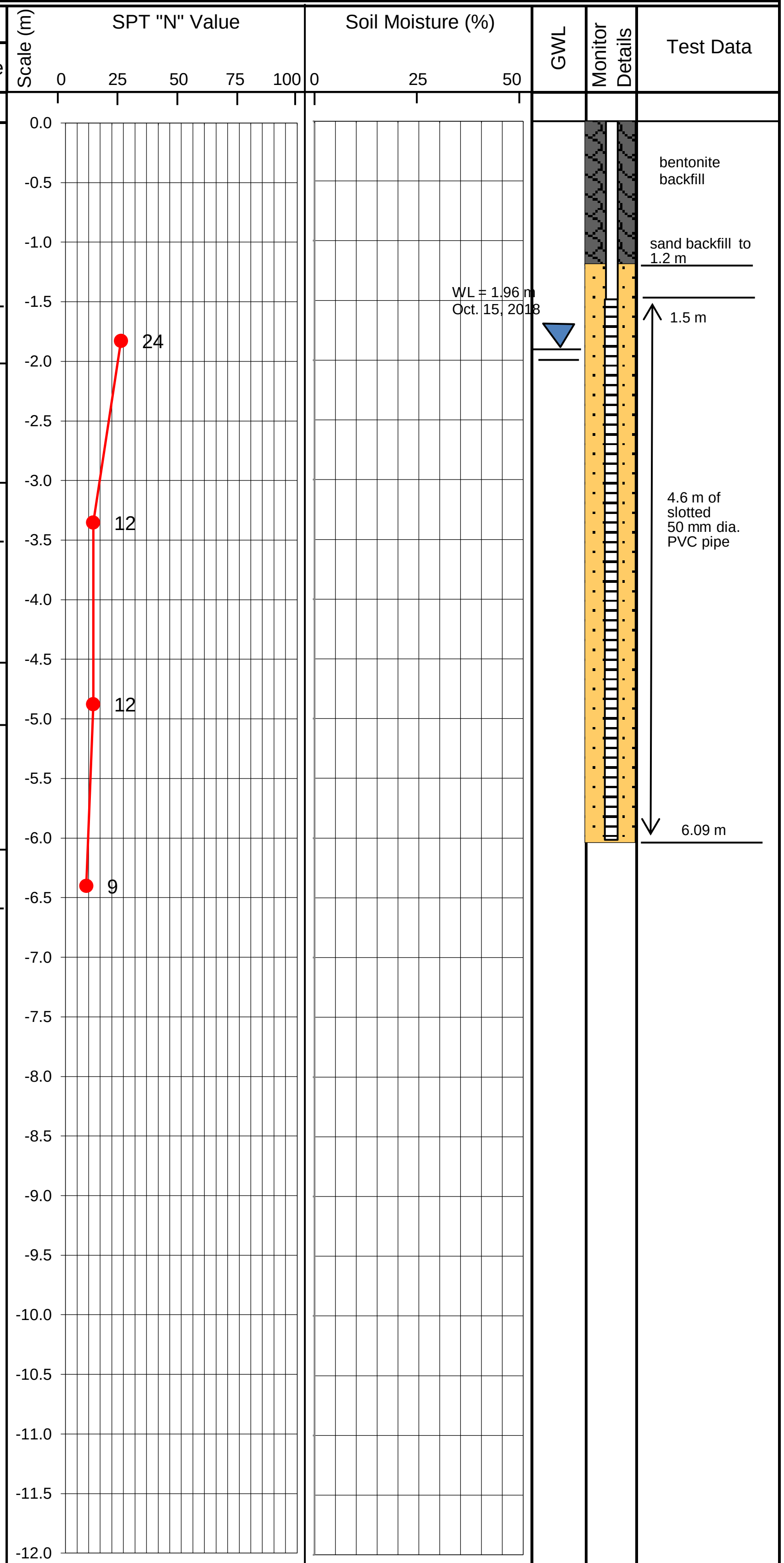
LOG OF BOREHOLE NO. MW6-S

Project No.:	16381	Drill Date:	December 9, 2016
Project:	Fruitland - Winona Block 3 Servicing Strategy	Drill Method:	[ ] solid stem [x] hollow stem [ ] vibratory
Location:	Barton Street, Winona	Datum:	Geodetic

Material Description	Elev. / Depth	Samples No.	Samples Type	SPT "N" Value
Ground Surface	92.2			
±350 mm organic soil thickness	0.0			
SILTY SAND medium grained, moist, brown	91.1 1.07			
CLAYEY SILT TILL trace gravel and shale, moist, brown-grey		1	SS	24
		2	SS	12
		3	SS	12
	85.6	4	SS	9
BOREHOLE TERMINATED	6.55			



Notes:
1. Monitoring well installed with 2" PVC pipe
2. Water level reading: well was measured DRY on Jan. 26, 2017.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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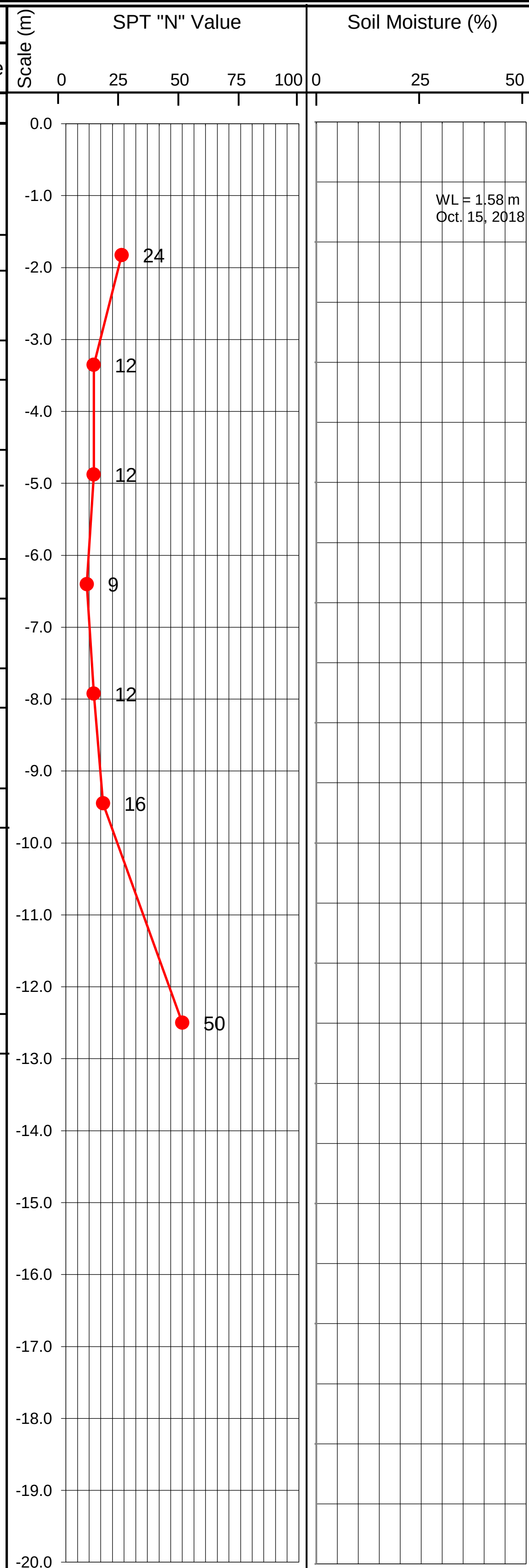
LOG OF BOREHOLE NO. MW6-D

Project No.:	16381	Drill Date:	December 9, 2016
Project:	Fruitland - Winona Block 3 Servicing Strategy	Drill Method:	[ ] solid stem [x] hollow stem [ ] vibratory
Location:	Barton Street, Winona	Datum:	Geodetic

Material Description	Elev. / Depth	Samples No.	Samples Type	SPT "N" Value	GWL	Test Data
Ground Surface	92.2					
±350 mm organic soil thickness						
SILTY SAND, medium grained, moist, brown	91.1 / 1.1				WL = 1.58 m Oct. 15, 2018	
CLAYEY SILT TILL trace fine gravel, trace shale, moist, brown/grey		1	SS	24		
		2	SS	12		
		3	SS	12		
		4	SS	9		bentonite backfill
		5	SS	12		
		6	SS	16		
	80.0 / 12.2					
SHALE red, weathered, moist		7	SS	50		sand backfill to 14.9 m; 15.24 m; 3.0 m of slotted 50 mm dia. PVC pipe; 18.3 m
	73.9 / 18.3					
BOREHOLE TERMINATED						



Notes:
1. Monitoring well installed with 2" PVC pipe
2. Water level reading: WL at 1.72 m below ground surface on Jan. 26, 2017.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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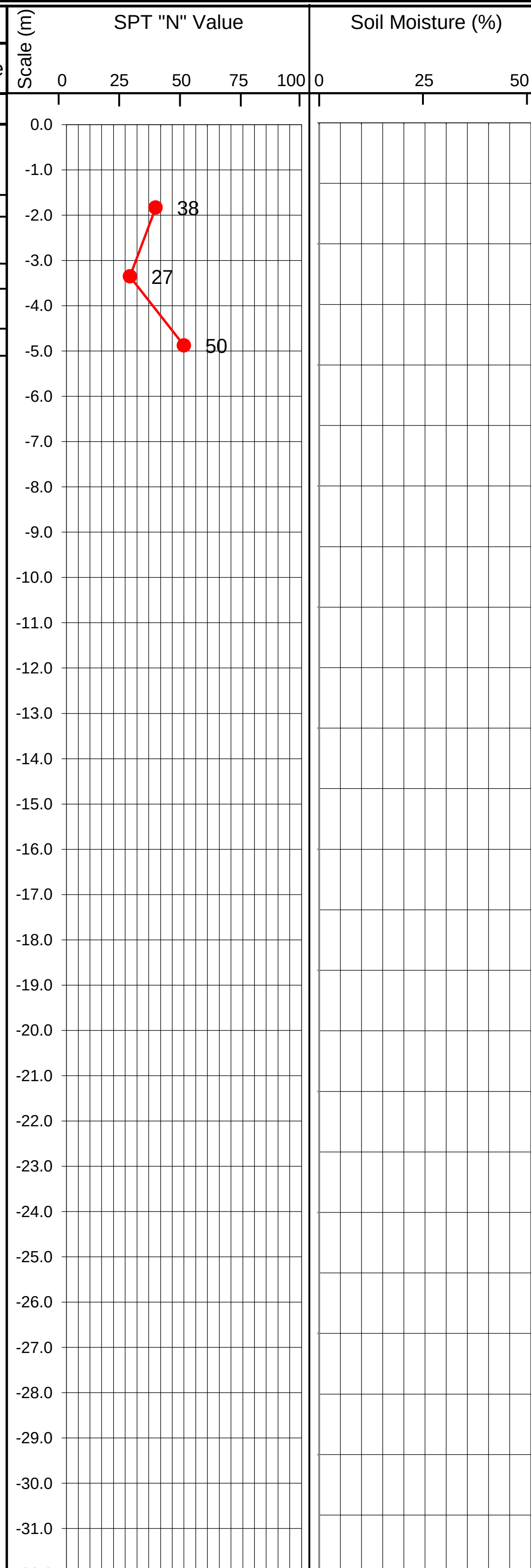
LOG OF BOREHOLE NO. MW7

Project No.:	16381	Drill Date:	December 6, 2016
Project:	Fruitland - Winona Block 3 Servicing Strategy	Drill Method:	[ ] solid stem [x] hollow stem [ ] vibratory
Location:	Barton Street, Winona	Datum:	Geodetic

Material Description	Symbol	Elev. / Depth	Sample No.	Sample Type	GWL	Test Data
Ground Surface		89.9				
±350 mm organic soil thickness						
CLAYEY SILT TILL trace sand and gravel, trace shale fragments, moist, brown			1	SS	▽	WL = 2.75 m Oct. 15, 2018
		85.5	2	SS		
SHALE red, weathered, moist		4.42	3	AUG		bentonite backfill
						sand backfill to 23.8 m
						24.4 m 6.1 m of slotted 50 mm dia. PVC pipe 30.5 m
		59.4				
BOREHOLE TERMINATED		30.5				



Notes:
1. Switched from augering to triconing after sample 3
2. Water level reading: WL at 2.72 m below ground surface on Jan. 26, 2017.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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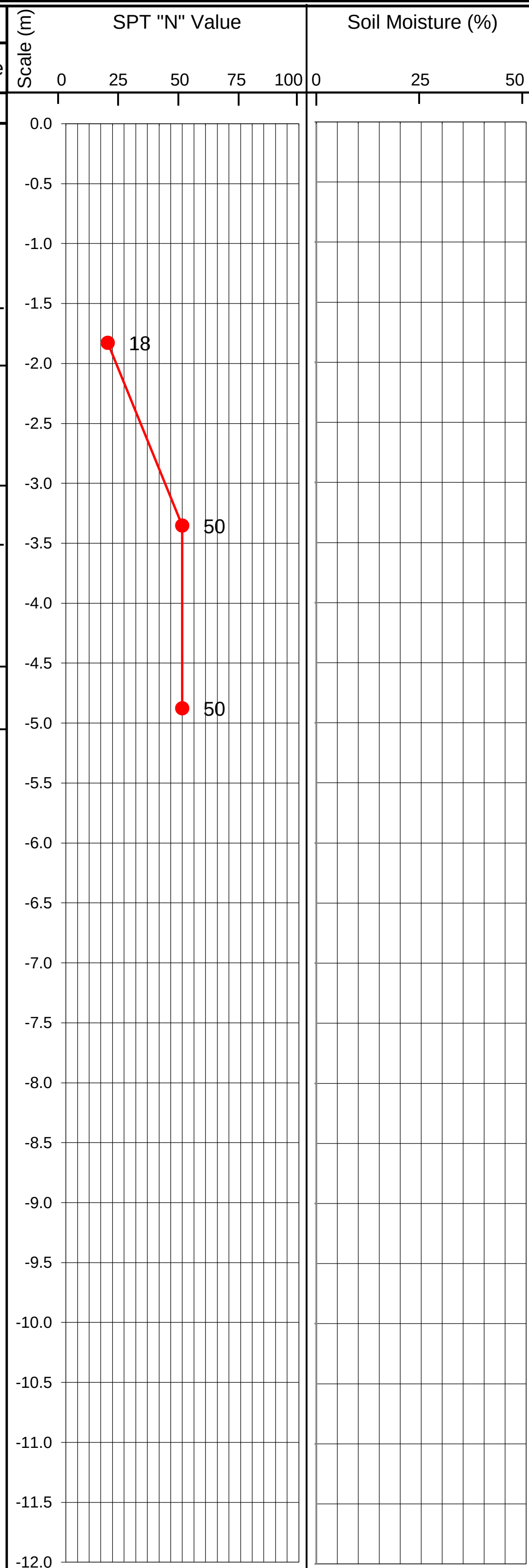
LOG OF BOREHOLE NO. MW8

Project No.:	16381	Drill Date:	December 5, 2016
Project:	Fruitland - Winona Block 3 Servicing Strategy	Drill Method:	[ ] solid stem [x] hollow stem [ ] vibratory
Location:	Barton Street, Winona	Datum:	Geodetic

Material Description	Elev. / Depth	Sample No.	Sample Type	SPT "N" Value	Test Data
Ground Surface	89.6				
±450 mm organic soil thickness					
CLAYEY SILT TILL trace fine to coarse sand, trace fine to coarse gravel, moist, cohesive, brown to grey		1	SS	18	WL = 1.23 m Oct. 15, 2018 bentonite backfill sand backfill to 2.7 m
SHALE red, weathered, moist	86.8 / 2.74	2	SS	50	3.05 m 1.5 m of slotted 50 mm dia. PVC pipe 4.57 m
	84.5	3	SS	50	
BOREHOLE TERMINATED	5.03				



Notes:
1. Monitoring well installed with 2" PVC pipe
2. Water level reading: WL at 0.18 m below ground surface on Jan. 26, 2017.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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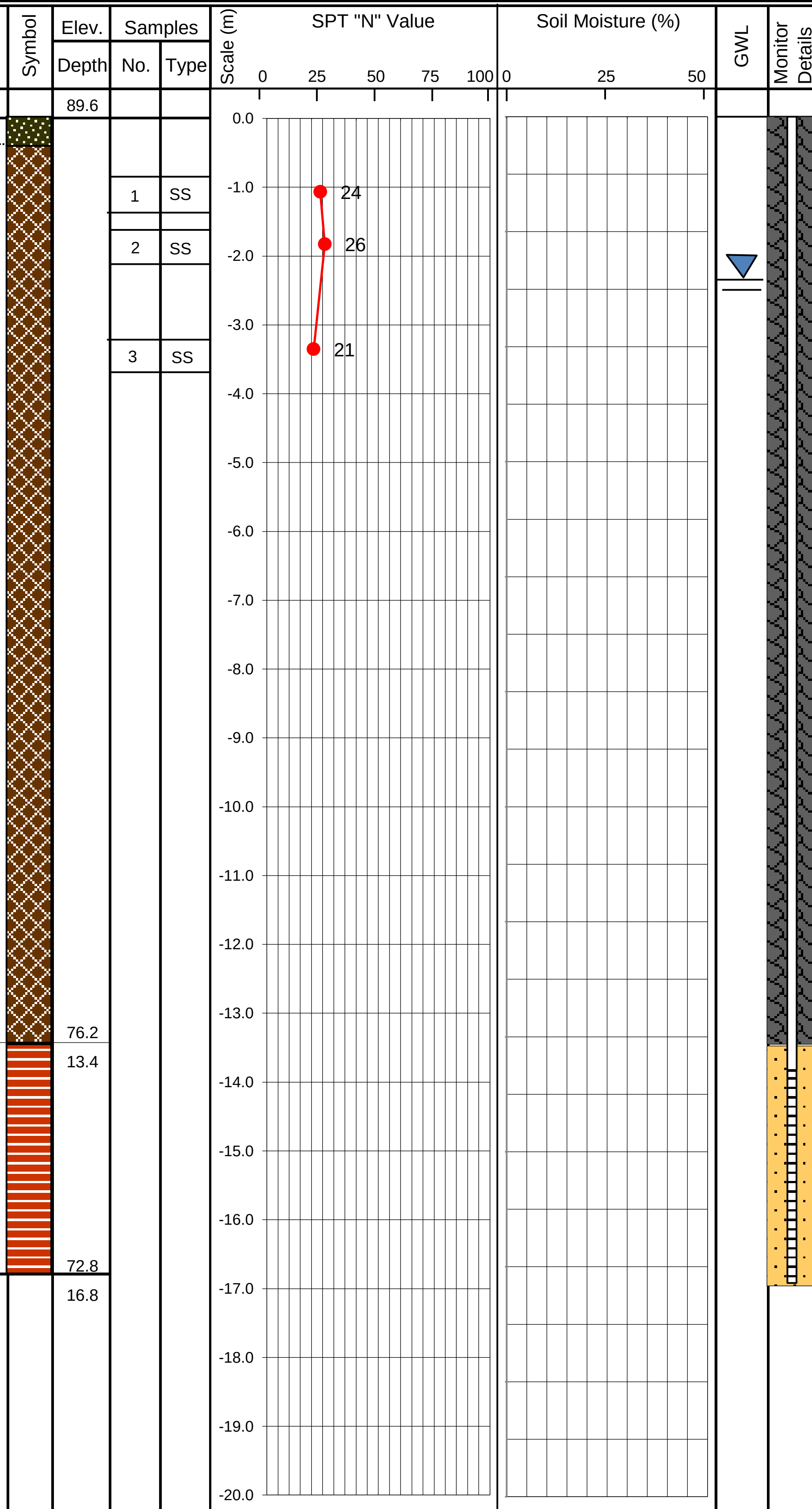
LANDTEK LIMITED — LOG OF BOREHOLE NO. MW9

Project No.:	16381	Drill Date:	January 26, 2017
Project:	Fruitland - Winona Block 3 Servicing Strategy	Drill Method:	[ ] solid stem [x] hollow stem [ ] vibratory
Location:	Barton Street, Winona	Datum:	Geodetic

Material Description	Elev. / Depth	Samples No.	Type	Test Data
Ground Surface	89.6			
±350 mm organic soil thickness				
CLAYEY SILT TILL trace fine gravel, trace shale, moist		1	SS	
		2	SS	WL = 2.37 m Oct. 15, 2018
		3	SS	bentonite backfill
	76.2 13.4			sand backfill to 13.4 m
SHALE red, weathered, moist water encountered at 15.2 m				13.7 m 3.0 m of slotted 50 mm dia. PVC pipe 16.8 m
	72.8			
BOREHOLE TERMINATED	16.8			



Notes: 1. Switched from augering to triconing after sample 3 due to dense till conditions
2. Water level reading: WL at 2.01 m below ground surface on Feb. 1, 2017.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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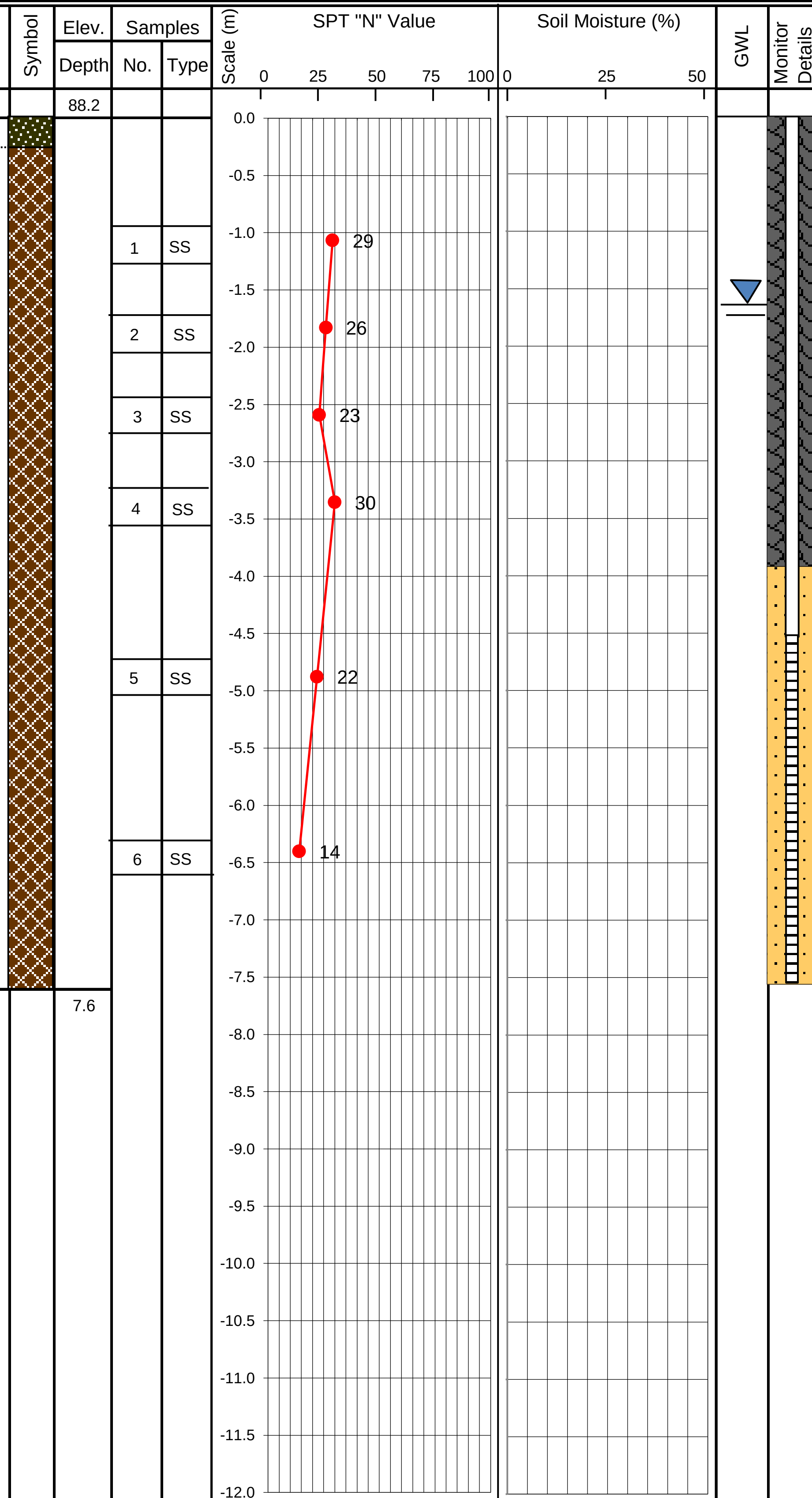
LANDTEK LIMITED

LOG OF BOREHOLE NO. MW10-S

Project No.:	16381	Drill Date:	January 25, 2017
Project:	Fruitland - Winona Block 3 Servicing Strategy	Drill Method:	[ ] solid stem [x] hollow stem [ ] vibratory
Location:	Barton Street, Winona	Datum:	Geodetic

Material Description	Elev. / Depth	Sample No.	Sample Type	SPT "N" Value	Test Data
Ground Surface	88.2				
±250 mm organic soil thickness					
CLAYEY SILT TILL trace fine gravel, trace shale, dry to moist		1	SS	29	
		2	SS	26	WL = 1.65 m Oct. 15, 2018; bentonite backfill
		3	SS	23	
		4	SS	30	sand backfill to 3.9 m
		5	SS	22	4.6 m
		6	SS	14	3.0 m of slotted 50 mm dia. PVC pipe; 7.6 m
BOREHOLE TERMINATED	7.6				



Notes: 1. Monitoring well installed with 2" PVC pipe
2. Water level reading: WL was measured DRY on Feb. 1, 2017.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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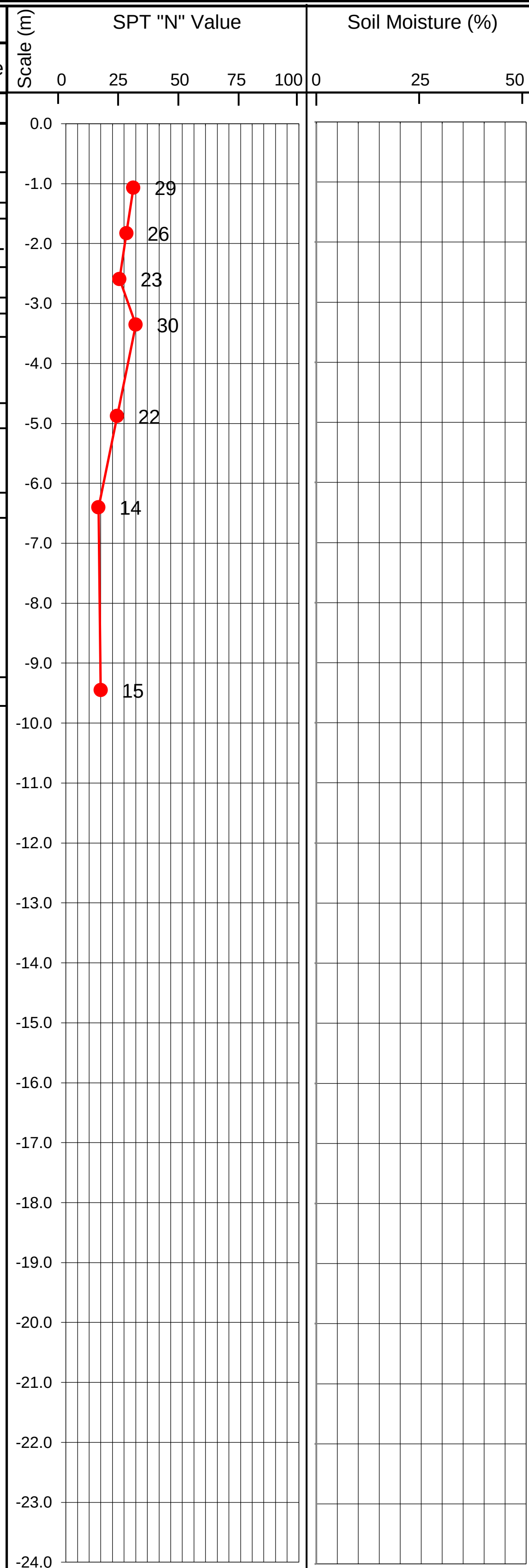
LOG OF BOREHOLE NO. MW10-D

Project No.:	16381	Drill Date:	January 25, 2017
Project:	Fruitland - Winona Block 3 Servicing Strategy	Drill Method:	[ ] solid stem [x] hollow stem [ ] vibratory
Location:	Barton Street, Winona	Datum:	Geodetic

Material Description	Elev. / Depth	Samples No.	Type	SPT "N" Value
Ground Surface	88.2			
±350 mm organic soil thickness				
CLAYEY SILT TILL trace fine gravel, trace shale, dry to moist		1	SS	29
		2	SS	26
		3	SS	23
		4	SS	30
		5	SS	22
		6	SS	14
		7	SS	15
	75.4 / 12.8			
SHALE red, weathered, moist				
	66.2 / 21.95			
BOREHOLE TERMINATED				



Test Data / Monitor Details:

- WL = 2.42 m, Oct. 15, 2018
- bentonite backfill
- sand backfill to 18.3 m
- 18.9 m
- 3.0 m of slotted 50 mm dia. PVC pipe
- 21.95 m

Notes:
1. Switched from augering to triconing after sample 7 due to dense till conditions
2. Water level reading: WL at 3.07 m below ground surface on Feb. 1, 2017.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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LANDTEK LIMITED — LOG OF BOREHOLE NO. MW11

Project No.:	16381	Drill Date:	January 27, 2017
Project:	Fruitland - Winona Block 3 Servicing Strategy	Drill Method:	[ ] solid stem [x] hollow stem [ ] vibratory
Location:	Barton Street, Winona	Datum:	Geodetic

Material Description	Elev. / Depth	Samples No.	Samples Type	SPT "N" Value	Monitor Details / Test Data
Ground Surface	89.2				
±350 mm organic soil thickness	0.0				
(FILL) Clayey silt, moist	88.0				
CLAYEY SILT TILL trace fine gravel, trace shale, dry to moist	1.2	1	SS	10	WL = 2.29 m Oct. 15, 2018
	77.0				bentonite backfill
SHALE red, weathered, moist	12.2				sand backfill to 15.9 m 16.5 m – 19.5 m: 3.0 m of slotted 50 mm dia. PVC pipe
	66.4				
BOREHOLE TERMINATED	22.8				

Scale (m): 0.0 to -24.0. SPT "N" Value: 0, 25, 50, 75, 100. Soil Moisture (%): 0, 25, 50. GWL.

Notes:
1. Augering was replaced by triconing after sample 1 since the till was too hard
2. Water level reading: WL at 3.91m below ground surface on Feb. 1, 2017.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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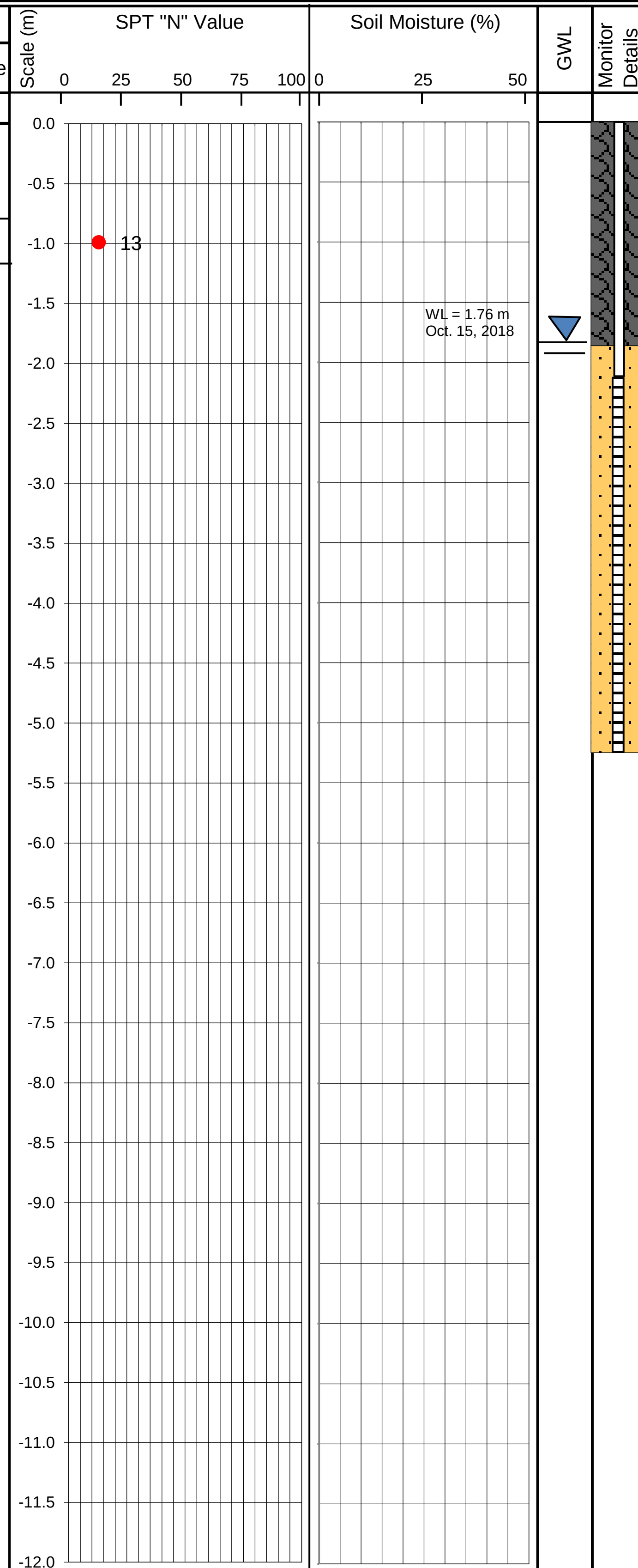
LANDTEK LIMITED — **LOG OF BOREHOLE NO. MW12**

Project No.:	16381	Drill Date:	January 27, 2017
Project:	Fruitland - Winona Block 3 Servicing Strategy	Drill Method:	[ ] solid stem [x] hollow stem [ ] vibratory
Location:	Barton Street, Winona	Datum:	Geodetic

Material Description	Elev. / Depth	Samples No.	Samples Type	SPT "N" Value	Test Data
Ground Surface	90.1				
±250 mm organic soil thickness					bentonite backfill
(FILL) Silty Clay medium grained, moist, reddish-brown, trace sand and gravel	88.9	1	SS	13 (at -1.0 m)	
SHALE Red, weathered, moist	1.2				sand backfill to 1.8 m
water encountered at 3.7 m					2.1 m; 3.0 m of slotted 50 mm dia. PVC pipe; 5.2 m
	84.92				
BOREHOLE TERMINATED	5.2				



Notes:
1. Augering was replaced by triconing after sample 1 since the till was too hard
2. Water level reading: WL at 0.74 m below ground surface on Feb. 1, 2017.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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LANDTEK LIMITED — **LOG OF BOREHOLE NO. MW13**

Project No.:	18270	Drill Date:	August 10, 2018
Project:	Fruitland - Winona BSS #3	Drill Method:	[ ] solid stem [x] hollow stem [ ] vibratory
Location:	Barton Street, Winona	Datum:	Geodetic

Material Description	Elev. / Depth	Samples No.	Type	SPT "N" Value	Soil Moisture (%)	GWL	Test Data
Ground Surface	98.5						
±250 mm organic soil thickness							
SILTY SAND medium grained, trace clay, moist						WL = 1.78 m Oct.15, 2018	bentonite backfill
CLAYEY SILT TILL trace gravel and shale, moist	96 2.0						
SHALE	92.1 3.2						sand backfill to 4.3 m 4.6 m 3.0 m of slotted 50 mm dia. PVC pipe 7.6 m
BOREHOLE TERMINATED	7.6						

Scale (m): 0.0 to -12.0 at 0.5 m intervals. SPT "N" Value axis: 0, 25, 50, 75, 100. Soil Moisture (%) axis: 0, 25, 50.

Notes:
1. Monitoring well installed with 2" PVC pipe
2. Water hit at 4.57 m below ground surface.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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LOG OF BOREHOLE NO. MW14

Project No.:	18270	Drill Date:	August 10, 2018
Project:	Fruitland - Winona BSS #3	Drill Method:	[ ] solid stem [x] hollow stem [ ] vibratory
Location:	Barton Street, Winona	Datum:	Geodetic

Material Description	Symbol	Elev. / Depth	Samples No.	Samples Type	Scale (m)	SPT "N" Value (0, 25, 50, 75, 100)	Soil Moisture (%) (0, 25, 50)	GWL	Monitor Details	Test Data
Ground Surface		99.7			0.0					
±250 mm organic soil thickness										
CLAYEY SILT TILL trace gravel and shale, moist		96.0 3.7			-0.5 to -3.5			WL		bentonite backfill WL = 2.86 m Oct.15, 2018
SHALE		92.1 7.6			-4.0 to -7.5					sand backfill to 4.3 m 4.6 m 3.0 m of slotted 50 mm dia. PVC pipe 7.6 m
BOREHOLE TERMINATED					-8.0 to -12.0					

Notes: 1. Monitoring well installed with 2" PVC pipe
2. Water level reading: WL at 2.38 m below ground surface on Jan. 26, 2017.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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LOG OF BOREHOLE NO. MW15

Project No.:	18270	Drill Date:	August 10, 2018
Project:	Fruitland - Winona BSS #3	Drill Method:	[ ] solid stem [x] hollow stem [ ] vibratory
Location:	Barton Street, Winona	Datum:	Geodetic

Material Description	Symbol	Elev. / Depth	Samples No.	Samples Type	Scale (m)	SPT "N" Value (0 25 50 75 100)	Soil Moisture (%) (0 25 50)	GWL	Monitor Details	Test Data
Ground Surface		90.7								
±250 mm organic soil thickness					0.0					
CLAYEY SILT TILL trace gravel and shale, moist					-0.5 to -3.5			WL (1.88 m)		bentonite backfill WL = 1.88 m Oct.15, 2018
SHALE		87.0 3.7			-4.0 to -7.5					sand backfill to 4.3 m 4.6 m 3.0 m of slotted 50 mm dia. PVC pipe 7.6 m
BOREHOLE TERMINATED		83.1 7.6			-8.0 to -12.0					

Scale (m): 0.0, -0.5, -1.0, -1.5, -2.0, -2.5, -3.0, -3.5, -4.0, -4.5, -5.0, -5.5, -6.0, -6.5, -7.0, -7.5, -8.0, -8.5, -9.0, -9.5, -10.0, -10.5, -11.0, -11.5, -12.0

Notes:
1. Monitoring well installed with 2" PVC pipe
2. Water hit at 5.20 m below ground surface.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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LANDTEK LIMITED — LOG OF BOREHOLE NO. MW16

Project No.:	18270	Drill Date:	August 10, 2018
Project:	Fruitland - Winona BSS #3	Drill Method:	[ ] solid stem [x] hollow stem [ ] vibratory
Location:	Barton Street, Winona	Datum:	Geodetic

Material Description	Symbol	Elev. / Depth	Samples No.	Samples Type	Scale (m)	SPT "N" Value (0 25 50 75 100)	Soil Moisture (%) (0 25 50)	GWL	Monitor Details	Test Data
Ground Surface		88.6								
±250 mm organic soil thickness					0.0					
CLAYEY SILT TILL trace gravel and shale, moist					-0.5 to -12.0			▽	bentonite backfill	WL = 0.93 m Oct.15, 2018; bentonite backfill; 10.3 m; 10.7 m
SHALE		76.4 / 12.2			-12.0 to -13.5					3.0 m of slotted 50 mm dia. PVC pipe
		74.9 / 13.7			-14.0					
BOREHOLE TERMINATED										

Scale (m): 0.0, -0.5, -1.0, -1.5, -2.0, -2.5, -3.0, -3.5, -4.0, -4.5, -5.0, -5.5, -6.0, -6.5, -7.0, -7.5, -8.0, -8.5, -9.0, -9.5, -10.0, -10.5, -11.0, -11.5, -12.0, -12.5, -13.0, -13.5, -14.0

Notes: 1. Monitoring well installed with 2" PVC pipe
2. Water hit at 12.2 m below ground surface.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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LOG OF BOREHOLE NO. MW17S

Project No.:	18270	Drill Date:	August 10, 2018
Project:	Fruitland - Winona BSS #3	Drill Method:	[ ] solid stem [x] hollow stem [ ] vibratory
Location:	Barton Street, Winona	Datum:	Geodetic

Material Description	Symbol	Elev. / Depth	Samples No.	Samples Type	Scale (m)	SPT "N" Value (0 25 50 75 100)	Soil Moisture (%) (0 25 50)	GWL	Monitor Details	Test Data
Ground Surface		90.6								
±250 mm organic soil thickness					0.0					
CLAYEY SILT TILL trace gravel and shale, moist					-0.5 to -12.0					bentonite backfill
					-9.5 / -10.0			▽		WL = 9.93 m Oct.15, 2018
					-10.5					sand backfill to 10.4 m
					-11.0					10.7 m 1.5 m of slotted 50 mm dia. PVC pipe
		78			-12.0					12.2 m
BOREHOLE TERMINATED		12.2 m			-12.5 to -21.0					

Scale (m): 0.0, -0.5, -1.0, -1.5, -2.0, -2.5, -3.0, -3.5, -4.0, -4.5, -5.0, -5.5, -6.0, -6.5, -7.0, -7.5, -8.0, -8.5, -9.0, -9.5, -10.0, -10.5, -11.0, -11.5, -12.0, -12.5, -13.0, -13.5, -14.0, -14.5, -15.0, -15.5, -16.0, -16.5, -17.0, -17.5, -18.0, -18.5, -19.0, -19.5, -20.0, -20.5, -21.0

Notes:
1. Monitoring well installed with 2" PVC pipe
2. No Water hit.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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LOG OF BOREHOLE NO. MW17D

Project No.:	18270	Drill Date:	August 10, 2018
Project:	Fruitland - Winona BSS #3	Drill Method:	[ ] solid stem [x] hollow stem [ ] vibratory
Location:	Barton Street, Winona	Datum:	Geodetic

Material Description

Ground Surface — Elev. 90.6

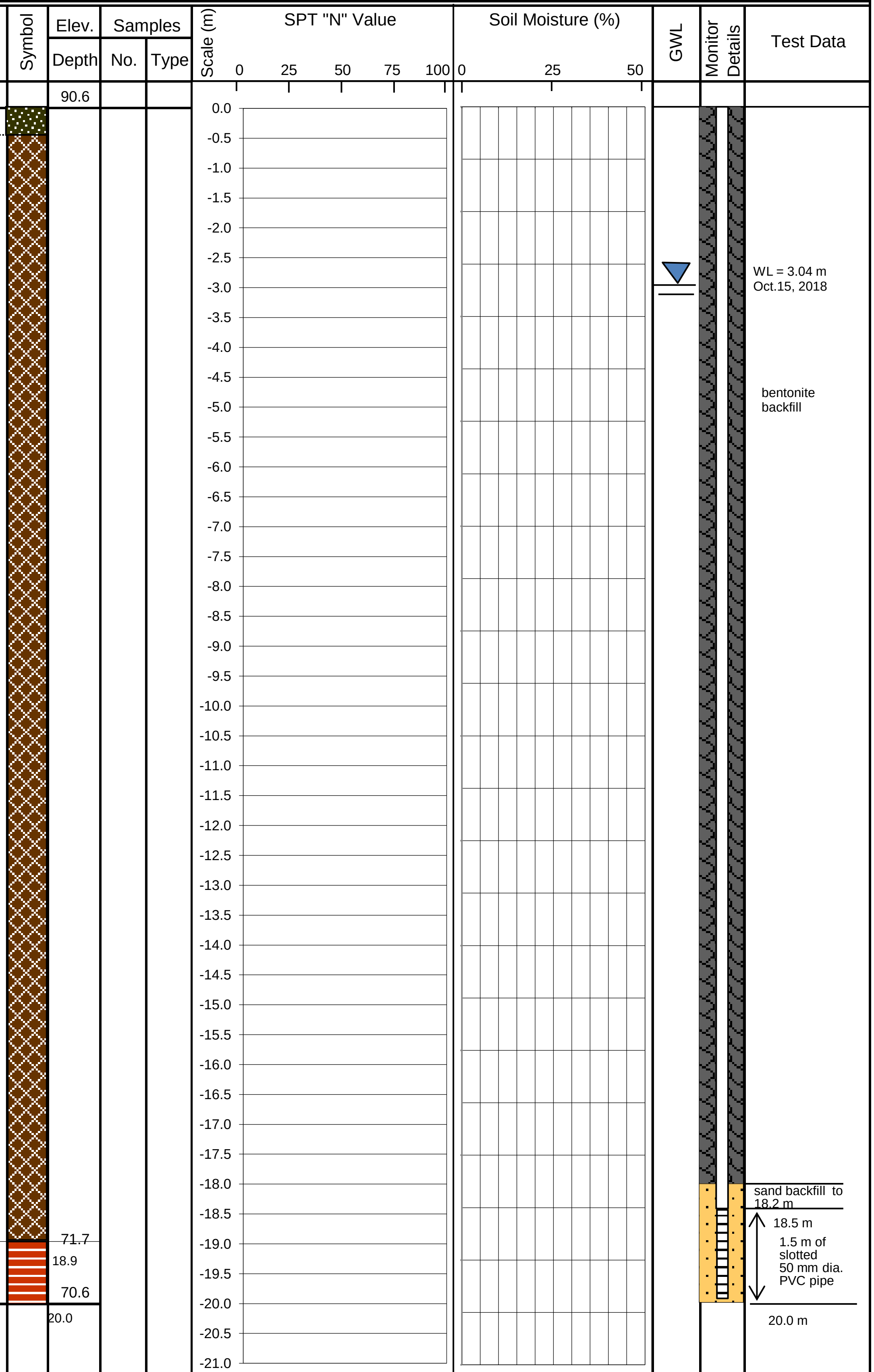
±250 mm organic soil thickness

CLAYEY SILT TILL
trace gravel and shale, moist

SHALE — Elev. 71.7, Depth 18.9

Elev. 70.6, Depth 20.0

BOREHOLE TERMINATED



Notes:
1. Monitoring well installed with 2" PVC pipe
2. Water hit at 18.9 m below ground surface.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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LOG OF BOREHOLE NO. MW18

Project No.:	18270	Drill Date:	August 10, 2018
Project:	Fruitland - Winona BSS #3	Drill Method:	[ ] solid stem [x] hollow stem [ ] vibratory
Location:	Barton Street, Winona	Datum:	Geodetic

Material Description	Symbol	Elev. / Depth	Samples No.	Samples Type
Ground Surface		92.0		
±250 mm organic soil thickness				
CLAYEY SILT TILL trace gravel and shale, moist		88.0 / 4.0		
SHALE		84.4 / 7.6		
BOREHOLE TERMINATED				

Scale (m): 0.0 to -12.0 (0.5 m intervals)

SPT "N" Value: 0, 25, 50, 75, 100

Soil Moisture (%): 0, 25, 50

GWL | Monitor Details | Test Data

Test Data:
- bentonite backfill
- WL = 3.77 m Oct.15, 2018
- sand backfill to 4.3 m
- 4.6 m
- 3.0 m of slotted 50 mm dia. PVC pipe
- 7.6 m

Notes:
1. Monitoring well installed with 2" PVC pipe
2. Water hit at 4.57 m below ground surface.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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LOG OF BOREHOLE NO. MW19

Project No.:	18270	Drill Date:	August 10, 2018
Project:	Fruitland - Winona BSS #3	Drill Method:	[ ] solid stem [x] hollow stem [ ] vibratory
Location:	Barton Street, Winona	Datum:	Geodetic

Material Description	Elev. / Depth	Samples No.	Samples Type	Test Data
Ground Surface	101.0			
±250 mm organic soil thickness				
CLAYEY SILT TILL trace gravel and shale, moist				bentonite backfill
SHALE	98.0 3.0			WL = 3.59 m Oct.15, 2018 sand backfill to 4.3 m 4.6 m 3.0 m of slotted 50 mm dia. PVC pipe 7.6 m
BOREHOLE TERMINATED	93.4 7.6			

Scale (m): 0.0, -0.5, -1.0, -1.5, -2.0, -2.5, -3.0, -3.5, -4.0, -4.5, -5.0, -5.5, -6.0, -6.5, -7.0, -7.5, -8.0, -8.5, -9.0, -9.5, -10.0, -10.5, -11.0, -11.5, -12.0

SPT "N" Value: 0 25 50 75 100

Soil Moisture (%): 0 25 50

GWL | Monitor Details

Notes:
1. Monitoring well installed with 2" PVC pipe
2. Water hit at 4.57 m below ground surface.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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APPENDIX C

MECP WELL RECORDS

UTM | | z | | E
| 9 | R | | N
Elev. | 9 | R | N
Basin | 2 | 4 |

68 № 4483

RECEIVED FEB 28 1951 GEOLOGICAL BRANCH DEPARTMENT OF MINES

ONTARIO

The Well Drillers Act

Department of Mines, Province of Ontario

Water Well Record

County or Territorial District... Wentworth ...... Township, ~~Village, Town or City~~... Saltfleet

Con... I ..... Lot... 3 .... Street and Number (if in Village, Town or City)..... Winona

Owner.... Canadian Legion .... Address... Station Rd. Winona

Date Completed... 24 (day) ... 7 (month) ... 50 (year) ... Cost of Well (excluding pump)... 100.00

Pipe and Casing Record	Pumping Test
Casing diameter(s)........ 6 1/4	Date.... July 24 - 50
Length(s) of casing(s)....... 18 ft.	Static level..... 7 ft.
Type of screen....... none	Pumping level... 25 ft.
Length of screen.......	Pumping rate.... 3 gal. min.
Distance from top of screen to ground level.......	Duration of test.... 1 hour.
Is well a gravel-wall type?... no	Distance from cylinder or bowls to ground level.......

Water Record

Kind (fresh or mineral)........ fresh.

Quality (hard, soft, contains iron, sulphur, etc.)..... hard.

Appearance (clear, cloudy, coloured)........ clear.

For what purpose(s) is the water to be used?..... toilet & Drinking

How far is well from possible source of contamination?... 35 ft.

What is the source of contamination?..... Septic Tank

Enclose a copy of any mineral analysis that has been made of water.......

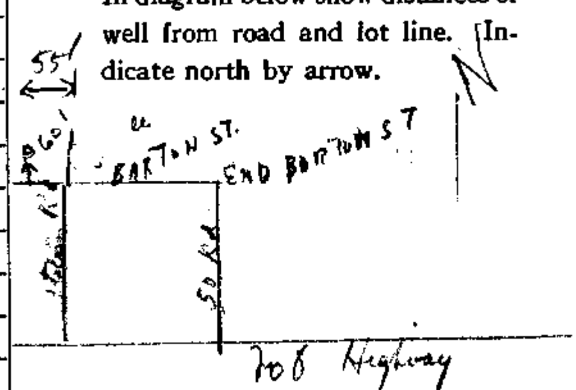
Depth(s) to Water Horizon(s)	Kind of Water	No. of Feet Water Rises
32 ft.	Good.	25 ft.

Well Log

Overburden and Bedrock Record	From	To
Red Clay.	0 ft.	15 ft.
Red Shale	15	32 ft

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



Situation: Is well on upland, in valley, or on hillside?...... Upland

Drilling Firm........ S. Gill

Address.......

Name of Driller......... Address..... 55 Agnes

Date......... Licence Number...... No. 3.

S. Gill

Signature of Licensee

Form 5

CSS.S8

UTM | | Z | | E

9 R | | N

Elev. 9 R

Basin 24

1

68 № ~~4530~~

ONTARIO

The Well Drillers Act

Department of Mines, Province of Ontario

Water Well Record

Wentworth

[redacted] ...leet ..... Con II Lot 5 Pt. Lot ....

No. 8 Highway Winona .... Acres 2.1

Date completed Aug 15 1950 ... Cost of Well (not including pump) ....

Pipe and Casing Record

Casing diameter(s) ...... 6"

Length(s) of casing(s) ...... 12 ft

Length of screen ...... none

Type of screen ....

Type of pump ....

Capacity of pump ....

Depth of pump setting ....

Pumping Test

Date ...... Aug 15 1950

Developed Capacity ...... 2 gal min

Duration of Test ...... 1/2 hours

Pumping Rate ...... 2 gal min

Drawdown ...... 24 ft

Static level of completed well ...... 12 ft from top

Is well a gravel-wall type? ...... no

Water Record

Kind (fresh or mineral) ...... little salt

Quality (hard, soft, contains iron, sulphur etc.) ...... hard

Appearance (clear, cloudy, coloured) ...... clear

For what purpose(s) is the water to be used? ...... household

How far is well from possible source of contamination? ...... 40 ft.

What is source of contamination? ...... septic tank

Enclose a copy of any mineral analysis that has been made of water ....

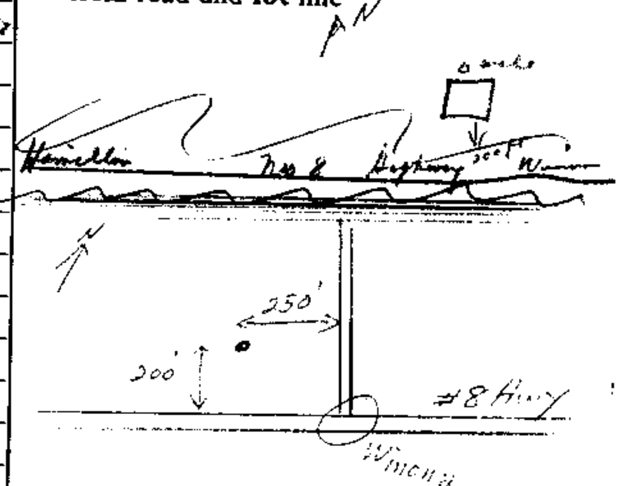
Depth(s) to Water Horizon(s)	Kind of Water	No. of Feet Water Rises
36 ft	Salt	~~12 ft~~ 12

Well Log

Drift and Bedrock Record	From	To
Red clay	0 ft.	10 ft.
Red shale	10	36 ft

Location of Well

In diagram below show distances of well from road and lot line



Situation: Is well on upland, in valley, or on hillside? ...... upland

Drilling Firm ...... J. Grice

Address ...... 55 alpine ave

Recorded by .... Address ...... 55 alpine ave

Date ...... Feb 25 1951 ...... Licence Number ...... No. 3

CSS.S8

UTM [|] Z [| | | | | |] E
[9] R [| | | | | |] N
Elev. [9] R [| | | |]
Basin [2|4] [| |]

36

ONTARIO

RECEIVED
JUL 31 1951 68
GEOLOGICAL BRANCH
DEPARTMENT OF MINES

№ 4531

The Well Drillers Act
Department of Mines, Province of Ontario

Water Well Record

[redacted] ~~Village, Town or City~~ ... Saltfleet
[redacted] own or City) ... Barton St. E.
[redacted] ... Winona
Date Completed ... July 26 (day) (month) 1951 (year) ... Cost of Well (excluding pump) ... 180.00

Pipe and Casing Record		Pumping Test	
Casing diameter(s)	6 1/4	Date	July 26 1951
Length(s) of casing(s)	9'	Static level	~~26~~ 4'
Type of screen	None	Pumping level	20'
Length of screen		Pumping rate	2 gal. min
Distance from top of screen to ground level		Duration of test	1/2 hour
Is well a gravel-wall type?	no	Distance from cylinder or bowls to ground level	

Water Record

Kind (fresh or mineral) ... fresh
Quality (hard, soft, contains iron, sulphur, etc.) ... hard
Appearance (clear, cloudy, coloured) ... clear
For what purpose(s) is the water to be used? ... household
How far is well from possible source of contamination? ... 40'
What is the source of contamination? ... Septic Tank
Enclose a copy of any mineral analysis that has been made of water ...

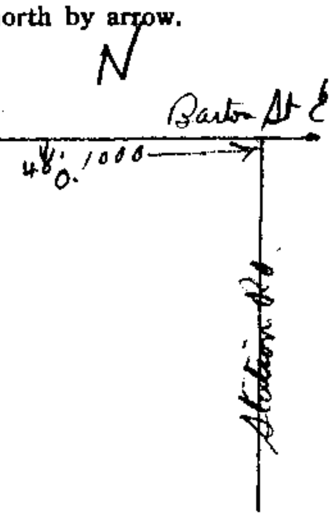
Depth(s) to Water Horizon(s)	Kind of Water	No. of Feet Water Rises
30'	Good	26'

Well Log

Overburden and Bedrock Record	From	To
Red clay	0 ft.	8 ft.
Red Shale	8'	30'

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



Situation: Is well on upland, in valley, or on hillside? ... upland
Drilling Firm ... S. Gill
Address ... 55 ... Ave
Name of Driller ... S. Gill ... Address ...
Date ... July 30 1951 ... Licence Number ... 3

S. Gill
Signature of Licensee

Form 5

CSS.S8

UTM | 1 | Z | | E
| 5 | R | | N
Elev. | 4 | R | |
Basin | 214 | |

68 № 4727

GROUND WATER BRANCH
JAN 1 0 1960
ONTARIO WATER
RESOURCES COMMISSION

The Ontario Water Resources Commission Act, 1957

WATER WELL RECORD

County or District Wentworth Township, ~~Village, Town or City~~ Saltfleet

[redacted] completed 20 (day) 6 (month) 59 (year)

[redacted]ress Winona

Casing and Screen Record	
Inside diameter of casing	5"
Total length of casing	35'
Type of screen	—
Length of screen	—
Depth to top of screen	—
Diameter of finished hole	5"

Pumping Test	
Static level	25'
Test-pumping rate	1 G.P.M.
Pumping level	50'
Duration of test pumping	30 min.
Water clear or cloudy at end of test	Clear
Recommended pumping rate	1 G.P.M.
with pumping level of	50'

Well Log / **Water Record**

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	No. of feet water rises	Kind of water (fresh, salty, sulphur)
Clay	0'	35'	DCO		
Red Shale	35'	59'	36' 59	34'	Fresh

For what purpose(s) is the water to be used?
House

Is well on upland, in valley, or on hillside?
Hillside

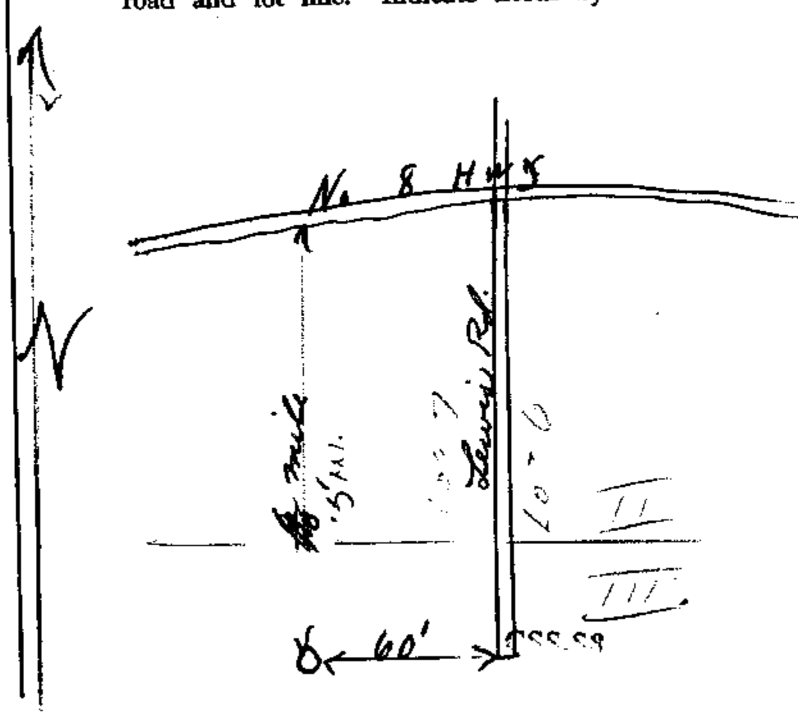
Drilling Firm Frank Merritt
Address R. R. 1, Smithville, Ont.

Licence Number 705
Name of Driller Frank Merritt
Address R. R. 1, Smithville, Ont.
Date Dec 14/59

Frank Merritt
(Signature of Licensed Drilling Contractor)

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



Form 5
15M-58-4149

Ministry of the Environment
Ontario

The Ontario Water Resources
WATER WELL RECORD

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

11 | 6811516 | MUNICIP 68008 | CON.

COUNTY OR DISTRICT	TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE	CON. BLOCK, TRACT, SURVEY, ETC.	LOT
[redacted]	Saltfleet	3	8

[redacted] 682 Arvin Ave Stoney Creek — DATE COMPLETED: DAY 13 MO June YR 88

RC | ELEVATION | RC | BASIN CODE

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	DEPTH - FEET TO
Grey	Limestone			0	60

31

32

41 WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
34-55	☒ 1 FRESH ☐ 2 SALTY ☐ 3 SULPHUR ☐ 4 MINERALS ☐ 6 GAS
	☐ 1 FRESH ☐ 2 SALTY ☐ 3 SULPHUR ☐ 4 MINERALS ☐ 6 GAS
	☐ 1 FRESH ☐ 2 SALTY ☐ 3 SULPHUR ☐ 4 MINERALS ☐ 6 GAS
	☐ 1 FRESH ☐ 2 SALTY ☐ 3 SULPHUR ☐ 4 MINERALS ☐ 6 GAS
	☐ 1 FRESH ☐ 2 SALTY ☐ 3 SULPHUR ☐ 4 MINERALS ☐ 6 GAS

51 CASING & OPEN HOLE RECORD

INSIDE DIAM INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	DEPTH - FEET TO
6 1/4	☒ 1 STEEL ☐ 2 GALVANIZED ☐ 3 CONCRETE ☒ 4 OPEN HOLE ☐ 5 PLASTIC	.188	0	20
			20	60
	☐ 1 STEEL ☐ 2 GALVANIZED ☐ 3 CONCRETE ☐ 4 OPEN HOLE ☐ 5 PLASTIC			
	☐ 1 STEEL ☐ 2 GALVANIZED ☐ 3 CONCRETE ☐ 4 OPEN HOLE ☐ 5 PLASTIC			

Well filled

SCREEN

SIZE(S) OF OPENING (SLOT NO.)	DIAMETER INCHES	LENGTH FEET

MATERIAL AND TYPE	DEPTH TO TOP OF SCREEN FEET

61 PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)
Nil	Nil	

71 PUMPING TEST

PUMPING TEST METHOD	PUMPING RATE	DURATION OF PUMPING
☐ 1 PUMP ☒ 2 BAILER	1 1/4 GPM	1 HOURS MINS

STATIC LEVEL	WATER LEVEL END OF PUMPING	15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
28 FEET	55 FEET	55 FEET	55 FEET	55 FEET	55 FEET

WATER LEVELS DURING: ☐ 1 PUMPING ☐ 2 RECOVERY

IF FLOWING, GIVE RATE ___ GPM | PUMP INTAKE SET AT ___ FEET | WATER AT END OF TEST: ☐ 1 CLEAR ☐ 2 CLOUDY

RECOMMENDED PUMP TYPE: ☐ SHALLOW ☐ DEEP | RECOMMENDED PUMP SETTING ___ FEET | RECOMMENDED PUMPING RATE ___ GPM

FINAL STATUS OF WELL

☒ 1 WATER SUPPLY ☐ 2 OBSERVATION WELL ☐ 3 TEST HOLE ☐ 4 RECHARGE WELL ☐ 5 ABANDONED, INSUFFICIENT SUPPLY ☐ 6 ABANDONED, POOR QUALITY ☐ 7 UNFINISHED ☐ 9 DEWATERING

WATER USE

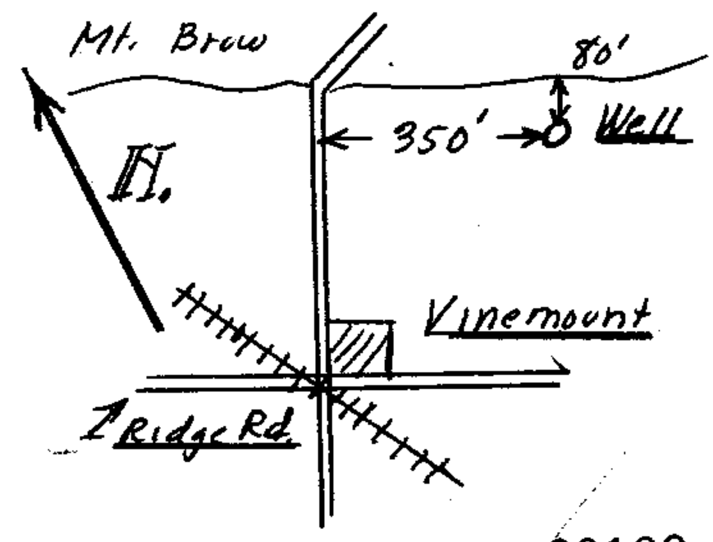
☒ 1 DOMESTIC ☒ 2 STOCK ☐ 3 IRRIGATION ☐ 4 INDUSTRIAL ☐ OTHER ☐ 5 COMMERCIAL ☐ 6 MUNICIPAL ☐ 7 PUBLIC SUPPLY ☐ 8 COOLING OR AIR CONDITIONING ☐ 9 NOT USED

METHOD OF CONSTRUCTION

☒ 1 CABLE TOOL ☐ 2 ROTARY (CONVENTIONAL) ☐ 3 ROTARY (REVERSE) ☐ 4 ROTARY (AIR) ☐ 5 AIR PERCUSSION ☐ 6 BORING ☐ 7 DIAMOND ☐ 8 JETTING ☐ 9 DRIVING ☐ DIGGING ☐ OTHER

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



20192

DRILLERS REMARKS

CONTRACTOR

NAME OF WELL CONTRACTOR: G. J. Wallis | WELL CONTRACTOR'S LICENCE NUMBER: 5417

ADDRESS: RR#2 Stoney Creek

NAME OF WELL TECHNICIAN | WELL TECHNICIAN'S LICENCE NUMBER

SIGNATURE OF TECHNICIAN/CONTRACTOR: George J Wallis | SUBMISSION DATE DAY ___ MO ___ YR ___

OFFICE USE ONLY

DATA SOURCE | CONTRACTOR 5417 | DATE RECEIVED SEP 07 1988

DATE OF INSPECTION | INSPECTOR

REMARKS

CSS.ES

MINISTRY OF THE ENVIRONMENT COPY

FORM NO. 0506 (11/86) FORM 9

Ministry of the Environment
Ontario

The Ontario Water Resources Act
WATER WELL RECORD

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

11 | 6812080 | MUNICIP. 68008 | CON. CON | 03

COUNTY OR DISTRICT	TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE	CON., BLOCK, TRACT, SURVEY, ETC.	LOT
[redacted] of Stoney creek		Conc 3	8

[redacted] Ridge Rd., Vinemount, Ont L0R-3G0

DATE COMPLETED: DAY 27 MO. 08 YR. 91

ELEVATION | RC. | BASIN CODE

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	DEPTH - FEET TO
Brown	Clay		Loose	0	12
Grey	Clay		Loose	12	31
Grey	Limestone		Hard	31	90
Red	Shale		Hard	90	105
Grey	Limestone		Hard	105	109
Red	Shale		Hard	109	130
Blue	Shale		Hard	130	140

31

32

41 WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
	1 ☐ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERALS 6 ☐ GAS
	1 ☐ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERALS 6 ☐ GAS
	1 ☐ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERALS 6 ☐ GAS
	1 ☐ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERALS 6 ☐ GAS
	1 ☐ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERALS 6 ☐ GAS

51 CASING & OPEN HOLE RECORD

INSIDE DIAM INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	DEPTH - FEET TO
6¼	1 ☒ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE 5 ☐ PLASTIC	.188	1	31
6	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☒ OPEN HOLE 5 ☐ PLASTIC		31	140
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE 5 ☐ PLASTIC			

SCREEN

SIZE(S) OF OPENING (SLOT NO.)	DIAMETER INCHES	LENGTH FEET
MATERIAL AND TYPE	DEPTH TO TOP OF SCREEN FEET	

61 PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)

71 PUMPING TEST

PUMPING TEST METHOD: 1 ☒ PUMP 2 ☐ BAILER
PUMPING RATE: 4GAL/Hr xx
DURATION OF PUMPING: 1 HOURS 0 MINS

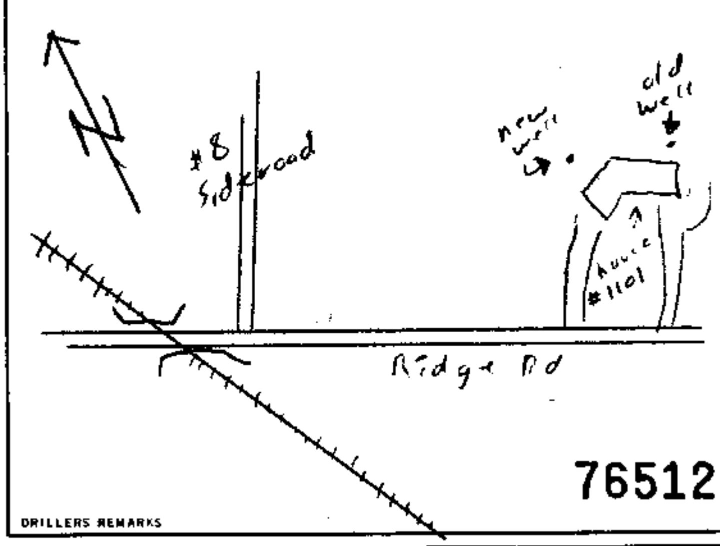
STATIC LEVEL	WATER LEVEL END OF PUMPING	15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
25 FEET	138 FEET	138 FEET	138 FEET	138 FEET	138 FEET

WATER LEVELS DURING: 1 ☐ PUMPING 2 ☐ RECOVERY

IF FLOWING, GIVE RATE: GPM
PUMP INTAKE SET AT: FEET
WATER AT END OF TEST: 1 ☐ CLEAR 2 ☒ CLOUDY
RECOMMENDED PUMP TYPE: ☐ SHALLOW ☐ DEEP
RECOMMENDED PUMP SETTING: FEET
RECOMMENDED PUMPING RATE: GPM

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



76512

DRILLERS REMARKS

FINAL STATUS OF WELL

1 ☒ WATER SUPPLY
2 ☐ OBSERVATION WELL
3 ☐ TEST HOLE
4 ☐ RECHARGE WELL
5 ☐ ABANDONED, INSUFFICIENT SUPPLY
6 ☐ ABANDONED, POOR QUALITY
7 ☐ UNFINISHED
☐ DEWATERING

WATER USE

1 ☒ DOMESTIC
2 ☐ STOCK
3 ☐ IRRIGATION
4 ☐ INDUSTRIAL
☐ OTHER
5 ☐ COMMERCIAL
6 ☐ MUNICIPAL
7 ☐ PUBLIC SUPPLY
8 ☐ COOLING OR AIR CONDITIONING
9 ☐ NOT USED

METHOD OF CONSTRUCTION

1 ☐ CABLE TOOL
2 ☐ ROTARY (CONVENTIONAL)
3 ☐ ROTARY (REVERSE)
4 ☐ ROTARY (AIR)
5 ☒ AIR PERCUSSION
6 ☐ BORING
7 ☐ DIAMOND
8 ☐ JETTING
9 ☐ DRIVING
☐ DIGGING
☐ OTHER

CONTRACTOR

NAME OF WELL CONTRACTOR: O'Connor well Drilling Ltd
WELL CONTRACTOR'S LICENCE NUMBER: 4005
ADDRESS: RR#1 Millgrove, Ont., L0R-1V0
NAME OF WELL TECHNICIAN: J.B. O'Connor
WELL TECHNICIAN'S LICENCE NUMBER: T-0148
SIGNATURE OF TECHNICIAN/CONTRACTOR: John W O'Connor
SUBMISSION DATE: DAY ___ MO. ___ YR. ___

OFFICE USE ONLY

DATA SOURCE | CONTRACTOR 4005 | DATE RECEIVED SEP 12 1991
DATE OF INSPECTION | INSPECTOR
REMARKS

CSS.ES

MINISTRY OF THE ENVIRONMENT COPY

FORM NO. 0506 (11/86) FORM 9

Ontario Ministry of Environment and Energy

The Ontario Water Resources Act
WATER WELL RECORD

Print only in spaces provided.
Mark correct box with a checkmark, where applicable.

11 — **6813862** — Municipality 68008 — Con. CON 03

County or District	Township/Borough/City/Town/Village	Con. block tract survey, etc.	Lot
[redacted]	Salt-fleet	Con 3	6

Address of Well Location: 1181 Ridge Rd — Date completed: 25 day 8 month 03 year

21 — UTM Zone — Easting — Northing — RC — Elevation — RC — Basin Code — ii — iii — iv

LOG OF OVERBURDEN AND BEDROCK MATERIALS (see instructions)

General colour	Most common material	Other materials	General description	Depth - feet From	Depth - feet To
			hand dug well	0	25
			previously drilled	25	46
	concrete		bottom dug hole	25	24½
	hole plug			24½	24
	screenings			24	11
	hole plug			11	10
	screenings	dug well plugged to 5'		10	5

31

32

WATER RECORD (41)

Water found at - feet	Kind of water
28	☑ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
45	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas

CASING & OPEN HOLE RECORD (51)

Inside diam inches	Material	Wall thickness inches	Depth - feet From	To
6¼	☑ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic	.188	0	25
5¾	☐ Steel ☐ Galvanized ☐ Concrete ☑ Open hole ☐ Plastic		25	46
	☐ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic			

SCREEN

Sizes of opening (Slot No.)	Diameter (Inches)	Length (feet)

Material and type	Depth at top of screen (feet)

PLUGGING & SEALING RECORD (61)

☐ Annular space ☐ Abandonment

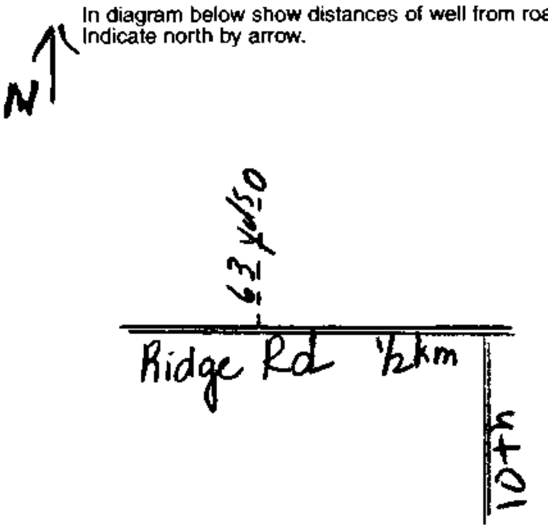
Depth set at - feet From	To	Material and type (Cement grout, bentonite, etc.)

PUMPING TEST (71)

Pumping test method: ☐ Pump ☑ Bailer	Pumping rate: 6 GPM	Duration of pumping: 1 Hours __ Mins			
Static level: 32 feet	Water level end of pumping: feet	Water levels during ☐ Pumping ☐ Recovery: 15 minutes feet	30 minutes feet	45 minutes feet	60 minutes feet
If flowing give rate: GPM	Pump intake set at: feet	Water at end of test: ☐ Clear ☐ Cloudy			
Recommended pump type: ☐ Shallow ☑ Deep	Recommended pump setting: 43 feet	Recommended pump rate: 5 GPM			

LOCATION OF WELL

In diagram below show distances of well from road and lot line. Indicate north by arrow.



260445

FINAL STATUS OF WELL (54)

☑ 1 Water supply ☐ 2 Observation well ☐ 3 Test hole ☐ 4 Recharge well ☐ 5 Abandoned, insufficient supply ☐ 6 Abandoned, poor quality ☐ 7 Abandoned (Other) ☐ 8 Dewatering ☐ 9 Unfinished ☐ 10 Replacement well

WATER USE (55-56)

☑ 1 Domestic ☐ 2 Stock ☐ 3 Irrigation ☐ 4 Industrial ☐ 5 Commercial ☐ 6 Municipal ☐ 7 Public supply ☐ 8 Cooling & air conditioning ☐ 9 Not use ☐ 10 Other

METHOD OF CONSTRUCTION (57)

☑ 1 Cable tool ☐ 2 Rotary (conventional) ☐ 3 Rotary (reverse) ☐ 4 Rotary (air) ☐ 5 Air percussion ☐ 6 Boring ☐ 7 Diamond ☐ 8 Jetting ☐ 9 Driving ☐ 10 Digging ☐ 11 Other

Name of Well Contractor: Donald Merritt	Well Contractor's Licence No.: 3640
Address: RR#1 Smithville	
Name of Well Technician: Donald Merritt	Well Technician's Licence No.: T372
Signature of Technician/Contractor: Donald Merritt	Submission date: 26 8 03

MINISTRY USE ONLY

Data source	Contractor: 3640	Date received: SEP 08 2003
Date of inspection	Inspector	
Remarks		

2 - MINISTRY OF ENVIRONMENT AND ENERGY COPY

0506 (06/02) Front Form 9

Sep 540519 [redacted] May 6/04

Ontario Ministry of the Environment

Well Tag Number (Place sticker and print number below)
A01179B
A 011798

Well Record

Regulation 903 Ontario Water Resources Act

page ___ of ___

Instructions for Completing Form

- For use in the **Province of Ontario** only. This document is a permanent **legal** document. Please retain for future reference.
- All Sections **must** be completed in full to avoid delays in processing. Further instructions and explanations are available on the back of this form.
- Questions regarding completing this application can be directed to the Water Well Management Coordinator at 416-235-6203.
- **All metre measurements shall be reported to 1/10th of a metre.**
- Please print clearly in blue or black ink only.

Ministry Use Only

MUN 68008 CON ____ LOT ____

Well Owner's Information and Location of Well Information

[redacted]

Address of Well Location (County/District/Municipality)	Township	Lot	Concession
Stoney Creek			

RR#/Street Number/Name	City/Town/Village	Site/Compartment/Block/Tract etc.
1052 South Service Rd	Stoney Creek	

GPS Reading NAD 8 3 Zone 17 Easting 608930 Northing 4786290 | Unit Make/Model | Mode of Operation: ☐ Undifferentiated ☐ Averaged ☐ Differentiated, specify

Log of Overburden and Bedrock Materials (see instructions)

General Colour	Most common material	Other Materials	General Description	Depth Metres From	Depth Metres To
Grey	Gravle			0	.60
Brown	Till			.60	4.50
Grey	dry clay			4.50	6.0

Hole Diameter

Depth Metres From	Depth Metres To	Diameter Centimetres
6.0	0	15

Water Record

Water found at ? Metres — Kind of Water

- ☐ m ☐ Fresh ☐ Sulphur ☐ Gas ☐ Salty ☐ Minerals ☐ Other:
- ☐ m ☐ Fresh ☐ Sulphur ☐ Gas ☐ Salty ☐ Minerals ☐ Other:
- ☐ m ☐ Fresh ☐ Sulphur ☐ Gas ☐ Salty ☐ Minerals ☐ Other:

After test of well yield, water was ☐ Clear and sediment free ☐ Other, specify

Chlorinated ☐ Yes ☐ No

Construction Record

Inside diam centimetres	Material	Wall thickness centimetres	Depth Metres From	Depth Metres To
Casing				
5	☐ Steel ☐ Fibreglass ☑ Plastic ☐ Concrete ☐ Galvanized	.7	3.0	0
	☐ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized			
	☐ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized			
Screen (Outside diam)		Slot No.		
6.4	☐ Steel ☐ Fibreglass ☑ Plastic ☐ Concrete ☐ Galvanized	10	6.0	3.0
No Casing or Screen	☐ Open hole			

Test of Well Yield

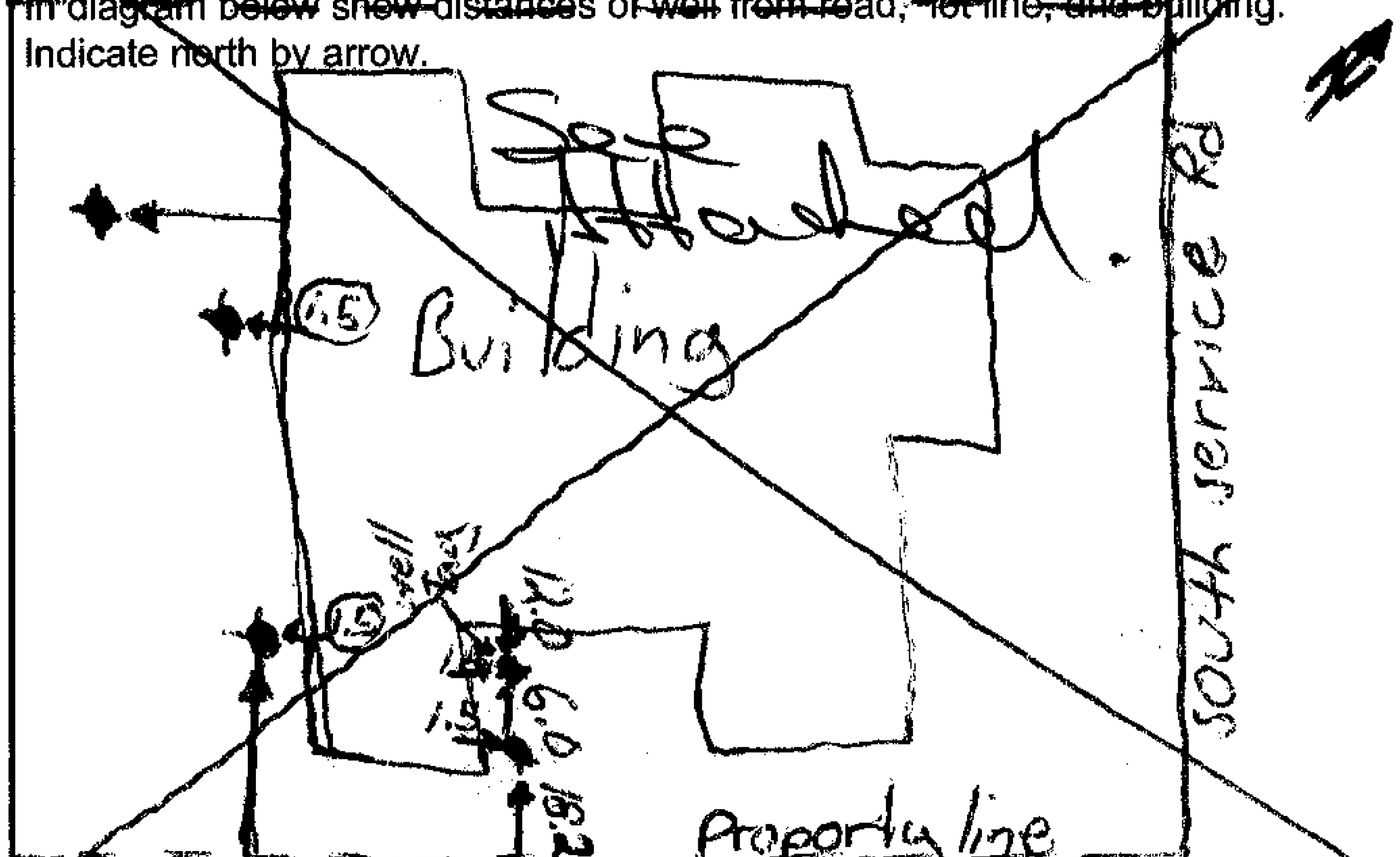
Pumping test method	Draw Down Time min	Draw Down Water Level Metres	Recovery Time min	Recovery Water Level Metres
Pump intake set at - (metres)	Static Level			
Pumping rate - (litres/min)	1		1	
Duration of pumping ____hrs + ____ min	2		2	
Final water level end of pumping ____metres	3		3	
Recommended pump type. ☐ Shallow ☐ Deep	4		4	
Recommended pump depth. ____metres	5		5	
Recommended pump rate. (litres/min)	10		10	
	15		15	
If flowing give rate - (litres/min)	20		20	
	25		25	
If pumping discontinued, give reason.	30		30	
	40		40	
	50		50	
	60		60	

Plugging and Sealing Record ☐ Annular space ☐ Abandonment

Depth set at - Metres From	To	Material and type (bentonite slurry, neat cement slurry) etc.	Volume Placed (cubic metres)
6.0	2.9	Sand	
2.9	0	Bentonite	

Location of Well

~~In diagram below show distances of well from road, lot line, and building.~~ Indicate north by arrow.



Method of Construction

☐ Cable Tool ☐ Rotary (conventional) ☐ Rotary (reverse) ☐ Rotary (air) ☐ Air percussion ☑ Boring ☐ Diamond ☐ Jetting ☐ Driving ☐ Digging ☐ Other

Water Use

☐ Domestic ☐ Stock ☐ Irrigation ☐ Industrial ☐ Commercial ☐ Municipal ☐ Public Supply ☐ Not used ☐ Cooling & air conditioning ☑ Other

Final Status of Well

☐ Water Supply ☑ Observation well ☐ Test Hole ☐ Recharge well ☐ Abandoned, insufficient supply ☐ Abandoned, poor quality ☐ Unfinished ☐ Dewatering ☐ Replacement well ☐ Abandoned, (Other)

Audit No. Z 11853

Date Well Completed YYYY 04 MM 05 DD 06

Was the well owner's information package delivered? ☐ Yes ☐ No

Date Delivered YYYY MM DD

Well Contractor/Technician Information

Name of Well Contractor: Geo-Environmental — Well Contractor's Licence No. 6607

Business Address (street name, number, city etc.): 340 Market Dr. Milton

Name of Well Technician (last name, first name): Justin DesRoches — Well Technician's Licence No. 03-969

Signature of Technician/Contractor X [signature] — Date Submitted YYYY 2004 MM 05 DD 06

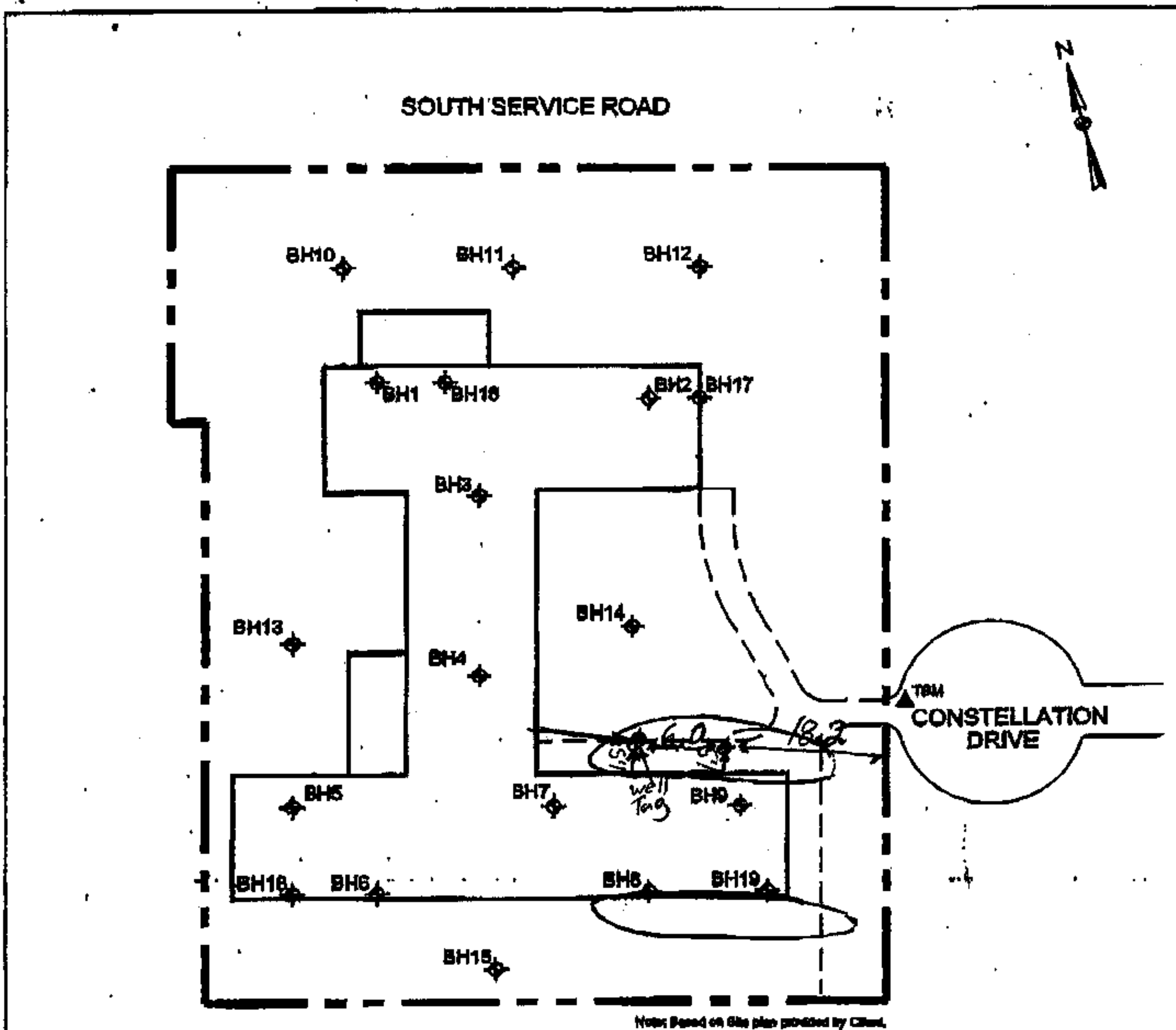
Ministry Use Only

Data Source — Contractor 6607

Date Received SEP 23 2004 — Date of Inspection YYYY MM DD

Remarks — Well Record Number 6814096

0506E (09/03) Contractor's Copy ☐ Ministry's Copy ☐ Well Owner's Copy ☐ *Cette formule est disponible en français*



Note: Based on Site plan provided by Client.

LEGEND

- APPROXIMATE PROPERTY BOUNDARY
- PROPOSED BUILDING LOCATION
- EXISTING ROADWAY
- PROPOSED ROADWAY
- BH3 BOREHOLE (AMEC, DECEMBER 2002 & January 2003)
- TBM TEMPORARY BENCH MARK (PK Nail 1, Elevation = 82.612 m)

6607 Z11853 SEP 2 3 2004

APPROXIMATE SCALE

amec Earth & Environmental	Date: January 2003	Approximate Scale: 1 : 1,750	Project No.: TB02018G
Vacant Property South Service Road Stoney Creek, Ontario	Drawn by: KH	Approved by: JC	Figure No.: 2 Borehole Location Plan

Ontario | Ministry of the Environment

Well Tag Number (Place sticker and print number below) A011798

Well Record

Regulation 903 Ontario Water Resources Act

page 1 of 1

Instructions for Completing Form

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- **All metre measurements shall be reported to 1/10th of a metre.**
- Please print clearly in blue or black ink only.

Ministry Use Only

[redacted]

Address of Well Location (County/District/Municipality)	Township	Lot	Concession
1052 South Service Rd.			

RR#/Street Number/Name	City/Town/Village	Site/Compartment/Block/Tract etc.
	Stoney Creek	

GPS Reading: NAD 83 | Zone 17 | Easting 608930 | Northing 4786290 | Unit Make/Model | Mode of Operation: ☐ Undifferentiated ☐ Averaged ☐ Differentiated, specify

Log of Overburden and Bedrock Materials (see instructions)

General Colour	Most common material	Other Materials	General Description	Depth Metres From	Depth Metres To
			see attached well record.		

Hole Diameter

Depth Metres From	Depth Metres To	Diameter Centimetres

Water Record

Water found at ___ Metres / Kind of Water

- ___ m ☐ Fresh ☐ Sulphur ☐ Gas ☐ Salty ☐ Minerals ☐ Other:
- ___ m ☐ Fresh ☐ Sulphur ☐ Gas ☐ Salty ☐ Minerals ☐ Other:
- ___ m ☐ Fresh ☐ Sulphur ☐ Gas ☐ Salty ☐ Minerals ☐ Other:

After test of well yield, water was ☐ Clear and sediment free ☐ Other, specify

Chlorinated ☐ Yes ☐ No

Construction Record

Inside diam centimetres	Material	Wall thickness centimetres	Depth Metres From	Depth Metres To
Casing				
	☐ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized			
	☐ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized			
	☐ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized			
Screen				
Outside diam	☐ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized	Slot No.		
No Casing or Screen				
	☐ Open hole			

Test of Well Yield

Pumping test method	Draw Down Time min	Draw Down Water Level Metres	Recovery Time min	Recovery Water Level Metres
Pump intake set at - (metres)	Static Level			
Pumping rate - (litres/min)	1		1	
Duration of pumping ___hrs + ___ min	2		2	
Final water level end of pumping ___ metres	3		3	
Recommended pump type. ☐ Shallow ☐ Deep	4		4	
Recommended pump depth. ___ metres	5		5	
Recommended pump rate. (litres/min)	10		10	
	15		15	
If flowing give rate - (litres/min)	20		20	
	25		25	
If pumping discontinued, give reason.	30		30	
	40		40	
	50		50	
	60		60	

Plugging and Sealing Record

☐ Annular space ☒ Abandonment

Depth set at - Metres From	Depth set at - Metres To	Material and type (bentonite slurry, neat cement slurry) etc.	Volume Placed (cubic metres)
0	6.0	Benseal	.08

Method of Construction

☐ Cable Tool ☐ Rotary (conventional) ☐ Rotary (reverse) ☐ Rotary (air) ☐ Air percussion ☐ Boring ☐ Diamond ☐ Jetting ☐ Driving ☐ Digging ☐ Other

Water Use

☐ Domestic ☐ Stock ☐ Irrigation ☐ Industrial ☐ Commercial ☐ Municipal ☐ Public Supply ☐ Not used ☐ Cooling & air conditioning ☐ Other

Final Status of Well

☐ Water Supply ☐ Observation well ☐ Test Hole ☐ Recharge well ☐ Abandoned, insufficient supply ☐ Abandoned, poor quality ☐ Unfinished ☐ Dewatering ☐ Replacement well ☒ Abandoned, (Other)

Well Contractor/Technician Information

Name of Well Contractor	Well Contractor's Licence No.
Groundwater Drilling Inc.	7091

Business Address (street name, number, city etc.): 28 Taber Rd. Toronto.

Name of Well Technician (last name, first name)	Well Technician's Licence No.
Rick Bertram	T 3165

Signature of Technician/Contractor: X [signature] | Date Submitted: 2004 12 15

Location of Well

In diagram below show distances of well from road, lot line, and building. Indicate north by arrow.

Audit No. Z 09227 | Date Well Completed YYYY MM DD | Date Delivered YYYY MM DD

Was the well owner's information package delivered? ☐ Yes ☐ No

Ministry Use Only

Data Source	Contractor 7091
Date Received APR 27 2005	Date of Inspection YYYY MM DD
Remarks D.W.C. via fax 2004/4/02	Well Record Number

0506E (09/03) Contractor's Copy ☐ Ministry's Copy ☑ Well Owner's Copy ☐ *Cette formule est disponible en français*

Sep 049314 [redacted] JP5268

Ontario Ministry of the Environment

Well Tag Number (Place sticker and print number below) A01179B

A011798

Well Record

Regulation 903 Ontario Water Resources Act

page ___ of ___

Instructions for Completing Form

- For use in the **Province of Ontario** only. This document is a permanent **legal** document. **Please retain for future reference.**
- All Sections must be completed in full to avoid delays in processing. Further instructions and explanations are available on the back of this form.
- Questions regarding completing this application can be directed to the Water Well Management Coordinator at 416-235-6203.
- **All metre measurements shall be reported to 1/10th of a metre.**
- Please print clearly in blue or black ink only.

Ministry Use Only: MUN ___ CON ___ LOT ___

Well Owner's Information and Location of Well Information

First Name	Last Name	Mailing Address (Street Number/Name, RR, Lot, Concession)
FTL Realty (Division of Russel Metals Inc)		95 St. Clair Ave. West Suite 1101

County/District/Municipality	Township/City/Town/Village	Province	Postal Code	Telephone Number (include area code)
	Toronto	Ontario	M4V 1N6	416-515-9393

Address of Well Location (County/District/Municipality)	Township	Lot	Concession
Stoney Creek			

RR#/Street Number/Name	City/Town/Village	Site/Compartment/Block/Tract etc.
1052 South Service Rd	Stoney Creek	

GPS Reading: NAD 8 3 Zone 17 Easting 608930 Northing 4786290 Unit Make/Model ___ Mode of Operation: ☐ Undifferentiated ☐ Averaged ☐ Differentiated, specify ___

Log of Overburden and Bedrock Materials (see instructions)

General Colour	Most common material	Other Materials	General Description	Depth Metres From	To
Grey	Gravle			Ø	.60
Brown	fill			.60	4.50
Grey	dry clay			4.50	6.0

Hole Diameter

Depth Metres From	To	Diameter Centimetres
6.0	Ø	15

Water Record

Water found at 2 Metres / Kind of Water

☐ m ☐ Fresh ☐ Sulphur ☐ Gas ☐ Salty ☐ Minerals ☐ Other: ___

☐ m ☐ Fresh ☐ Sulphur ☐ Gas ☐ Salty ☐ Minerals ☐ Other: ___

☐ m ☐ Fresh ☐ Sulphur ☐ Gas ☐ Salty ☐ Minerals ☐ Other: ___

After test of well yield, water was ☐ Clear and sediment free ☐ Other, specify ___

Chlorinated ☐ Yes ☐ No

Construction Record

Inside diam centimetres	Material	Wall thickness centimetres	Depth Metres From	To
Casing				
5	☐ Steel ☐ Fibreglass ☑ Plastic ☐ Concrete ☐ Galvanized	.7	3.0	Ø
	☐ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized			
	☐ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized			
Screen		Slot No.		
Outside diam 6.4	☐ Steel ☐ Fibreglass ☑ Plastic ☐ Concrete ☐ Galvanized	10	6.0	3.0
No Casing or Screen				
	☐ Open hole			

Test of Well Yield

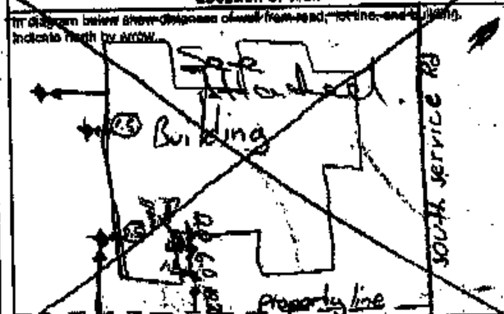
Pumping test method	Draw Down Time min	Water Level Metres	Recovery Time min	Water Level Metres
Pump intake set at - (metres)	Static Level			
Pumping rate - (litres/min)	1		1	
Duration of pumping ___ hrs + ___ min	2		2	
Final water level end of pumping ___ metres	3		3	
Recommended pump type. ☐ Shallow ☐ Deep	4		4	
Recommended pump depth. ___ metres	5		5	
Recommended pump rate. (litres/min)	10		10	
If flowing give rate - (litres/min)	15		15	
If pumping discontinued, give reason.	20		20	
	25		25	
	30		30	
	40		40	
	50		50	
	60		60	

Plugging and Sealing Record ☐ Annular space ☐ Abandonment

Depth set at - Metres From	To	Material and type (bentonite slurry, neat cement slurry) etc.	Volume Placed (cubic metres)
6.0	2.9	Sand	
2.9	Ø	Bentonite	

Location of Well

In diagram below show distances of well from road, lot line, and building. Indicate north by arrow.



Method of Construction

☐ Cable Tool ☐ Rotary (conventional) ☐ Rotary (reverse) ☐ Rotary (air) ☐ Air percussion ☑ Boring ☐ Diamond ☐ Jetting ☐ Driving ☐ Digging ☐ Other

Water Use

☐ Domestic ☐ Stock ☐ Irrigation ☐ Industrial ☐ Commercial ☐ Municipal ☐ Public Supply ☐ Not used ☐ Cooling & air conditioning ☑ Other

Final Status of Well

☐ Water Supply ☑ Observation well ☐ Test Hole ☐ Recharge well ☐ Abandoned, insufficient supply ☐ Abandoned, poor quality ☐ Unfinished ☐ Dewatering ☐ Replacement well ☐ Abandoned, (Other)

Audit No. Z 11853 Date Well Completed YYYY 04 MM 05 DD 06

Was the well owner's information package delivered? ☐ Yes ☐ No Date Delivered YYYY MM DD

Well Contractor/Technician Information

Name of Well Contractor: Geo-Environmental

Well Contractor's Licence No.: 6607

Business Address (street name, number, city etc.): 340 Market Dr. Milton

Name of Well Technician (last name, first name): Justin Berkoches

Well Technician's Licence No.: 03-969

Signature of Technician/Contractor: X [signature]

Date Submitted YYYY MM DD: 2004 05 06

Ministry Use Only

Data Source	Contractor
Date Received YYYY MM DD	Date of Inspection YYYY MM DD
Remarks	Well Record Number

0506E (09/03) Contractor's Copy ☐ Ministry's Copy ☐ Well Owner's Copy ☐ Cette formule est disponible en français

7091

Z09227

APR 27 2006

Ontario Ministry of the Environment

Well Tag (Below) AO57027 A 057027

Well Record

Regulation 903 Ontario Water Resources Act

Page 1 of 1

Well Owner's Information

[redacted]

WINONA RD. & Q.E.W.

County/District/Municipality	City/Town/Village	Province	Postal Code
	STONEY CREEK	Ontario	

UTM Coordinates NAD 83 Zone 17 Easting 609675 Northing 4785639 | GPS Unit Make | Model | Mode of Operation: ☐ Undifferentiated ☐ Averaged ☐ Differentiated, specify

Overburden and Bedrock Materials (see instructions on the back of this form) FEET

General Colour	Most Common Material	Other Materials	General Description	Depth (~~Metres~~) From	To
BROWN	TILL		HARD	0	10'
RED	SHALE	GREEN SHALE		10'	30'

Annular Space/Abandonment Sealing Record FT

Depth Set at (~~Metres~~) From	To	Type of Sealant Used (Material and Type)	Volume Placed (Cubic Metres)
0	15'	BENTONITE HOLEPLUG	
15'	30'	SILICA SAND	

Results of Well Yield Testing

Check box if after test of well yield, water was: ☐ Clear and sand free ☐ Cannot develop to sand-free state

If pumping discontinued, give reason:

Pumping test method

Pump intake set at (Metres)

Pumping rate (Litres/min)

Duration of pumping ___ hrs + ___ min N/A

Final water level end of pumping (Metres)

Recommended pump type ☐ Shallow ☐ Deep

Recommended pump depth ___ Metres

Recommended pump rate (Litres/min)

If flowing give rate (Litres/min)

Draw Down Time (Min)	Water Level (Metres)	Recovery Time (Min)	Water Level (Metres)
Static Level		Static Level	
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60		60	

Method of Construction

☐ Cable Tool ☐ Diamond ☐ Rotary (Conventional) ☐ Jetting ☐ Rotary (Reverse) ☐ Driving ☐ Rotary (Air) ☐ Digging ☐ Air percussion ☑ Boring ☐ Other, specify

Water Use

☐ Public ☐ Commercial ☐ Not used ☐ Domestic ☐ Municipal ☐ Dewatering ☐ Livestock ☐ Test Hole ☑ Monitoring ☐ Irrigation ☐ Cooling & Air Conditioning ☐ Industrial ☐ Other, specify

Status of Well

☐ Water Supply ☐ Dewatering Well ☑ Observation and/or Monitoring Hole ☐ Replacement Well ☐ Abandoned, Insufficient Supply ☐ Alteration (Construction) ☐ Test Hole ☐ Abandoned, Poor Water Quality ☐ Other, specify ☐ Recharge Well ☐ Abandoned, other, specify

Location of Well

Please provide a map below showing:
- all property boundaries, and measurements sufficient to locate the well in relation to fixed points,
- an arrow indicating the North direction
- detailed drawings can be provided as attachments no larger than legal size (8.5" by 14")
- vidigital pictures of inside of well can also be provided

SEE ATTACHED

Water Details N/A

Water found at Depth ___ Metres ☐ Gas — Kind of Water ☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals

Water found at Depth ___ Metres ☐ Gas — Kind of Water ☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals

Water found at Depth ___ Metres ☐ Gas — Kind of Water ☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals

Date Well Completed (yyyy/mm/dd)	Was the well owner's information package delivered?	Date the Well Record and Package Delivered to Well Owner (yyyy/mm/dd)
2007/07/27	☐ Yes ☑ No	

Casing Used: ☐ Galvanized ☐ Steel ☐ Fibreglass ☑ Plastic ☐ Concrete

Screen Used: ☐ Galvanized ☐ Steel ☐ Fibreglass ☑ Plastic ☐ Concrete

Casing and Well Details

Diameter of the Hole (~~Centimetres~~): 3 7/8

Depth of the Hole (~~Metres~~) FEET: 30'

Wall Thickness (~~Metres~~): SCH 40

Inside Diameter of the Casing (~~Metres~~): 2"

Depth of the Casing (~~Metres~~) FEET: 20'

No Casing and Screen Used: ☐ Open Hole

Disinfected? ☐ Yes ☐ No

Well Contractor and Well Technician Information

Business Name of Well Contractor: LANTECH DRILLING SERVICES INC. — Well Contractor's Licence No. 6809

Business Address (Street No./Name, number, RR): 3661 MT. ALBERT ROAD SHARON — Municipality

Province: ONTARIO — Postal Code: L0G 1V0 — Business E-mail Address

Bus.Telephone No. (inc. area code): 9054782243 — Name of Well Technician (Last Name, First Name): TODD /ASCO

Well Technician's Licence No.: 2252 — Signature of Technician — Date Submitted (yyyy/mm/dd): 2007/08/10

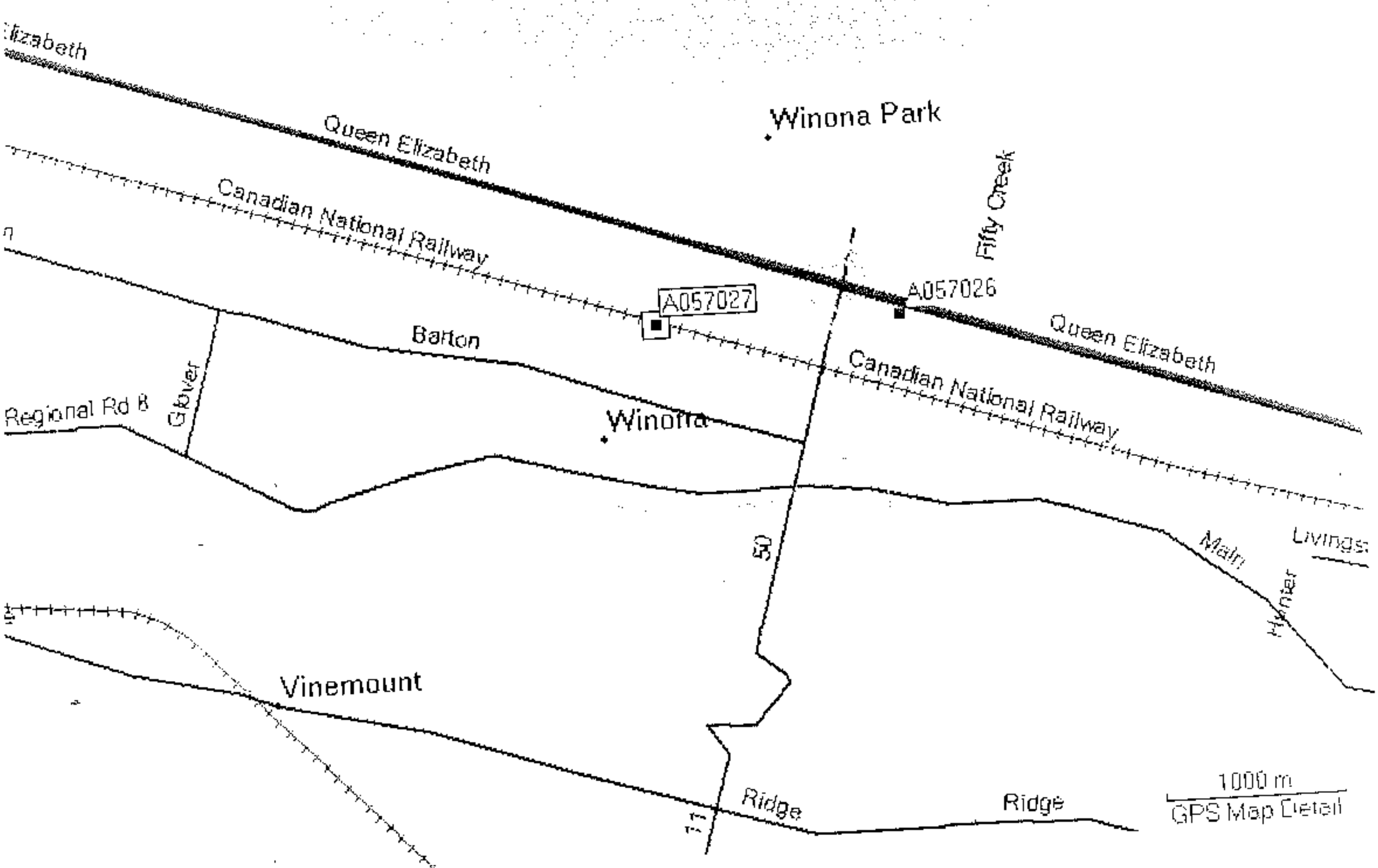
Ministry Use Only

Audit No. Z63329 — Well Contractor No. 6809

Date Received (yyyy/mm/dd): AUG 28 2007 — Date of Inspection (yyyy/mm/dd)

Remarks

0506E (11/2006) Ministry's Copy



AUG 2 8 2007

Z 63329

6809

Ontario Ministry of the Environment

Well Tag No. (Place Sticker and/or Print Below): AO56995 — A056995

Well Record

Regulation 903 Ontario Water Resources Act

Page 1 of 1

Well Owner's Information

First Name: THE CITY OF | Last Name: HAMILTON | E-mail Address: | ☐ Well Constructed by Well Owner

Mailing Address (Street Number/Name, RR): 320-77 JAMES ST. NORTH | Municipality: HAMILTON | Province: ONTARIO | Postal Code: L8R2K3 | Telephone No. (inc. area code):

Part A Construction and/or Major Alteration of a Well

Address of Well Location (Street Number/Name, RR): McNEILLY ROAD | Township: | Lot: | Concession:

County/District/Municipality: | City/Town/Village: STONEY CREEK | Province: Ontario | Postal Code:

UTM Coordinates: NAD 83 | Zone 17 | Easting 608127 | Northing 4785802 | GPS Unit Make: | Model: | Mode of Operation: ☐ Undifferentiated ☐ Averaged ☐ Differentiated, specify

Overburden and Bedrock Materials (see instructions on the back of this form)

General Colour	Most Common Material	Other Materials	General Description	Depth (~~Metres~~ FEET) From	To
BROWN	TILL			0	10'
GREY	TILL			10'	35'
RED	SHALE			35'	51'

FEET Annular Space/Abandonment Sealing Record

Depth Set at (~~Metres~~) From	To	Type of Sealant Used (Material and Type)	Volume Placed (Cubic Metres)
0	47'	BENTONITE HOLEPLUG	
47'	51'	SILICA SAND	

Results of Well Yield Testing

Check box if after test of well yield, water was: ☐ Clear and sand free ☐ Cannot develop to sand-free state

If pumping discontinued, give reason:

Pumping test method:

Pump intake set at (Metres):

Pumping rate (Litres/min):

Duration of pumping: ___ hrs + ___ min

Final water level end of pumping (Metres):

Recommended pump type: ☐ Shallow ☐ Deep

Recommended pump depth: ___ Metres

Recommended pump rate (Litres/min):

If flowing give rate (Litres/min):

N/A

Draw Down Time (Min)	Water Level (Metres)	Recovery Time (Min)	Water Level (Metres)
Static Level		Static Level	
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60		60	

Method of Construction

☐ Cable Tool ☑ Diamond ☐ Rotary (Conventional) ☐ Jetting ☐ Rotary (Reverse) ☐ Driving ☐ Rotary (Air) ☐ Digging ☐ Air percussion ☑ Boring ☐ Other, specify

Water Use

☐ Public ☐ Commercial ☐ Not used ☐ Domestic ☐ Municipal ☐ Dewatering ☐ Livestock ☐ Test Hole ☑ Monitoring ☐ Irrigation ☐ Cooling & Air Conditioning ☐ Industrial ☐ Other, specify

Status of Well

☐ Water Supply ☐ Dewatering Well ☑ Observation and/or Monitoring Hole ☐ Replacement Well ☐ Abandoned, Insufficient Supply ☐ Alteration (Construction) ☐ Test Hole ☐ Abandoned, Poor Water Quality ☐ Other, specify ☐ Recharge Well ☐ Abandoned, other, specify

Water Details

Water found at Depth ___ Metres ☐ Gas | Kind of Water: ☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals

Water found at Depth ___ Metres ☐ Gas | Kind of Water: ☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals

Water found at Depth ___ Metres ☐ Gas | Kind of Water: ☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals

N/A

Location of Well

Please provide a map below showing:
- all property boundaries, and measurements sufficient to locate the well in relation to fixed points,
- an arrow indicating the North direction
- detailed drawings can be provided as attachments no larger than legal size (8.5" by 14")
- vidigital pictures of inside of well can also be provided

SEE ATTACHED

Casing Used

☐ Galvanized ☐ Steel ☐ Fibreglass ☑ Plastic ☐ Concrete

Screen Used

☐ Galvanized ☐ Steel ☐ Fibreglass ☑ Plastic ☐ Concrete

Casing and Well Details

Diameter of the Hole (~~Centimetres~~): 3 7/8"

Depth of the Hole (~~Metres~~) FEET: 51'

Wall Thickness (~~Metres~~): SCH 40

Inside Diameter of the Casing (~~Metres~~): 2"

Depth of the Casing (~~Metres~~) FEET: 41'

No Casing and Screen Used

☐ Open Hole

Disinfected? ☐ Yes ☐ No

Date Well Completed (yyyy/mm/dd): 2007/07/24 | Was the well owner's information package delivered? ☐ Yes ☑ No | Date the Well Record and Package Delivered to Well Owner (yyyy/mm/dd):

Well Contractor and Well Technician Information

Business Name of Well Contractor: LANTECH DRILLING SERVICES INC | Well Contractor's Licence No.: 6809

Business Address (Street No./Name, number, RR): 3661 MT. ALBERT ROAD, SHARON | Municipality:

Province: ONTARIO | Postal Code: L0G1V0 | Business E-mail Address:

Bus.Telephone No. (inc. area code): 9054782245 | Name of Well Technician (Last Name, First Name): TODD PASCO

Well Technician's Licence No.: 2252 | Signature of Technician: [signature] | Date Submitted (yyyy/mm/dd): 2007/08/10

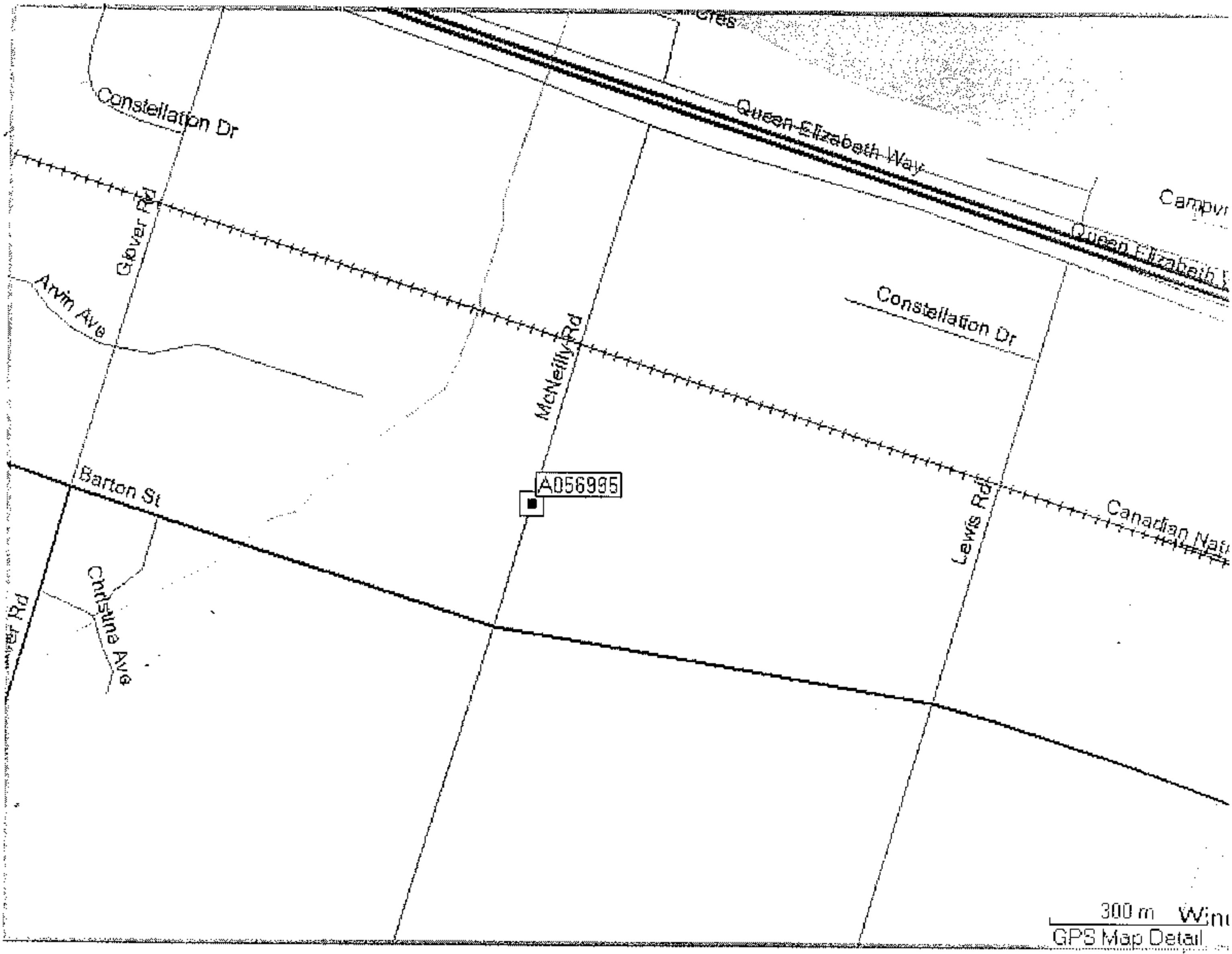
Ministry Use Only

Audit No.: Z63327 | Well Contractor No.: 6809

Date Received (yyyy/mm/dd): AUG 28 2007 | Date of Inspection (yyyy/mm/dd):

Remarks:

0506E (11/2006) Ministry's Copy



AUG 2 8 2007

Z 63327

6809

Ontario | Ministry of the Environment

Well Tag No. (Pla... **A 074667**

A074667

Well Record

Regulation 903 Ontario Water Resources Act

Well Owner's Information

[redacted]

988 Highway No 8 | Saltfleet | 9 | 2

County/District/Municipality	City/Town/Village	Province	Postal Code
Wentworth	Stoney Creek	Ontario	L8E5H9

UTM Coordinates	Zone	Easting	Northing	GPS Unit Make	Model	Mode of Operation:
NAD 8 3	17	607579	4784630	magellan		☐ Undifferentiated ☒ Averaged ☐ Differentiated, specify

Overburden and Bedrock Materials *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (feet) From	To
brown	sand soil	stones	packed	0	12
brown	stones	sand	loose	12	14
brown	clay	gravel	packed	14	45
brown	gravel	clay	packed	45	60
brown	sand	gravel	packed	60	70
brown	clay	gravel	packed	70	85
grey	clay		dense	85	94
brown	sand	gravel	loose	94	94-9"

Annular Space/Abandonment Sealing Record

Depth Set at (Metres) From	To	Type of Sealant Used (Material and Type)	Volume Placed (Cubic Metres)

Method of Construction

☒ Cable Tool ☐ Diamond ☐ Rotary (Conventional) ☐ Jetting ☐ Rotary (Reverse) ☐ Driving ☐ Rotary (Air) ☐ Digging ☐ Air percussion ☐ Boring ☐ Other, specify

Water Use

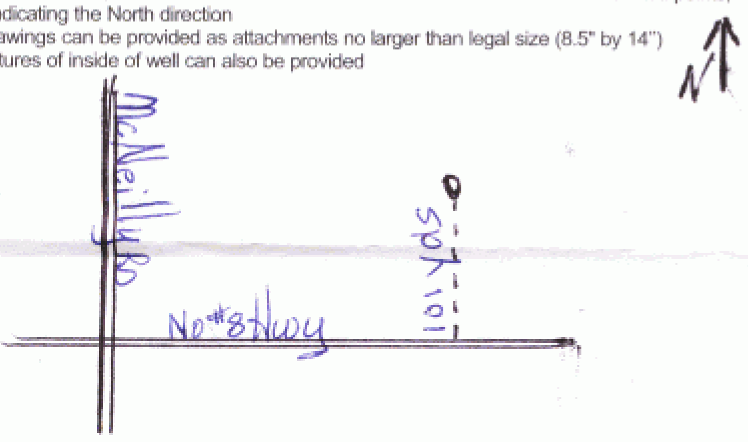
☒ Public ☐ Commercial ☐ Not used ☐ Domestic ☐ Municipal ☐ Dewatering ☐ Livestock ☐ Test Hole ☐ Monitoring ☐ Irrigation ☐ Cooling & Air Conditioning ☐ Industrial ☐ Other, specify

Status of Well

☒ Water Supply ☐ Dewatering Well ☐ Observation and/or Monitoring Hole ☐ Replacement Well ☐ Abandoned, Insufficient Supply ☐ Alteration (Construction) ☐ Test Hole ☐ Abandoned, Poor Water Quality ☐ Other, specify ☐ Recharge Well ☐ Abandoned, other, specify

Location of Well

Please provide a map below showing:
- all property boundaries, and measurements sufficient to locate the well in relation to fixed points,
- an arrow indicating the North direction
- detailed drawings can be provided as attachments no larger than legal size (8.5" by 14")
- vidigital pictures of inside of well can also be provided



Date Well Completed (yyyy/mm/dd)	Was the well owner's information package delivered?	Date the Well Record and Package Delivered to Well Owner (yyyy/mm/dd)
2009 03 24	☒ Yes ☐ No	2009 03 26

Well Contractor and Well Technician Information

Business Name of Well Contractor	Well Contractor's Licence No.
Donald Merritt	3 6 4 0

Business Address (Street No./Name, number, RR)	Municipality
7594 Regional Rd 20	Niagara

Province	Postal Code	Business E-mail Address
Ontario	L0R2A0	

Bus.Telephone No. (inc. area code)	Name of Well Technician (Last Name, First Name)
9059573370	Merritt Donald

Well Technician's Licence No.	Signature of Technician	Date Submitted (yyyy/mm/dd)
T 3 7 2	Donald Merritt	2009 03 26

Results of Well Yield Testing

Check box if after test of well yield, water was:
☐ Clear and sand free
☒ Cannot develop to sand-free state

If pumping discontinued, give reason:

Pumping test method: bailer

Pump intake set at (feet): 80

Pumping rate (gals/min): 8

Duration of pumping: 2 hrs + ___ min

Final water level end of pumping (feet): 80

Recommended pump type: ☐ Shallow ☒ Deep

Recommended pump depth: 75 feet

Recommended pump rate (gals/min): 4

If flowing give rate (Litres/min)

Draw Down Time (Min)	Water Level (feet)	Recovery Time (Min)	Water Level (feet)
Static Level	22	Static Level	75
1	29-6"	1	72-6"
2	37	2	70
3	44-6"	3	67-6
4	52	4	65
5	59-6"	5	62-6
10	75	10	50
15	75	15	38
20	75	20	28
25	75	25	22
30	75	30	22
40	75	40	22
50	75	50	22
60	75	60	22

Water Details

Water found at Depth	Kind of Water
94 feet ☐ Gas	☐ Fresh ☒ Salty ☐ Sulphur ☐ Minerals
Metres ☐ Gas	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals
Metres ☐ Gas	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals

Casing Used

☐ Galvanized ☒ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete

Screen Used

☐ Galvanized ☐ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete

No Casing and Screen Used

☐ Open Hole

Disinfected? ☒ Yes ☐ No

Casing and Well Details

Diameter of the Hole (inches): 6¼

Depth of the Hole (feet): 94

Wall Thickness (inches): .188

Inside Diameter of the Casing (inches): 6¼

Depth of the Casing (feet): 94-9"

Ministry Use Only

Audit No.	Well Contractor No.
Z61689	

Date Received (yyyy/mm/dd)	Date of Inspection (yyyy/mm/dd)
MAY 05 2009	

Remarks

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Ontario Ministry of the Environment

Well Record

Regulation 903 Ontario Water Resources Act

Measurements recorded in: ☐ Metric ☑ Imperial

Well Tag No. *(Place Sticker and/or Print Below)* A156060

[redacted]

Address of Well Location (Street Number/Name)	Township	Lot	Concession
255 WINONA RD.			

County/District/Municipality	City/Town/Village	Province	Postal Code
	WINONA	Ontario	L8E5L3

UTM Coordinates	Zone	Easting	Northing	Municipal Plan and Sublot Number	Other
NAD 83	17	593903	4312311		

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	To
BROWN	TOPSOIL		SOFT	0'	1'
BROWN	FILL		CHUNKY	1'	3'
RED	SHALE		HARD	3'	20'

Annular Space

Depth Set at (m/ft) From	To	Type of Sealant Used (Material and Type)	Volume Placed (m³/ft³)
0'	9'	5/8 BENTONITE CHIPS	

Results of Well Yield Testing

After test of well yield, water was: ☐ Clear and sand free ☐ Other, specify

If pumping discontinued, give reason:

Pump intake set at (m/ft)

Pumping rate (l/min / GPM)

Duration of pumping ___ hrs + ___ min

Final water level end of pumping (m/ft)

If flowing give rate (l/min / GPM)

Recommended pump depth (m/ft)

Recommended pump rate (l/min / GPM)

Well production (l/min / GPM)

Disinfected? ☐ Yes ☐ No

Draw Down Time (min)	Water Level (m/ft)	Recovery Time (min)	Water Level (m/ft)
Static Level			
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60		60	

Method of Construction

☐ Cable Tool ☐ Diamond ☐ Rotary (Conventional) ☐ Jetting ☐ Rotary (Reverse) ☐ Driving ☑ Boring ☐ Digging ☐ Air percussion ☐ Other, specify

Well Use

☐ Public ☐ Commercial ☐ Not used ☐ Domestic ☐ Municipal ☐ Dewatering ☐ Livestock ☐ Test Hole ☑ Monitoring ☐ Irrigation ☐ Cooling & Air Conditioning ☐ Industrial ☐ Other, specify

Construction Record - Casing

Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft) From	To
1.8"	PLASTIC	.2"	0'	10'

Construction Record - Screen

Outside Diameter (cm/in)	Material (Plastic, Galvanized, Steel)	Slot No.	Depth (m/ft) From	To
2"	PLASTIC	10'	10'	20'

Status of Well

☐ Water Supply ☐ Replacement Well ☐ Test Hole ☐ Recharge Well ☐ Dewatering Well ☐ Observation and/or Monitoring Hole ☐ Alteration (Construction) ☐ Abandoned, Insufficient Supply ☐ Abandoned, Poor Water Quality ☐ Abandoned, other, specify ☐ Other, specify

Water Details

Water found at Depth (m/ft) Kind of Water: ☐ Fresh ☐ Untested ☐ Gas ☐ Other, specify

Water found at Depth (m/ft) Kind of Water: ☐ Fresh ☐ Untested ☐ Gas ☐ Other, specify

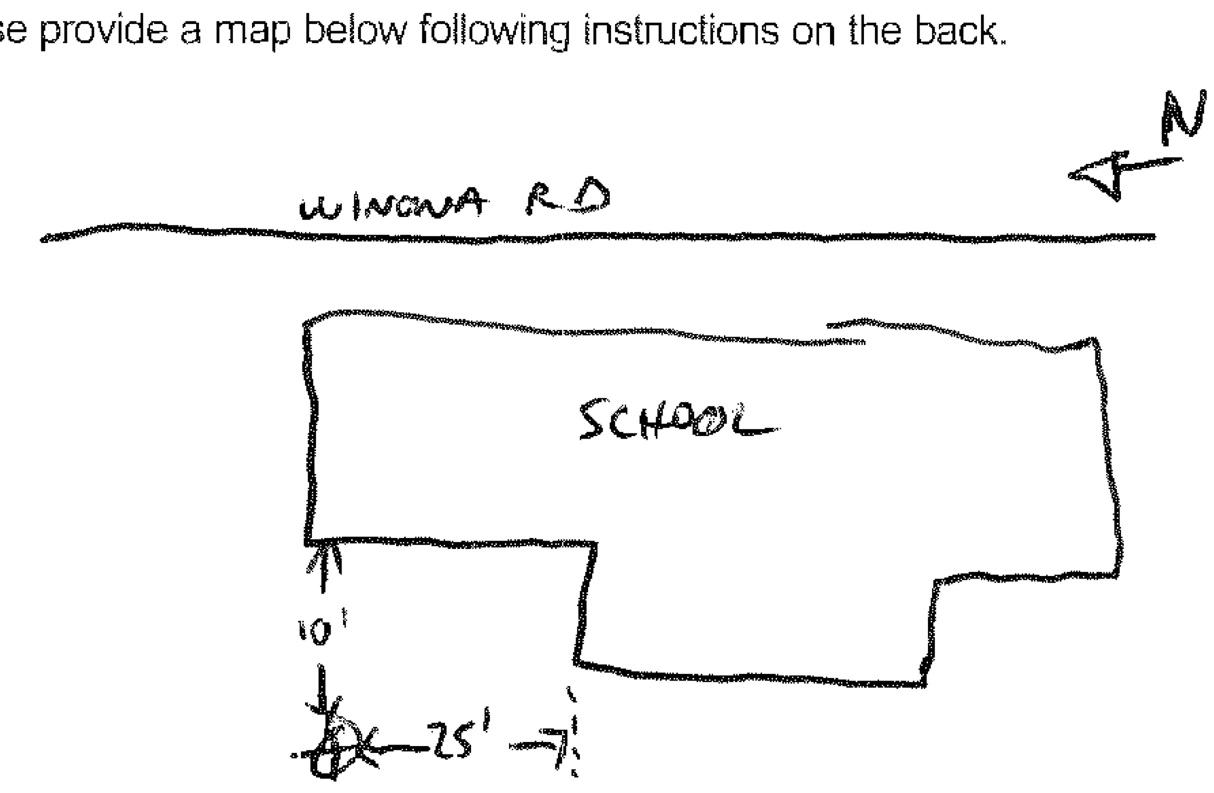
Water found at Depth (m/ft) Kind of Water: ☐ Fresh ☐ Untested ☐ Gas ☐ Other, specify

Hole Diameter

Depth (m/ft) From	To	Diameter (cm/in)

Map of Well Location

Please provide a map below following instructions on the back.



Well Contractor and Well Technician Information

Business Name of Well Contractor: DETERMINATION DRILLING

Well Contractor's Licence No.: 7245

Business Address (Street Number/Name): 2493 HENDERSHOT RD

Municipality: HAMILTON

Province: ONTARIO

Postal Code: L0R1C0

Business E-mail Address: DAN@DETERMINATIONDRILLING.COM

Bus.Telephone No. (inc. area code): 9056922481

Name of Well Technician (Last Name, First Name): BARRETT, ANDREW

Well Technician's Licence No.: 2463

Signature of Technician and/or Contractor: [signature]

Date Submitted: 20140425

Comments: AMEC - JOHN

Well owner's information package delivered: ☐ Yes ☑ No

Date Package Delivered: Y Y Y Y M M D D

Date Work Completed: 20140603

Ministry Use Only

Audit No. Z192862

Received JUL 23 2014

0506E (2007/12)

Ministry's Copy

Well ID

Well ID Number: 7274729
Well Audit Number: *Z220108*
Well Tag Number: *A192858*

This table contains information from the original well record and any subsequent updates.

Well Location

Address of Well Location	911 ARVIN AVE
Township	SALTFLEET TOWNSHIP
Lot	010
Concession	CON 01
County/District/Municipality	WENTWORTH
City/Town/Village	Hamilton
Province	ON
Postal Code	n/a
UTM Coordinates	NAD83 — Zone 17 Easting: 607610.00 Northing: 4786158.00
Municipal Plan and Sublot Number	
Other	

Overburden and Bedrock Materials Interval

General Colour	Most Common Material	Other Materials	General Description	Depth From	Depth To
BRWN	FILL		SOFT	0 ft	1.8 ft
GREY	CLAY	TILL	DNSE	1.8 ft	2.7 ft
RED	SHLE	LMSN	HARD	2.7 ft	6.1 ft

Annular Space/Abandonment Sealing Record

Depth From	Depth To	Type of Sealant Used (Material and Type)	Volume Placed
0 ft	.3 ft	CONCRETE	
.3 ft	3.4 ft	BENTONITE CHIPS	

Method of Construction & Well Use

Method of Construction	Well Use
Boring	
	Monitoring

Status of Well

Observation Wells

Construction Record - Casing

Inside Diameter	Open Hole or material	Depth From	Depth To
5.1 inch	PLASTIC	0 ft	3.6 ft

Construction Record - Screen

Outside Diameter	Material	Depth From	Depth To
6.4 inch	PLASTIC	3.6 ft	6.1 ft

Well Contractor and Well Technician Information

Well Contractor's Licence Number: 6607

Results of Well Yield Testing

After test of well yield, water was
If pumping discontinued, give reason
Pump intake set at
Pumping Rate
Duration of Pumping
Final water level
If flowing give rate
Recommended pump depth
Recommended pump rate
Well Production
Disinfected?

Draw Down & Recovery

Draw Down Time(min)	Draw Down Water level	Recovery Time(min)	Recovery Water level
SWL			
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
45		45	
50		50	
60		60	

Water Details

Water Found at Depth	Kind

Hole Diameter

Depth From	Depth To	Diameter
0 ft	6.1 ft	21 inch

Audit Number: Z220108

Date Well Completed: October 22, 2015

Date Well Record Received by MOE: November 08, 2016

Updated: June 28, 2018
RateRate

Well ID

Well ID Number: 7274730
Well Audit Number: *Z219992*
Well Tag Number: *A192868*

This table contains information from the original well record and any subsequent updates.

Well Location

Address of Well Location	911 ARVIN AVE
Township	SALTFLEET TOWNSHIP
Lot	010
Concession	CON 01
County/District/Municipality	WENTWORTH
City/Town/Village	Hamilton
Province	ON
Postal Code	n/a
UTM Coordinates	NAD83 — Zone 17 Easting: 607611.00 Northing: 4786065.00
Municipal Plan and Sublot Number	
Other	

Overburden and Bedrock Materials Interval

General Colour	Most Common Material	Other Materials	General Description	Depth From	Depth To
BRWN	FILL		SOFT	0 m	1.8 m
GREY	CLAY	TILL	DNSE	1.8 m	2.7 m
RED	SHLE	LMSN	HARD	2.7 m	6.1 m

Annular Space/Abandonment Sealing Record

Depth From	Depth To	Type of Sealant Used (Material and Type)	Volume Placed
0 m	.3 m	CONCRETE	
.3 m	3.4 m	BENTONITE CHIPS	

Method of Construction & Well Use

Method of Construction	Well Use
Boring	
	Monitoring

Status of Well

Observation Wells

Construction Record - Casing

Inside Diameter	Open Hole or material	Depth From	Depth To
5.1 cm	PLASTIC	0 m	3.6 m

Construction Record - Screen

Outside Diameter	Material	Depth From	Depth To
6.4 cm	PLASTIC	3.6 m	6.1 m

Well Contractor and Well Technician Information

Well Contractor's Licence Number: 6607

Results of Well Yield Testing

After test of well yield, water was	
If pumping discontinued, give reason	
Pump intake set at	
Pumping Rate	
Duration of Pumping	
Final water level	
If flowing give rate	
Recommended pump depth	
Recommended pump rate	
Well Production	
Disinfected?	

Draw Down & Recovery

Draw Down Time(min)	Draw Down Water level	Recovery Time(min)	Recovery Water level
SWL			
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
45		45	
50		50	
60		60	

Water Details

Water Found at Depth	Kind

Hole Diameter

Depth From	Depth To	Diameter
0 m	6.1 m	21 cm

Audit Number: Z219992

Date Well Completed: October 22, 2015

Date Well Record Received by MOE: November 08, 2016

Updated: June 28, 2018
RateRate

Well ID

Well ID Number: 7274731
Well Audit Number: *Z219993*
Well Tag Number: *A192864*

This table contains information from the original well record and any subsequent updates.

Well Location

Address of Well Location	911 ARVIN AVE
Township	SALTFLEET TOWNSHIP
Lot	010
Concession	CON 01
County/District/Municipality	WENTWORTH
City/Town/Village	Hamilton
Province	ON
Postal Code	n/a
UTM Coordinates	NAD83 — Zone 17 Easting: 607677.00 Northing: 4786214.00
Municipal Plan and Sublot Number	
Other	

Overburden and Bedrock Materials Interval

General Colour	Most Common Material	Other Materials	General Description	Depth From	Depth To
BRWN	FILL		SOFT	0 m	1.8 m
GREY	CLAY	TILL	DNSE	1.8 m	2.7 m
RED	SHLE	LMSN	HARD	2.7 m	7.6 m

Annular Space/Abandonment Sealing Record

Depth From	Depth To	Type of Sealant Used (Material and Type)	Volume Placed
0 m	.3 m	CONCRETE	
.3 m	3.9 m	BENTONITE CHIPS	

Method of Construction & Well Use

Method of Construction	Well Use
Boring	
	Monitoring

Status of Well

Observation Wells

Construction Record - Casing

Inside Diameter	Open Hole or material	Depth From	Depth To
5.1 cm	PLASTIC	0 m	4.5 m

Construction Record - Screen

Outside Diameter	Material	Depth From	Depth To
6.4 cm	PLASTIC	4.5 m	7.6 m

Well Contractor and Well Technician Information

Well Contractor's Licence Number: 6607

Results of Well Yield Testing

After test of well yield, water was	
If pumping discontinued, give reason	
Pump intake set at	
Pumping Rate	
Duration of Pumping	
Final water level	
If flowing give rate	
Recommended pump depth	
Recommended pump rate	
Well Production	
Disinfected?	

Draw Down & Recovery

Draw Down Time(min)	Draw Down Water level	Recovery Time(min)	Recovery Water level
SWL			
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
45		45	
50		50	
60		60	

Water Details

Water Found at Depth	Kind

Hole Diameter

Depth From	Depth To	Diameter
0 m	7.6 m	21 cm

Audit Number: Z219993

Date Well Completed: October 22, 2015

Date Well Record Received by MOE: November 08, 2016

Updated: June 28, 2018
RateRate

Well ID

Well ID Number: 7276166
Well Audit Number: *Z218836*
Well Tag Number:

This table contains information from the original well record and any subsequent updates.

Well Location

Address of Well Location	1091 BARTON ST E
Township	SALTFLEET TOWNSHIP
Lot	007
Concession	CON 01
County/District/Municipality	WENTWORTH
City/Town/Village	SALTFLEET
Province	ON
Postal Code	n/a
UTM Coordinates	NAD83 — Zone 17 Easting: 608575.00 Northing: 4785569.00
Municipal Plan and Sublot Number	
Other	

Overburden and Bedrock Materials Interval

General Colour	Most Common Material	Other Materials	General Description	Depth From	Depth To
				0 m	

Annular Space/Abandonment Sealing Record

Depth From	Depth To	Type of Sealant Used (Material and Type)	Volume Placed
0 m	1.5 m	CLEAN FILL	
1.5 m	1.8 m	BENTONITE CHIPS	
1.8 m	2.3 m	BENTONTIE SLURRY	
2.3 m	3.66 m	CLEAN GRAVEL	

Method of Construction & Well Use

Method of Construction	Well Use

Status of Well

Abandoned-Other

Construction Record - Casing

Inside Diameter	Open Hole or material	Depth From	Depth To
152 cm	CONCRETE	0 m	3.66 m

Construction Record - Screen

Outside Diameter	Material	Depth From	Depth To

Well Contractor and Well Technician Information

Well Contractor's Licence Number: 7523

Results of Well Yield Testing

After test of well yield, water was	
If pumping discontinued, give reason	WATER REMOVED
Pump intake set at	
Pumping Rate	
Duration of Pumping	
Final water level	
If flowing give rate	
Recommended pump depth	
Recommended pump rate	
Well Production	
Disinfected?	Y

Draw Down & Recovery

Draw Down Time(min)	Draw Down Water level	Recovery Time(min)	Recovery Water level
SWL			
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
45		45	
50		50	
60		60	

Water Details

Water Found at Depth	Kind

Hole Diameter

Depth From	Depth To	Diameter

Audit Number: Z218836

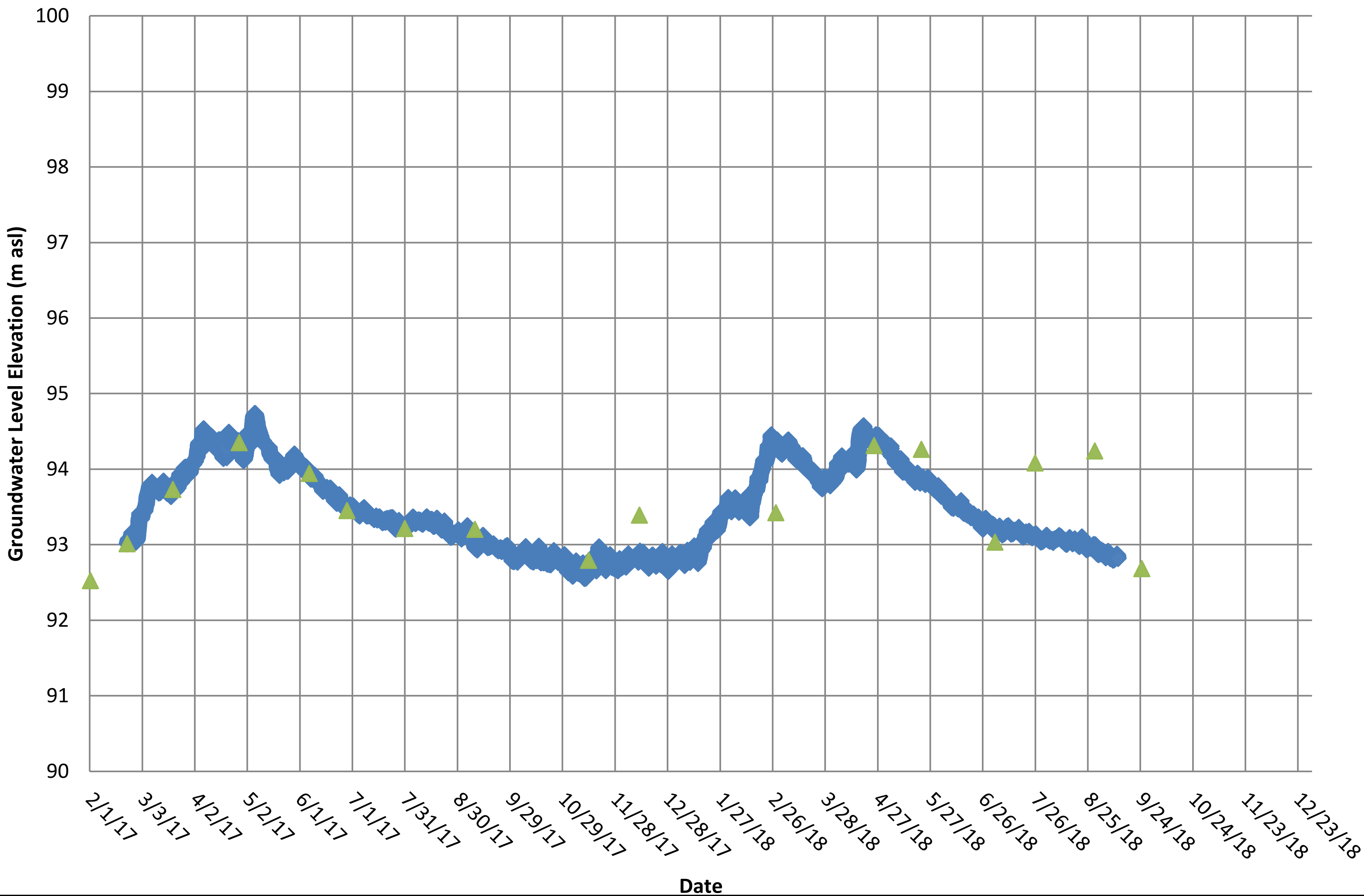
Date Well Completed: October 05, 2015

Date Well Record Received by MOE: November 30, 2016

Updated: June 28, 2018
RateRate

APPENDIX D

HYDROGRAPHS



LEGEND

◆ MW1 Logger Data

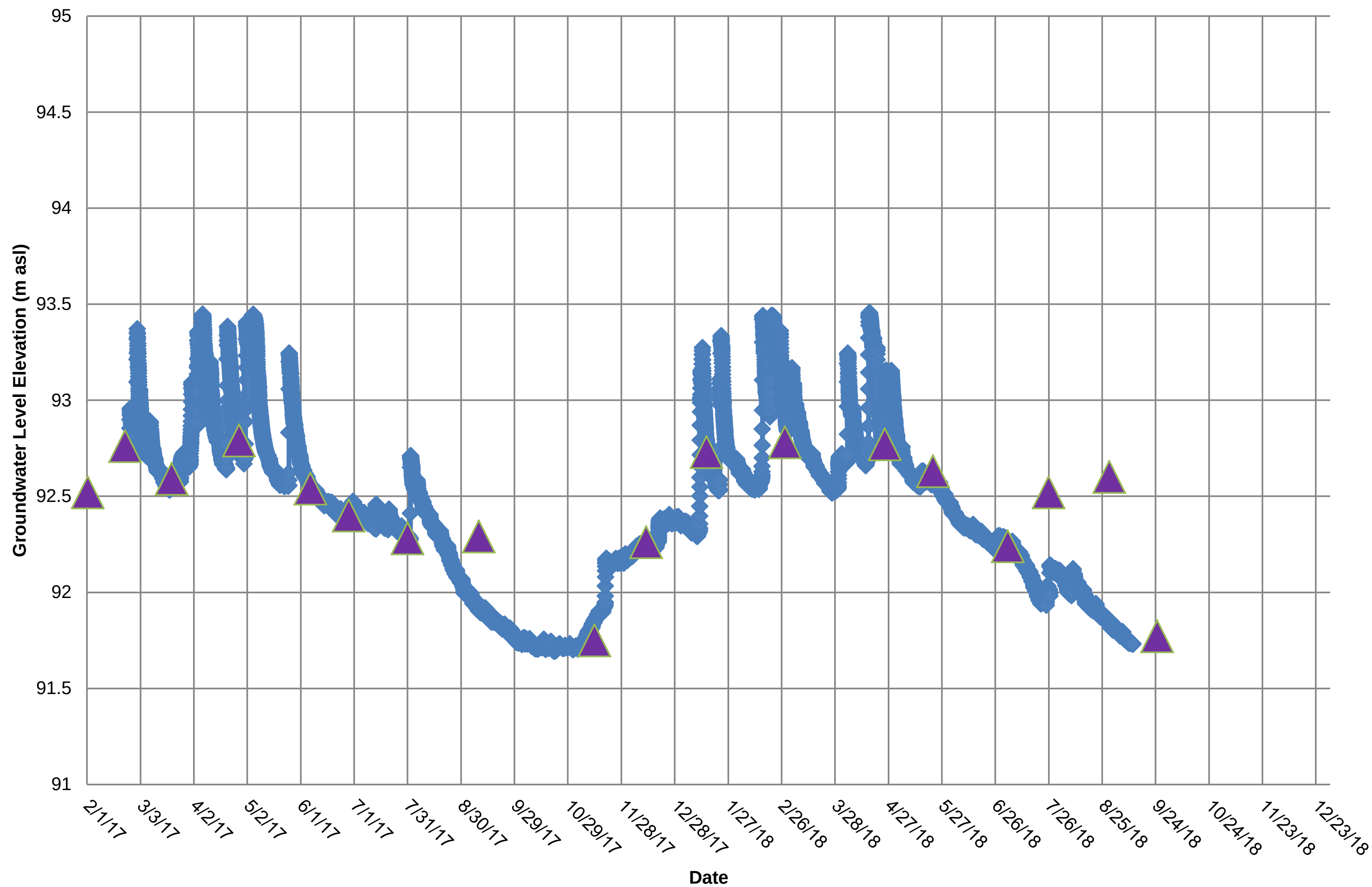
▲ Manual Water Levels

■ Rainfall

LANDTEK LIMITED

Groundwater Elevations at MW1

Project:	Hydrogeological Report Winona Block 3 Winona ON
Figure:	1
Date:	October 2018
Project No.	16381



LEGEND

MW2 Logger Data

Manual Water Levels

LANDTEK LIMITED

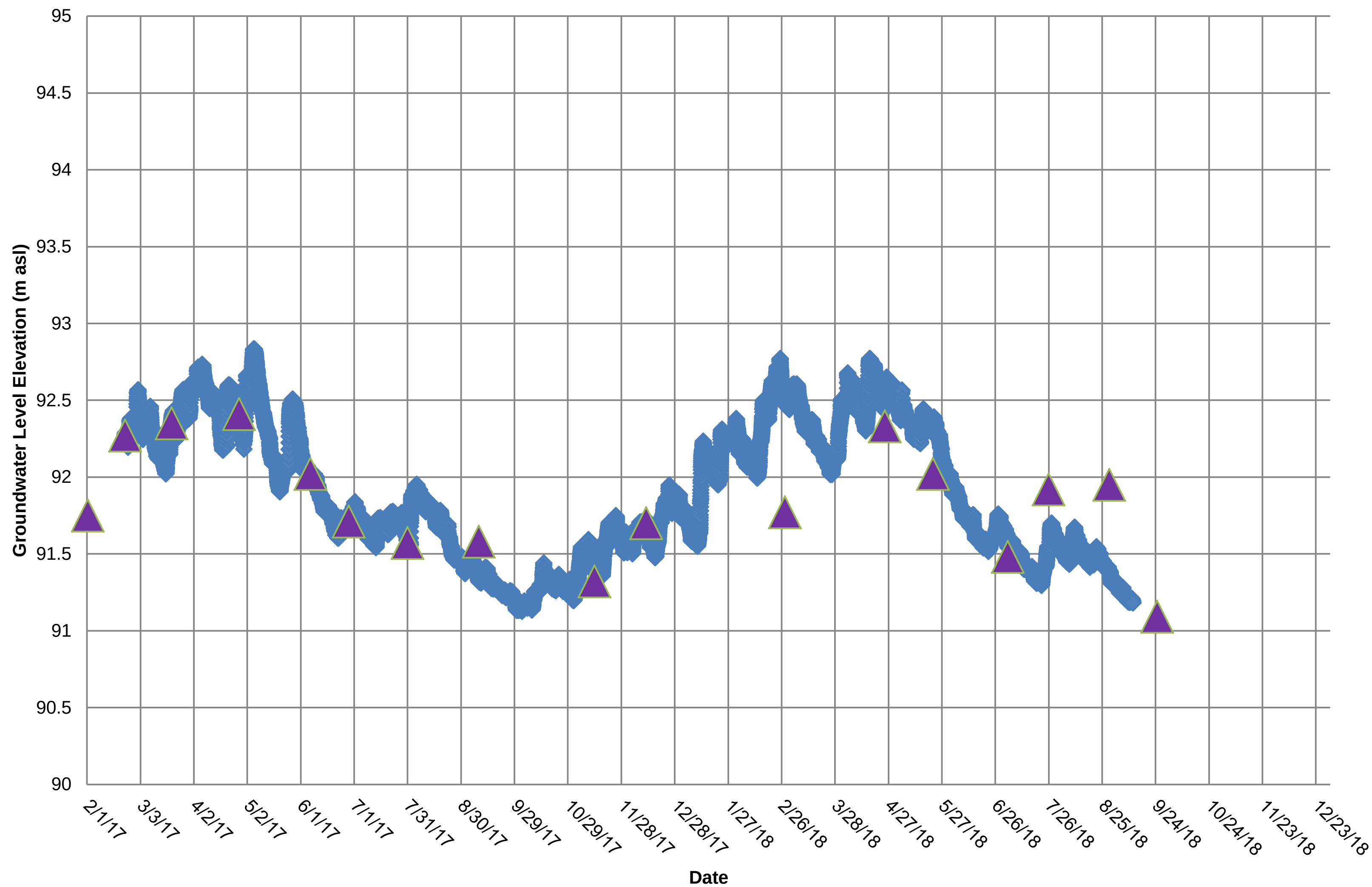
Groundwater Elevations at MW2

Project: Hydrogeological Report
Winona Block 3
Winona ON

Figure: 2

Date: June 2017

Project No. 16381



LEGEND

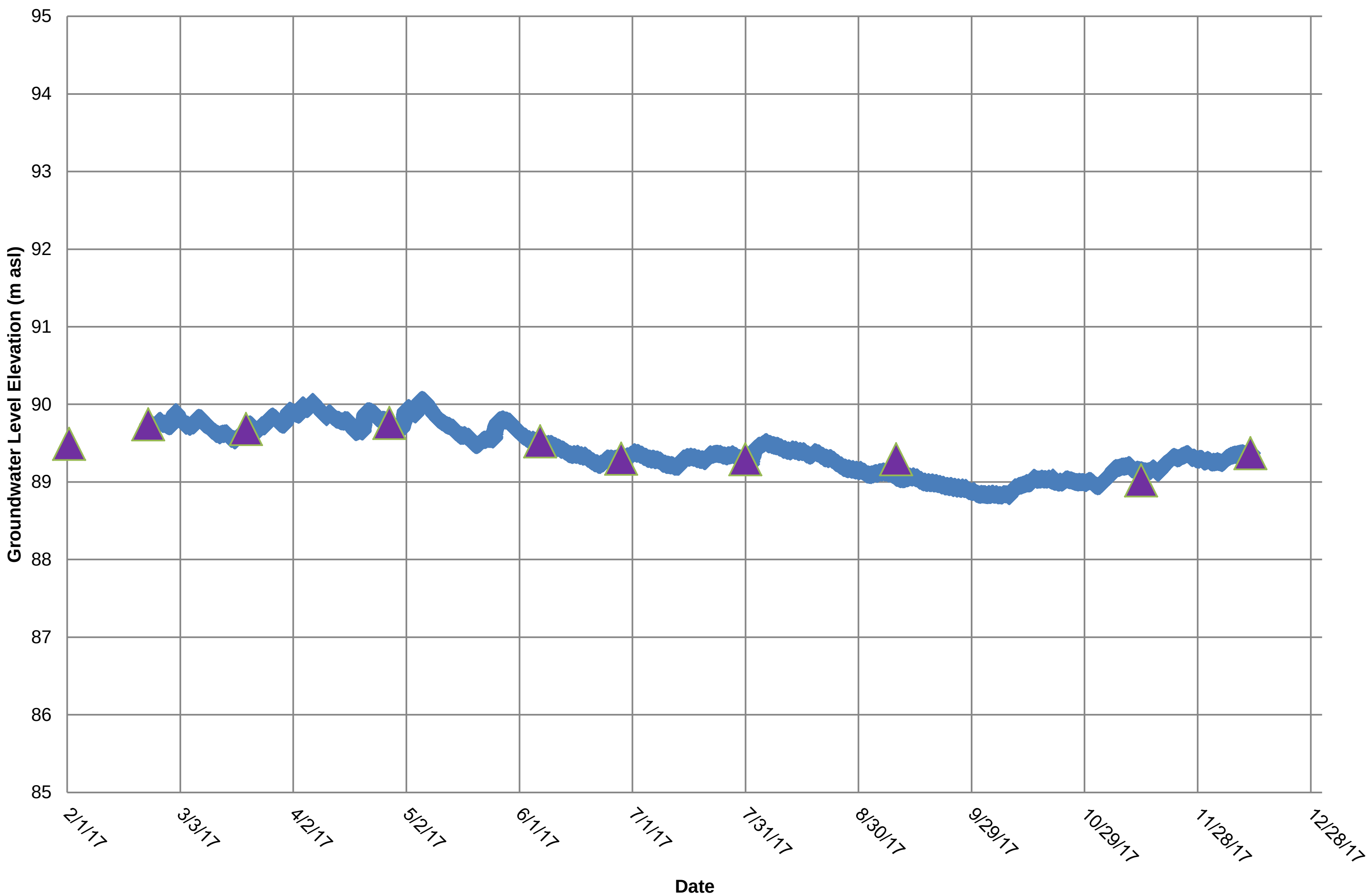
MW4 Logger Data

Manual Water Levels

LANDTEK LIMITED

Groundwater Elevations at MW4

Project:	Hydrogeological Report Winona Block 3 Winona ON
Figure:	3
Date:	January 2018
Project No.	16381



LEGEND

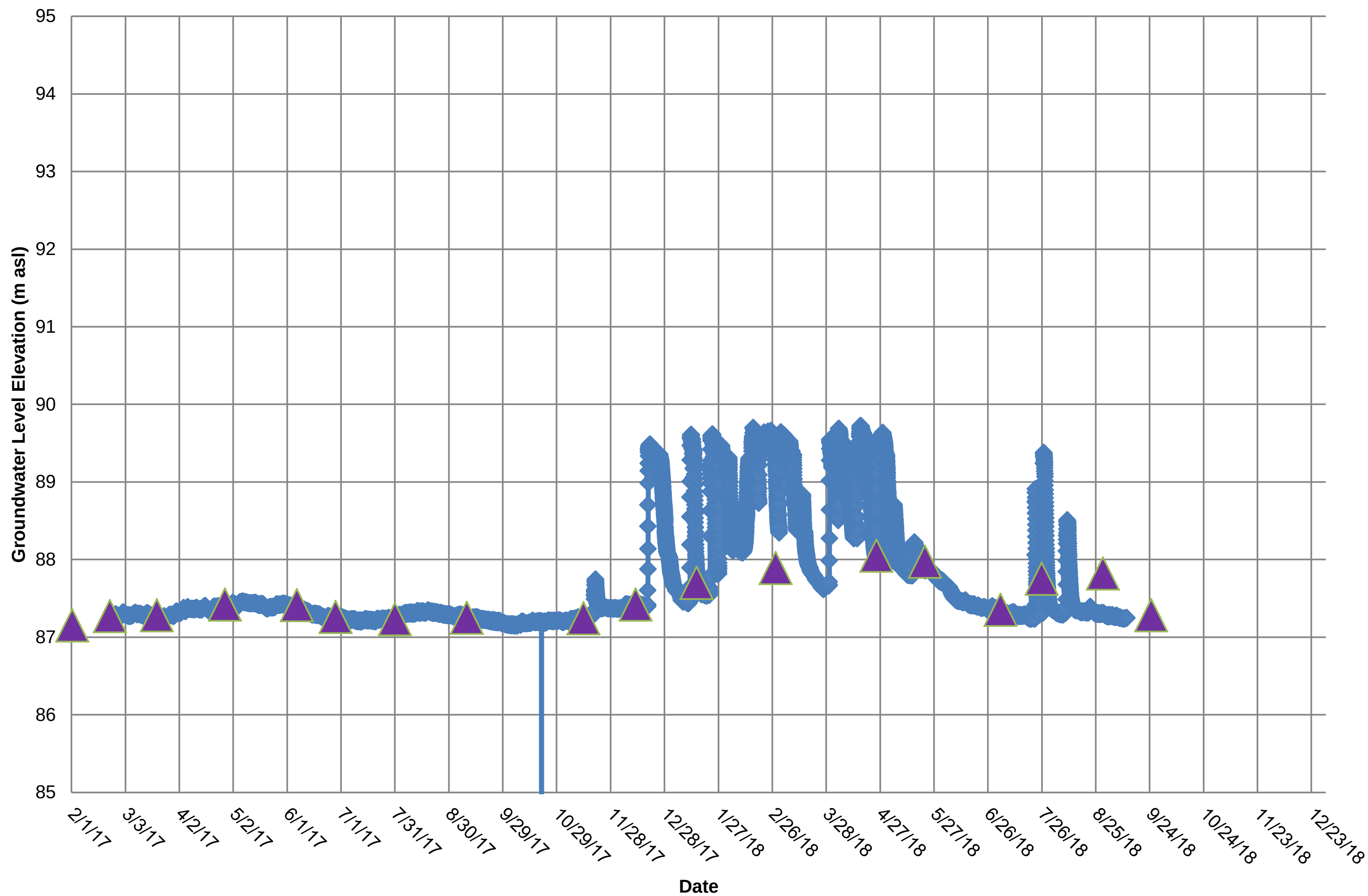
MW5 Logger Data

Manual Water Levels

LANDTEK LIMITED

Groundwater Elevations at MW5

Project:	Hydrogeological Report Winona Block 3 Winona ON
Figure:	4
Date:	December 2018
Project No.	16381



LEGEND

MW7 Logger Data

Manual Water Levels

LANDTEK LIMITED

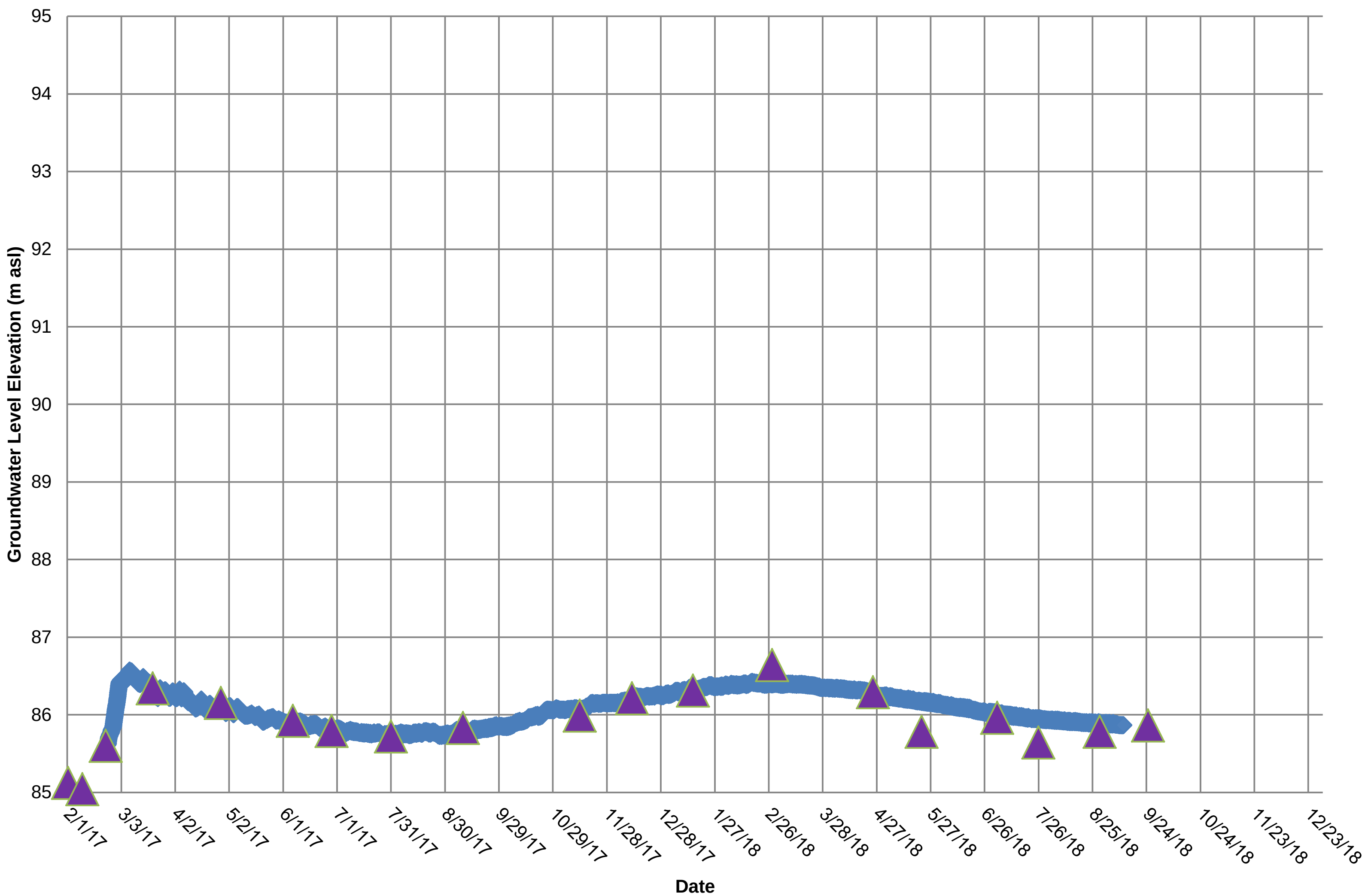
Groundwater Elevations at MW7

Project: Hydrogeological Report
Winona Block 3
Winona ON

Figure: 5

Date: June 2017

Project No. 16381



LEGEND

MW10-D Logger Data

Manual Water Levels

LANDTEK LIMITED

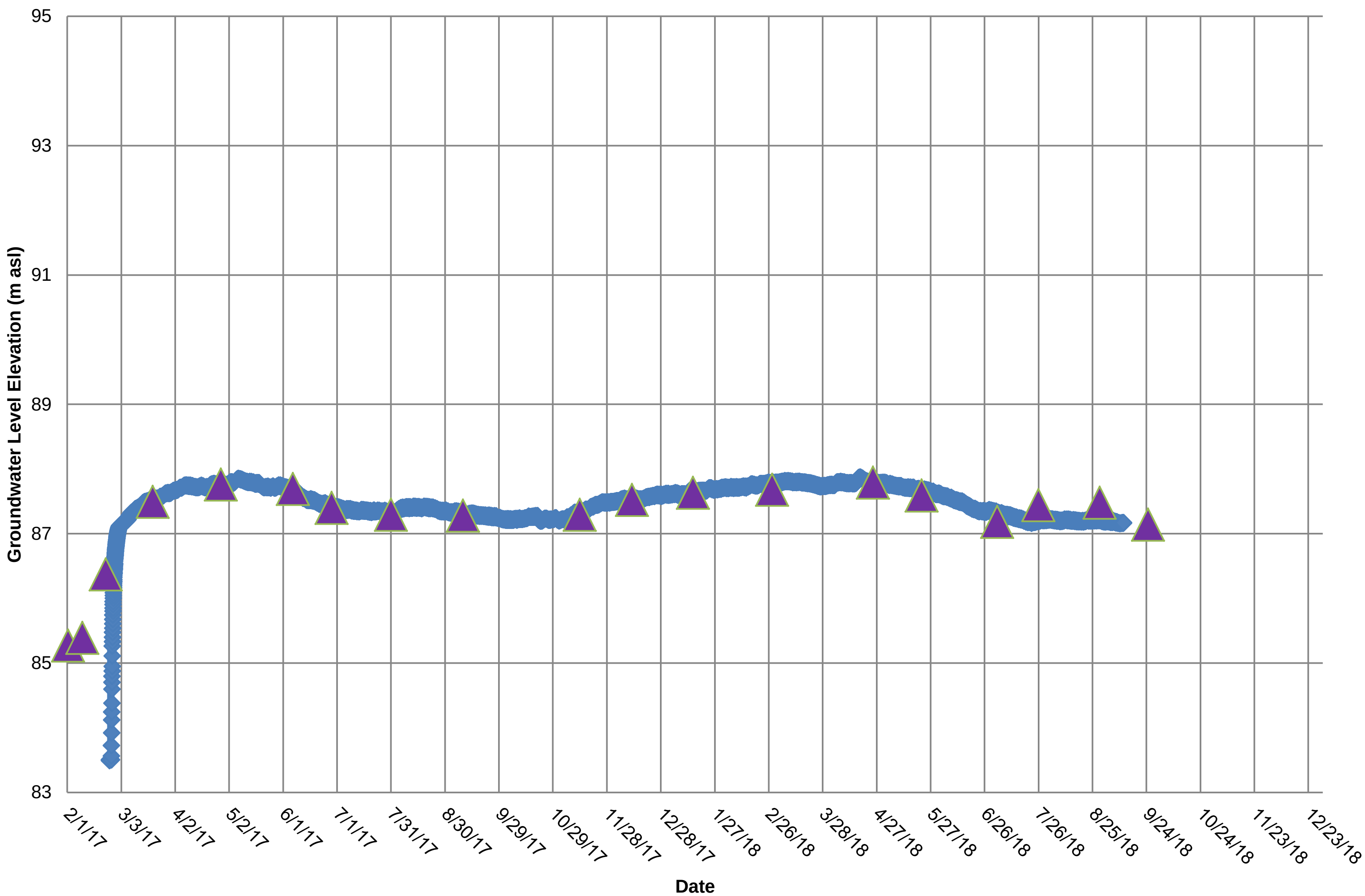
Groundwater Elevations at MW10-D

Project: Hydrogeological Report
Winona Block 3
Winona ON

Figure: 6

Date: June 2017

Project No. 16381



LEGEND

MW11 Logger Data

Manual Water Levels

LANDTEK LIMITED

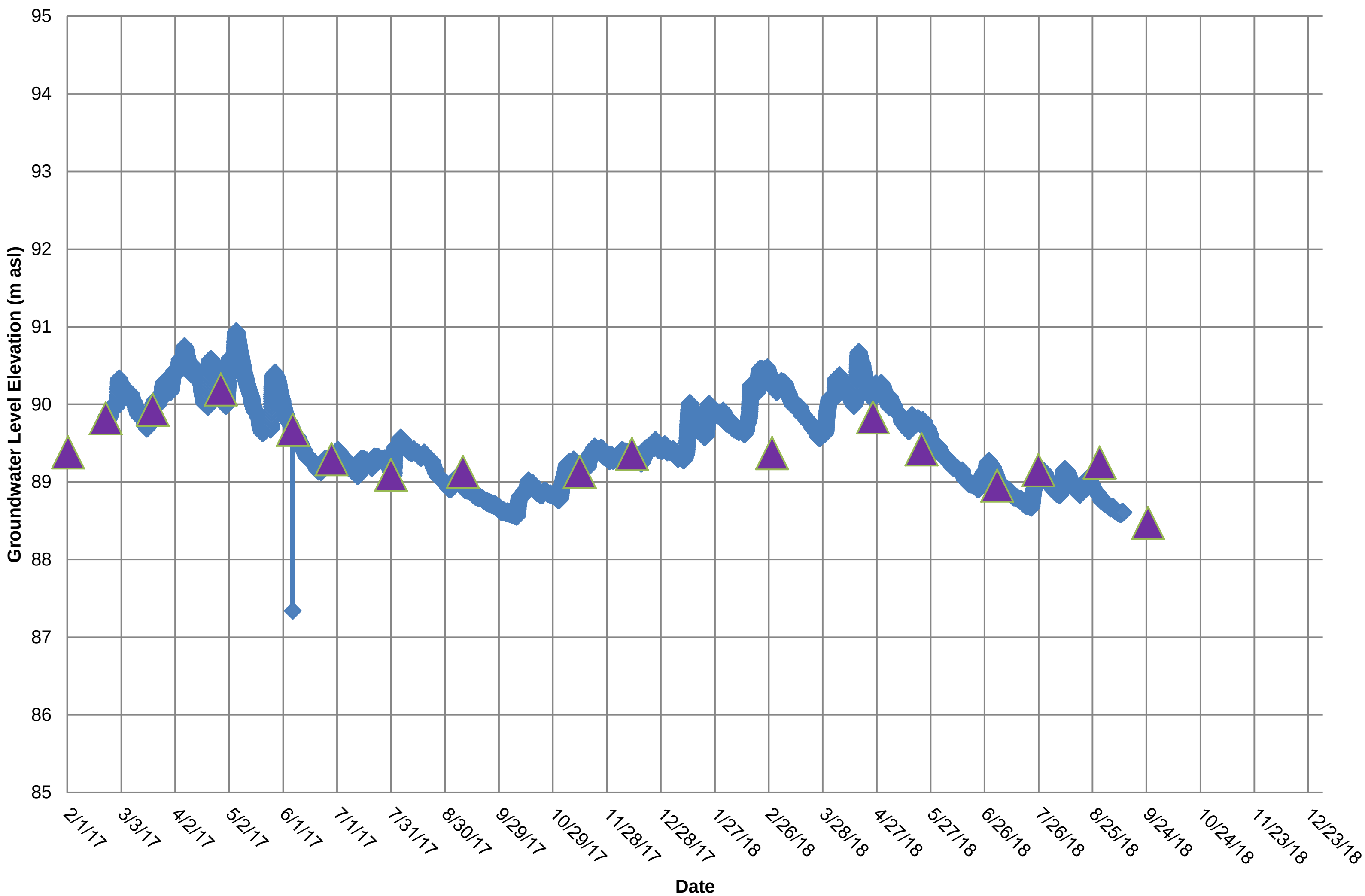
Groundwater Elevations at MW11

Project: Hydrogeological Report
Winona Block 3
Winona ON

Figure: 7

Date: June 2017

Project No. 16381



LEGEND

MW12 Logger Data

Manual Water Levels

LANDTEK LIMITED

Groundwater Elevations at MW12

Project: Hydrogeological Report
Winona Block 3
Winona ON

Figure: 8

Date: June 2017

Project No. 16381

APPENDIX E

SIEVE AND HYDROMETER ANALYSIS

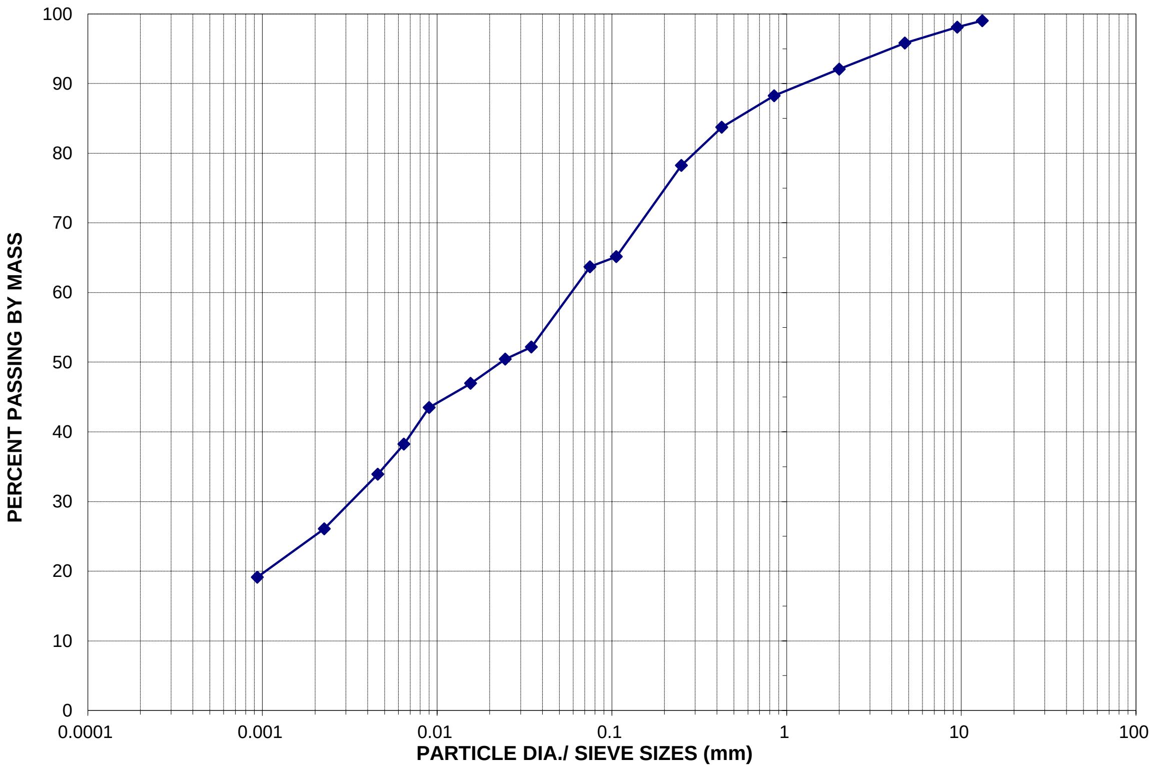
LANDTEK LIMITED
CONSULTING ENGINEERS

PARTICLE SIZE ANALYSIS

PROJECT: Hydrogeological Investigation
LOCATION: BLOCK SERVICING STRATEGY AREA WINONA #3
CLIENT : Block 3 Landowners Group
SOIL TYPE: SILTY SAND
SOURCE: BH13 (0.7-1.2 m)

FILE NO.: 18270
LAB SAMPLE NO.: S304
SAMPLE DATE: September 10, 2018
SAMPLED BY: RF

PARTICLE SIZE DISTRIBUTION



←	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	COARSE
CLAY	**SILT**			**SAND**			**GRAVEL**	

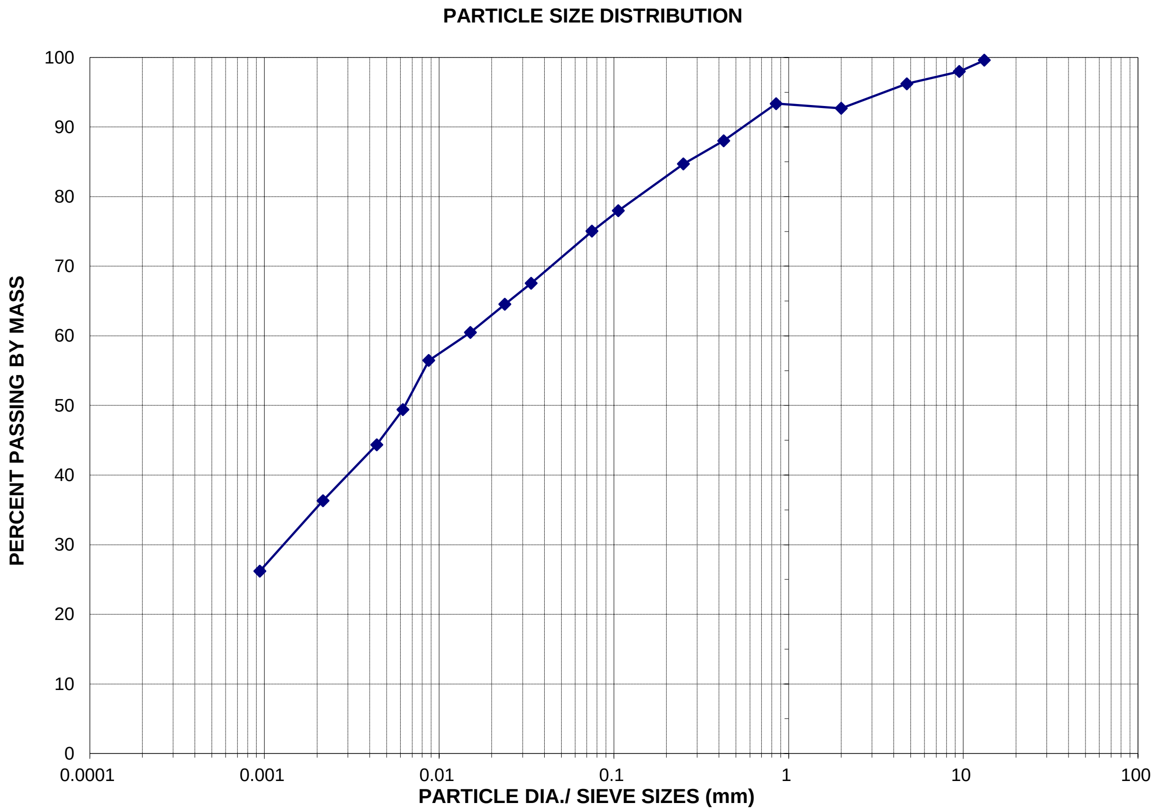
SIEVE SIZE /PARTICLE DIA. (mm)	PERCENT PASSING SAMPLE	COMMENTS
13.2	99.0	
9.5	98.1	
4.75	95.8	
2.0	92.1	
0.850	88.3	
0.425	83.7	
0.250	78.3	
0.106	65.2	
0.075	63.7	
0.0347	52.2	
0.0246	50.4	
0.0156	47.0	
0.0090	43.5	
0.0065	38.3	
0.0046	33.9	
0.0023	26.1	
0.0009	19.1	

LANDTEK LIMITED
CONSULTING ENGINEERS

PARTICLE SIZE ANALYSIS

PROJECT: Hydrogeological Investigation
LOCATION: BLOCK SERVICING STRATEGY AREA WINONA #3
CLIENT : Block 3 Landowners Group
SOIL TYPE: CLAYEY SILT
SOURCE: BH14 (0.7-1.2 m)

FILE NO.: 18270
LAB SAMPLE NO.: S305
SAMPLE DATE: September 6, 2018
SAMPLED BY: RF



CLAY	SILT			SAND			GRAVEL	
←	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	COARSE

SIEVE SIZE /PARTICLE DIA. (mm)	PERCENT PASSING SAMPLE	COMMENTS
13.2	99.6	
9.5	98.0	
4.75	96.2	
2.0	92.7	
0.850	93.4	
0.425	88.0	
0.250	84.7	
0.106	78.0	
0.075	75.0	
0.0336	67.6	
0.0238	64.5	
0.0151	60.5	
0.0087	56.5	
0.0062	49.4	
0.0044	44.4	
0.0022	36.3	
0.0009	26.2	

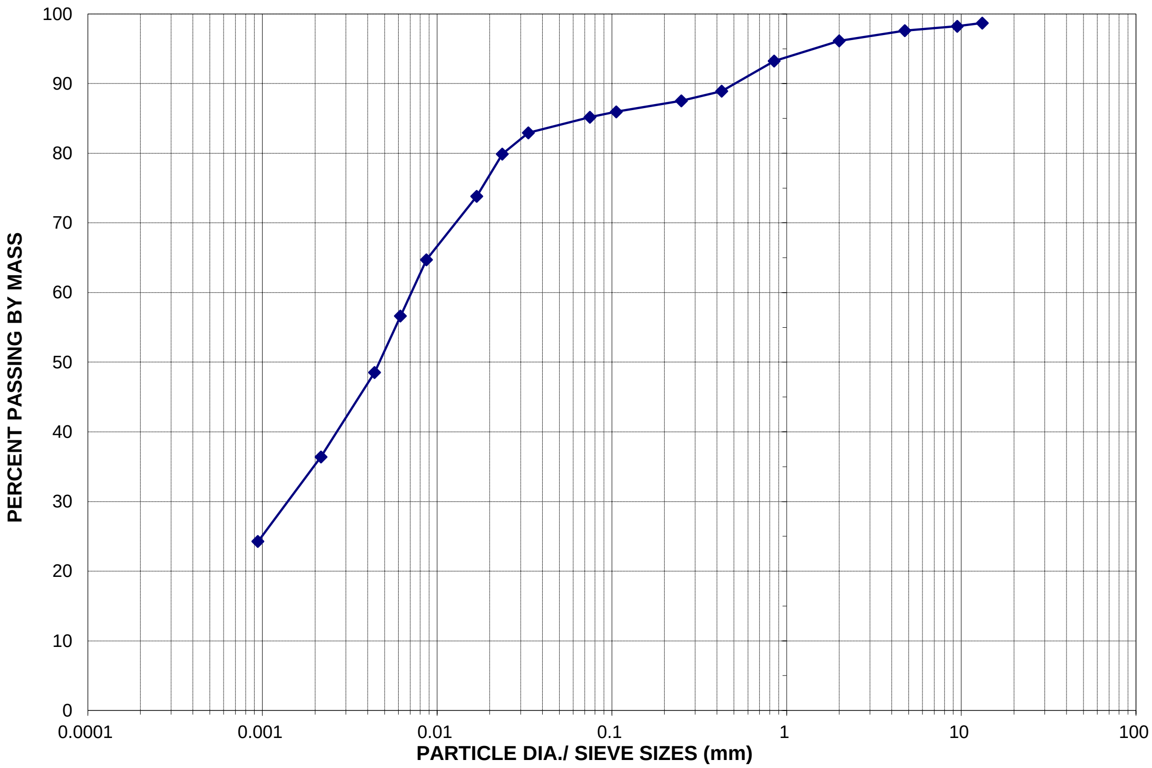
LANDTEK LIMITED
CONSULTING ENGINEERS

PARTICLE SIZE ANALYSIS

PROJECT: Hydrogeological Investigation
LOCATION: BLOCK SERVICING STRATEGY AREA WINONA #3
CLIENT : Block 3 Landowners Group
SOIL TYPE: CLATEY SILT
SOURCE: BH15 (0.7-1.2 m)

FILE NO.: 18270
LAB SAMPLE NO.: S306
SAMPLE DATE: September 6, 2018
SAMPLED BY: RF

PARTICLE SIZE DISTRIBUTION



←	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	COARSE
CLAY	**SILT**			**SAND**			**GRAVEL**	

SIEVE SIZE /PARTICLE DIA. (mm)	PERCENT PASSING SAMPLE	COMMENTS
13.2	98.7	
9.5	98.2	
4.75	97.6	
2.0	96.1	
0.850	93.2	
0.425	88.9	
0.250	87.5	
0.106	86.0	
0.075	85.2	
0.0333	82.9	
0.0236	79.9	
0.0169	73.8	
0.0087	64.7	
0.0062	56.6	
0.0044	48.5	
0.0022	36.4	
0.0009	24.3	

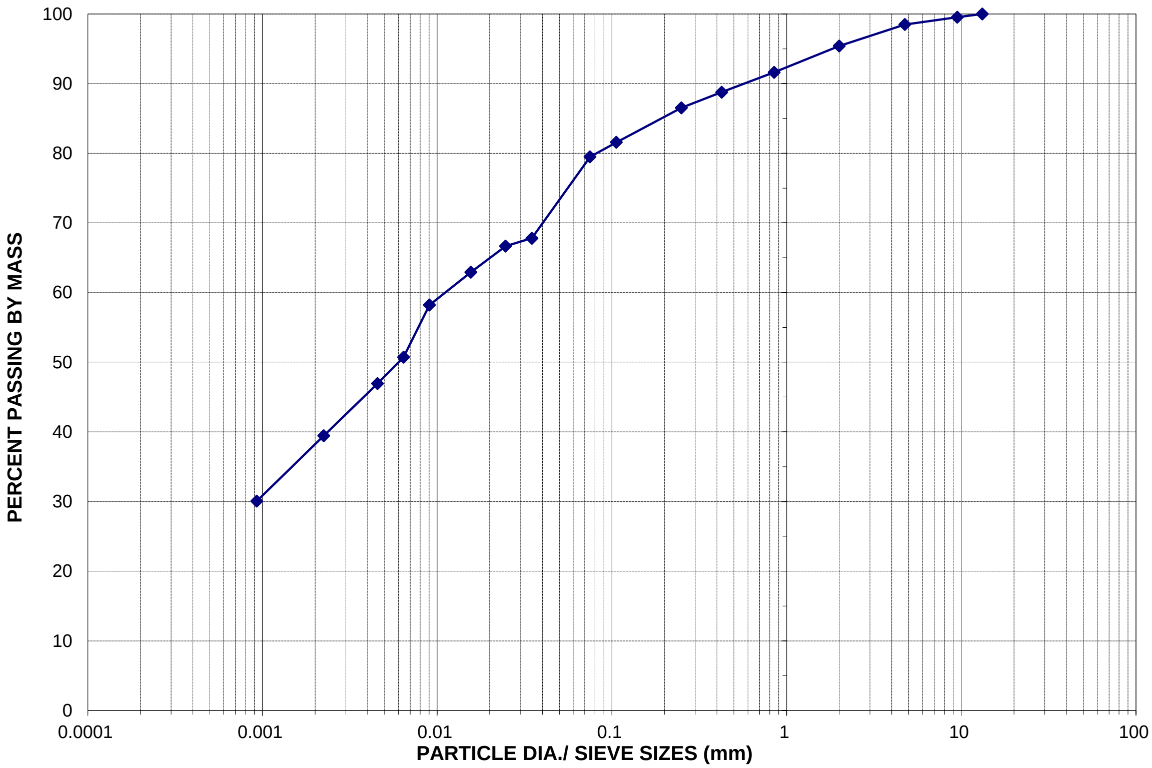
LANDTEK LIMITED
CONSULTING ENGINEERS

PARTICLE SIZE ANALYSIS

PROJECT: Hydrogeological Investigation
LOCATION: BLOCK SERVICING STRATEGY AREA WINONA #3
CLIENT : Block 3 Landowners Group
SOIL TYPE: CLATEY SILT
SOURCE: BH16 (0.7-1.2 m)

FILE NO.: 18270
LAB SAMPLE NO.: S307
SAMPLE DATE: September 10, 2018
SAMPLED BY: RF

PARTICLE SIZE DISTRIBUTION



←	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	COARSE
CLAY	**SILT**			**SAND**			**GRAVEL**	

SIEVE SIZE /PARTICLE DIA. (mm)	PERCENT PASSING SAMPLE	COMMENTS
13.2	100.0	
9.5	99.5	
4.75	98.5	
2.0	95.4	
0.850	91.6	
0.425	88.8	
0.250	86.5	
0.106	81.6	
0.075	79.5	
0.0348	67.8	
0.0246	66.7	
0.0156	62.9	
0.0090	58.2	
0.0064	50.7	
0.0046	47.0	
0.0022	39.4	
0.0009	30.1	

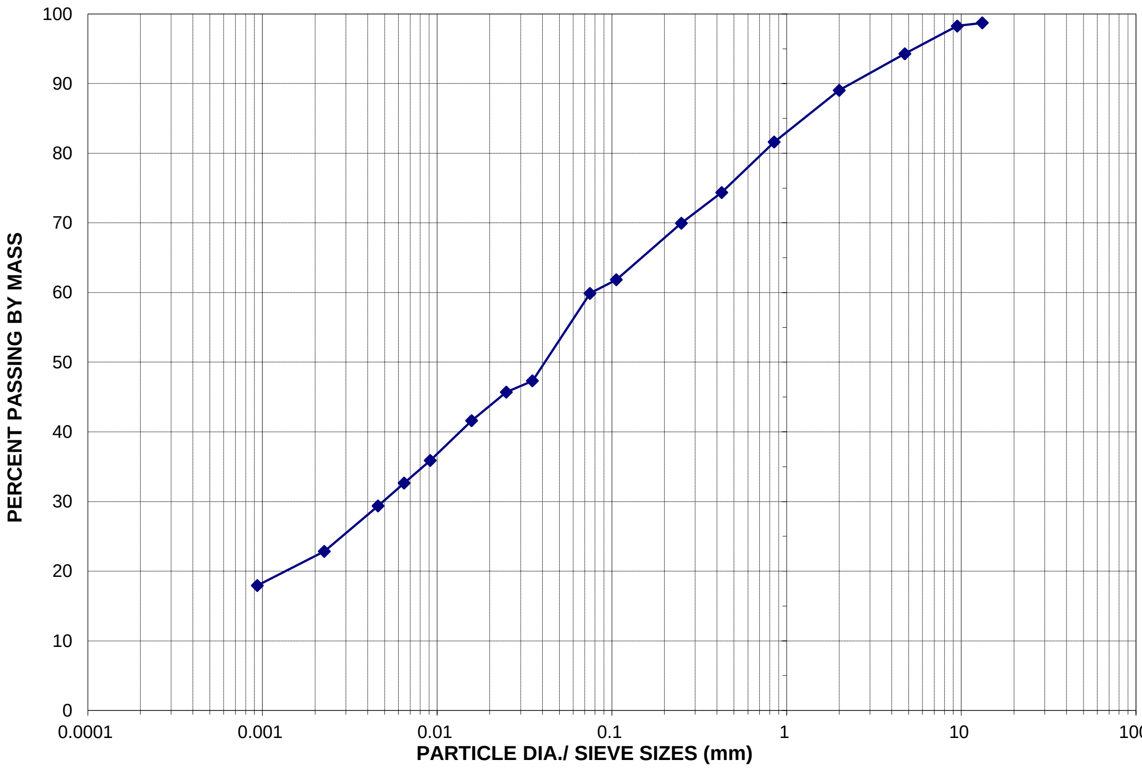
LANDTEK LIMITED
CONSULTING ENGINEERS

PARTICLE SIZE ANALYSIS

PROJECT: Hydrogeological Investigation
LOCATION: BLOCK SERVICING STRATEGY AREA WINONA #3
CLIENT : Block 3 Landowners Group
SOIL TYPE: CLATEY SILT
SOURCE: BH17 (0.7-1.2 m)

FILE NO.: 18270
LAB SAMPLE NO.: S308
SAMPLE DATE: September 10, 2018
SAMPLED BY: RF

PARTICLE SIZE DISTRIBUTION



←	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	COARSE
CLAY	SILT			SAND			GRAVEL	

SIEVE SIZE /PARTICLE DIA. (mm)	PERCENT PASSING SAMPLE	COMMENTS
13.2	98.7	
9.5	98.3	
4.75	94.3	
2.0	89.0	
0.850	81.6	
0.425	74.4	
0.250	70.0	
0.106	61.8	
0.075	59.9	
0.0351	47.3	
0.0249	45.7	
0.0158	41.6	
0.0091	35.9	
0.0065	32.6	
0.0046	29.4	
0.0023	22.8	
0.0009	18.0	

APPENDIX F

ATTERBERG LIMITS

LANDTEK LIMITED

Atterberg Limits

Project:	Hydrogeological Investigation	Sampled By:	RF
Location:	BLOCK SERVICING STRATEGY AREA WINONA #3	Tested By:	VH
Job No.:	18270	Sample Date	September 9, 2018
Borehole No:	BH13	Depth (m):	0.7-1.2 m
Report Date:	October 26, 2018	Test Date:	September 11, 2018

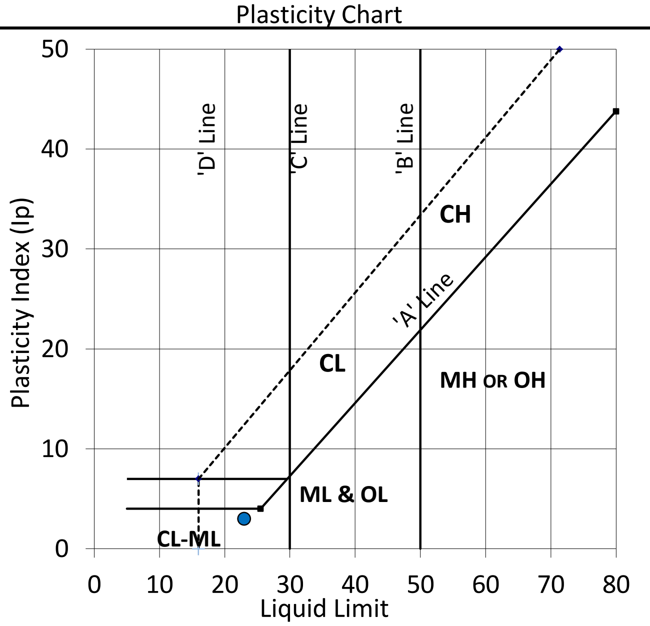
Liquid Limit Test

Trial	A	B	C
No. of Blows	35	20	23
Tare Number	NP13	NP20	NP21
Wt. of Tare, g	13.70	14.00	13.90
Wt. Wet Soil + Tare, g	39.20	36.50	35.80
Wt. Dry Soil + Tare, g	34.60	32.10	31.70
Wt. of Water, g	4.60	4.40	4.10
Wt. of Dry Soil, g	20.90	18.10	17.80
Moisture Content (%)	22.0	24.3	23.0

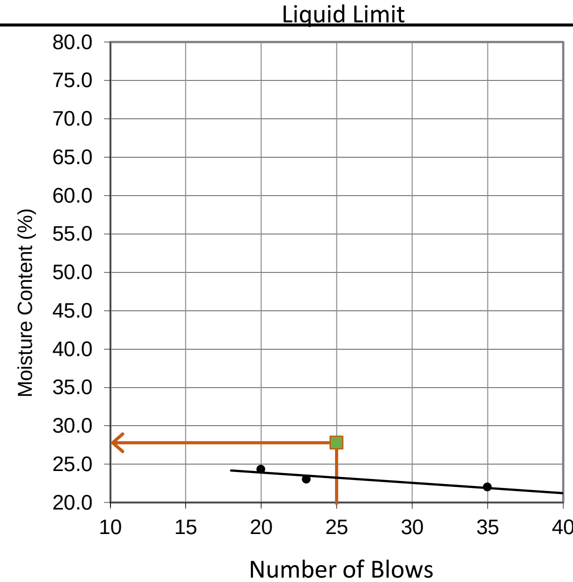
Plastic Limit Test

Trial	A	B
Tare Number	NP49	NP7
Wt. of Tare, g	13.90	14.00
Wt. Wet Soil + Tare, g	32.40	32.60
Wt. Dry Soil + Tare, g	29.00	29.80
Wt. of Water, g	3.40	2.80
Wt. of Dry Soil, g	15.10	15.80
Moisture Content (%)	22.5	17.7

Plasticity Chart



Liquid Limit



USCS Symbol	CL	Soil Description:	Low Plasticity
Liquid Limit (%)	23		
Plastic Limit (%)	20		
Plasticity Index (%)	3		

Reporting of these test results constitutes a testing service only. Engineering interpretation or evaluation of the results is provided only on written request.

LANDTEK LIMITED

Atterberg Limits

Project:	Hydrogeological Investigation	Sampled By:	RF
Location:	BLOCK SERVICING STRATEGY AREA WINONA #3	Tested By:	VH
Job No.:	18270	Sample Date	September 6, 2018
Borehole No:	BH14	Depth (m):	0.7-1.2 m
Report Date:	October 26, 2018	Test Date:	September 7, 2018

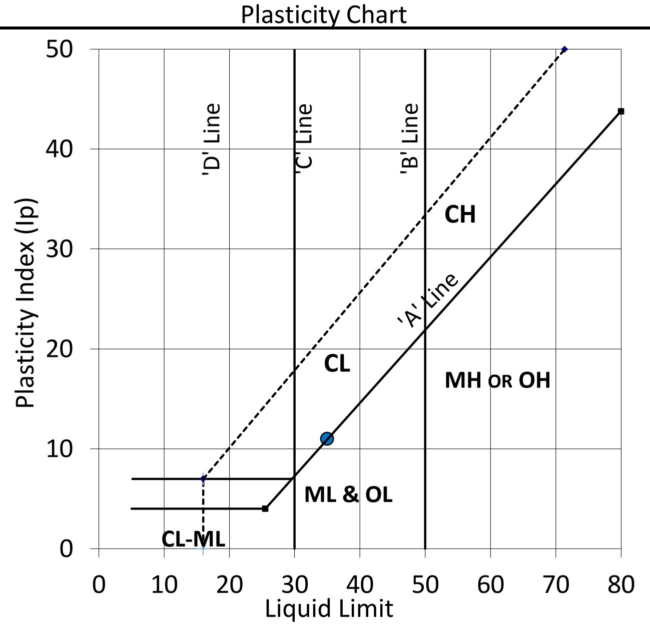
Liquid Limit Test

Trial	A	B	C
No. of Blows	20	25	35
Tare Number	NP28	T20	NP13
Wt. of Tare, g	13.80	13.30	13.80
Wt. Wet Soil + Tare, g	36.50	37.60	35.40
Wt. Dry Soil + Tare, g	30.00	31.70	30.30
Wt. of Water, g	6.50	5.90	5.10
Wt. of Dry Soil, g	16.20	18.40	16.50
Moisture Content (%)	40.1	32.1	30.9

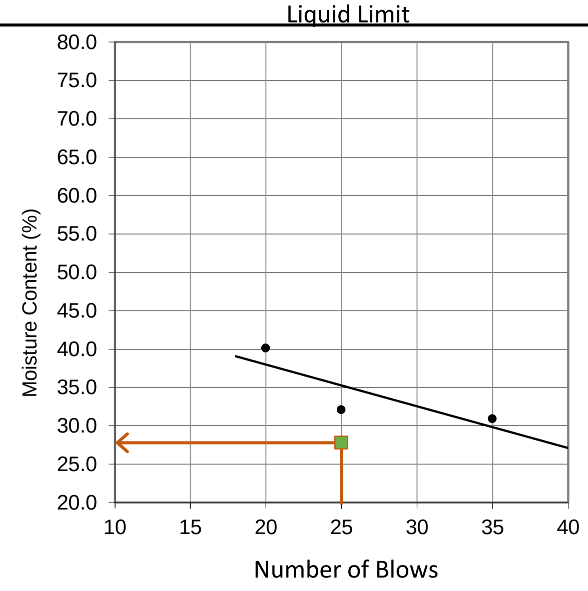
Plastic Limit Test

Trial	A	B
Tare Number	NP51	NP7
Wt. of Tare, g	13.60	13.80
Wt. Wet Soil + Tare, g	25.10	27.40
Wt. Dry Soil + Tare, g	22.20	25.70
Wt. of Water, g	2.90	1.70
Wt. of Dry Soil, g	8.60	11.90
Moisture Content (%)	33.7	14.3

Plasticity Chart



Liquid Limit



USCS Symbol	CL	Soil Description:	Medium Plasticity
Liquid Limit (%)	35		
Plastic Limit (%)	24		
Plasticity Index (%)	11		

LANDTEK LIMITED

Atterberg Limits

Project:	Hydrogeological Investigation	Sampled By:	RF
Location:	BLOCK SERVICING STRATEGY AREA WINONA #3	Tested By:	VH
Job No.:	18270	Sample Date	September 6, 2018
Borehole No:	BH15	Depth (m):	0.7-1.2 m
Report Date:	October 26, 2018	Test Date:	September 7, 2018

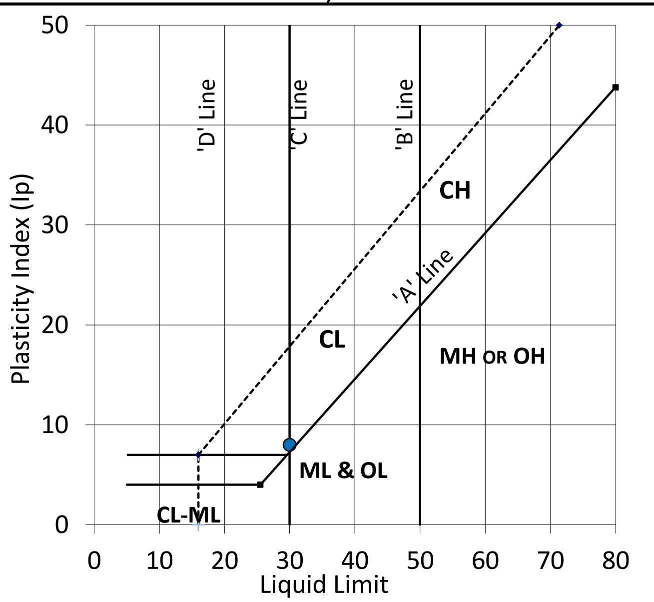
Liquid Limit Test

Trial	A	B	C
No. of Blows	26	35	21
Tare Number	NA	NP19	NP46
Wt. of Tare, g	13.80	13.50	13.60
Wt. Wet Soil + Tare, g	41.80	28.80	37.20
Wt. Dry Soil + Tare, g	35.80	25.30	31.40
Wt. of Water, g	6.00	3.50	5.80
Wt. of Dry Soil, g	22.00	11.80	17.80
Moisture Content (%)	27.3	29.7	32.6

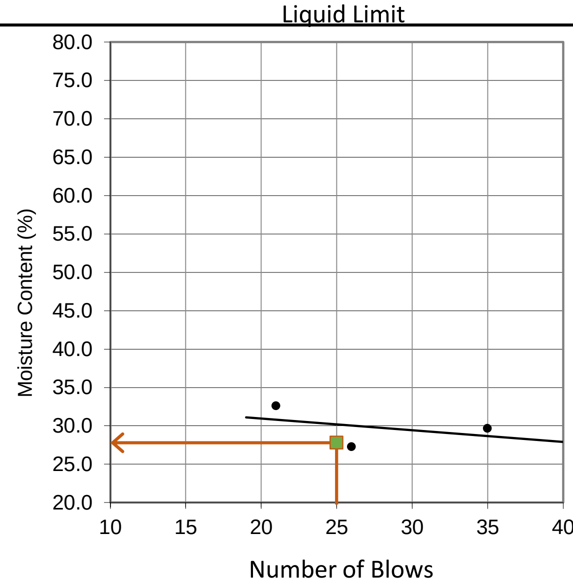
Plastic Limit Test

Trial	A	B
Tare Number	T10	NP59
Wt. of Tare, g	13.50	13.60
Wt. Wet Soil + Tare, g	33.90	37.90
Wt. Dry Soil + Tare, g	29.50	34.60
Wt. of Water, g	4.40	3.30
Wt. of Dry Soil, g	16.00	21.00
Moisture Content (%)	27.5	15.7

Plasticity Chart



Liquid Limit



USCS Symbol	CL	Soil Description:	Medium Plasticity
Liquid Limit (%)	30		
Plastic Limit (%)	22		
Plasticity Index (%)	8		

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LANDTEK LIMITED

Atterberg Limits

Project:	Hydrogeological Investigation	Sampled By:	RF
Location:	BLOCK SERVICING STRATEGY AREA WINONA #3	Tested By:	VH
Job No.:	18270	Sample Date	September 10, 2018
Borehole No:	BH16	Depth (m):	0.7-1.2 m
Report Date:	October 26, 2018	Test Date:	September 12, 2018

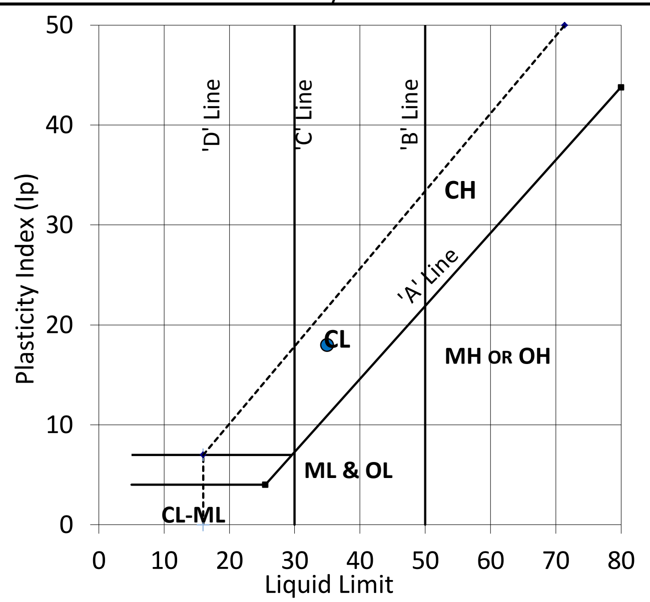
Liquid Limit Test

Trial	A	B	C
No. of Blows	35	25	18
Tare Number	T10	NP46	NP51
Wt. of Tare, g	13.50	13.70	13.70
Wt. Wet Soil + Tare, g	35.30	30.70	36.10
Wt. Dry Soil + Tare, g	29.90	26.40	30.10
Wt. of Water, g	5.40	4.30	6.00
Wt. of Dry Soil, g	16.40	12.70	16.40
Moisture Content (%)	32.9	33.9	36.6

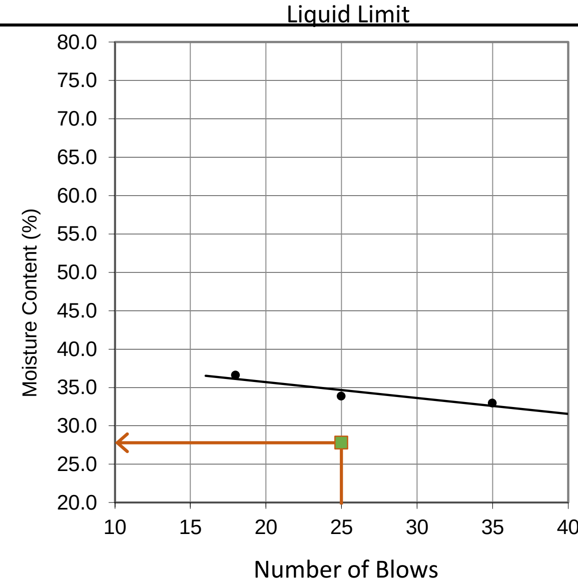
Plastic Limit Test

Trial	A	B
Tare Number	NP19	NP37
Wt. of Tare, g	13.50	13.70
Wt. Wet Soil + Tare, g	31.60	31.90
Wt. Dry Soil + Tare, g	29.00	29.10
Wt. of Water, g	2.60	2.80
Wt. of Dry Soil, g	15.50	15.40
Moisture Content (%)	16.8	18.2

Plasticity Chart



Liquid Limit



USCS Symbol	CL
Liquid Limit (%)	35
Plastic Limit (%)	17
Plasticity Index (%)	18

Soil Description: Medium Plasticity

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LANDTEK LIMITED

Atterberg Limits

Project:	Hydrogeological Investigation	Sampled By:	RF
Location:	BLOCK SERVICING STRATEGY AREA WINONA #3	Tested By:	VH
Job No.:	18270	Sample Date	September 10, 2018
Borehole No:	BH17	Depth (m):	0.7-1.2 m
Report Date:	October 26, 2018	Test Date:	September 12, 2018

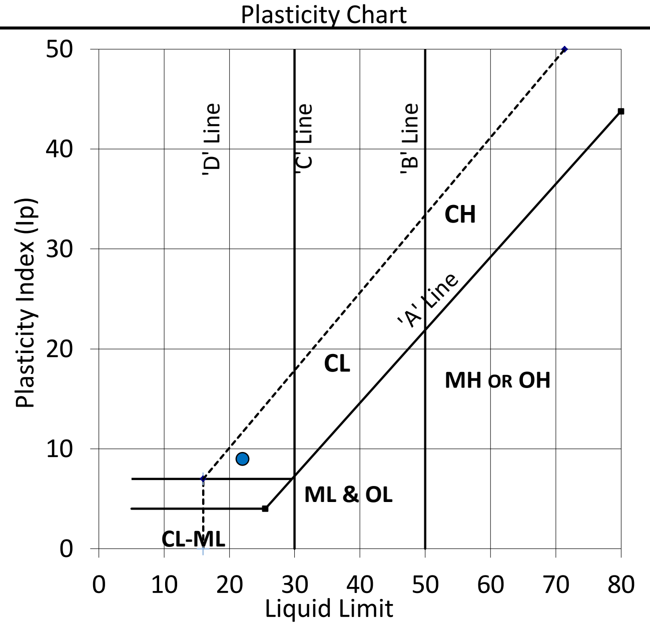
Liquid Limit Test

Trial	A	B	C
No. of Blows	33	25	20
Tare Number	Carl G	T20	TZ
Wt. of Tare, g	13.50	13.30	13.50
Wt. Wet Soil + Tare, g	35.30	39.60	46.30
Wt. Dry Soil + Tare, g	31.50	34.80	40.20
Wt. of Water, g	3.80	4.80	6.10
Wt. of Dry Soil, g	18.00	21.50	26.70
Moisture Content (%)	21.1	22.3	22.8

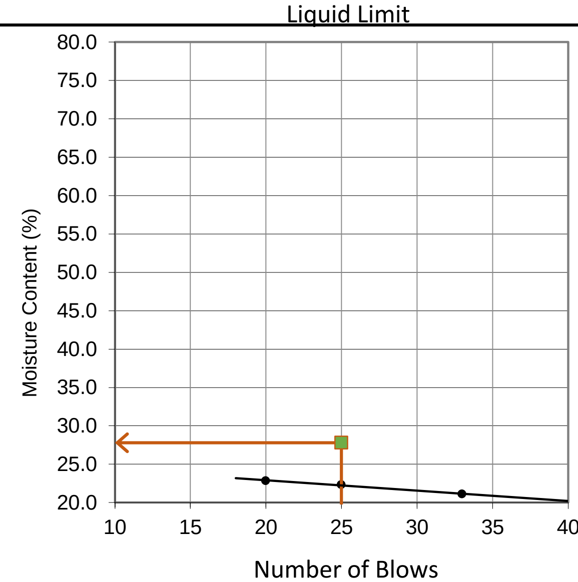
Plastic Limit Test

Trial	A	B
Tare Number	NP28	NA
Wt. of Tare, g	14.00	13.80
Wt. Wet Soil + Tare, g	31.20	31.50
Wt. Dry Soil + Tare, g	29.50	29.20
Wt. of Water, g	1.70	2.30
Wt. of Dry Soil, g	15.50	15.40
Moisture Content (%)	11.0	14.9

Plasticity Chart



Liquid Limit



USCS Symbol	CL	Soil Description:	Low Plasticity
Liquid Limit (%)	22		
Plastic Limit (%)	13		
Plasticity Index (%)	9		

APPENDIX G

HYDRAULIC CONDUCTIVITY TESTING ANALYSIS RESULTS

Appendix C
Monitoring Well Conductivity Tests

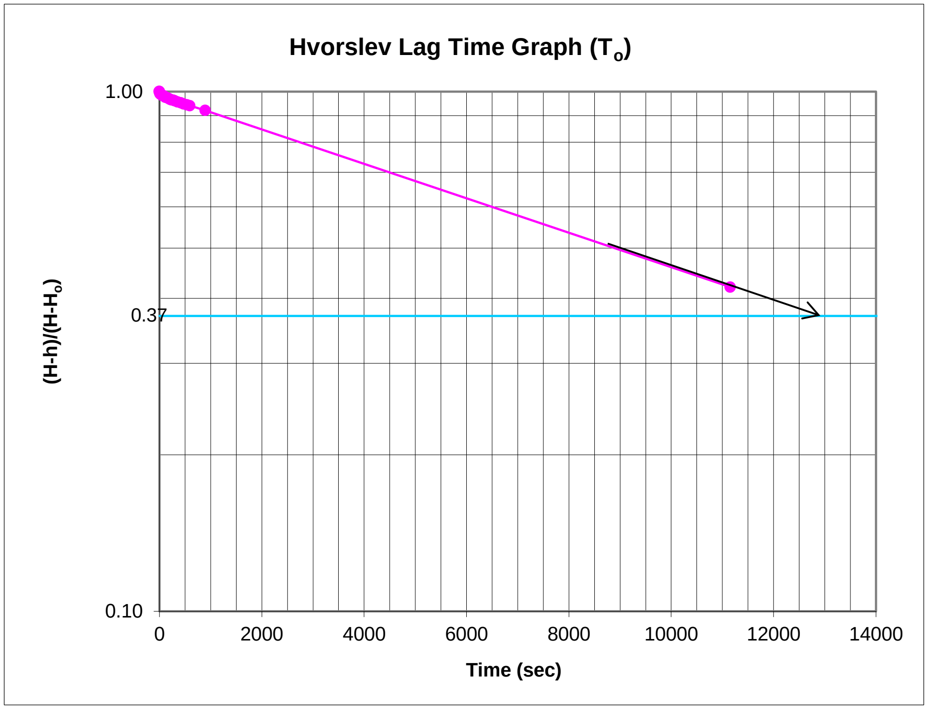
Hvorslev Calculation
(for Hydraulic Conductivity from Response Tests)

Well Name =	**MW1**	
Well Depth =	6.86 m	
Initial WL (H_o) =	3.38 m	
Radius of pipe (r) =	0.025 m	(2.0" diameter)
Radius of hole (R) =	0.152 m	(4.25" hollow auger I.D., 12" O.D.)
Length of screen (L) =	3.048 m	(10 foot screen)
Water Level at Max Drawdown (H) =	6.020 m	
$H-H_o$ =	2.640 m	
Lag time (T_o) =	12750	(time at $(H-h)/(H-H_o)$ = 0.37 on graph)

Hydraulic Cond.(K) = **2.41E-08 m/s**
2.41E-06 cm/s

Screened material = Clayey Silt TILL

Time (sec)	WL (m)	$H-H_o$ (m)	$(H-h)/(H-H_o)$
0	6.02	2.64	1.00
5	6.02	2.64	1.00
10	6	2.62	0.99
20	5.99	2.61	0.99
25	5.99	2.61	0.99
30	5.99	2.61	0.99
40	5.985	2.61	0.99
50	5.98	2.60	0.98
60	5.975	2.60	0.98
90	5.97	2.59	0.98
120	5.955	2.58	0.98
150	5.95	2.57	0.97
180	5.94	2.56	0.97
210	5.93	2.55	0.97
240	5.925	2.55	0.96
270	5.92	2.54	0.96
300	5.915	2.54	0.96
360	5.9	2.52	0.95
420	5.89	2.51	0.95



Appendix C
Monitoring Well Conductivity Tests

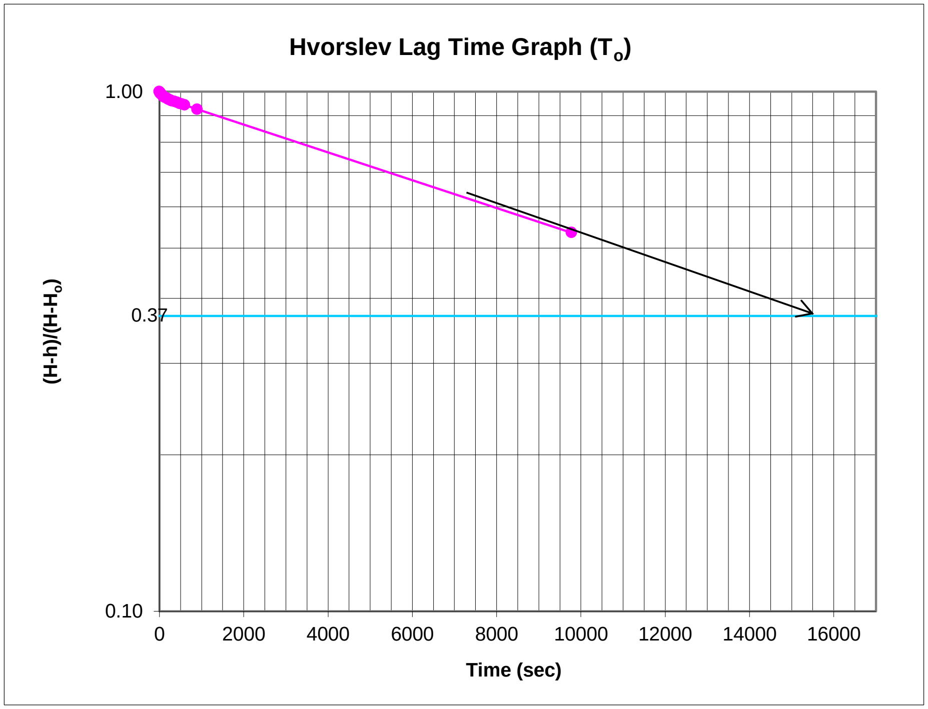
Hvorslev Calculation
(for Hydraulic Conductivity from Response Tests)

Well Name =	**MW2**	
Well Depth =	5.35 m	
Initial WL (H_o) =	1.77 m	
Radius of pipe (r) =	0.025 m	(2.0" diameter)
Radius of hole (R) =	0.152 m	(4.25" hollow auger I.D., 12" O.D.)
Length of screen (L) =	3.048 m	(10 foot screen)
Water Level at Max Drawdown (H) =	4.030 m	
$H-H_o$ =	2.260 m	
Lag time (T_o) =	15750	(time at $(H-h)/(H-H_o)$ = 0.37 on graph)

Hydraulic Cond.(K) = **1.95E-08 m/s**
1.95E-06 cm/s

Screened material = clayey silt TILL

Time (sec)	WL (m)	$H-H_o$ (m)	$(H-h)/(H-H_o)$
0	4.03	2.26	1.00
10	4.025	2.26	1.00
15	4.02	2.25	1.00
20	4.02	2.25	1.00
25	4.015	2.25	0.99
30	4.01	2.24	0.99
40	4.01	2.24	0.99
50	4.005	2.24	0.99
60	4	2.23	0.99
90	3.985	2.22	0.98
120	3.975	2.21	0.98
150	3.97	2.20	0.97
180	3.965	2.20	0.97
210	3.955	2.19	0.97
240	3.95	2.18	0.96
270	3.945	2.18	0.96
300	3.94	2.17	0.96
360	3.935	2.17	0.96
420	3.925	2.16	0.95



Appendix C
Monitoring Well Conductivity Tests

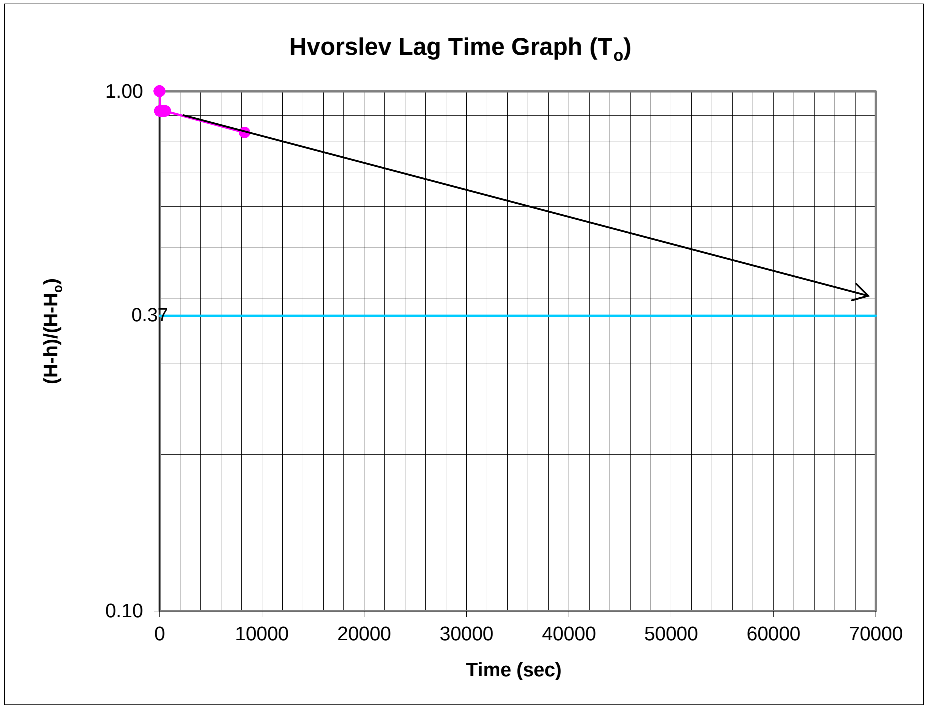
Hvorslev Calculation
(for Hydraulic Conductivity from Response Tests)

Well Name =	**MW3**	
Well Depth =	5.22 m	
Initial WL (H_o) =	5.04 m	
Radius of pipe (r) =	0.025 m	(2.0" diameter)
Radius of hole (R) =	0.152 m	(4.25" hollow auger I.D., 12" O.D.)
Length of screen (L) =	3.048 m	(10 foot screen)
Water Level at Max Drawdown (H) =	5.100 m	
$H-H_o$ =	0.060 m	
Lag time (T_o) =	72000	(time at $(H-h)/(H-H_o)$ = 0.37 on graph)

Hydraulic Cond.(K) = **4.27E-09 m/s**
4.27E-07 cm/s

Screened material = clayey silt TILL

Time (sec)	WL (m)	$H-H_o$ (m)	$(H-h)/(H-H_o)$
0	5.1	0.06	1.00
10	5.1	0.06	1.00
15	5.1	0.06	1.00
20	5.1	0.06	1.00
25	5.1	0.06	1.00
30	5.1	0.06	1.00
40	5.1	0.06	1.00
50	5.095	0.05	0.92
60	5.095	0.05	0.92
90	5.095	0.05	0.92
120	5.095	0.05	0.92
150	5.095	0.05	0.92
180	5.095	0.05	0.92
210	5.095	0.05	0.92
240	5.095	0.05	0.92
270	5.095	0.05	0.92
300	5.095	0.05	0.92
360	5.095	0.05	0.92
420	5.095	0.05	0.92



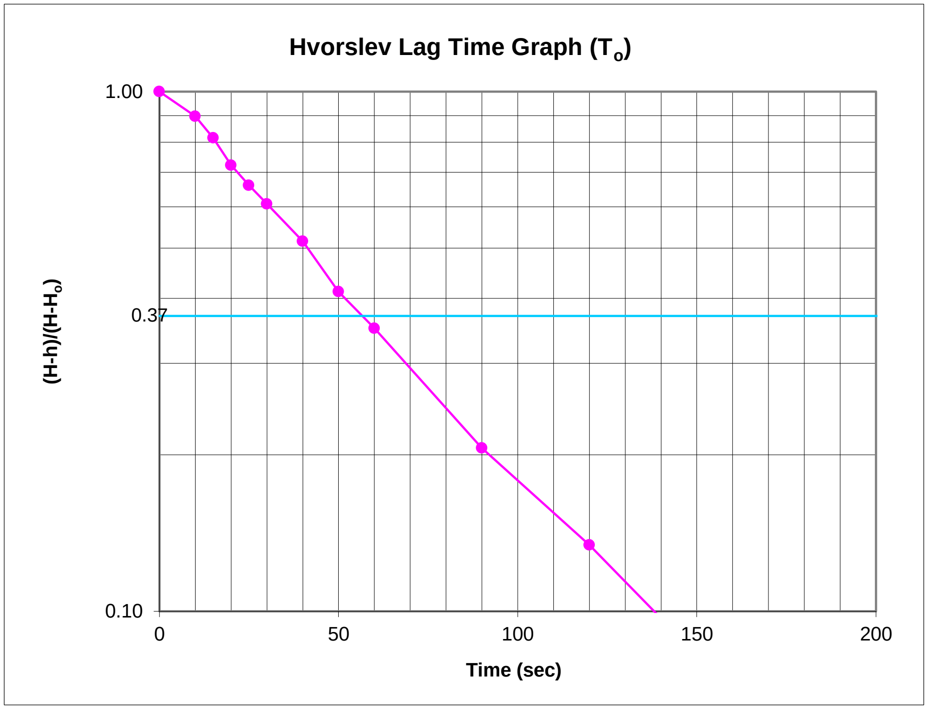
Hvorslev Calculation
(for Hydraulic Conductivity from Response Tests)

Well Name = **MW4**
Well Depth = 7.00 m
Initial WL (H_o) = 2.58 m
Radius of pipe (r) = 0.025 m (2.0" diameter)
Radius of hole (R) = 0.152 m (4.25" hollow auger I.D., 12" O.D.)
Length of screen (L) = 3.048 m (10 foot screen)
Water Level at Max Drawdown (H) = 3.550 m
$H-H_o$ = 0.970 m
Lag time (T_o) = 58 (time at $(H-h)/(H-H_o)$ = 0.37 on graph)

Hydraulic Cond.(K) = 5.30E-06 m/s
5.30E-04 cm/s

Screened material = bedrock (shale)

Time (sec)	WL (m)	$H-H_o$ (m)	$(H-h)/(H-H_o)$
0	3.55	0.97	1.00
10	3.45	0.87	0.90
15	3.37	0.79	0.81
20	3.28	0.70	0.72
25	3.22	0.64	0.66
30	3.17	0.59	0.61
40	3.08	0.50	0.52
50	2.98	0.40	0.41
60	2.92	0.34	0.35
90	2.78	0.20	0.21
120	2.71	0.13	0.13
150	2.66	0.08	0.08
180	2.64	0.06	0.06
210	2.63	0.05	0.05
240	2.62	0.04	0.04
270	2.61	0.03	0.03
300	2.61	0.03	0.03



Appendix C
Monitoring Well Conductivity Tests

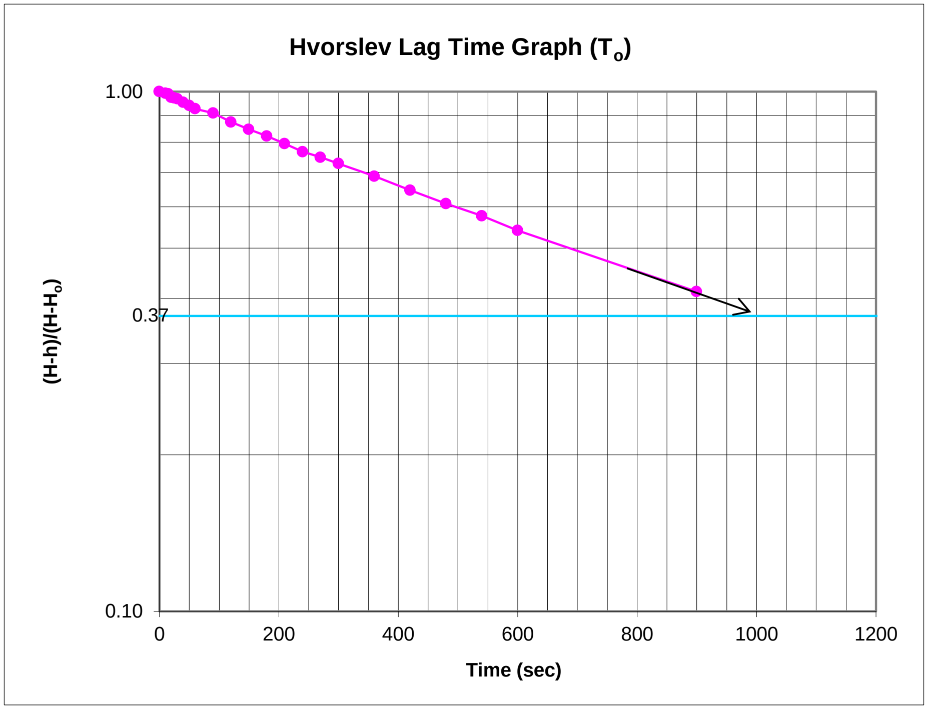
Hvorslev Calculation
(for Hydraulic Conductivity from Response Tests)

Well Name =	**MW5**	
Well Depth =	15.50 m	
Initial WL (H_o) =	2.39 m	
Radius of pipe (r) =	0.025 m	(2.0" diameter)
Radius of hole (R) =	0.152 m	(4.25" hollow auger I.D., 12" O.D.)
Length of screen (L) =	3.048 m	(10 foot screen)
Water Level at Max Drawdown (H) =	14.200 m	
$H-H_o$ =	11.810 m	
Lag time (T_o) =	1000	(time at $(H-h)/(H-H_o)$ = 0.37 on graph)

Hydraulic Cond.(K) = **3.07E-07 m/s**
3.07E-05 cm/s

Screened material = clayey silt till and upper weathered bedrock (shale)

Time (sec)	WL (m)	$H-H_o$ (m)	$(H-h)/(H-H_o)$
0	14.2	11.81	1.00
10	14.12	11.73	0.99
15	14.08	11.69	0.99
20	13.91	11.52	0.98
25	13.88	11.49	0.97
30	13.83	11.44	0.97
40	13.65	11.26	0.95
50	13.5	11.11	0.94
60	13.34	10.95	0.93
90	13.13	10.74	0.91
120	12.71	10.32	0.87
150	12.38	9.99	0.85
180	12.09	9.70	0.82
210	11.77	9.38	0.79
240	11.44	9.05	0.77
270	11.22	8.83	0.75
300	10.98	8.59	0.73
360	10.51	8.12	0.69
420	10.02	7.63	0.65



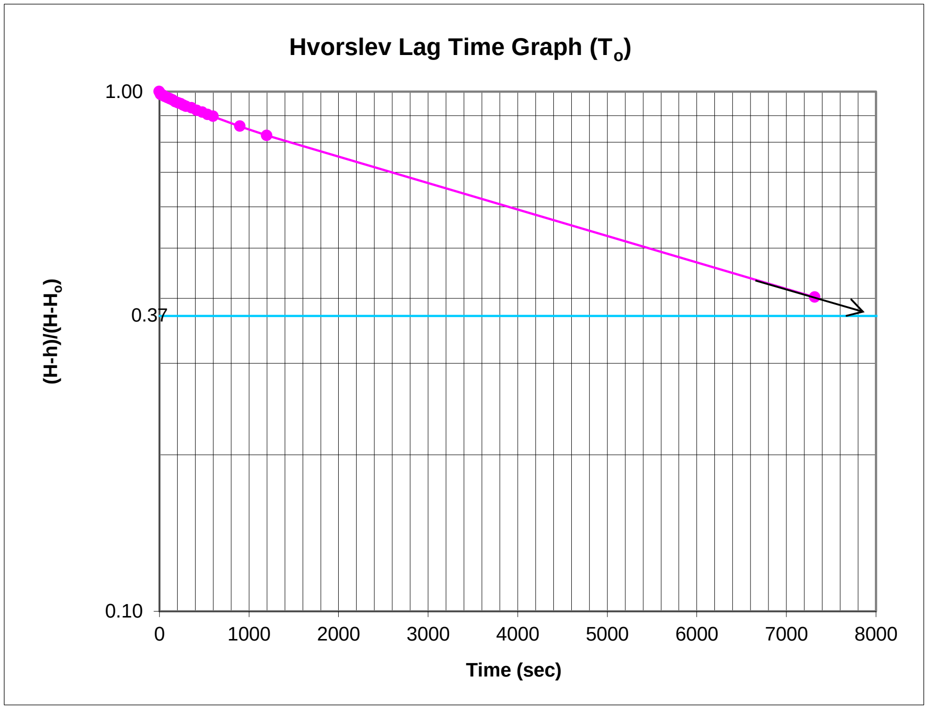
Hvorslev Calculation
(for Hydraulic Conductivity from Response Tests)

Well Name =	**MW6-D (deep)**	
Well Depth =	19.11 m	
Initial WL (H_o) =	2.60 m	
Radius of pipe (r) =	0.025 m	(2.0" diameter)
Radius of hole (R) =	0.152 m	(4.25" hollow auger I.D., 12" O.D.)
Length of screen (L) =	3.048 m	(10 foot screen)
Water Level at Max Drawdown (H) =	7.650 m	
$H-H_o$ =	5.050 m	
Lag time (T_o) =	7900	(time at $(H-h)/(H-H_o)$ = 0.37 on graph)

Hydraulic Cond.(K) = **3.89E-08 m/s**
3.89E-06 cm/s

Screened material = shale bedrock

Time (sec)	WL (m)	$H-H_o$ (m)	$(H-h)/(H-H_o)$
0	7.65	5.05	1.00
10	7.62	5.02	0.99
15	7.59	4.99	0.99
20	7.585	4.99	0.99
25	7.58	4.98	0.99
30	7.58	4.98	0.99
40	7.57	4.97	0.98
50	7.56	4.96	0.98
60	7.545	4.95	0.98
90	7.52	4.92	0.97
120	7.49	4.89	0.97
150	7.465	4.87	0.96
180	7.43	4.83	0.96
210	7.405	4.81	0.95
240	7.385	4.79	0.95
270	7.355	4.76	0.94
300	7.33	4.73	0.94
360	7.3	4.70	0.93
420	7.245	4.65	0.92



Appendix C
Monitoring Well Conductivity Tests

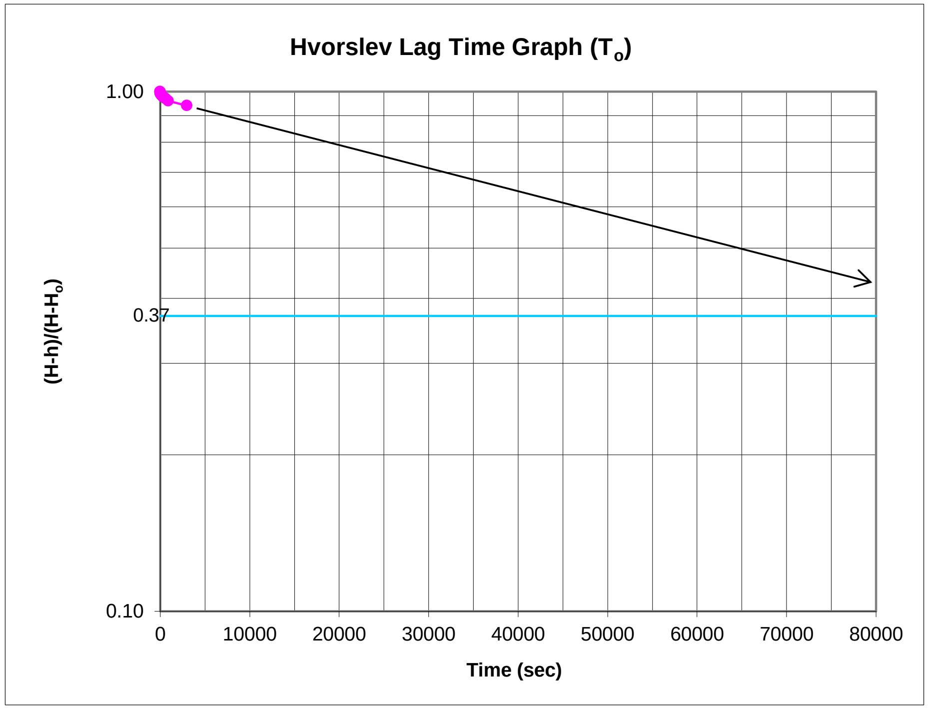
Hvorslev Calculation
(for Hydraulic Conductivity from Response Tests)

Well Name =	**MW7**	
Well Depth =	31.25 m	
Initial WL (H_o) =	3.37 m	
Radius of pipe (r) =	0.025 m	(2.0" diameter)
Radius of hole (R) =	0.152 m	(4.25" hollow auger I.D., 12" O.D.)
Length of screen (L) =	6.096 m	(20 foot screen)
Water Level at Max Drawdown (H) =	19.200 m	
$H-H_o$ =	15.835 m	
Lag time (T_o) =	90000	(time at $(H-h)/(H-H_o)$ = 0.37 on graph)

Hydraulic Cond.(K) = 2.10E-09 m/s
2.10E-07 cm/s

Screened material = shale bedrock

Time (sec)	WL (m)	$H-H_o$ (m)	$(H-h)/(H-H_o)$
0	19.2	15.84	1.00
10	19.18	15.82	1.00
15	19.16	15.80	1.00
20	19.13	15.77	1.00
25	19.11	15.75	0.99
30	19.08	15.72	0.99
40	19.07	15.71	0.99
50	19.05	15.69	0.99
60	19.04	15.68	0.99
90	19.01	15.65	0.99
120	18.99	15.63	0.99
150	18.96	15.60	0.98
180	18.94	15.58	0.98
210	18.92	15.56	0.98
240	18.905	15.54	0.98
270	18.89	15.53	0.98
300	18.88	15.52	0.98
360	18.84	15.48	0.98
420	18.81	15.45	0.98



Appendix C
Monitoring Well Conductivity Tests

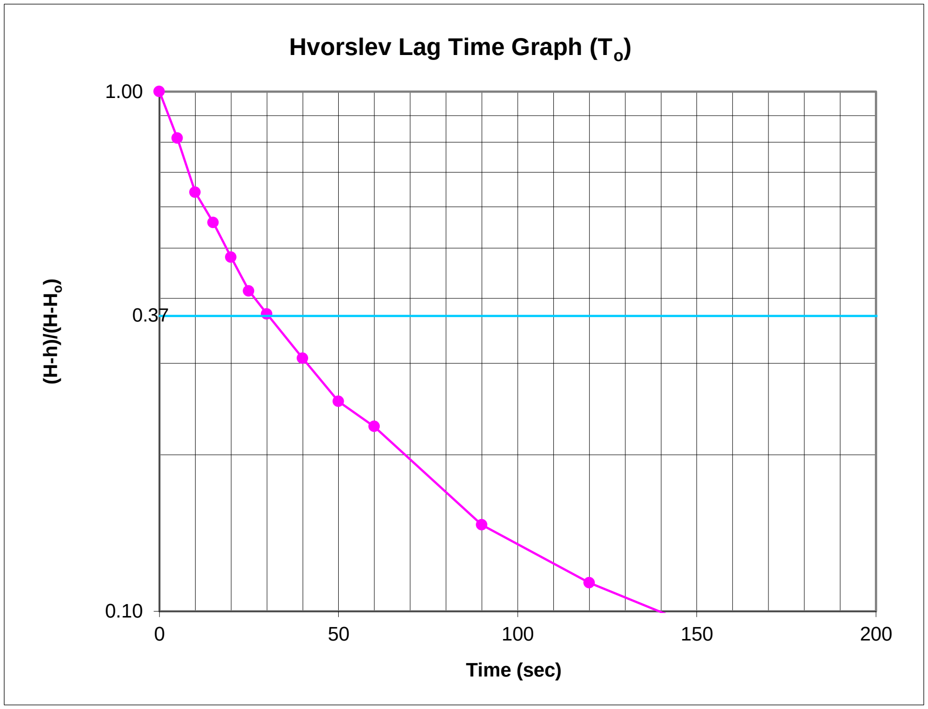
Hvorslev Calculation
(for Hydraulic Conductivity from Response Tests)

Well Name =	**MW8**	
Well Depth =	5.49 m	
Initial WL (H_o) =	1.20 m	
Radius of pipe (r) =	0.025 m	(2.0" diameter)
Radius of hole (R) =	0.152 m	(4.25" hollow auger I.D., 12" O.D.)
Length of screen (L) =	1.520 m	(5 foot screen)
Water Level at Max Drawdown (H) =	1.950 m	
$H-H_o$ =	0.750 m	
Lag time (T_o) =	30	(time at $(H-h)/(H-H_o)$ = 0.37 on graph)

Hydraulic Cond.(K) = **1.58E-05 m/s**
1.58E-03 cm/s

Screened material = shallow weathered shale bedrock

Time (sec)	WL (m)	$H-H_o$ (m)	$(H-h)/(H-H_o)$
0	1.95	0.75	1.00
5	1.81	0.61	0.81
10	1.68	0.48	0.64
15	1.62	0.42	0.56
20	1.56	0.36	0.48
25	1.51	0.31	0.41
30	1.48	0.28	0.37
40	1.43	0.23	0.31
50	1.39	0.19	0.25
60	1.37	0.17	0.23
90	1.31	0.11	0.15
120	1.285	0.09	0.11
150	1.27	0.07	0.09
180	1.265	0.06	0.09
210	1.26	0.06	0.08
240	1.25	0.05	0.07
270	1.25	0.05	0.07
300	1.245	0.05	0.06



Appendix C
Monitoring Well Conductivity Tests

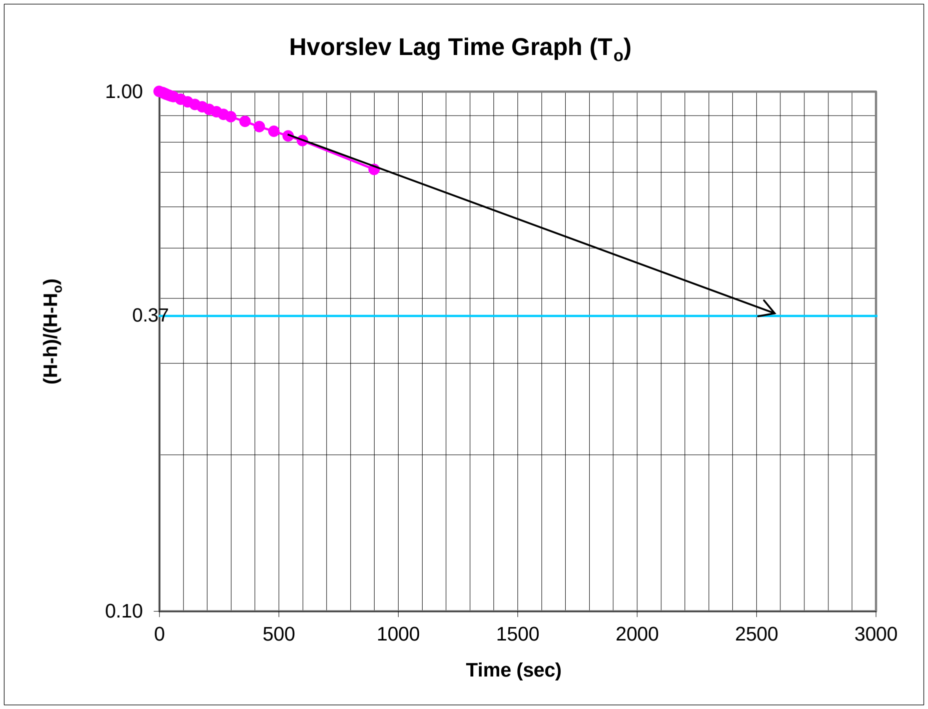
Hvorslev Calculation
(for Hydraulic Conductivity from Response Tests)

Well Name =	**MW9**	
Well Depth =	18.20 m	
Initial WL (H_o) =	2.97 m	
Radius of pipe (r) =	0.025 m	(2.0" diameter)
Radius of hole (R) =	0.152 m	(4.25" hollow auger I.D., 12" O.D.)
Length of screen (L) =	3.048 m	(10 foot screen)
Water Level at Max Drawdown (H) =	17.300 m	
$H-H_o$ =	14.330 m	
Lag time (T_o) =	2600	(time at $(H-h)/(H-H_o)$ = 0.37 on graph)

Hydraulic Cond.(K) = **1.18E-07 m/s**
1.18E-05 cm/s

Screened material = shallow weathered shale bedrock

Time (sec)	WL (m)	$H-H_o$ (m)	$(H-h)/(H-H_o)$
0	17.3	14.33	1.00
15	17.23	14.26	1.00
20	17.19	14.22	0.99
25	17.16	14.19	0.99
30	17.12	14.15	0.99
40	17.07	14.10	0.98
50	17.02	14.05	0.98
60	16.97	14.00	0.98
90	16.81	13.84	0.97
120	16.66	13.69	0.96
150	16.5	13.53	0.94
180	16.35	13.38	0.93
210	16.2	13.23	0.92
240	16.06	13.09	0.91
270	15.92	12.95	0.90
300	15.79	12.82	0.89
360	15.52	12.55	0.88
420	15.23	12.26	0.86
480	14.99	12.02	0.84



Appendix C
Monitoring Well Conductivity Tests

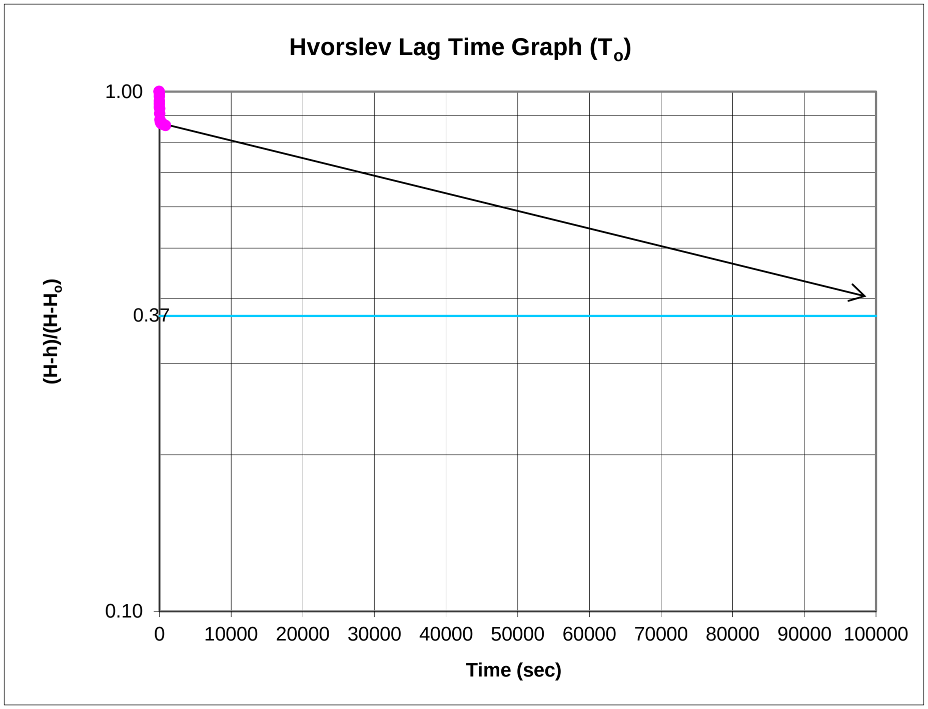
Hvorslev Calculation
(for Hydraulic Conductivity from Response Tests)

Well Name =	**MW10-D (deep)**	
Well Depth =	21.22 m	
Initial WL (H_o) =	4.13 m	
Radius of pipe (r) =	0.025 m	(2.0" diameter)
Radius of hole (R) =	0.152 m	(4.25" hollow auger I.D., 12" O.D.)
Length of screen (L) =	3.048 m	(10 foot screen)
Water Level at Max Drawdown (H) =	21.000 m	
$H-H_o$ =	16.870 m	
Lag time (T_o) =	100000	(time at $(H-h)/(H-H_o)$ = 0.37 on graph)

Hydraulic Cond.(K) = **3.07E-09 m/s**
3.07E-07 cm/s

Screened material = shale bedrock

Time (sec)	WL (m)	$H-H_o$ (m)	$(H-h)/(H-H_o)$
0	21	16.87	1.00
15	20.98	16.85	1.00
20	20.87	16.74	0.99
25	20.64	16.51	0.98
30	20.31	16.18	0.96
40	20.09	15.96	0.95
50	19.88	15.75	0.93
60	19.77	15.64	0.93
90	19.44	15.31	0.91
120	19.02	14.89	0.88
150	18.91	14.78	0.88
180	18.88	14.75	0.87
210	18.86	14.73	0.87
240	18.82	14.69	0.87
270	18.79	14.66	0.87
300	18.77	14.64	0.87
360	18.75	14.62	0.87
420	18.74	14.61	0.87
480	18.73	14.60	0.87



Branthaven Homes Development Site
Block 3, Winona, Ontario

Landtek Limited

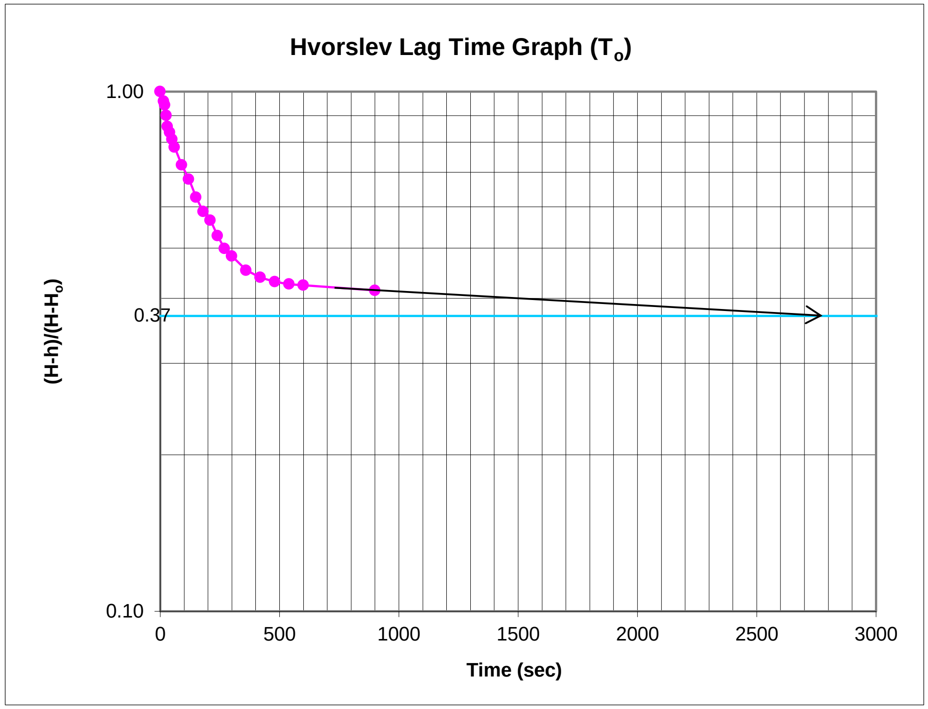
Hvorslev Calculation
(for Hydraulic Conductivity from Response Tests)

Well Name =	**MW11**	
Well Depth =	17.36 m	
Initial WL (H_o) =	4.76 m	
Radius of pipe (r) =	0.025 m	(2.0" diameter)
Radius of hole (R) =	0.152 m	(4.25" hollow auger I.D., 12" O.D.)
Length of screen (L) =	3.048 m	(10 foot screen)
Water Level at Max Drawdown (H) =	13.300 m	
$H-H_o$ =	8.540 m	
Lag time (T_o) =	2750	(time at $(H-h)/(H-H_o)$ = 0.37 on graph)

Hydraulic Cond.(K) = **1.12E-07 m/s**
1.12E-05 cm/s

Screened material = shale bedrock

Time (sec)	WL (m)	$H-H_o$ (m)	$(H-h)/(H-H_o)$
0	13.3	8.54	1.00
15	12.95	8.19	0.96
20	12.81	8.05	0.94
25	12.45	7.69	0.90
30	12.08	7.32	0.86
40	11.89	7.13	0.83
50	11.67	6.91	0.81
60	11.44	6.68	0.78
90	10.93	6.17	0.72
120	10.55	5.79	0.68
150	10.11	5.35	0.63
180	9.78	5.02	0.59
210	9.59	4.83	0.57
240	9.27	4.51	0.53
270	9.02	4.26	0.50
300	8.88	4.12	0.48
360	8.63	3.87	0.45
420	8.51	3.75	0.44
480	8.44	3.68	0.43



Appendix C
Monitoring Well Conductivity Tests

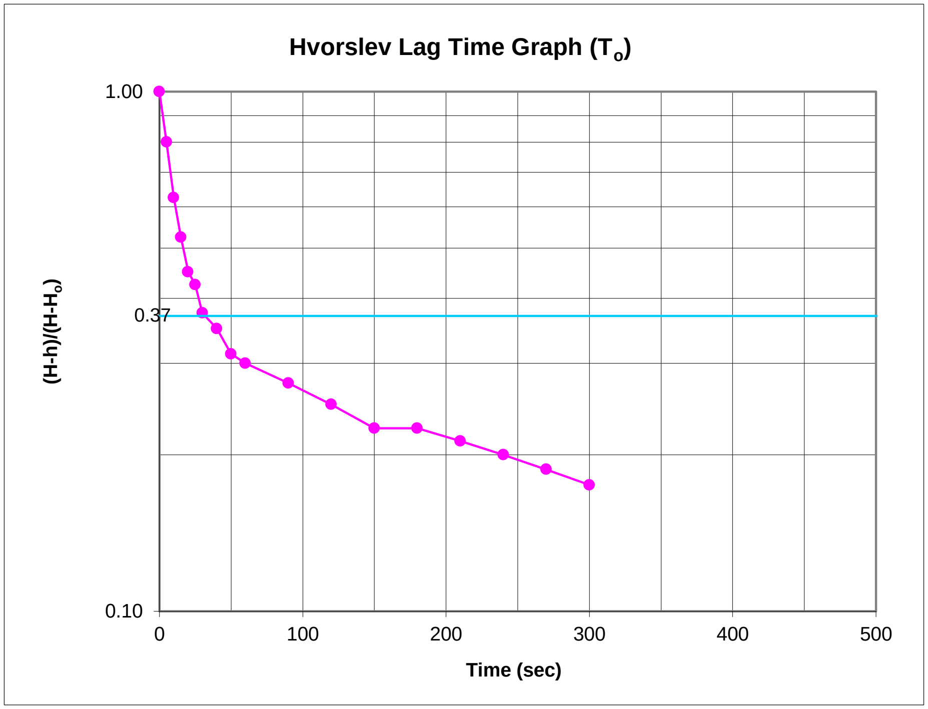
Hvorslev Calculation
(for Hydraulic Conductivity from Response Tests)

Well Name =	**MW12**	
Well Depth =	6.55 m	
Initial WL (H_o) =	1.75 m	
Radius of pipe (r) =	0.025 m	(2.0" diameter)
Radius of hole (R) =	0.152 m	(4.25" hollow auger I.D., 12" O.D.)
Length of screen (L) =	3.048 m	(10 foot screen)
Water Level at Max Drawdown (H) =	2.150 m	
$H-H_o$ =	0.400 m	
Lag time (T_o) =	32	(time at $(H-h)/(H-H_o)$ = 0.37 on graph)

Hydraulic Cond.(K) = **9.60E-06 m/s**
9.60E-04 cm/s

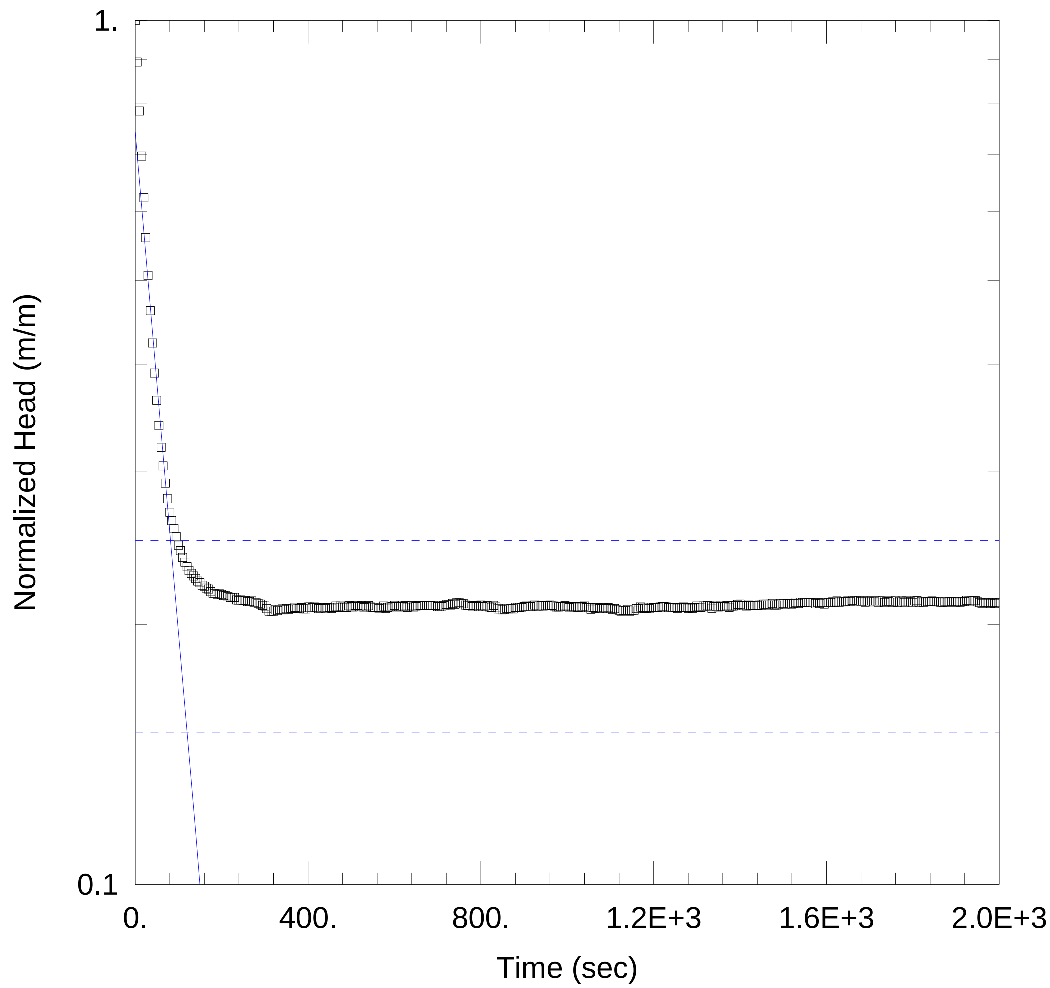
Screened material = weathered shale bedrock

Time (sec)	WL (m)	$H-H_o$ (m)	$(H-h)/(H-H_o)$
0	2.15	0.40	1.00
5	2.07	0.32	0.80
10	2	0.25	0.63
15	1.96	0.21	0.53
20	1.93	0.18	0.45
25	1.92	0.17	0.43
30	1.9	0.15	0.38
40	1.89	0.14	0.35
50	1.875	0.13	0.31
60	1.87	0.12	0.30
90	1.86	0.11	0.28
120	1.85	0.10	0.25
150	1.84	0.09	0.23
180	1.84	0.09	0.23
210	1.835	0.09	0.21
240	1.83	0.08	0.20
270	1.825	0.08	0.19
300	1.82	0.07	0.18



Branthaven Homes Development Site
Block 3, Winona, Ontario

Landtek Limited



FRUITLAND - WINONA BSS #3

Data Set: F:\LANDTEK K TESTS\Add Winona Block 3\Aqtesolve\MW14.aqt
Date: 09/25/18 Time: 10:57:15

PROJECT INFORMATION

Company: Landtek Limited
Client: Urbantech West
Project: 18270
Location: Winona
Test Well: MW14
Test Date: September 12, 2018

AQUIFER DATA

Saturated Thickness: 5.03 m
Anisotropy Ratio (Kz/Kr): 1.

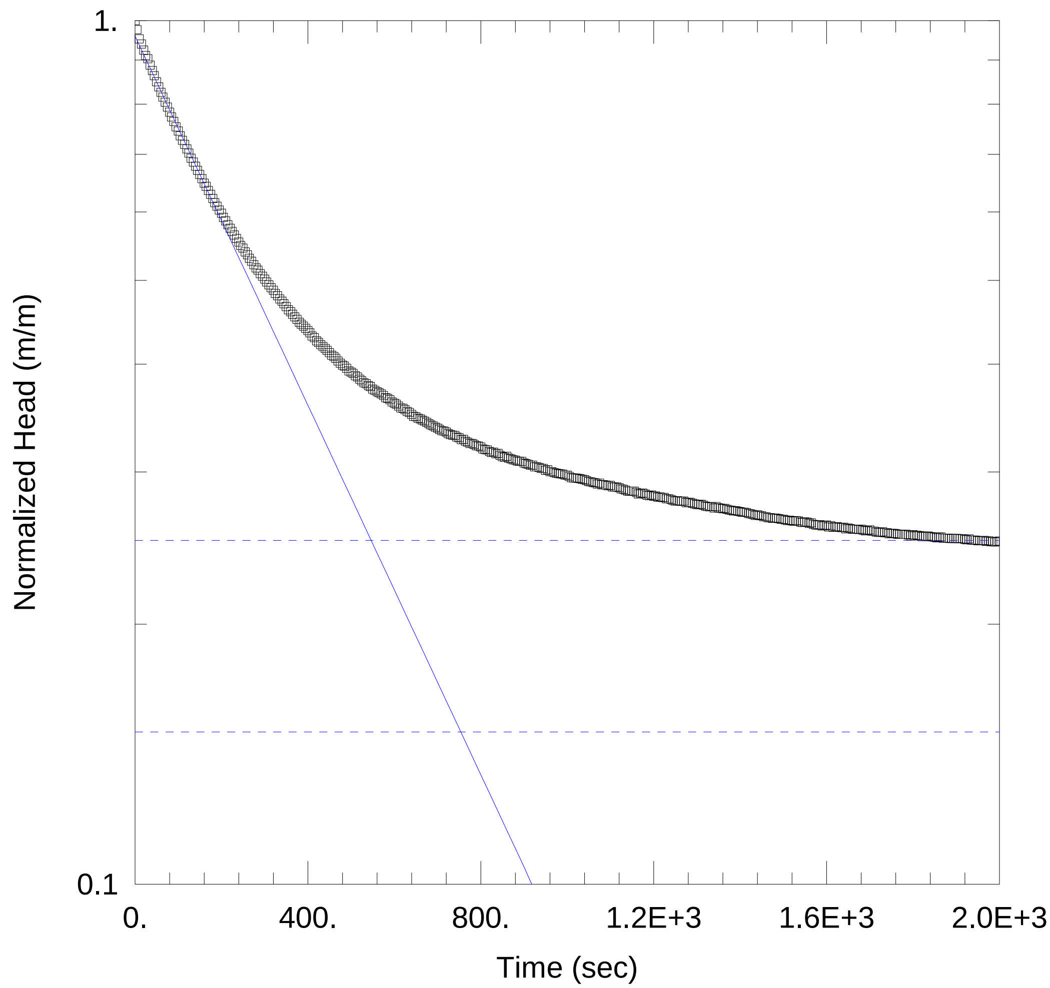
WELL DATA (MW14)

Initial Displacement: 0.4475 m
Total Well Penetration Depth: 5.03 m
Casing Radius: 0.0254 m
Static Water Column Height: 5.03 m
Screen Length: 3. m
Well Radius: 0.0254 m
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 6.839E-6 m/sec
y0 = 0.3319 m



FRUITLAND - WINONA BSS #3

Data Set: F:\LANDTEK K TESTS\Add Winona Block 3\Aqtesolve\MW16.aqt
Date: 09/25/18 Time: 10:51:16

PROJECT INFORMATION

Company: Landtek Limited
Client: Urbantech West
Project: 18270
Location: Winona
Test Well: MW16
Test Date: September 12, 2018

AQUIFER DATA

Saturated Thickness: 10.26 m
Anisotropy Ratio (Kz/Kr): 1.

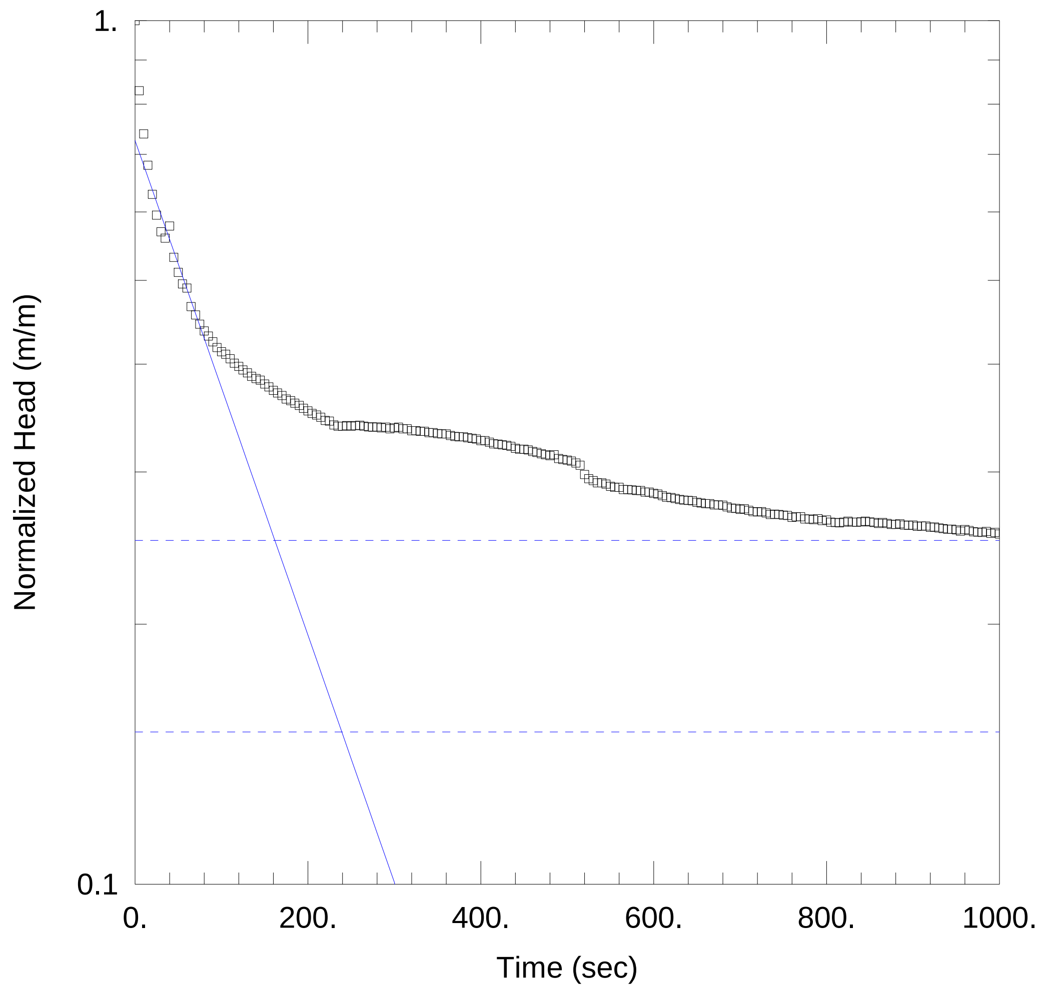
WELL DATA (MW16)

Initial Displacement: 0.5 m
Total Well Penetration Depth: 10.26 m
Casing Radius: 0.0254 m
Static Water Column Height: 10.26 m
Screen Length: 3. m
Well Radius: 0.0254 m
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 1.447E-6 m/sec
y0 = 0.4798 m



FRUITLAND - WINONA BSS #3

Data Set: F:\LANDTEK K TESTS\Add Winona Block 3\Aqtesolve\MW17D.aqt
Date: 09/25/18 Time: 10:53:27

PROJECT INFORMATION

Company: Landtek Limited
Client: Urbantech West
Project: 18270
Location: Winona
Test Well: MW17D
Test Date: September 12, 2018

AQUIFER DATA

Saturated Thickness: 17.13 m
Anisotropy Ratio (Kz/Kr): 1.

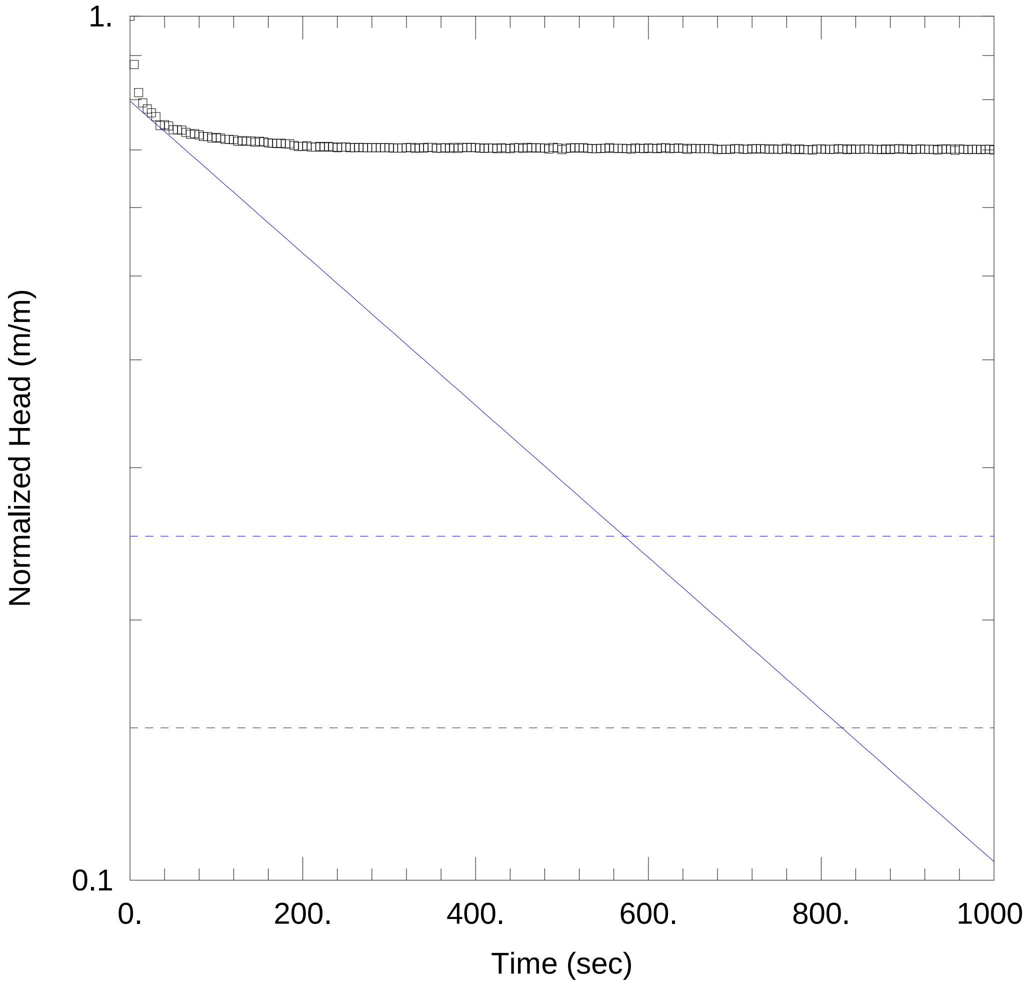
WELL DATA (MW17D)

Initial Displacement: 0.3967 m
Total Well Penetration Depth: 17.13 m
Casing Radius: 0.0254 m
Static Water Column Height: 17.13 m
Screen Length: 1.5 m
Well Radius: 0.0254 m
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 6.767E-6 m/sec
y0 = 0.2881 m



FRUITLAND - WINONA BSS #3

Data Set: F:\LANDTEK K TESTS\Add Winona Block 3\Aqtesolve\MW17.aqt
Date: 09/25/18 Time: 10:51:52

PROJECT INFORMATION

Company: Landtek Limited
Client: Urbantech West
Project: 18270
Location: Winona
Test Well: MW17S
Test Date: September 12, 2018

AQUIFER DATA

Saturated Thickness: 1.72 m Anisotropy Ratio (Kz/Kr): 1.

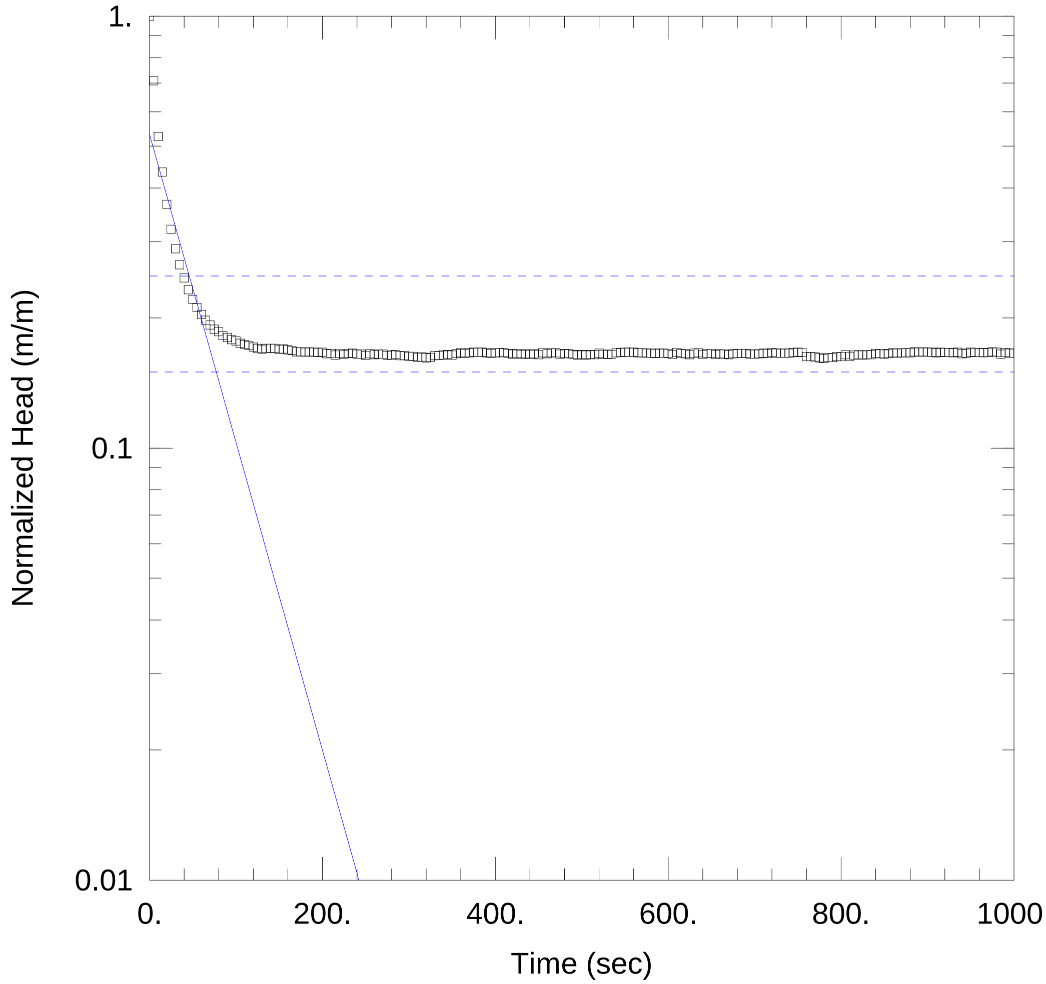
WELL DATA (MW17S)

Initial Displacement: 0.4048 m
Total Well Penetration Depth: 1.72 m
Casing Radius: 0.0254 m
Static Water Column Height: 1.72 m
Screen Length: 1.5 m
Well Radius: 0.0254 m
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 2.08E-6 m/sec y0 = 0.3227 m



FRUITLAND - WINONA BSS #3

Data Set: F:\LANDTEK K TESTS\Add Winona Block 3\Aqtesolve\MW18.aqt
Date: 09/25/18 Time: 10:54:38

PROJECT INFORMATION

Company: Landtek Limited
Client: Urbantech West
Project: 18270
Location: Winona
Test Well: MW18
Test Date: September 12, 2018

AQUIFER DATA

Saturated Thickness: 4.12 m
Anisotropy Ratio (Kz/Kr): 1.

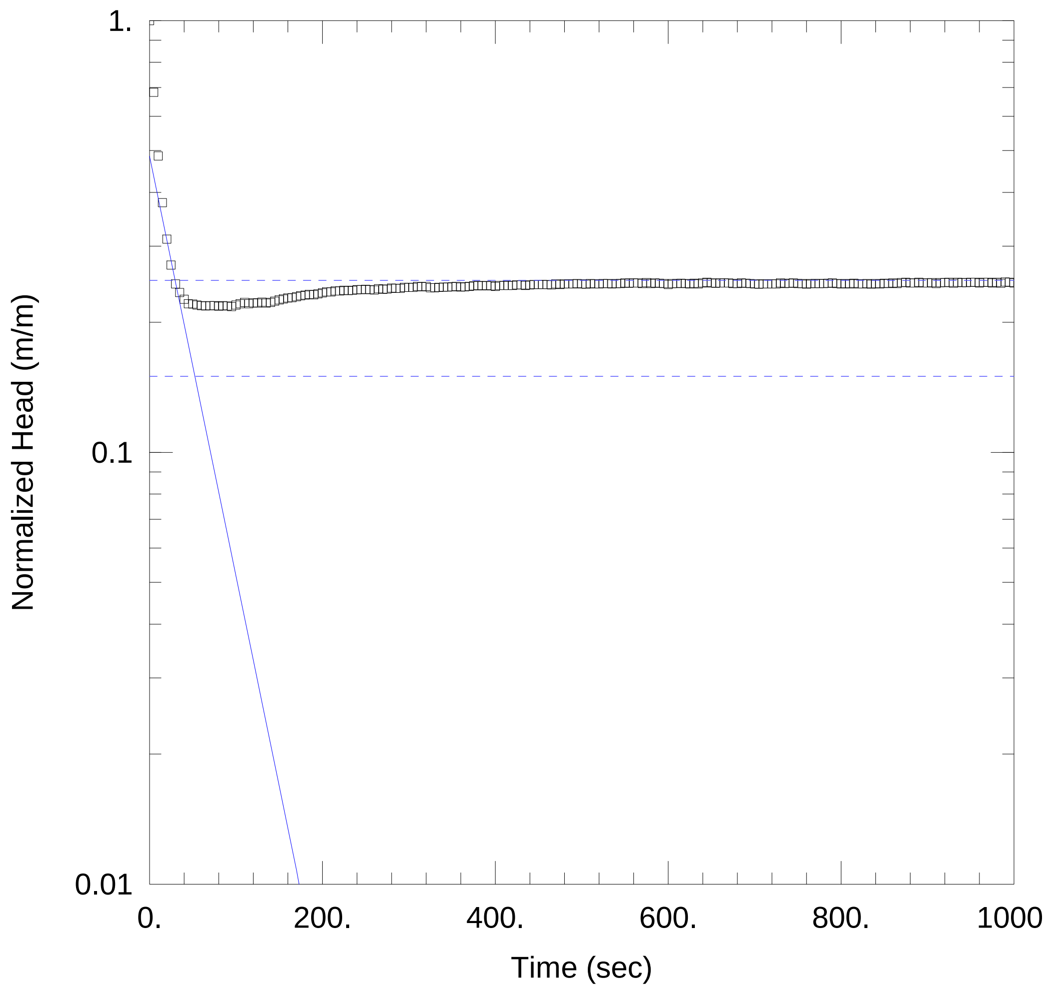
WELL DATA (MW18)

Initial Displacement: 0.3783 m
Total Well Penetration Depth: 7.12 m
Casing Radius: 0.0254 m
Static Water Column Height: 4.12 m
Screen Length: 3. m
Well Radius: 0.0254 m
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 9.639E-6 m/sec
y0 = 0.2011 m



FRUITLAND - WINONA BSS #3

Data Set: F:\LANDTEK K TESTS\Add Winona Block 3\Aqtesolve\MW19.aqt
Date: 09/25/18 Time: 10:56:28

PROJECT INFORMATION

Company: Landtek Limited
Client: Urbantech West
Project: 18270
Location: Winona
Test Well: MW19
Test Date: September 12, 2018

AQUIFER DATA

Saturated Thickness: 4.2 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW19)

Initial Displacement: 0.3901 m
Total Well Penetration Depth: 4.2 m
Casing Radius: 0.0254 m
Static Water Column Height: 4.2 m
Screen Length: 3. m
Well Radius: 0.0254 m
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Unconfined Solution Method: Hvorslev

K = 1.316E-5 m/sec y0 = 0.1892 m

APPENDIX H

LABORATORY CERTIFICATE OF ANALYSIS

LANDTEK LIMITED
ATTN: HENRY EREBOR
205 NEBO ROAD, UNIT 3
HAMILTON ON L8W 2E1

Date Received: 25-SEP-18
Report Date: 03-OCT-18 14:57 (MT)
Version: FINAL

Client Phone: 905-383-3733

Certificate of Analysis

Lab Work Order #: L2170497

Project P.O. #: NOT SUBMITTED
Job Reference: 18270
C of C Numbers: 17-618803
Legal Site Desc:

Mathy Mahadeva
Account Manager

Sample Details Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits #1	#2
L2170497-1	MW13							
Sampled By:	CLIENT on 24-SEP-18							
Matrix:	WATER							
Physical Tests								
	Colour, Apparent	5.0		2.0	CU	26-SEP-18		5
	Conductivity	1510		3.0	umhos/cm	26-SEP-18		
	pH	7.96		0.10	pH units	26-SEP-18		6.5-8.5
	Redox Potential	250	PEHR	-1000	mV	28-SEP-18		
	Total Dissolved Solids	875	DLDS	20	mg/L	27-SEP-18		*500
	Turbidity	3.54		0.10	NTU	26-SEP-18		5
Anions and Nutrients								
	Alkalinity, Bicarbonate (as CaCO3)	129		10	mg/L	28-SEP-18		
	Alkalinity, Carbonate (as CaCO3)	<10		10	mg/L	28-SEP-18		
	Alkalinity, Hydroxide (as CaCO3)	<10		10	mg/L	28-SEP-18		
	Alkalinity, Total (as CaCO3)	129		10	mg/L	28-SEP-18		30-500
	Ammonia, Total (as N)	1.44	DLHC	0.040	mg/L	03-OCT-18		
	Bromide (Br)	<0.50	DLDS	0.50	mg/L	27-SEP-18		
	Chloride (Cl)	343	DLDS	2.5	mg/L	27-SEP-18		*250
	Computed Conductivity	1480			uS/cm	28-SEP-18		
	Conductivity % Difference	-1.9			%	28-SEP-18		
	Fluoride (F)	0.16	DLDS	0.10	mg/L	27-SEP-18	1.5	
	Hardness (as CaCO3)	294			mg/L	28-SEP-18		*80-100
	Ion Balance	96.0			%	28-SEP-18		
	Langelier Index	0.4			No Unit	28-SEP-18		
	Nitrate (as N)	<0.10	DLDS	0.10	mg/L	27-SEP-18	10	
	Nitrite (as N)	1.09	DLDS	0.050	mg/L	27-SEP-18	*1	
	Saturation pH	7.52			pH	28-SEP-18		
	Orthophosphate-Dissolved (as P)	<0.0030		0.0030	mg/L	27-SEP-18		
	TDS (Calculated)	924			mg/L	28-SEP-18		
	Sulfate (SO4)	183	DLDS	1.5	mg/L	27-SEP-18		500
	Anion Sum	15.7			me/L	28-SEP-18		
	Cation Sum	15.1			me/L	28-SEP-18		
	Cation - Anion Balance	-2.1			%	28-SEP-18		
Inorganic Parameters								
	Silica	10.3		2.1	mg/L	26-SEP-18		
Bacteriological Tests								
	E. Coli	0		0	CFU/100mL	27-SEP-18	0	
	Total Coliform Background	31000	DLM	1000	CFU/100mL	27-SEP-18		
	Total Coliforms	150	DLM	10	CFU/100mL	27-SEP-18	*0	
Metals								
	Sodium Adsorption Ratio	5.31		0.10	SAR	26-SEP-18		
Total Metals								
	Aluminum (Al)-Total	0.061	DLHC	0.050	mg/L	26-SEP-18		0.1
	Antimony (Sb)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18	0.006	
	Arsenic (As)-Total	0.0025	DLHC	0.0010	mg/L	26-SEP-18	0.0100	
	Barium (Ba)-Total	0.0558	DLHC	0.0010	mg/L	26-SEP-18	1	
	Beryllium (Be)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
	Bismuth (Bi)-Total	<0.00050	DLHC	0.00050	mg/L	26-SEP-18		

** Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
* Analytical result for this parameter exceeds Guideline Limit listed on this report. Guideline Limits applied:

Ontario Drinking Water Regulation (ODWQS) JAN.1,2018 = [Suite] - ON-DW-STANDARD+GUIDELINES

#1: Schedule 1 (Microbiological) and 2 (Chemical) Standards (JAN,2018) **#2: Ontario DW Aesthetic and Operational Guidelines**

ANALYTICAL GUIDELINE REPORT

18270

Sample Details Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits #1	Guideline Limits #2
L2170497-1 MW13								
Sampled By: CLIENT on 24-SEP-18								
Matrix: WATER							#1	#2
Total Metals								
	Boron (B)-Total	0.45	DLHC	0.10	mg/L	26-SEP-18	5	
	Cadmium (Cd)-Total	<0.000050	DLHC	0.000050	mg/L	26-SEP-18	0.005	
	Calcium (Ca)-Total	78.8	DLHC	0.50	mg/L	26-SEP-18		
	Cesium (Cs)-Total	<0.00010	DLHC	0.00010	mg/L	26-SEP-18		
	Chromium (Cr)-Total	<0.0050	DLHC	0.0050	mg/L	26-SEP-18	0.05	
	Cobalt (Co)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
	Copper (Cu)-Total	<0.010	DLHC	0.010	mg/L	26-SEP-18		1
	Iron (Fe)-Total	<0.10	DLHC	0.10	mg/L	26-SEP-18		0.3
	Lead (Pb)-Total	<0.00050	DLHC	0.00050	mg/L	26-SEP-18	0.01	
	Magnesium (Mg)-Total	23.7	DLHC	0.050	mg/L	26-SEP-18		
	Manganese (Mn)-Total	0.0598	DLHC	0.0050	mg/L	26-SEP-18		*0.05
	Molybdenum (Mo)-Total	0.0229	DLHC	0.00050	mg/L	26-SEP-18		
	Nickel (Ni)-Total	<0.0050	DLHC	0.0050	mg/L	26-SEP-18		
	Phosphorus (P)-Total	<0.50	DLHC	0.50	mg/L	26-SEP-18		
	Potassium (K)-Total	3.22	DLHC	0.50	mg/L	26-SEP-18		
	Rubidium (Rb)-Total	<0.0020	DLHC	0.0020	mg/L	26-SEP-18		
	Selenium (Se)-Total	0.00079	DLHC	0.00050	mg/L	26-SEP-18	0.05	
	Silicon (Si)-Total	4.8	DLHC	1.0	mg/L	26-SEP-18		
	Silver (Ag)-Total	<0.00050	DLHC	0.00050	mg/L	26-SEP-18		
	Sodium (Na)-Total	209	DLHC	0.50	mg/L	26-SEP-18	*20	*200
	Strontium (Sr)-Total	2.14	DLHC	0.010	mg/L	26-SEP-18		
	Sulfur (S)-Total	58.2	DLHC	5.0	mg/L	26-SEP-18		
	Tellurium (Te)-Total	<0.0020	DLHC	0.0020	mg/L	26-SEP-18		
	Thallium (Tl)-Total	<0.00010	DLHC	0.00010	mg/L	26-SEP-18		
	Thorium (Th)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
	Tin (Sn)-Total	0.0013	DLHC	0.0010	mg/L	26-SEP-18		
	Titanium (Ti)-Total	<0.0030	DLHC	0.0030	mg/L	26-SEP-18		
	Tungsten (W)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
	Uranium (U)-Total	0.00230	DLHC	0.00010	mg/L	26-SEP-18	0.02	
	Vanadium (V)-Total	<0.0050	DLHC	0.0050	mg/L	26-SEP-18		
	Zinc (Zn)-Total	<0.030	DLHC	0.030	mg/L	26-SEP-18		5
	Zirconium (Zr)-Total	<0.0030	DLHC	0.0030	mg/L	26-SEP-18		
L2170497-2 MW14								
Sampled By: CLIENT on 24-SEP-18								
Matrix: WATER							#1	#2
Physical Tests								
	Colour, Apparent	16.4		2.0	CU	26-SEP-18		*5
	Conductivity	1320		3.0	umhos/cm	26-SEP-18		
	pH	7.65		0.10	pH units	26-SEP-18		6.5-8.5
	Redox Potential	244	PEHR	-1000	mV	28-SEP-18		
	Total Dissolved Solids	959	DLDS	20	mg/L	27-SEP-18		*500
	Turbidity	17.8		0.10	NTU	26-SEP-18		*5
Anions and Nutrients								
	Alkalinity, Bicarbonate (as CaCO3)	221		10	mg/L	28-SEP-18		
	Alkalinity, Carbonate (as CaCO3)	<10		10	mg/L	28-SEP-18		
	Alkalinity, Hydroxide (as CaCO3)	<10		10	mg/L	28-SEP-18		

** Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
* Analytical result for this parameter exceeds Guideline Limit listed on this report. Guideline Limits applied:

Ontario Drinking Water Regulation (ODWQS) JAN.1,2018 = [Suite] - ON-DW-STANDARD+GUIDELINES

#1: Schedule 1 (Microbiological) and 2 (Chemical) Standards (JAN,2018) **#2: Ontario DW Aesthetic and Operational Guidelines**

Sample Details Grouping / Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits #1	Guideline Limits #2
L2170497-2 MW14							
Sampled By: CLIENT on 24-SEP-18							
Matrix: WATER							
Anions and Nutrients							
Alkalinity, Total (as CaCO3)	221		10	mg/L	28-SEP-18		30-500
Ammonia, Total (as N)	4.77	DLHC	0.10	mg/L	03-OCT-18		
Bromide (Br)	<0.50	DLDS	0.50	mg/L	27-SEP-18		
Chloride (Cl)	153	DLDS	2.5	mg/L	27-SEP-18		250
Computed Conductivity	1420			uS/cm	28-SEP-18		
Conductivity % Difference	7.7			%	28-SEP-18		
Fluoride (F)	0.20	DLDS	0.10	mg/L	27-SEP-18	1.5	
Hardness (as CaCO3)	613			mg/L	28-SEP-18		*80-100
Ion Balance	98.2			%	28-SEP-18		
Langelier Index	0.8			No Unit	28-SEP-18		
Nitrate (as N)	<0.10	DLDS	0.10	mg/L	27-SEP-18	10	
Nitrite (as N)	<0.050	DLDS	0.050	mg/L	27-SEP-18	1	
Saturation pH	6.90			pH	28-SEP-18		
Orthophosphate-Dissolved (as P)	<0.0030		0.0030	mg/L	27-SEP-18		
TDS (Calculated)	922			mg/L	28-SEP-18		
Sulfate (SO4)	343	DLDS	1.5	mg/L	27-SEP-18		500
Anion Sum	15.1			me/L	28-SEP-18		
Cation Sum	14.8			me/L	28-SEP-18		
Cation - Anion Balance	-0.9			%	28-SEP-18		
Inorganic Parameters							
Silica	12.7		2.1	mg/L	26-SEP-18		
Bacteriological Tests							
E. Coli	0		0	CFU/100mL	27-SEP-18	0	
Total Coliform Background	51000	DLM	1000	CFU/100mL	27-SEP-18		
Total Coliforms	900	DLM	100	CFU/100mL	27-SEP-18	*0	
Metals							
Sodium Adsorption Ratio	0.90		0.10	SAR	26-SEP-18		
Total Metals							
Aluminum (Al)-Total	0.097	DLHC	0.050	mg/L	26-SEP-18		0.1
Antimony (Sb)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18	0.006	
Arsenic (As)-Total	0.0017	DLHC	0.0010	mg/L	26-SEP-18	0.0100	
Barium (Ba)-Total	0.0157	DLHC	0.0010	mg/L	26-SEP-18	1	
Beryllium (Be)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
Bismuth (Bi)-Total	<0.00050	DLHC	0.00050	mg/L	26-SEP-18		
Boron (B)-Total	1.48	DLHC	0.10	mg/L	26-SEP-18	5	
Cadmium (Cd)-Total	<0.000050	DLHC	0.000050	mg/L	26-SEP-18	0.005	
Calcium (Ca)-Total	204	DLHC	0.50	mg/L	26-SEP-18		
Cesium (Cs)-Total	<0.00010	DLHC	0.00010	mg/L	26-SEP-18		
Chromium (Cr)-Total	<0.0050	DLHC	0.0050	mg/L	26-SEP-18	0.05	
Cobalt (Co)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
Copper (Cu)-Total	<0.010	DLHC	0.010	mg/L	26-SEP-18		1
Iron (Fe)-Total	0.90	DLHC	0.10	mg/L	26-SEP-18		*0.3
Lead (Pb)-Total	<0.00050	DLHC	0.00050	mg/L	26-SEP-18	0.01	
Magnesium (Mg)-Total	25.3	DLHC	0.050	mg/L	26-SEP-18		

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Ontario Drinking Water Regulation (ODWQS) JAN.1,2018 = [Suite] - ON-DW-STANDARD+GUIDELINES

#1: Schedule 1 (Microbiological) and 2 (Chemical) Standards (JAN,2018) **#2: Ontario DW Aesthetic and Operational Guidelines**

Sample Details Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits #1	#2
L2170497-2 MW14								
Sampled By: CLIENT on 24-SEP-18								
Matrix: WATER							#1	#2
Total Metals								
	Manganese (Mn)-Total	0.0702	DLHC	0.0050	mg/L	26-SEP-18		*0.05
	Molybdenum (Mo)-Total	0.00452	DLHC	0.00050	mg/L	26-SEP-18		
	Nickel (Ni)-Total	<0.0050	DLHC	0.0050	mg/L	26-SEP-18		
	Phosphorus (P)-Total	<0.50	DLHC	0.50	mg/L	26-SEP-18		
	Potassium (K)-Total	13.7	DLHC	0.50	mg/L	26-SEP-18		
	Rubidium (Rb)-Total	0.0088	DLHC	0.0020	mg/L	26-SEP-18		
	Selenium (Se)-Total	<0.00050	DLHC	0.00050	mg/L	26-SEP-18	0.05	
	Silicon (Si)-Total	5.9	DLHC	1.0	mg/L	26-SEP-18		
	Silver (Ag)-Total	<0.00050	DLHC	0.00050	mg/L	26-SEP-18		
	Sodium (Na)-Total	51.2	DLHC	0.50	mg/L	26-SEP-18	*20	200
	Strontium (Sr)-Total	6.18	DLHC	0.010	mg/L	26-SEP-18		
	Sulfur (S)-Total	107	DLHC	5.0	mg/L	26-SEP-18		
	Tellurium (Te)-Total	<0.0020	DLHC	0.0020	mg/L	26-SEP-18		
	Thallium (Tl)-Total	<0.00010	DLHC	0.00010	mg/L	26-SEP-18		
	Thorium (Th)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
	Tin (Sn)-Total	0.0015	DLHC	0.0010	mg/L	26-SEP-18		
	Titanium (Ti)-Total	<0.0030	DLHC	0.0030	mg/L	26-SEP-18		
	Tungsten (W)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
	Uranium (U)-Total	0.00116	DLHC	0.00010	mg/L	26-SEP-18	0.02	
	Vanadium (V)-Total	<0.0050	DLHC	0.0050	mg/L	26-SEP-18		
	Zinc (Zn)-Total	<0.030	DLHC	0.030	mg/L	26-SEP-18		5
	Zirconium (Zr)-Total	<0.0030	DLHC	0.0030	mg/L	26-SEP-18		
L2170497-3 MW15								
Sampled By: CLIENT on 24-SEP-18								
Matrix: WATER							#1	#2
Physical Tests								
	Colour, Apparent	37.0		2.0	CU	26-SEP-18		*5
	Conductivity	1140		3.0	umhos/cm	26-SEP-18		
	pH	7.66		0.10	pH units	26-SEP-18		6.5-8.5
	Redox Potential	249	PEHR	-1000	mV	28-SEP-18		
	Total Dissolved Solids	833	DLDS	20	mg/L	27-SEP-18		*500
	Turbidity	32.4		0.10	NTU	26-SEP-18		*5
Anions and Nutrients								
	Alkalinity, Bicarbonate (as CaCO3)	255		10	mg/L	28-SEP-18		
	Alkalinity, Carbonate (as CaCO3)	<10		10	mg/L	28-SEP-18		
	Alkalinity, Hydroxide (as CaCO3)	<10		10	mg/L	28-SEP-18		
	Alkalinity, Total (as CaCO3)	255		10	mg/L	28-SEP-18		30-500
	Ammonia, Total (as N)	5.30	DLHC	0.20	mg/L	03-OCT-18		
	Bromide (Br)	<0.50	DLDS	0.50	mg/L	27-SEP-18		
	Chloride (Cl)	84.5	DLDS	2.5	mg/L	27-SEP-18		250
	Computed Conductivity	1250			uS/cm	28-SEP-18		
	Conductivity % Difference	9.4			%	28-SEP-18		
	Fluoride (F)	0.25	DLDS	0.10	mg/L	27-SEP-18	1.5	
	Hardness (as CaCO3)	562			mg/L	28-SEP-18		*80-100
	Ion Balance	98.0			%	28-SEP-18		
	Langelier Index	0.8			No Unit	28-SEP-18		

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Ontario Drinking Water Regulation (ODWQS) JAN.1,2018 = [Suite] - ON-DW-STANDARD+GUIDELINES

#1: Schedule 1 (Microbiological) and 2 (Chemical) Standards (JAN,2018) **#2: Ontario DW Aesthetic and Operational Guidelines**

ANALYTICAL GUIDELINE REPORT

Sample Details Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits #1	#2
L2170497-3 MW15								
Sampled By: CLIENT on 24-SEP-18								
Matrix: WATER								
Anions and Nutrients								
	Nitrate (as N)	<0.10	DLDS	0.10	mg/L	27-SEP-18	10	
	Nitrite (as N)	<0.050	DLDS	0.050	mg/L	27-SEP-18	1	
	Saturation pH	6.90			pH	28-SEP-18		
	Orthophosphate-Dissolved (as P)	<0.0030		0.0030	mg/L	27-SEP-18		
	TDS (Calculated)	819			mg/L	28-SEP-18		
	Sulfate (SO4)	328	DLDS	1.5	mg/L	27-SEP-18		500
	Anion Sum	13.4			me/L	28-SEP-18		
	Cation Sum	13.2			me/L	28-SEP-18		
	Cation - Anion Balance	-1.0			%	28-SEP-18		
Inorganic Parameters								
	Silica	12.2		2.1	mg/L	26-SEP-18		
Bacteriological Tests								
	E. Coli	0		0	CFU/100mL	27-SEP-18	0	
	Total Coliform Background	NR	NDOGT	1000	CFU/100mL	27-SEP-18		
	Total Coliforms	1600	DLM	100	CFU/100mL	27-SEP-18	*0	
Metals								
	Sodium Adsorption Ratio	0.67		0.10	SAR	26-SEP-18		
Total Metals								
	Aluminum (Al)-Total	0.220	DLHC	0.050	mg/L	26-SEP-18		*0.1
	Antimony (Sb)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18	0.006	
	Arsenic (As)-Total	0.0023	DLHC	0.0010	mg/L	26-SEP-18	0.0100	
	Barium (Ba)-Total	0.0237	DLHC	0.0010	mg/L	26-SEP-18	1	
	Beryllium (Be)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
	Bismuth (Bi)-Total	<0.00050	DLHC	0.00050	mg/L	26-SEP-18		
	Boron (B)-Total	0.96	DLHC	0.10	mg/L	26-SEP-18	5	
	Cadmium (Cd)-Total	<0.000050	DLHC	0.000050	mg/L	26-SEP-18	0.005	
	Calcium (Ca)-Total	171	DLHC	0.50	mg/L	26-SEP-18		
	Cesium (Cs)-Total	<0.00010	DLHC	0.00010	mg/L	26-SEP-18		
	Chromium (Cr)-Total	<0.0050	DLHC	0.0050	mg/L	26-SEP-18	0.05	
	Cobalt (Co)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
	Copper (Cu)-Total	<0.010	DLHC	0.010	mg/L	26-SEP-18		1
	Iron (Fe)-Total	0.37	DLHC	0.10	mg/L	26-SEP-18		*0.3
	Lead (Pb)-Total	<0.00050	DLHC	0.00050	mg/L	26-SEP-18	0.01	
	Magnesium (Mg)-Total	32.8	DLHC	0.050	mg/L	26-SEP-18		
	Manganese (Mn)-Total	0.0677	DLHC	0.0050	mg/L	26-SEP-18		*0.05
	Molybdenum (Mo)-Total	0.00951	DLHC	0.00050	mg/L	26-SEP-18		
	Nickel (Ni)-Total	<0.0050	DLHC	0.0050	mg/L	26-SEP-18		
	Phosphorus (P)-Total	<0.50	DLHC	0.50	mg/L	26-SEP-18		
	Potassium (K)-Total	13.2	DLHC	0.50	mg/L	26-SEP-18		
	Rubidium (Rb)-Total	0.0086	DLHC	0.0020	mg/L	26-SEP-18		
	Selenium (Se)-Total	<0.00050	DLHC	0.00050	mg/L	26-SEP-18	0.05	
	Silicon (Si)-Total	5.7	DLHC	1.0	mg/L	26-SEP-18		
	Silver (Ag)-Total	<0.00050	DLHC	0.00050	mg/L	26-SEP-18		
	Sodium (Na)-Total	36.4	DLHC	0.50	mg/L	26-SEP-18	*20	200

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Ontario Drinking Water Regulation (ODWQS) JAN.1,2018 = [Suite] - ON-DW-STANDARD+GUIDELINES

#1: Schedule 1 (Microbiological) and 2 (Chemical) Standards (JAN,2018) **#2: Ontario DW Aesthetic and Operational Guidelines**

Sample Details Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits #1	#2
L2170497-3 MW15								
Sampled By: CLIENT on 24-SEP-18								
Matrix: WATER								
Total Metals								
	Strontium (Sr)-Total	7.01	DLHC	0.010	mg/L	26-SEP-18		
	Sulfur (S)-Total	95.5	DLHC	5.0	mg/L	26-SEP-18		
	Tellurium (Te)-Total	<0.0020	DLHC	0.0020	mg/L	26-SEP-18		
	Thallium (Tl)-Total	<0.00010	DLHC	0.00010	mg/L	26-SEP-18		
	Thorium (Th)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
	Tin (Sn)-Total	0.0017	DLHC	0.0010	mg/L	26-SEP-18		
	Titanium (Ti)-Total	<0.0070	DLUI	0.0070	mg/L	26-SEP-18		
	Tungsten (W)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
	Uranium (U)-Total	0.00702	DLHC	0.00010	mg/L	26-SEP-18	0.02	
	Vanadium (V)-Total	<0.0050	DLHC	0.0050	mg/L	26-SEP-18		
	Zinc (Zn)-Total	<0.030	DLHC	0.030	mg/L	26-SEP-18		5
	Zirconium (Zr)-Total	<0.0030	DLHC	0.0030	mg/L	26-SEP-18		
L2170497-4 MW16								
Sampled By: CLIENT on 24-SEP-18								
Matrix: WATER								
Physical Tests								
	Colour, Apparent	23.8		2.0	CU	26-SEP-18		*5
	Conductivity	5140		3.0	umhos/cm	26-SEP-18		
	pH	7.65		0.10	pH units	26-SEP-18		6.5-8.5
	Redox Potential	249	PEHR	-1000	mV	28-SEP-18		
	Total Dissolved Solids	3980	DLDS	20	mg/L	27-SEP-18		*500
	Turbidity	28.4		0.10	NTU	26-SEP-18		*5
Anions and Nutrients								
	Alkalinity, Bicarbonate (as CaCO3)	79		10	mg/L	28-SEP-18		
	Alkalinity, Carbonate (as CaCO3)	<10		10	mg/L	28-SEP-18		
	Alkalinity, Hydroxide (as CaCO3)	<10		10	mg/L	28-SEP-18		
	Alkalinity, Total (as CaCO3)	79		10	mg/L	28-SEP-18		30-500
	Ammonia, Total (as N)	5.32	DLHC	0.20	mg/L	03-OCT-18		
	Bromide (Br)	11.8	DLDS	1.0	mg/L	27-SEP-18		
	Chloride (Cl)	925	DLDS	5.0	mg/L	27-SEP-18		*250
	Computed Conductivity	5830			uS/cm	28-SEP-18		
	Conductivity % Difference	12.6			%	28-SEP-18		
	Fluoride (F)	0.28	DLDS	0.20	mg/L	27-SEP-18	1.5	
	Hardness (as CaCO3)	1670			mg/L	28-SEP-18		*80-100
	Ion Balance	81.3			%	28-SEP-18		
	Langelier Index	0.4			No Unit	28-SEP-18		
	Nitrate (as N)	<0.20	DLDS	0.20	mg/L	27-SEP-18	10	
	Nitrite (as N)	<0.10	DLDS	0.10	mg/L	27-SEP-18	1	
	Saturation pH	7.20			pH	28-SEP-18		
	Orthophosphate-Dissolved (as P)	<0.0030		0.0030	mg/L	27-SEP-18		
	TDS (Calculated)	4780			mg/L	28-SEP-18		
	Sulfate (SO4)	2490	DLDS	3.0	mg/L	27-SEP-18		*500
	Anion Sum	79.3			me/L	28-SEP-18		
	Cation Sum	64.4			me/L	28-SEP-18		
	Cation - Anion Balance	-10.3			%	28-SEP-18		
Inorganic Parameters								

Sample Details / Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits #1	#2
L2170497-4	MW16							
Sampled By:	CLIENT on 24-SEP-18							
Matrix:	WATER							
Inorganic Parameters								
	Silica	8.5		2.1	mg/L	26-SEP-18		
Bacteriological Tests								
	E. Coli	0		0	CFU/100mL	27-SEP-18	0	
	Total Coliform Background	NR	NDOGT	1000	CFU/100mL	27-SEP-18		
	Total Coliforms	10		0	CFU/100mL	27-SEP-18	*0	
Metals								
	Sodium Adsorption Ratio	7.46		0.10	SAR	26-SEP-18		
Total Metals								
	Aluminum (Al)-Total	0.143	DLHC	0.050	mg/L	26-SEP-18		*0.1
	Antimony (Sb)-Total	0.0011	DLHC	0.0010	mg/L	26-SEP-18	0.006	
	Arsenic (As)-Total	0.0018	DLHC	0.0010	mg/L	26-SEP-18	0.0100	
	Barium (Ba)-Total	0.0253	DLHC	0.0010	mg/L	26-SEP-18	1	
	Beryllium (Be)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
	Bismuth (Bi)-Total	<0.00050	DLHC	0.00050	mg/L	26-SEP-18		
	Boron (B)-Total	4.20	DLHC	0.10	mg/L	26-SEP-18	5	
	Cadmium (Cd)-Total	<0.000050	DLHC	0.000050	mg/L	26-SEP-18	0.005	
	Calcium (Ca)-Total	476	DLHC	0.50	mg/L	26-SEP-18		
	Cesium (Cs)-Total	0.00024	DLHC	0.00010	mg/L	26-SEP-18		
	Chromium (Cr)-Total	<0.0050	DLHC	0.0050	mg/L	26-SEP-18	0.05	
	Cobalt (Co)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
	Copper (Cu)-Total	<0.010	DLHC	0.010	mg/L	26-SEP-18		1
	Iron (Fe)-Total	0.37	DLHC	0.10	mg/L	26-SEP-18		*0.3
	Lead (Pb)-Total	<0.00050	DLHC	0.00050	mg/L	26-SEP-18	0.01	
	Magnesium (Mg)-Total	116	DLHC	0.050	mg/L	26-SEP-18		
	Manganese (Mn)-Total	0.336	DLHC	0.0050	mg/L	26-SEP-18		*0.05
	Molybdenum (Mo)-Total	0.00831	DLHC	0.00050	mg/L	26-SEP-18		
	Nickel (Ni)-Total	<0.0050	DLHC	0.0050	mg/L	26-SEP-18		
	Phosphorus (P)-Total	<0.50	DLHC	0.50	mg/L	26-SEP-18		
	Potassium (K)-Total	29.5	DLHC	0.50	mg/L	26-SEP-18		
	Rubidium (Rb)-Total	0.0187	DLHC	0.0020	mg/L	26-SEP-18		
	Selenium (Se)-Total	<0.00050	DLHC	0.00050	mg/L	26-SEP-18	0.05	
	Silicon (Si)-Total	4.0	DLHC	1.0	mg/L	26-SEP-18		
	Silver (Ag)-Total	<0.00050	DLHC	0.00050	mg/L	26-SEP-18		
	Sodium (Na)-Total	699	DLHC	0.50	mg/L	26-SEP-18	*20	*200
	Strontium (Sr)-Total	10.0	DLHC	0.010	mg/L	26-SEP-18		
	Sulfur (S)-Total	749	DLHC	5.0	mg/L	26-SEP-18		
	Tellurium (Te)-Total	<0.0020	DLHC	0.0020	mg/L	26-SEP-18		
	Thallium (Tl)-Total	<0.00010	DLHC	0.00010	mg/L	26-SEP-18		
	Thorium (Th)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
	Tin (Sn)-Total	0.0022	DLHC	0.0010	mg/L	26-SEP-18		
	Titanium (Ti)-Total	<.0050	DLUI	0.0050	mg/L	26-SEP-18		
	Tungsten (W)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
	Uranium (U)-Total	0.00115	DLHC	0.00010	mg/L	26-SEP-18	0.02	
	Vanadium (V)-Total	<0.0050	DLHC	0.0050	mg/L	26-SEP-18		

** Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
* Analytical result for this parameter exceeds Guideline Limit listed on this report. Guideline Limits applied:

Ontario Drinking Water Regulation (ODWQS) JAN.1,2018 = [Suite] - ON-DW-STANDARD+GUIDELINES

#1: Schedule 1 (Microbiological) and 2 (Chemical) Standards (JAN,2018) **#2: Ontario DW Aesthetic and Operational Guidelines**

Sample Details Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits #1	#2		
L2170497-4	MW16									
Sampled By:	CLIENT on 24-SEP-18									
Matrix:	WATER						#1	#2		
Total Metals										
	Zinc (Zn)-Total	<0.030	DLHC	0.030	mg/L	26-SEP-18		5		
	Zirconium (Zr)-Total	<0.0030	DLHC	0.0030	mg/L	26-SEP-18				
L2170497-5	MW17S									
Sampled By:	CLIENT on 24-SEP-18									
Matrix:	WATER						#1	#2		
Physical Tests										
	Colour, Apparent	23.2		2.0	CU	26-SEP-18		*5		
	Conductivity	5860		3.0	umhos/cm	26-SEP-18				
	pH	7.64		0.10	pH units	26-SEP-18		6.5-8.5		
	Redox Potential	252	PEHR	-1000	mV	28-SEP-18				
	Total Dissolved Solids	4570	DLDS	20	mg/L	27-SEP-18		*500		
	Turbidity	18.8		0.10	NTU	26-SEP-18		*5		
Anions and Nutrients										
	Alkalinity, Bicarbonate (as CaCO3)	52		10	mg/L	28-SEP-18				
	Alkalinity, Carbonate (as CaCO3)	<10		10	mg/L	28-SEP-18				
	Alkalinity, Hydroxide (as CaCO3)	<10		10	mg/L	28-SEP-18				
	Alkalinity, Total (as CaCO3)	52		10	mg/L	28-SEP-18		30-500		
	Ammonia, Total (as N)	3.69	DLHC	0.10	mg/L	03-OCT-18				
	Bromide (Br)	19.0	DLDS	1.0	mg/L	27-SEP-18				
	Chloride (Cl)	1610	DLDS	5.0	mg/L	27-SEP-18		*250		
	Computed Conductivity	6460			uS/cm	28-SEP-18				
	Conductivity % Difference	9.8			%	28-SEP-18				
	Fluoride (F)	0.32	DLDS	0.20	mg/L	27-SEP-18	1.5			
	Hardness (as CaCO3)	1840			mg/L	28-SEP-18		*80-100		
	Ion Balance	82.5			%	28-SEP-18				
	Langelier Index	0.3			No Unit	28-SEP-18				
	Nitrate (as N)	<0.20	DLDS	0.20	mg/L	27-SEP-18	10			
	Nitrite (as N)	<0.10	DLDS	0.10	mg/L	27-SEP-18	1			
	Saturation pH	7.36			pH	28-SEP-18				
	Orthophosphate-Dissolved (as P)	<0.0030		0.0030	mg/L	27-SEP-18				
	TDS (Calculated)	5160			mg/L	28-SEP-18				
	Sulfate (SO4)	2020	DLDS	3.0	mg/L	27-SEP-18		*500		
	Anion Sum	88.5			me/L	28-SEP-18				
	Cation Sum	73.0			me/L	28-SEP-18				
	Cation - Anion Balance	-9.6			%	28-SEP-18				
Inorganic Parameters										
	Silica	8.1		2.1	mg/L	26-SEP-18				
Bacteriological Tests										
	E. Coli	1		0	CFU/100mL	27-SEP-18	*0			
	Total Coliform Background	NR	NDOGT	1000	CFU/100mL	27-SEP-18				
	Total Coliforms	53		0	CFU/100mL	27-SEP-18	*0			
Metals										
	Sodium Adsorption Ratio	8.27		0.10	SAR	26-SEP-18				

** Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
* Analytical result for this parameter exceeds Guideline Limit listed on this report. Guideline Limits applied:

Ontario Drinking Water Regulation (ODWQS) JAN.1,2018 = [Suite] - ON-DW-STANDARD+GUIDELINES

#1: Schedule 1 (Microbiological) and 2 (Chemical) Standards (JAN,2018) **#2: Ontario DW Aesthetic and Operational Guidelines**

ANALYTICAL GUIDELINE REPORT

Sample Details Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits #1	#2
L2170497-5 MW17S								
Sampled By: CLIENT on 24-SEP-18								
Matrix: WATER							#1	#2
Total Metals								
	Aluminum (Al)-Total	0.189	DLHC	0.050	mg/L	26-SEP-18		*0.1
	Antimony (Sb)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18	0.006	
	Arsenic (As)-Total	0.0012	DLHC	0.0010	mg/L	26-SEP-18	0.0100	
	Barium (Ba)-Total	0.0202	DLHC	0.0010	mg/L	26-SEP-18	1	
	Beryllium (Be)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
	Bismuth (Bi)-Total	<0.00050	DLHC	0.00050	mg/L	26-SEP-18		
	Boron (B)-Total	3.09	DLHC	0.10	mg/L	26-SEP-18	5	
	Cadmium (Cd)-Total	<0.000050	DLHC	0.000050	mg/L	26-SEP-18	0.005	
	Calcium (Ca)-Total	513	DLHC	0.50	mg/L	26-SEP-18		
	Cesium (Cs)-Total	0.00020	DLHC	0.00010	mg/L	26-SEP-18		
	Chromium (Cr)-Total	<0.0050	DLHC	0.0050	mg/L	26-SEP-18	0.05	
	Cobalt (Co)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
	Copper (Cu)-Total	<0.010	DLHC	0.010	mg/L	26-SEP-18		1
	Iron (Fe)-Total	0.32	DLHC	0.10	mg/L	26-SEP-18		*0.3
	Lead (Pb)-Total	<0.00050	DLHC	0.00050	mg/L	26-SEP-18	0.01	
	Magnesium (Mg)-Total	136	DLHC	0.050	mg/L	26-SEP-18		
	Manganese (Mn)-Total	0.497	DLHC	0.0050	mg/L	26-SEP-18		*0.05
	Molybdenum (Mo)-Total	0.0227	DLHC	0.00050	mg/L	26-SEP-18		
	Nickel (Ni)-Total	<0.0050	DLHC	0.0050	mg/L	26-SEP-18		
	Phosphorus (P)-Total	<0.50	DLHC	0.50	mg/L	26-SEP-18		
	Potassium (K)-Total	25.6	DLHC	0.50	mg/L	26-SEP-18		
	Rubidium (Rb)-Total	0.0163	DLHC	0.0020	mg/L	26-SEP-18		
	Selenium (Se)-Total	<0.00050	DLHC	0.00050	mg/L	26-SEP-18	0.05	
	Silicon (Si)-Total	3.8	DLHC	1.0	mg/L	26-SEP-18		
	Silver (Ag)-Total	<0.00050	DLHC	0.00050	mg/L	26-SEP-18		
	Sodium (Na)-Total	816	DLHC	0.50	mg/L	26-SEP-18	*20	*200
	Strontium (Sr)-Total	12.8	DLHC	0.010	mg/L	26-SEP-18		
	Sulfur (S)-Total	610	DLHC	5.0	mg/L	26-SEP-18		
	Tellurium (Te)-Total	<0.0020	DLHC	0.0020	mg/L	26-SEP-18		
	Thallium (Tl)-Total	<0.00010	DLHC	0.00010	mg/L	26-SEP-18		
	Thorium (Th)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
	Tin (Sn)-Total	0.0022	DLHC	0.0010	mg/L	26-SEP-18		
	Titanium (Ti)-Total	<0.0050	DLUI	0.0050	mg/L	26-SEP-18		
	Tungsten (W)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
	Uranium (U)-Total	0.00044	DLHC	0.00010	mg/L	26-SEP-18	0.02	
	Vanadium (V)-Total	<0.0050	DLHC	0.0050	mg/L	26-SEP-18		
	Zinc (Zn)-Total	<0.030	DLHC	0.030	mg/L	26-SEP-18		5
	Zirconium (Zr)-Total	<0.0030	DLHC	0.0030	mg/L	26-SEP-18		
L2170497-6 MW17D								
Sampled By: CLIENT on 24-SEP-18								
Matrix: WATER							#1	#2
Physical Tests								
	Colour, Apparent	13.9		2.0	CU	26-SEP-18		*5
	Conductivity	5880		3.0	umhos/cm	26-SEP-18		
	pH	7.64		0.10	pH units	26-SEP-18		6.5-8.5
	Redox Potential	248	PEHR	-1000	mV	28-SEP-18		

** Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.

* Analytical result for this parameter exceeds Guideline Limit listed on this report. Guideline Limits applied:

Ontario Drinking Water Regulation (ODWQS) JAN.1,2018 = [Suite] - ON-DW-STANDARD+GUIDELINES

#1: Schedule 1 (Microbiological) and 2 (Chemical) Standards (JAN,2018) **#2: Ontario DW Aesthetic and Operational Guidelines**

Sample Details Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits #1	Guideline Limits #2
L2170497-6	MW17D							
Sampled By:	CLIENT on 24-SEP-18							
Matrix:	WATER							
Physical Tests								
	Total Dissolved Solids	4840	DLDS	20	mg/L	27-SEP-18		*500
	Turbidity	13.6		0.10	NTU	26-SEP-18		*5
Anions and Nutrients								
	Alkalinity, Bicarbonate (as CaCO3)	55		10	mg/L	28-SEP-18		
	Alkalinity, Carbonate (as CaCO3)	<10		10	mg/L	28-SEP-18		
	Alkalinity, Hydroxide (as CaCO3)	<10		10	mg/L	28-SEP-18		
	Alkalinity, Total (as CaCO3)	55		10	mg/L	28-SEP-18		30-500
	Ammonia, Total (as N)	3.80	DLHC	0.10	mg/L	03-OCT-18		
	Bromide (Br)	18.2	DLDS	1.0	mg/L	27-SEP-18		
	Chloride (Cl)	1540	DLDS	5.0	mg/L	27-SEP-18		*250
	Computed Conductivity	6270			uS/cm	28-SEP-18		
	Conductivity % Difference	6.4			%	28-SEP-18		
	Fluoride (F)	0.29	DLDS	0.20	mg/L	27-SEP-18	1.5	
	Hardness (as CaCO3)	1870			mg/L	28-SEP-18		*80-100
	Ion Balance	85.3			%	28-SEP-18		
	Langelier Index	0.3			No Unit	28-SEP-18		
	Nitrate (as N)	<0.20	DLDS	0.20	mg/L	27-SEP-18	10	
	Nitrite (as N)	<0.10	DLDS	0.10	mg/L	27-SEP-18	1	
	Saturation pH	7.33			pH	28-SEP-18		
	Orthophosphate-Dissolved (as P)	<0.0030		0.0030	mg/L	27-SEP-18		
	TDS (Calculated)	4960			mg/L	28-SEP-18		
	Sulfate (SO4)	1930	DLDS	3.0	mg/L	27-SEP-18		*500
	Anion Sum	84.4			me/L	28-SEP-18		
	Cation Sum	72.0			me/L	28-SEP-18		
	Cation - Anion Balance	-7.9			%	28-SEP-18		
Inorganic Parameters								
	Silica	7.7		2.1	mg/L	26-SEP-18		
Bacteriological Tests								
	E. Coli	1		0	CFU/100mL	27-SEP-18	*0	
	Total Coliform Background	NR	NDOGT	1000	CFU/100mL	27-SEP-18		
	Total Coliforms	1000	DLM	100	CFU/100mL	27-SEP-18	*0	
Metals								
	Sodium Adsorption Ratio	7.89		0.10	SAR	26-SEP-18		
Total Metals								
	Aluminum (Al)-Total	0.157	DLHC	0.050	mg/L	26-SEP-18		*0.1
	Antimony (Sb)-Total	0.0010	DLHC	0.0010	mg/L	26-SEP-18	0.006	
	Arsenic (As)-Total	0.0013	DLHC	0.0010	mg/L	26-SEP-18	0.0100	
	Barium (Ba)-Total	0.0205	DLHC	0.0010	mg/L	26-SEP-18	1	
	Beryllium (Be)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
	Bismuth (Bi)-Total	<0.00050	DLHC	0.00050	mg/L	26-SEP-18		
	Boron (B)-Total	3.11	DLHC	0.10	mg/L	26-SEP-18	5	
	Cadmium (Cd)-Total	<0.000050	DLHC	0.000050	mg/L	26-SEP-18	0.005	
	Calcium (Ca)-Total	521	DLHC	0.50	mg/L	26-SEP-18		
	Cesium (Cs)-Total	0.00020	DLHC	0.00010	mg/L	26-SEP-18		

** Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
* Analytical result for this parameter exceeds Guideline Limit listed on this report. Guideline Limits applied:

Ontario Drinking Water Regulation (ODWQS) JAN.1,2018 = [Suite] - ON-DW-STANDARD+GUIDELINES

#1: Schedule 1 (Microbiological) and 2 (Chemical) Standards (JAN,2018) **#2: Ontario DW Aesthetic and Operational Guidelines**

Sample Details Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits #1	#2
L2170497-6 MW17D								
Sampled By: CLIENT on 24-SEP-18								
Matrix: WATER							#1	#2
Total Metals								
	Chromium (Cr)-Total	<0.0050	DLHC	0.0050	mg/L	26-SEP-18	0.05	
	Cobalt (Co)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
	Copper (Cu)-Total	<0.010	DLHC	0.010	mg/L	26-SEP-18		1
	Iron (Fe)-Total	0.28	DLHC	0.10	mg/L	26-SEP-18		0.3
	Lead (Pb)-Total	<0.00050	DLHC	0.00050	mg/L	26-SEP-18	0.01	
	Magnesium (Mg)-Total	137	DLHC	0.050	mg/L	26-SEP-18		
	Manganese (Mn)-Total	0.483	DLHC	0.0050	mg/L	26-SEP-18		*0.05
	Molybdenum (Mo)-Total	0.0224	DLHC	0.00050	mg/L	26-SEP-18		
	Nickel (Ni)-Total	<0.0050	DLHC	0.0050	mg/L	26-SEP-18		
	Phosphorus (P)-Total	<0.50	DLHC	0.50	mg/L	26-SEP-18		
	Potassium (K)-Total	25.2	DLHC	0.50	mg/L	26-SEP-18		
	Rubidium (Rb)-Total	0.0164	DLHC	0.0020	mg/L	26-SEP-18		
	Selenium (Se)-Total	<0.00050	DLHC	0.00050	mg/L	26-SEP-18	0.05	
	Silicon (Si)-Total	3.6	DLHC	1.0	mg/L	26-SEP-18		
	Silver (Ag)-Total	<0.00050	DLHC	0.00050	mg/L	26-SEP-18		
	Sodium (Na)-Total	783	DLHC	0.50	mg/L	26-SEP-18	*20	*200
	Strontium (Sr)-Total	12.7	DLHC	0.010	mg/L	26-SEP-18		
	Sulfur (S)-Total	593	DLHC	5.0	mg/L	26-SEP-18		
	Tellurium (Te)-Total	<0.0020	DLHC	0.0020	mg/L	26-SEP-18		
	Thallium (Tl)-Total	<0.00010	DLHC	0.00010	mg/L	26-SEP-18		
	Thorium (Th)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
	Tin (Sn)-Total	0.0046	DLHC	0.0010	mg/L	26-SEP-18		
	Titanium (Ti)-Total	<0.0040	DLUI	0.0040	mg/L	26-SEP-18		
	Tungsten (W)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
	Uranium (U)-Total	0.00046	DLHC	0.00010	mg/L	26-SEP-18	0.02	
	Vanadium (V)-Total	<0.0050	DLHC	0.0050	mg/L	26-SEP-18		
	Zinc (Zn)-Total	<0.030	DLHC	0.030	mg/L	26-SEP-18		5
	Zirconium (Zr)-Total	<0.0030	DLHC	0.0030	mg/L	26-SEP-18		
L2170497-7 MW18								
Sampled By: CLIENT on 24-SEP-18								
Matrix: WATER							#1	#2
Physical Tests								
	Colour, Apparent	6.4		2.0	CU	26-SEP-18		*5
	Conductivity	795		3.0	umhos/cm	26-SEP-18		
	pH	7.62		0.10	pH units	26-SEP-18		6.5-8.5
	Redox Potential	256	PEHR	-1000	mV	28-SEP-18		
	Total Dissolved Solids	516	DLDS	20	mg/L	27-SEP-18		*500
	Turbidity	4.56		0.10	NTU	26-SEP-18		5
Anions and Nutrients								
	Alkalinity, Bicarbonate (as CaCO3)	300		10	mg/L	28-SEP-18		
	Alkalinity, Carbonate (as CaCO3)	<10		10	mg/L	28-SEP-18		
	Alkalinity, Hydroxide (as CaCO3)	<10		10	mg/L	28-SEP-18		
	Alkalinity, Total (as CaCO3)	300		10	mg/L	28-SEP-18		30-500
	Ammonia, Total (as N)	1.31	DLHC	0.040	mg/L	03-OCT-18		
	Bromide (Br)	<0.10		0.10	mg/L	27-SEP-18		
	Chloride (Cl)	25.5		0.50	mg/L	27-SEP-18		250

** Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
* Analytical result for this parameter exceeds Guideline Limit listed on this report. Guideline Limits applied:

Ontario Drinking Water Regulation (ODWQS) JAN.1,2018 = [Suite] - ON-DW-STANDARD+GUIDELINES

#1: Schedule 1 (Microbiological) and 2 (Chemical) Standards (JAN,2018) **#2: Ontario DW Aesthetic and Operational Guidelines**

Sample Details Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits #1	#2
L2170497-7 MW18 Sampled By: CLIENT on 24-SEP-18 Matrix: WATER								
Anions and Nutrients								
	Computed Conductivity	776			uS/cm	28-SEP-18		
	Conductivity % Difference	-2.4			%	28-SEP-18		
	Fluoride (F)	0.114		0.020	mg/L	27-SEP-18	1.5	
	Hardness (as CaCO3)	403			mg/L	28-SEP-18		*80-100
	Ion Balance	113			%	28-SEP-18		
	Langelier Index	0.7			No Unit	28-SEP-18		
	Nitrate (as N)	9.99		0.020	mg/L	27-SEP-18	10	
	Nitrite (as N)	<0.010		0.010	mg/L	27-SEP-18	1	
	Saturation pH	6.92			pH	28-SEP-18		
	Orthophosphate-Dissolved (as P)	<0.0030		0.0030	mg/L	27-SEP-18		
	TDS (Calculated)	500			mg/L	28-SEP-18		
	Sulfate (SO4)	79.2		0.30	mg/L	27-SEP-18		500
	Anion Sum	8.03			me/L	28-SEP-18		
	Cation Sum	9.08			me/L	28-SEP-18		
	Cation - Anion Balance	6.1			%	28-SEP-18		
Inorganic Parameters								
	Silica	8.99		0.21	mg/L	26-SEP-18		
Bacteriological Tests								
	E. Coli	0		0	CFU/100mL	27-SEP-18	0	
	Total Coliform Background	132000	DLM	1000	CFU/100mL	27-SEP-18		
	Total Coliforms	340	DLM	10	CFU/100mL	27-SEP-18	*0	
Metals								
	Sodium Adsorption Ratio	0.44		0.10	SAR	26-SEP-18		
Total Metals								
	Aluminum (Al)-Total	0.191		0.010	mg/L	26-SEP-18		*0.1
	Antimony (Sb)-Total	0.00018		0.00010	mg/L	26-SEP-18	0.006	
	Arsenic (As)-Total	0.00047		0.00010	mg/L	26-SEP-18	0.0100	
	Barium (Ba)-Total	0.0472		0.00020	mg/L	26-SEP-18	1	
	Beryllium (Be)-Total	<0.00010		0.00010	mg/L	26-SEP-18		
	Bismuth (Bi)-Total	<0.000050		0.000050	mg/L	26-SEP-18		
	Boron (B)-Total	0.133		0.010	mg/L	26-SEP-18	5	
	Cadmium (Cd)-Total	<0.000010		0.000010	mg/L	26-SEP-18	0.005	
	Calcium (Ca)-Total	119		0.50	mg/L	26-SEP-18		
	Cesium (Cs)-Total	0.000050		0.000010	mg/L	26-SEP-18		
	Chromium (Cr)-Total	0.00058		0.00050	mg/L	26-SEP-18	0.05	
	Cobalt (Co)-Total	0.00016		0.00010	mg/L	26-SEP-18		
	Copper (Cu)-Total	<0.0010		0.0010	mg/L	26-SEP-18		1
	Iron (Fe)-Total	0.198		0.050	mg/L	26-SEP-18		0.3
	Lead (Pb)-Total	0.00022		0.00010	mg/L	26-SEP-18	0.01	
	Magnesium (Mg)-Total	25.8		0.050	mg/L	26-SEP-18		
	Manganese (Mn)-Total	0.0161		0.00050	mg/L	26-SEP-18		0.05
	Molybdenum (Mo)-Total	0.000553		0.000050	mg/L	26-SEP-18		
	Nickel (Ni)-Total	0.00079		0.00050	mg/L	26-SEP-18		
	Phosphorus (P)-Total	<0.050		0.050	mg/L	26-SEP-18		

** Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
* Analytical result for this parameter exceeds Guideline Limit listed on this report. Guideline Limits applied:

Ontario Drinking Water Regulation (ODWQS) JAN.1,2018 = [Suite] - ON-DW-STANDARD+GUIDELINES

#1: Schedule 1 (Microbiological) and 2 (Chemical) Standards (JAN,2018) **#2: Ontario DW Aesthetic and Operational Guidelines**

Sample Details Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits #1	#2
L2170497-7 MW18								
Sampled By: CLIENT on 24-SEP-18								
Matrix: WATER							#1	#2
Total Metals								
	Potassium (K)-Total	5.44		0.050	mg/L	26-SEP-18		
	Rubidium (Rb)-Total	0.00305		0.00020	mg/L	26-SEP-18		
	Selenium (Se)-Total	0.00111		0.000050	mg/L	26-SEP-18	0.05	
	Silicon (Si)-Total	4.20		0.10	mg/L	26-SEP-18		
	Silver (Ag)-Total	<0.000050		0.000050	mg/L	26-SEP-18		
	Sodium (Na)-Total	20.2		0.50	mg/L	26-SEP-18	*20	200
	Strontium (Sr)-Total	0.712		0.0010	mg/L	26-SEP-18		
	Sulfur (S)-Total	28.7		0.50	mg/L	26-SEP-18		
	Tellurium (Te)-Total	0.00031		0.00020	mg/L	26-SEP-18		
	Thallium (Tl)-Total	<0.000010		0.000010	mg/L	26-SEP-18		
	Thorium (Th)-Total	<0.00010		0.00010	mg/L	26-SEP-18		
	Tin (Sn)-Total	0.00056		0.00010	mg/L	26-SEP-18		
	Titanium (Ti)-Total	0.00489		0.00030	mg/L	26-SEP-18		
	Tungsten (W)-Total	<0.00010		0.00010	mg/L	26-SEP-18		
	Uranium (U)-Total	0.00264		0.000010	mg/L	26-SEP-18	0.02	
	Vanadium (V)-Total	0.00116		0.00050	mg/L	26-SEP-18		
	Zinc (Zn)-Total	<0.0030		0.0030	mg/L	26-SEP-18		5
	Zirconium (Zr)-Total	0.00037		0.00030	mg/L	26-SEP-18		
L2170497-8 MW19								
Sampled By: CLIENT on 24-SEP-18								
Matrix: WATER							#1	#2
Physical Tests								
	Colour, Apparent	210		2.0	CU	26-SEP-18		*5
	Conductivity	1400		3.0	umhos/cm	26-SEP-18		
	pH	7.64		0.10	pH units	26-SEP-18		6.5-8.5
	Redox Potential	245	PEHR	-1000	mV	28-SEP-18		
	Total Dissolved Solids	1050	DLDS	20	mg/L	27-SEP-18		*500
	Turbidity	225		0.10	NTU	26-SEP-18		*5
Anions and Nutrients								
	Alkalinity, Bicarbonate (as CaCO3)	387		10	mg/L	28-SEP-18		
	Alkalinity, Carbonate (as CaCO3)	<10		10	mg/L	28-SEP-18		
	Alkalinity, Hydroxide (as CaCO3)	<10		10	mg/L	28-SEP-18		
	Alkalinity, Total (as CaCO3)	387		10	mg/L	28-SEP-18		30-500
	Ammonia, Total (as N)	0.969	DLHC	0.040	mg/L	03-OCT-18		
	Bromide (Br)	<0.50	DLDS	0.50	mg/L	27-SEP-18		
	Chloride (Cl)	38.6	DLDS	2.5	mg/L	27-SEP-18		250
	Computed Conductivity	1510			uS/cm	28-SEP-18		
	Conductivity % Difference	7.7			%	28-SEP-18		
	Fluoride (F)	0.12	DLDS	0.10	mg/L	27-SEP-18	1.5	
	Hardness (as CaCO3)	710			mg/L	28-SEP-18		*80-100
	Ion Balance	106			%	28-SEP-18		
	Langelier Index	0.9			No Unit	28-SEP-18		
	Nitrate (as N)	2.77	DLDS	0.10	mg/L	27-SEP-18	10	
	Nitrite (as N)	<0.050	DLDS	0.050	mg/L	27-SEP-18	1	
	Saturation pH	6.71			pH	28-SEP-18		
	Orthophosphate-Dissolved (as P)	<0.0030		0.0030	mg/L	27-SEP-18		

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Ontario Drinking Water Regulation (ODWQS) JAN.1,2018 = [Suite] - ON-DW-STANDARD+GUIDELINES

#1: Schedule 1 (Microbiological) and 2 (Chemical) Standards (JAN,2018) **#2: Ontario DW Aesthetic and Operational Guidelines**

Sample Details Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits #1	#2
L2170497-8	MW19							
Sampled By:	CLIENT on 24-SEP-18							
Matrix:	WATER							
Anions and Nutrients								
	TDS (Calculated)	1030			mg/L	28-SEP-18		
	Sulfate (SO4)	422	DLDS	1.5	mg/L	27-SEP-18		500
	Anion Sum	16.4			me/L	28-SEP-18		
	Cation Sum	17.5			me/L	28-SEP-18		
	Cation - Anion Balance	3.1			%	28-SEP-18		
Inorganic Parameters								
	Silica	9.8		2.1	mg/L	26-SEP-18		
Bacteriological Tests								
	E. Coli	1		0	CFU/100mL	27-SEP-18	*0	
	Total Coliform Background	NR	NDOGT	1000	CFU/100mL	27-SEP-18		
	Total Coliforms	12000	DLM	1000	CFU/100mL	27-SEP-18	*0	
Metals								
	Sodium Adsorption Ratio	1.15		0.10	SAR	26-SEP-18		
Total Metals								
	Aluminum (Al)-Total	0.396	DLHC	0.050	mg/L	26-SEP-18		*0.1
	Antimony (Sb)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18	0.006	
	Arsenic (As)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18	0.0100	
	Barium (Ba)-Total	0.0211	DLHC	0.0010	mg/L	26-SEP-18	1	
	Beryllium (Be)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
	Bismuth (Bi)-Total	<0.00050	DLHC	0.00050	mg/L	26-SEP-18		
	Boron (B)-Total	0.72	DLHC	0.10	mg/L	26-SEP-18	5	
	Cadmium (Cd)-Total	<0.000050	DLHC	0.000050	mg/L	26-SEP-18	0.005	
	Calcium (Ca)-Total	187	DLHC	0.50	mg/L	26-SEP-18		
	Cesium (Cs)-Total	<0.00010	DLHC	0.00010	mg/L	26-SEP-18		
	Chromium (Cr)-Total	<0.0050	DLHC	0.0050	mg/L	26-SEP-18	0.05	
	Cobalt (Co)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
	Copper (Cu)-Total	<0.010	DLHC	0.010	mg/L	26-SEP-18		1
	Iron (Fe)-Total	0.31	DLHC	0.10	mg/L	26-SEP-18		*0.3
	Lead (Pb)-Total	<0.00050	DLHC	0.00050	mg/L	26-SEP-18	0.01	
	Magnesium (Mg)-Total	59.1	DLHC	0.050	mg/L	26-SEP-18		
	Manganese (Mn)-Total	0.0816	DLHC	0.0050	mg/L	26-SEP-18		*0.05
	Molybdenum (Mo)-Total	0.00332	DLHC	0.00050	mg/L	26-SEP-18		
	Nickel (Ni)-Total	<0.0050	DLHC	0.0050	mg/L	26-SEP-18		
	Phosphorus (P)-Total	<0.50	DLHC	0.50	mg/L	26-SEP-18		
	Potassium (K)-Total	9.93	DLHC	0.50	mg/L	26-SEP-18		
	Rubidium (Rb)-Total	0.0055	DLHC	0.0020	mg/L	26-SEP-18		
	Selenium (Se)-Total	0.00106	DLHC	0.00050	mg/L	26-SEP-18	0.05	
	Silicon (Si)-Total	4.6	DLHC	1.0	mg/L	26-SEP-18		
	Silver (Ag)-Total	<0.00050	DLHC	0.00050	mg/L	26-SEP-18		
	Sodium (Na)-Total	70.5	DLHC	0.50	mg/L	26-SEP-18	*20	200
	Strontium (Sr)-Total	5.01	DLHC	0.010	mg/L	26-SEP-18		
	Sulfur (S)-Total	146	DLHC	5.0	mg/L	26-SEP-18		
	Tellurium (Te)-Total	<0.0020	DLHC	0.0020	mg/L	26-SEP-18		
	Thallium (Tl)-Total	<0.00010	DLHC	0.00010	mg/L	26-SEP-18		

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#1: Schedule 1 (Microbiological) and 2 (Chemical) Standards (JAN,2018) **#2: Ontario DW Aesthetic and Operational Guidelines**

Sample Details Grouping	Analyte	Result	Qualifier	D.L.	Units	Analyzed	Guideline Limits #1	#2
L2170497-8	MW19							
Sampled By:	CLIENT on 24-SEP-18							
Matrix:	WATER							
Total Metals								
	Thorium (Th)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
	Tin (Sn)-Total	0.0036	DLHC	0.0010	mg/L	26-SEP-18		
	Titanium (Ti)-Total	<0.0080	DLUI	0.0080	mg/L	26-SEP-18		
	Tungsten (W)-Total	<0.0010	DLHC	0.0010	mg/L	26-SEP-18		
	Uranium (U)-Total	0.0113	DLHC	0.00010	mg/L	26-SEP-18	0.02	
	Vanadium (V)-Total	<0.0050	DLHC	0.0050	mg/L	26-SEP-18		
	Zinc (Zn)-Total	<0.030	DLHC	0.030	mg/L	26-SEP-18		5
	Zirconium (Zr)-Total	<0.0030	DLHC	0.0030	mg/L	26-SEP-18		

** Detection Limit for result exceeds Guideline Limit. Assessment against Guideline Limit cannot be made.
* Analytical result for this parameter exceeds Guideline Limit listed on this report. Guideline Limits applied:

Ontario Drinking Water Regulation (ODWQS) JAN.1,2018 = [Suite] - ON-DW-STANDARD+GUIDELINES

#1: Schedule 1 (Microbiological) and 2 (Chemical) Standards (JAN,2018) **#2: Ontario DW Aesthetic and Operational Guidelines**

Reference Information

Sample Parameter Qualifier key listed:

Qualifier	Description
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
PEHR	Parameter Exceeded Recommended Holding Time On Receipt: Proceed With Analysis As Requested.
NDOGT	NO DATA: Overgrown with Target
DLUI	Detection Limit Raised: Unknown Interference generated an apparent false positive test result.
DLM	Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).
DLHC	Detection Limit Raised: Dilution required due to high concentration of test analyte(s).

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Method Reference***
ALK-AUTO-WT	Water	Automated Speciated Alkalinity	EPA 310.2

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

ALK-SPECIATED-WT	Water	pH Measurement for Spec. Alk	APHA 4500 H-Electrode

Water samples are analyzed directly by a calibrated pH meter.

BR-IC-N-WT	Water	Bromide in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

CL-IC-N-WT	Water	Chloride by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

COLOUR-APPARENT-WT	Water	Colour	APHA 2120

Apparent Colour is measured spectrophotometrically by comparison to platinum-cobalt standards using the single wavelength method after sample decanting. Colour measurements can be highly pH dependent, and apply to the pH of the sample as received (at time of testing), without pH adjustment. Concurrent measurement of sample pH is recommended.

EC-MF-WT	Water	E. coli	SM 9222D

A 100 mL volume of sample is filtered through a membrane, the membrane is placed on mFC-BCIG agar and incubated at 44.5 –0 .2 °C for 24 – 2 h.
Method ID: WT-TM-1200

EC-WT	Water	Conductivity	APHA 2510 B

Water samples can be measured directly by immersing the conductivity cell into the sample.

ETL-SAR-CALC-WT	Water	Sodium Adsorption Ratio	Calculation
ETL-SILICA-CALC-WT	Water	Calculate from SI-TOT-WT	EPA 200.8
F-IC-N-WT	Water	Fluoride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

IONBALANCE-OP03-WT	Water	Detailed Ion Balance Calculation	APHA 1030E, 2330B, 2510A
MET-T-CCMS-WT	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

NH3-WT	Water	Ammonia, Total as N	EPA 350.1

Sample is measured colorimetrically. When sample is turbid a distillation step is required, sample is distilled into a solution of boric acid and measured colorimetrically.

NO2-IC-WT	Water	Nitrite in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-IC-WT	Water	Nitrate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

PO4-DO-COL-WT	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P PHOSPHORUS

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

Reference Information

REDOX-POTENTIAL-WT	Water	Redox Potential	APHA 2580

This analysis is carried out in accordance with the procedure described in the "APHA" method 2580 "Oxidation-Reduction Potential" 2012. Results are reported as observed oxidation-reduction potential of the platinum metal-reference electrode employed, in mV.

It is recommended that this analysis be conducted in the field.

SO4-IC-N-WT	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

SOLIDS-TDS-WT	Water	Total Dissolved Solids	APHA 2540C

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TC-MF-WT	Water	Total Coliforms	SM 9222B

A 100mL volume of sample is filtered through a membrane, the membrane is placed on mENDO LES agar and incubated at 35–0.5°C for 24–2h.
Method ID: WT-TM-1200

TCB-MF-WT	Water	Total Coliform Background	SM 9222B

A 100mL volume of sample is filtered through a membrane, the membrane is placed on mENDO LES agar and incubated at 35–0.5°C for 24–2h.
Method ID: WT-TM-1200.

TURBIDITY-WT	Water	Turbidity	APHA 2130 B

Sample result is based on a comparison of the intensity of the light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. Sample readings are obtained from a Nephelometer.

*** ALS test methods may incorporate modifications from specified reference methods to improve performance.

Chain of Custody numbers:

17-618803

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA		

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Application of guidelines is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to, fitness for a particular purpose, or non-infringement. ALS assumes no responsibility for errors or omissions in the information. Guideline limits are not adjusted for the hardness, pH or temperature of the sample (the most conservative values are used). Measurement uncertainty is not applied to test results prior to comparison with specified criteria values.

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L2170497-COFC

COC Number: 17 - 618803

Page 1 of 1

Report To	Contact and company name below will appear on the final report
Company:	Landtek Limited
Contact:	Henry Ereltor
Phone:	289-880-3992
Company address below will appear on the final report	
Street:	205 Nebo Rd. Unit 3
City/Province:	Hamilton ON
Postal Code:	L8W 2E1

Report Format / Distribution
Select Report Format: [X] PDF [X] EXCEL [ ] EDD (DIGITAL)
Quality Control (QC) Report with Report [ ] YES [ ] NO
[X] Compare Results to Criteria on Report - provide details below if box checked
Select Distribution: [X] EMAIL [ ] MAIL [ ] FAX
Email 1 or Fax
Email 2
Email 3

Select Service Level Below - Contact your AM to confirm all E&P TATs (surcharges may apply)
Regular [R] [X] Standard TAT if received by 3 pm - business days - no surcharges apply
PRIORITY (Business Days): 4 day [P4-20%] [ ]; 3 day [P3-25%] [ ]; 2 day [P2-50%] [ ]
EMERGENCY: 1 Business day [E-100%] [ ]; Same Day, Weekend or Statutory holiday [E2-200% (Laboratory opening fees may apply)] [ ]
Date and Time Required for all E&P TATs: dd-mmm-yy hh:mm
For tests that can not be performed according to the service level selected, you will be contacted.

Invoice To	
Same as Report To	[X] YES [ ] NO
Copy of Invoice with Report	[X] YES [ ] NO
Company:	Landtek Limited
Contact:	Henry Ereltor

Invoice Distribution
Select Invoice Distribution: [X] EMAIL [ ] MAIL [ ] FAX
Email 1 or Fax
Email 2

Project Information
ALS Account # / Quote #:
Job #: 18270
PO / AFE:
LSD:

Oil and Gas Required Fields (client use)
AFE/Cost Center: | PO#
Major/Minor Code: | Routing Code:
Requisitioner:
Location:

ALS Lab Work Order # (lab use only): L2170497 BSC
ALS Contact:
Sampler:

Analysis Request
Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	O.DWQS (Potability)	SAMPLES ON HOLD	Sample is hazardous (please provide further details)	NUMBER OF CONTAINERS
1	MW13	24-Sep-18		Water	X			4
2	MW14	↓			X			4
3	MW15				X			4
4	MW16				X			4
5	MW17S				X			4
6	MWFD				X			4
7	MW18				X			4
8	MW19				X			4

Drinking Water (DW) Samples[1] (client use)
Are samples taken from a Regulated DW System? [ ] YES [X] NO
Are samples for human consumption/ use? [ ] YES [X] NO

Special Instructions / Specify Criteria to add on report by clicking on the drop-down list below (electronic COC only)

SAMPLE CONDITION AS RECEIVED (lab use only)
Frozen [ ] | SIF Observations Yes [ ] No [ ]
Ice Packs [ ] Ice Cubes [ ] | Custody seal intact Yes [ ] No [ ]
Cooling Initiated [ ]
INITIAL COOLER TEMPERATURES °C:
FINAL COOLER TEMPERATURES °C: 9.1

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Henry Ereltor	Date: Sept 25 2018	Time:	Received by:	Date: SEPT 25/18	Time: 1015	Received by: GB	Date: 09/25/18	Time: 3 pm

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION
WHITE - LABORATORY COPY YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

JULY 2017 FRONT

APPENDIX I

SANITARY AND STORM SEWERS EXCAVATION DEWATERING CALCULATIONS

Appendix I: Table – Sanitary and Storm Sewers Excavation Dewatering Calculations

$$Q=[(0.73+0.27\frac{H-h}{H})\frac{xk(H^2-h^2)}{L}$$

Equation 1: Dewatering requirements for the potential dewatering construction activities /sources have been calculated using the method of dewatering for a long narrow trench, partial penetration by a single row of well points for an unconfined aquifer (unconfined conditions) midway between two equidistant and parallel line sources (p. 22 of CIRIA, by Somerville, 1986).

Where: Q = pumping rate (m^3/s)
k = hydraulic conductivity (m/s)
H = distance from the static water level to the bottom of the aquifer (m)
h = height of the water table (m) (height of the bottom of excavation above the bottom of the aquifer)
x = length of trench (m)

$$L = C(H - h)\sqrt{k}$$

L = distance to line source, taken as equal to radius of influence (m), and given by

Where C = 1750 (Source: P.18 of CIRIA Somerville, 1986)

Equation 2: The potential calculated Zone of Influence (ZOI) represents the area where groundwater levels may be affected by a dewatering activity as a result of groundwater withdrawal. The Zone of Influence is dependent on the hydraulic conductivity, the type of aquifer and the amount by which the water level is to be lowered (Somerville, 1988). The calculation for the ZOI utilizes the method for the calculation of radius of influence, as provided on page 18 of CIRIA (Somerville, 1986).

Excavation	Excavation Trench length (m)	Excavation Depth Below Water Table	H (m)	h (m)	Zone of Influence (L) (m)	Dewatering Rate (Q) L/day
Overburden	50	5	6.0	1.0	1.9	3,424
Bedrock	50	5	6.0	2.0	19.7	46,327

Assumptions for hydrogeological setting:

1. An unconfined aquifer is presumed to exist locally with the existing water table estimated to at 0.78 and extending to an estimated depth of approximately 6.0 mbgs and 7.0 mbgs in clayey silt and bedrock, respectively.
2. An ideal aquifer is assumed for the preliminary calculations of pumping rates and drawdown, as described in CIRIA (Somerville, 1986).
3. The maximum excavation depth of construction activities is assumed to be 5.0 mbgl (0.5 m below invert of the Sewers)
4. It is assumed that as a requirement of the proposed construction activities the trench will be pumped dry.
5. The geometric mean of the hydraulic conductivity values for clayey silt and bedrock beneath the site were determined to be 4.505×10^{-8} m/s and 5.0865×10^{-6} m/s, respectively.

APPENDIX J

TOWNHOMES AND DETACHED HOMES BASEMENTS EXCAVATION CALCULATIONS

Appendix J Table – Townhouses and Detached Homes Basement Excavation Dewatering Calculations

Refer to Section 4.1.1 of the Hydrogeological Report for Lengths and Width of Excavations

$$Q = \pi K\,(H^2 - h_w^2)/\ln(R_o/r_e)$$

Equation 1: The potential groundwater flow rate to the excavation for the proposed lots segments was estimated using the dewatering equation for a fully penetrated well of unconfined aquifer fed by circular source (Powers, et al., 2007).

Where: Q = pumping rate (m^3/s)π√√
K = hydraulic conductivity (m/s)
H = saturated thickness of the aquifer before dewatering (m)
h_w = saturated thickness of the aquifer after dewatering (m)
R = radius of cone of depression (m)
r_e = equivalent radius (m)

R = C*(H – h)*√(K) Radius of Influence - Sichardt's equation

r_e = √(L * B)/π (applies when a/b>1.5 and R0 << rs)

r_e = (L + B)/π (applies when a/b<1.5 and R0 >>rs)

Excavation	K	H	h_w	R	r_e	Q L/day	Q with 1.2 Factor of Safety
Overburden							
Townhouse	4.505 x 10^{-8} m/s	6	3	2	5.0	909	1,091
Detached Home	4.505 x 10^{-8} m/s	6	3	2	7.2	1,236	1,483
Bedrock							
Townhouse	5.0865 x 10^{-6} m/s	7	4	20	6.0	38,843	46,612
Detached Home	5.0865 x 10^{-6} m/s	7	4	20	8.5	53,326	63,991

Assumptions for hydrogeological setting:

1. An unconfined aquifer is presumed to exist locally with the existing water table estimated to at 0.00 mbgs and extending to an estimated depth of approximately 6.0 mbgs and 7.0 mbgs for clayey silt and bedrock, respectively.
2. An ideal aquifer is assumed for the preliminary calculations of pumping rates and drawdown, as described in CIRIA (Somerville, 1986).
3. The maximum excavation depth of construction activities is assumed to be 3.0 mbgl (0.5 m below invert of the Basement Floor)
4. It is assumed that as a requirement of the proposed construction excavation will be pumped dry.
5. The geometric mean of the hydraulic conductivity values for clayey silt and bedrock beneath the site were determined to be 4.505 x 10^{-8}m/, respectively.

APPENDIX K

WATER BALANCE

APPENDIX K: DETAILED WATER BALANCE - Fruitland Winona BSS #3

1. Climate Information

Precipitation (collected from Env. Canada data)	930	mm/a
Evapotranspiration (calculated by Thornthwaite methoc	609	mm/a
Water Surplus	321	mm/a

2. Infiltration Rates

Infiltration Factors (Table 2)

Flat Land (average slope not exceeding 0.6 m per km)	0.3
Medium combinations of clay and loam	0.2
Cultivated Lands	0.1
TOTAL	0.6

Infiltration (0.6 x 321 mm/a)	193	mm/a
Run-off (321 mm/a - 193 mm/a)	128	mm/a

Typical Recharge Rates (Table 3)

Clayey Silt	100-125	mm/a
Silt	125-150	mm/a
silty sand to sandy silt	150-200	mm/a

Site development area is underlain by glaciolacustrine material (clayey silt overlying silty material).

Based on the above, the recharge rate is approximately 112.5 mm/a

with runoff of 208.5 mm/a

3. Site Statistics

Pre-Development:

Building roofs	4.72	ha	47,200	m^2
Parking Areas, Roadways, Other impervious Areas	11.46	ha	114,600	m^2
Green space, open space, natural areas	89.52	ha	895,200	m^2
TOTAL	105.70	ha	1,057,000	m^2

Post-Development:

Building roofs	21.62	ha	216,200	m^2
Parking Areas, Roadways, Other impervious Areas	22.15	ha	221,500	m^2
Green space, SWMP, natural areas	61.93	ha	619,300	m^2
TOTAL	105.70	ha	1,057,000	m^2

Commercial Buildings

Landscape coverage (58.6%)	61.93	ha	619,300	m^2
Parking/Roadway coverage (21.0%)	22.15	ha	221,500	m^2
Building (20.4%)	21.62	ha	216,200	m^2

4. Annual Pre-Development Water Balance

Land Use	Area (m^2)	Precipitation (m^3)	Evapotranspiration (m^3)	Infiltration (m^3)	Run-Off (m^3)
Building Roofs	47,200	43,896	-	-	43,896
Green Space	895,200	832,536	545,177	100,710	186,649
Roads, Other impervious	114,600	106,578	-	-	106,578
TOTAL	1,057,000	983,010	545,177	100,710	337,123

5. Annual Post-Development Water Balance

Land Use	Area (m^2)	Precipitation (m^3)	Evapotranspiration (m^3)	Infiltration (m^3)	Run-Off (m^3)
Building Roofs	216,200	201,066	-	-	201,066
Roads, Other impervious	221,500	205,995	-	-	205,995
Green space, open space, natural areas	619,300	575,949	377,154	69,671	129,124
TOTAL	1,057,000	983,010	377,154	69,671	536,185

6. Comparison of Pre-Development and Post-Development

	Precipitation (m^3)	Evapotranspiration (m^3)	Infiltration (m^3)	Run-Off (m^3)
Pre-Development	983,010	545,177	100,710	337,123
Post-Development	983,010	377,154	69,671	536,185

7. Post development infiltration measures

Post-development infiltration volume	69,671	m^3
Pre-development infiltration volume	100,710	m^3
Deficit from pre to post-development infiltration	31,039	m^3
Percentage of water collected from roof area required to match pre-development infiltration	15	%

Thornthwaite method for determining potential evapotranspiration

A monthly index is obtained from the equation:

$i = (t/5)^{1.514}$

Summation of the 12 monthly values gives an appropriate heat index, I.

To calculate a, the expression is:

$a = 0.000000675I^3 - 0.0000771I^2 + 0.01792I + 0.49239$

From these relations, a general equation for potential evapotranspiration is obtained. It is:

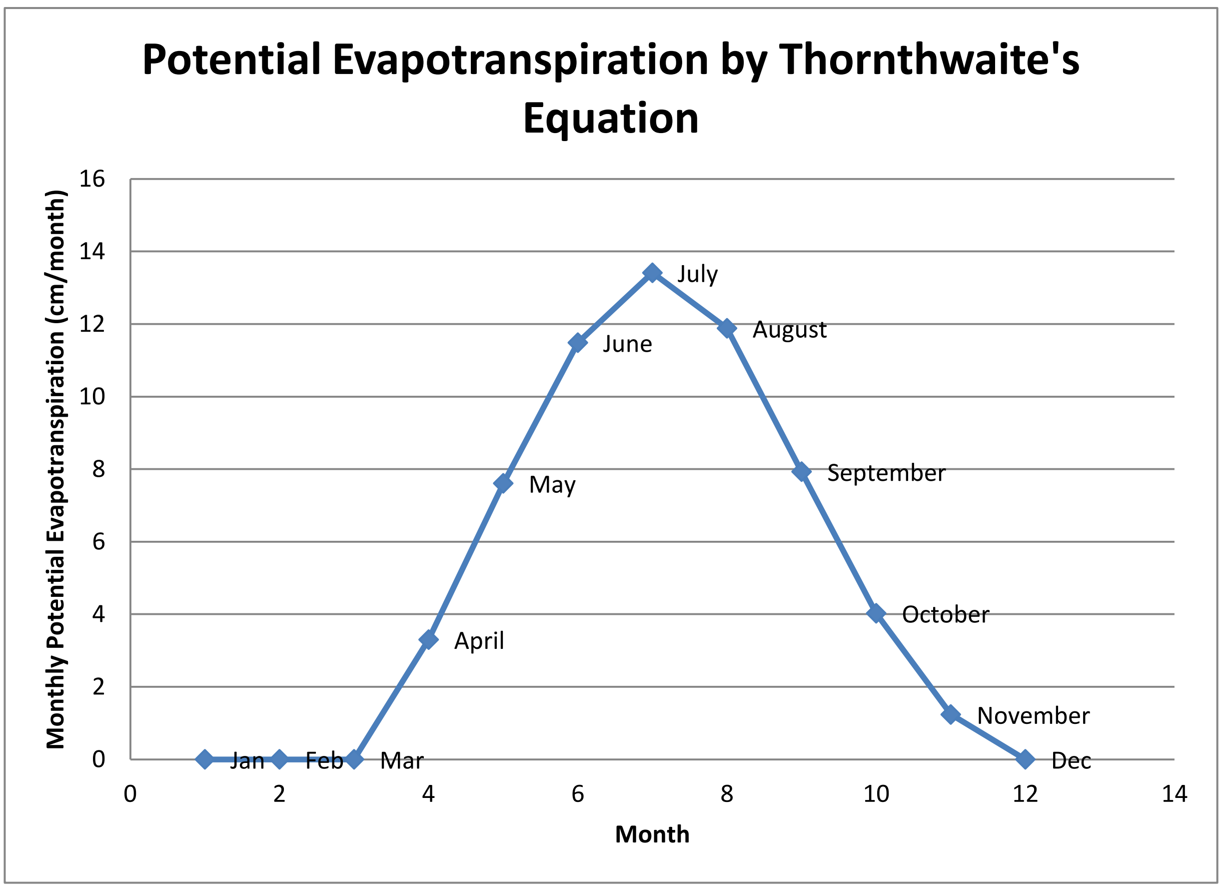
$e = 1.6(10t/I)^a$

in which a has the value given in the equation above.

APPENDIX K: Thornthwaite Method For Calculating Evapotranspiration

Hamilton Airport Climate Data

	Daily Average Temp (C^o)	Monthly index (i)	Potential Evapotranspiration (cm)	Adjusted Potential Evaportranspiration (cm)	
Jan	-5.5			0	
Feb	-4.6			0	
Mar	-0.1			0	
April	6.7	1.557530876	2.946791827	3.300406846	
May	12.8	4.150260027	6.038429267	7.608420877	
June	18.3	7.13034204	8.973741023	11.48638851	
July	20.9	8.718883818	10.39718	13.4123622	
August	20	8.156781464	9.902149829	11.88257979	
September	15.8	5.708555702	7.625570812	7.930593644	
October	9.3	2.558836857	4.238152363	4.026244745	
November	3.7	0.633894267	1.526004012	1.236063249	
Dec	-2.3			0	
	HEAT INDEX (I) =	38.61508505		**60.88**	**cm/year**
				608.83	**mm/year**
	a =	1.108273042			



APPENDIX B-3
Figure 1a – Excerpt from Toronto's Wet Weather Flow Management Guidelines

APPENDIX I

WATER BALANCE

APPENDIX I: D ETAILED WATER BALANCE - Fruitland Winona Secondary Plan Block 3

1. Climate Information

Precipitation (collected from Env. Canada data)	930	mm/a
Evapotranspiration (calculated by Thornthwaite methoc	609	mm/a
Water Surplus	321	mm/a

2. Infiltration Rates

Infiltration Factors (Table 2)		
Rolling Land (average slope from 2.8 m to 3.8 m per ki	0.3	
Medium combinations of clay and loam	0.2	
Cultivated Lands	0.1	
TOTAL	0.6	
Infiltration	193	mm/a
Run-off (321 mm/a - 161 mm/a)	128	mm/a
Typical Recharge Rates (Table 3)		
Clayey Silt/Clayey Silt	100-125	mm/a
Silt	125-150	mm/a
silty sand to sandy silt	150-200	mm/a

Site development area is underlain by glaciolacustrine material (clayey silt/silty clay material).

Based on the above, the recharge rate is approximately 112.5 mm/a

with runoff of 208.5 mm/a

3. Site Statistics

Includes all areas - Planned and unplanned areas for development

Pre-Development:

Building roofs +		ha		m^2
Parking Areas, Roadways, Other impervious Areas	6.35	ha	63,459	m^2
Green space, open space, natural areas	69.36	ha	693,600	m^2
TOTAL	75.71	ha	757,059	m^2

Post-Development:

Building Roof	19.15	ha	191,500	m^2
Parking Areas, Roadways, Other impervious Areas	17.04	ha	170,400	m^2
Green space, SWMP, natural areas	39.52	ha	395,159	m^2
TOTAL	75.71	ha	757,059	m^2
Industrial Buildings				
Landscape coverage (52.2%)	39.52	ha	395,159	m^2
Parking/Roadway coverage (22.5%)	17.04	ha	170,400	m^2
Building (25.3%)	19.15	ha	191,500	m^2

4. Annual Pre-Development Water Balance

Land Use	Area (m^2)	Precipitation (m^3)	Evapotranspiration (m^3)	Infiltration (m^3)	Run-Off (m^3)
Building Roofs	0	0	-	-	0
Green Space	693,600	645,048	422,402	78,030	144,616
Roads, Other impervious	63,459	59,017	-	-	59,017
TOTAL	757,059	704,065	422,402	78,030	203,633

5. Annual Post-Development Water Balance

Land Use	Area (m^2)	Precipitation (m^3)	Evapotranspiration (m^3)	Infiltration (m^3)	Run-Off (m^3)
Building Roofs	191,500	178,095	-	-	178,095
Roads, Other impervious	170,400	158,472	-	-	158,472
Green space, open space, natural areas	395,159	367,498	240,652	44,455	82,391
TOTAL	757,059	704,065	240,652	44,455	418,958

6. Comparison of Pre-Development and Post-Development

		Precipitation (m^3)	Evapotranspiration (m^3)	Infiltration (m^3)	Run-Off (m^3)
Pre-Development		704,065	422,402	78,030	203,633
Post-Development		704,065	240,652	44,455	418,958

7. Post development infiltration measures

Post-development infiltration volume	44,455	m^3
Pre-development infiltration volume	78,030	m^3
Deficit from pre to post-development infiltration	33,575	m^3
Percentage of water collected from roof area required to match pre-development infiltration	19	%

Thornthwaite method for determining potential evapotranspiration

A monthly index is obtained from the equation:

$i = (t/5)^{1.514}$

Summation of the 12 monthly values gives an appropriate heat index, I.

To calculate a, the expression is:

$a = 0.000000675I^3 - 0.0000771I^2 + 0.01792I + 0.49239$

From these relations, a general equation for potential evapotranspiration is obtained. It is:

$$e = 1.6\left(\frac{10t}{I}\right)^a$$

in which a has the value given in the equation above.

APPENDIX I: Thornthwaite Method For Calculating Evapotranspiration

Hamilton Airport Climate Data

	Daily Average Temp (C°)	Monthly index (i)	Potential Evapotranspiration (cm)	Adjusted Potential Evaportranspiration (cm)	
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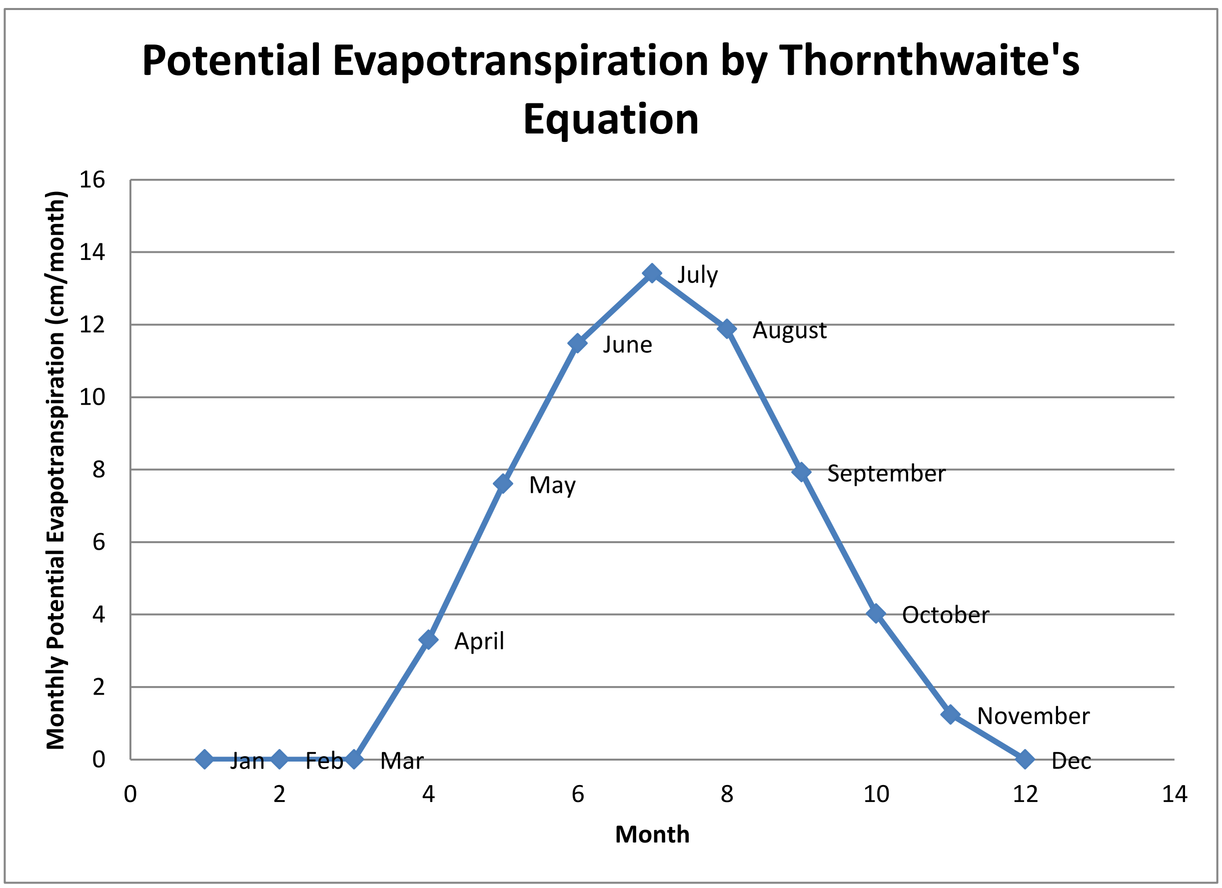


Figure 1a- % of Total Annual Average Rainfall Depth Vs. Daily Rainfall Amounts (Based on 1991 Toronto Rainfall Data from 16 Rain Gauge Stations)

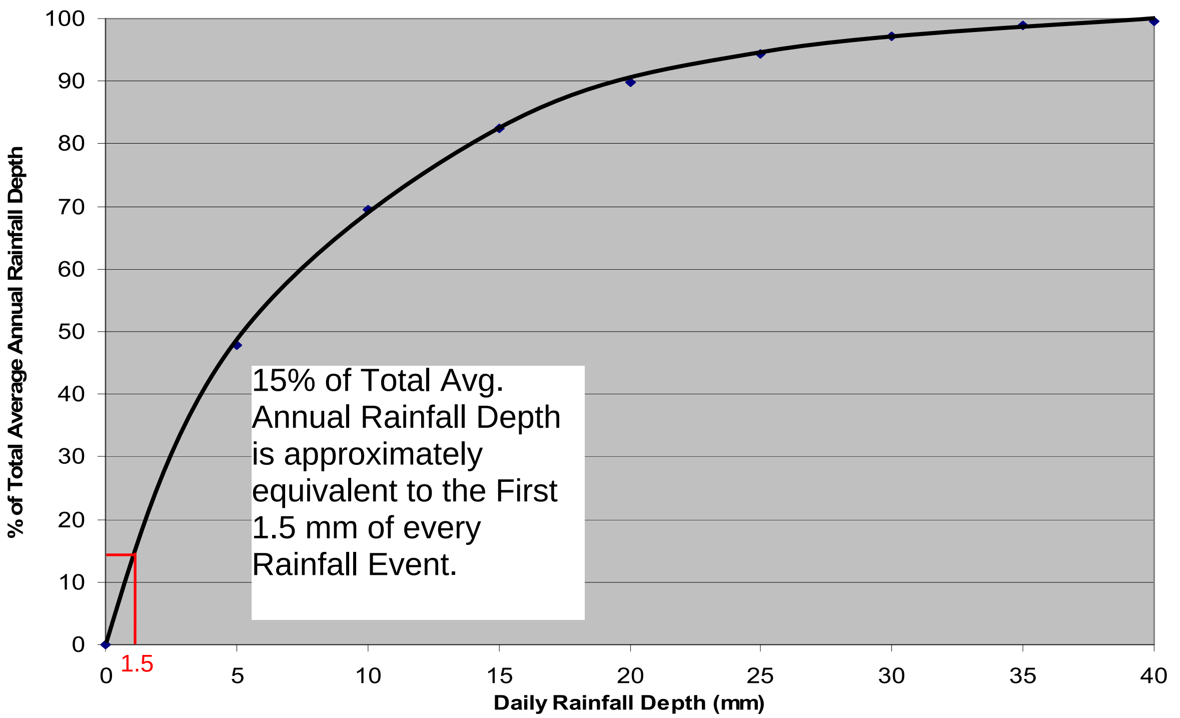
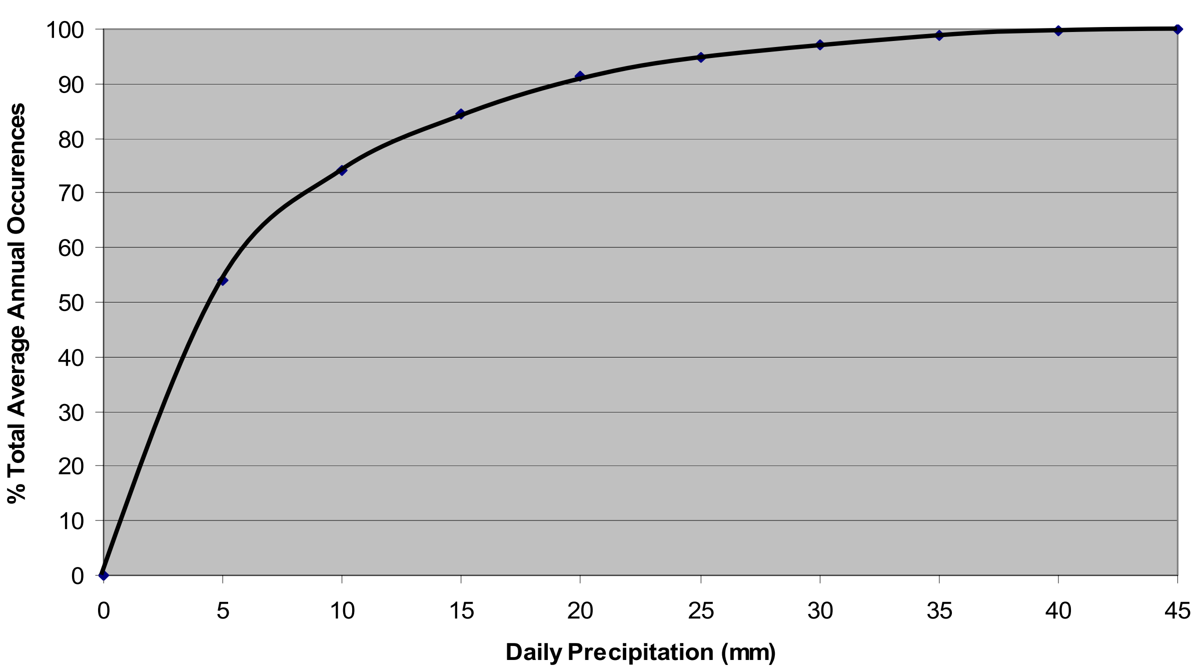


Figure 1b-Total Average Annual Occurences vs Daily Precipitation (based on 1991 Toronto Rainfall Data from 16 Rain Gauge Stations)



APPENDIX C
TERRESTRIAL DATA

C-1 Updated Environmental Impact Statement, Block 3
(Arcadis, February 2020)

Landowners Group

UPDATED ENVIRONMENTAL IMPACT STATEMENT, BLOCK 3

Stoney Creek, Ontario

February 2020

UPDATED ENVIRONMENTAL IMPACT STATEMENT, Block 3

Stoney Creek, Ontario

Prepared for:

Landowners Group
c/o Urbantech West
2030 Bristol Circle
Oakville, Ontario L6H 0H2

Prepared by:

Arcadis Canada Inc.
121 Granton Drive
Richmond Hill, Ontario L4B 3N4
Tel 905 764 9380

Date:
February 2020

Our Ref.:
30030165

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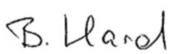

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Senior Biologist and Discipline Lead, Natural Sciences

Jennifer Kirk, Ph.D., QPRA
Discipline Lead, Risk Assessment

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APPENDICES

EXECUTIVE SUMMARY

Arcadis Canada Inc. (Arcadis) was retained by Urbantech West on behalf of the Landowners Group to complete an Environmental Impact Statement (EIS) for a Block Servicing Strategy (BSS) in support of Draft Plan applications for their lands in Block 3 of the Fruitland-Winona Secondary Plan Area in Stoney Creek. This EIS addresses proposed development for the entire Block 3 area Concept Plan (hereafter referred to as “the Site”).

The completion of an EIS was required by City of Hamilton and in order to assess if the proposed development could potentially have negative impacts on ecological, hydrological or hydrogeological features and functions.

Significant natural features were not identified on the Site, there are no Core Areas located within Block 3.

Potentially negative impacts were identified through the EIS and mitigation measures have to be implemented to eliminate or minimize impacts on the natural environment:

In accordance with the Migratory Birds Convention Act, mitigation measures for the protection of migratory birds and their nests have to be implemented before trees and shrubs can be removed and development begins. This applies for tree nesting as well as ground nesting species of breeding birds. Tree, shrub and vegetation removal should occur outside of the breeding bird season, which in Stoney Creek runs from the end of March to the end of August.

A tree preservation and protection plan is recommended to identify trees that should be retained. This should include a detailed evaluation of trees in hedgerows which consist of native species. The tree preservation plan should be developed by a certified arborist. Wherever possible, hedgerow like plantings using native species should be incorporated in landscape plans for green spaces.

It is recommended to include pollinator friendly plantings of native trees, shrubs and flowering plants in green spaces in Block 3 to provide habitat for birds and insects, including caterpillars. In addition, planting of native grasses and sedges should be included in the landscape design, wherever possible.

Carolina wren, a locally rare species was noted during breeding bird surveys. In order to mitigate loss of habitat, including old orchard and hedgerows, nest boxes could be provided in green spaces. In addition, plantings of native plant species will attract the insects Carolina wren feeds on and will provide nesting opportunities.

Mitigation measures are recommended for general earthworks such as grading and construction. It is recommended to install silt fencing to prevent excessive run off entering drainage ditches to avoid sedimentation and to regularly inspect the integrity and effectiveness of the silt fencing as a barrier.

Development of a residential subdivision with paved surfaces and roofs may result in indirect effects such as increased sediment transport, diversion of water, changes in volumes of surface runoff. Stormwater will be directed to two stormwater ponds which will be located south of Barton Street, one will be constructed west of the existing school and one east of Lewis Street.

It is recommended that the functions of the watercourses (i.e., surface water conveyance) should be maintained (e.g., with stormwater management), and any potential disruptions should be properly mitigated (e.g., silt fencing to limit sediment loading). Consistent with the recommendations of the approved subwatershed study, the proposed stormwater management plan will replace the water quality and quantity function of the drainage features in the study area.

Provided that mitigation measures are implemented, long term or residual effects on natural environment features in the vicinity of Block 3 are not expected.

.

1 INTRODUCTION

Arcadis Canada Inc. (Arcadis) was retained by Urbantech West on behalf of the Landowners Group to complete an Environmental Impact Statement (EIS) for a Block Servicing Strategy (BSS) in support of Draft Plan applications for their lands in Block 3 of the Fruitland-Winona Secondary Plan Area in Stoney Creek. This EIS addresses proposed development for the entire Block 3 area Tertiary Plan (hereafter referred to as “the Site”) (Figure 1-1).

Reference: ESRI ArcGIS Online Base Layers

The completion of an EIS was required by City of Hamilton and in order to assess if the proposed development could potentially have negative impacts on ecological, hydrological or hydrogeological features and functions. If potentially negative impacts are identified through the EIS, mitigation measures have to be implemented to eliminate or minimize impacts on the natural environment.

1.1 Policy Review

1.1.1 Provincial Policy Statement

Technical guidance for implementing the natural heritage policies of the 2014 Provincial Policy Statement (PPS) is provided in the Ministry of Natural Resources Natural Heritage Reference Manual (OMNR 2010). This manual presents the Province's recommended technical considerations in line with the PPS for protection of natural heritage features and areas in Ontario.

In accordance with Section 2.1. of the 2014 PPS issued under Section 3 of the Planning Act (MAH, 2014), this EIS considers the protection of natural features, areas, functions and biodiversity. Applicable policies within the PPS include:

- Policy 2.1.1 Natural features and areas shall be protected for the long-term;
- Policy 2.1.2 The diversity and connectivity of natural features in an area, and the long-term ecological function and biodiversity of natural heritage systems, should be maintained, restored, or where possible, improved, recognizing linkages between and among natural heritage features and areas, surface water features and ground water features;
- Policy 2.1.7 Development and site alteration shall not be permitted in habitat of endangered species and threatened species, except in accordance with provincial and federal regulations; and
- Policy 2.1.8 Development and site alteration shall not be permitted on adjacent lands to natural heritage features and areas identified in policies 2.1.4, 2.1.5 and 2.1.6 unless the ecological function of the adjacent lands has been evaluated and it has been demonstrated that there will be no negative impacts on the natural features or on their ecological functions.

1.1.2 City of Hamilton Official Plan

The Site is located within the Urban Official Plan (UHOP) (City of Hamilton, 2013). Schedule B of the UHOP shows the Hamilton Natural Heritage System which does not identify Core Areas on and adjacent to the Site. However, there are features within the Natural Heritage System that have not been mapped including habitat for Species at Risk (SAR) and Significant Wildlife Habitat (SWH).

Applicable policies within the UHOP include:

- Policy C.2.5.2 New development and site alteration shall not be permitted within provincially significant wetlands, significant coastal wetlands or significant habitat of threatened and endangered species;
- Policy C.2.5.4 New development and site alteration shall not be permitted within significant woodlands, significant valleylands, significant wildlife habitat and significant areas of natural and

scientific interest unless it has been demonstrated that there shall be no negative impacts on the natural features or on their ecological functions;

- Policy C.2.5.5 New development and site alteration shall not be permitted on adjacent lands to the natural heritage features and areas identified in Section C.2.5.2 to C.2.5.4 unless the ecological function of the adjacent lands has been evaluated and it has been demonstrated that there shall be no negative impacts on the natural features or on their ecological functions.

1.1.3 Hamilton Conservation Authority Policies

Based on agency mapping the drainage features and associated floodplain at the Site is regulated by Hamilton Conservation Authority (HCA) in accordance with Ontario Regulation (O. Reg.) 161/06 under the Conservation Authorities Act: “Hamilton Conservation Authority: Regulation of Development, Interference with Wetlands and Alterations to Shorelines and Watercourses”. This Regulation prohibits development in regulated areas, unless a permit is granted by the HCA.

1.1.4 Fruitland-Winona Secondary Plan

The Fruitland-Winona Secondary Plan was developed to provide guidance for development within the Secondary Plan area and includes general policies for residential and commercial development, amongst others. It also includes a Block Servicing Strategy and policies for cultural heritage resources. The general policies for the natural heritage system include core areas, linkages, vegetation protection zones and restoration areas.

Applicable policies within the Fruitland-Winona Secondary Plan include:

Policy 7.4.2.5 Natural Heritage - Ensure natural heritage features, such as environmentally significant areas, valley lands, streams, significant woodlands and wetlands are protected and enhanced; Prohibit development on lands with natural hazards such as flood plains; and, Ensure that the natural beauty and distinctive landscape character created/ provided by the Niagara Escarpment and the adjacent agricultural areas are considered and protected as development proceeds.

Policy 7.4.11 Natural Heritage System General Policies- Natural Heritage System consists of Core Areas, Linkages, Vegetation Protection Zones and Restoration Areas. Wherever possible, development within the Fruitland-Winona Secondary Plan Area shall promote a healthy Natural Heritage System by restoring, enhancing, and linking habitat/Core Areas, vegetation protection zones, linkages, and restoration areas; All development within the Fruitland-Winona Secondary Plan area shall comply with the Endangered Species Act. 2007 or its successor legislation; and, Protection and enhancement of natural heritage features that provide opportunities for corridors from the Niagara Escarpment to Lake Ontario shall be encouraged. Where possible, the Vegetation Protection Zone should restore or enhance the features and/or ecological functions of the Core Area as recommended by an Environmental Impact Statement prepared in accordance with Section F.3.2.1 of Volume 1, to the satisfaction of the City; When new development or site alteration is proposed adjacent to or within a Restoration rea, the Restoration Area shall be evaluated through an Environmental Impact Statement in accordance with the SCUBE Sub-watershed Studies where required by the City of Hamilton and shall require site specific restoration or planting plans as per the completed

Environmental Impact Statement. A portion of Watercourse No. 5 located north of Sherwood Park Road may be considered for relocation and natural channel design reconstruction to the satisfaction of the City in consultation with the Conservation Authority.

Policy 7.4.14 Block Servicing Strategy- This policy has provisions for lands to be developed within the Fruitland-Winona Secondary Plan, including Block 3. Provisions include that the City of Hamilton prepares a Terms of Reference for a Block Servicing Strategy in consultation with the Conservation Authority and develops the Block Servicing Strategy itself. Other provision in this policy include that the Fruitland-Winona Sub-Watershed Studies shall form the basis of all Block Servicing Strategies; A Block Servicing Strategy shall conform to the vision, objectives and policies of this Plan and shall identify the land use designations, densities and natural heritage features, including Vegetation Protection Zones and Restoration Areas. I addition, it identifies requirements for studies, such as hydrogeological investigations and stormwater studies and design criteria for the protection of natural features such as watercourses.

The location of the Site is outside the boundaries of the Niagara Escarpment Plan, outside Escarpment Protection Areas and the Greenbelt Plan and therefore, is not subject to policies related to those plans.

In 2012 Stantec completed avian Species at Risk (SAR) and breeding bird surveys within the Fruitland-Winona Secondary Plan area. SAR surveys were conducted for bobolink, Eastern meadowlark, barn swallow and chimney swift as there was a potential for these species to occur and breed in the area. Based on the surveys, no areas were recommended for SAR habitat preservation due to small or non-existent populations and low quality habitat. Stantec recommended that the City be aware that these SAR and SAR habitats occur in the area and that the City cooperate with the Ministry of Natural Resources and Forestry (MNRF) to ensure that the *Endangered Species Act* (ESA, 2007) is applied to all SAR species (now under Ministry of the Environment, Conservation and Parks, MECP) and Significant Wildlife Habitat (SWH) during future development and the review of any land use changes.

The Stoney Creek Urban Boundary Expansion Subwatershed Study (SCUBESS) provided the management and implementation strategy for the Fruitland-Winona Secondary Plan area (Aquafor Beech, 2013). The Secondary Plan area includes four parcels: SCUBE West, SCUBE Central, SCUBE East -Parcel A and SCUBE East -Parcel B. The limits and bounding streets of the parcels are shown in Figure 1.1. The City of Hamilton has also provided a Block Servicing Schedule for this area (Map B.7.4-4 – Fruitland-Winona Secondary Plan-Block Servicing Strategy Area Delineation).

The SCUBESS aims at maintaining a sustainable Natural Heritage System (NHS) for preserving landscape diversity within an urban context. It has provided recommendations for management of natural heritage and stream systems. There are certain lands, including watercourses that are restricted from development and have specified limitations or constraints. During the Phase 1 study, investigations were carried out to identify environmental constraints and opportunities for natural resources. A management strategy was developed to protect and enhance significant natural features at the Phase 2 study level. This strategy also provided requirements with regard to stormwater management, land use policies and servicing. The Phase 3 study has been completed to introduce an implementation plan for this strategy.

2 FIELD INVENTORIES METHODOLOGY

2.1 Background Information

Background information was obtained from various sources, including Ministry of Natural Resources and Forestry Natural Heritage Information Centre (NHIC, 2018), the City of Hamilton Natural Areas Inventory (2014), City of Hamilton Official Plan (2013), Significant Wildlife Habitat Technical Guide (MNRF, 2010), Ontario Breeding Bird Atlas (2005), aerial photographs, previous reports and the SCUBESS (Aquafor Beech, 2013). Species significance ranking was based on the provincial rank (S Rank), listing on the Endangered Species Act (ESA, 2007), the Committee on the Status of Wildlife in Canada (COSEWIC, 2018), the Species at Risk Act (SARA, 2002) and the local status in the City of Hamilton as recorded in the 2014 Hamilton Natural Areas Inventory Project Species Checklist (City of Hamilton, 2014).

2.2 Biological Surveys

Terms of Reference for the EIS were compiled by Arcadis and submitted to the City of Hamilton and Hamilton Conservation Authority for review, comments and approval. The Terms of Reference are contained in Appendix B. Site visits were carried out in order to complete Natural Environment inventories in accordance with the Terms of Reference and the Environmental Impact Statement (EIS) Guidelines (City of Hamilton, 2015). Table 2-1 shows the dates and site visits completed.

Table 2-1 Summary of Natural Environment Surveys Completed

Site Visit (Date and Time)	Personnel on Site	Survey Completed	Weather Conditions	Comments
May 28, 2015, 6 am to 9.30 am	Barbara Hard	Breeding bird survey, spring vegetation survey, incidental wildlife, Species at Risk.	15 ºC, clear, sunny, light wind	
July 7, 2015, 5 am to 8 am	Barbara Hard, Elaine Mason	Breeding bird survey, summer vegetation survey, incidental wildlife, Species at Risk.	19 ºC, clear, sunny, light wind	
August 20, 2015, 9 am to 1 pm	Barbara Hard	Late summer vegetation survey, incidental wildlife, Species at Risk.	15 ºC, few clouds, sunny, light wind	
June 1, 2016 5.30 am to 8.30 am	Barbara Hard, Elaine Mason	Breeding bird survey, spring vegetation survey, incidental wildlife, Species at Risk.	17 ºC, clear, sunny, light wind	
July 13, 2016 6 am to 9.30 am	Barbara Hard	Breeding bird survey, summer vegetation survey, incidental wildlife, Species at Risk.	20ºC, clear, sunny, no wind	
November 17, 2016, 9 am to 12 pm.	Barbara Hard	Site walk, vegetation survey, incidental wildlife.	10 ºC, some clouds, sunny, light wind	Site walk with City, HCA and Consultants
June 5, 2017 6 am to 9.30 am	Barbara Hard	Breeding bird survey, spring vegetation survey, incidental wildlife, Species at Risk.	15 ºC, early morning fog, light wind	
July 7, 2017 6.15 am to 11 am	Barbara Hard	Breeding bird survey, summer vegetation survey, incidental wildlife, Species at Risk.	21ºC, clear, sunny, no wind	
June 26, 2019, 5.40 am to 2.30 pm	Barbara Hard	Bobolink and Meadowlark Survey, Aquatic Habitat Assessment	19 ºC, scattered clouds, sunny, no wind	

Site Visit (Date and Time)	Personnel on Site	Survey Completed	Weather Conditions	Comments
July 3, 2019 5.35 am to 12.20 pm	Barbara Hard	Bobolink and Meadowlark Survey, Aquatic Habitat Assessment	18 °C, clear, sunny, light wind	
July 10, 2019 5.45 am to 3 pm	Barbara Hard, Sean McKee	Bobolink and Meadowlark Survey, Aquatic Habitat Assessment	19 °C, few clouds, sunny, light wind	
November 22, 2019 2 pm to 5 pm	Barbara Hard	Aquatic Habitat Assessment	5 °C, heavy clouds, moderate wind	Survey conducted following rain and snow melt

2.2.1 Vegetation

Plant species lists were compiled in spring, summer and fall by walking the Site. Vegetation communities were classified in accordance with Ecological Land Classification (ELC) for southern Ontario (Lee et al., 1998) and mapped on an aerial photograph of the Block 3 area.

2.2.2 Breeding Birds

All birds seen or heard during site visits were recorded. The breeding bird survey was carried out in accordance with the Ontario Breeding Bird Atlas protocols and consisted of 5 minute long point counts. Six (6) breeding bird surveys were carried out: May 28, 2015; July 7, 2015; June 1, 2016 July 13, 2016, June 5, 2017 and July 7, 2017. Bobolink and Meadowlark surveys were conducted on June 26, 2019, July 3, 2019 and July 10, 2019 following the MNRF Bobolink Survey Protocol provided by the City of Hamilton.

Species significance was evaluated based on national, provincial and local level published literature and current status lists, including the Hamilton Natural Areas Inventory Project 3rd Edition (2014) Species Checklist.

2.2.3 Other Wildlife

Incidental observations of mammals, amphibians, reptiles and insects during the site visits were recorded. Observations included direct sightings and indirect evidence such as calls, tracks, scat, burrows, dens and browse. The species list includes federal, provincial rankings and local status. Local status was based on the Hamilton Natural Areas Inventory Project 3rd Edition (2014) Species Checklist.

2.2.4 Fish Habitat Assessment

Fish habitat assessments were conducted on June 26, 2019, July 3, 2019, July 10, 2019 and November 22, 2019 on the drainage ditches and Watercourse 7.2 and 9 located north of Block 3. The assessment report and methodology are contained in Appendix E.

3 EXISTING CONDITIONS

3.1 Site Description

The Site consists predominantly of agricultural land and a mixture of land uses. South of Barton Street the lands are primarily agricultural with an existing school, single family residential and local commercial uses. North of Barton Street the existing land use is mostly local commercial and vacant agricultural lands. At the north east corner of Barton Street and Lewis Road the extension of Arvin Avenue has recently been completed. This work was undertaken as part of an industrial subdivision and the lands in this area are currently being developed as an industrial park.

3.1.1 Geology, Landforms and Topography

A review of the geology map indicates that the Site is situated on a shale plain located between the Niagara Escarpment and Lake Ontario. The bedrock in the area is dominated by the Queenston formation consisting of shale and siltstone with minor limestone and sandstone. The area soils are identified as clay to silt textured till derived from glaciolacustrine deposits and shale (Ontario Geological Survey, 2010). The existing topography of the Site is gently sloping from south to north.

3.1.2 Significant Habitat

3.1.2.1 Areas of Natural and Scientific Interest

The MNRF NHIC lists no ANSI’s on or in the vicinity of the Site (NHIC, 2018). The closest ANSIs are located approximately 10 km from the Site: Devil’s Punch Bowl, a provincially significant Life Science ANSI on the Niagara Escarpment to the south west of the Site and the regionally significant North Vinemount Escarpment Life Science ANSI, south east of the Site. The Niagara Escarpment Natural Area is located between 300 m (from the corner of McNeilly Road and Highway 8) and 750 m (from the corner of Lewis Road and Highway 8) south of the Site. The Niagara Escarpment Protection Area begins south of Highway 8 and extends to the Niagara Escarpment Natural Area.

3.1.2.2 Provincially Significant Wetlands

According to the NHIC mapping, there are no Provincially Significant Wetlands (PSWs) located on or in the vicinity of the Site. The Fifty Creek Environmentally Significant Area (ESA) and the Fifty Creek locally significant wetland complex are located approximately 2 km east of the Site. Both the Niagara Escarpment Natural Area and Fifty Creek are shown as core areas in the Hamilton Official Plan (2013).

3.1.2.3 Surface water Bodies and Fish Habitat

Surface water bodies and fish habitat were not identified during the natural environment surveys. A number of intermittent drainage ditches and watercourses are present throughout the Site and along roads, e.g., Lewis Road and Barton Street, however, they are dry most of the year.

A fish habitat assessment was undertaken to verify the findings of the approved SCUBESS (Aquafor Beech, 2013) which does not identify watercourses on the Site and to determine whether an authorization or review is required as part of the DFO Self-Assessment. Arcadis conducted fish habitat assessments for the following watercourses and ditches (Appendix E):

- Watercourse 7.2;
- Watercourse 9;
- Three (3) watercourses between McNeilly Road and Lewis Road; and
- Ditches along Barton Street, Lewis Road, and Highway 8.

As part of this DFO Fish Habitat Self-Assessment a total of nine locations were assessed for potential fish habitat. None of the watercourses and ditches comprise direct fish habitat. As noted previously (Aquafor Beech 2013), Watercourses 7.2 and 9 provide indirect habitat (i.e., surface water conveyance) to downstream sections, however, there are barriers to fish passage to the watercourses in Block 3. The conveyance of surface water was found to be limited and deemed to be seasonal and/or transient in nature, e.g., Drainage Ditch 3 (Appendix E, Figure 2) was found to be dry for most of the year and was only found to have standing water after a snow melt and heavy rain event in the fall, whereas the drainage ditches along Lewis Road between Highway 8 and Barton Street remained dry . In general, the watercourses in the area are ephemeral and have been modified/channelized, and have been incorporated into roadside drainage ditches, developed areas, or agricultural drainage. Although these watercourses and ditches are not considered fish habitat, some locations provide surface water conveyance to downstream sections that do comprise fish habitat, there is potential for impacts to fish or fish habitat as part of the development.

3.1.2.4 Wetlands

Wetlands are not present on the Site. A small area of cattails and common reed is found on the City property west of Lewis Road which indicates a seasonally wet area associated with the drainage ditch that runs along the west side of the Winona Elementary School property boundary.

3.1.2.5 Significant Woodlands and Valleylands

There are no natural or significant woodlots or valleylands on or in the vicinity of the Site and contiguous woodlands of 0.5 hectares or more are not present. Furthermore, the Hamilton Official Plan does not identify any significant woodlands on the Site. The Site is largely comprised of actively farmed and fallow agricultural land, including maintained and overgrown orchards interspersed with hedgerows.

3.2 Vegetation Surveys

Vegetation communities were classified in accordance with Ecological Land Classification (ELC) for southern Ontario (Lee et al*.,* 1998) and mapped. According to the Terms of Reference, the spring survey was to be carried out between the end of April and June, the summer survey was to be carried out in late August/early September. The plant species list contained in Appendix C includes provincial rankings and local status. Local status was based on the Hamilton Natural Areas Inventory Project 3rd Edition (2014) Species Checklist. Non-native species are identified.

3.2.1 Ecological Land Classification

Vegetation communities were classified in accordance with Ecological Land Classification (ELC) for southern Ontario (Lee et al., 1998) and mapped (Figure 3-1). The Site is comprised of cultural meadows, old orchards and agricultural fields interspersed with hedgerows. There are no natural communities present and all communities have been strongly influenced by anthropogenic activities.

Legend

Ecological Land Classification (ELC)

CUM1-1= Dry-Moist Old Field Meadow
CUS1= Cultural Savannah
HR= Hedgerow
MAS2-1= Cattail Mineral Shallow Marsh
OR= Orchard
BB= Breeding Bird Survey location

Title: **Ecological Land Classification (ELC)**	
Project: **Environmental Impact Statement, Block 3**	
Client: **Landowners Group**	
ARCADIS	Date: **December 15, 2018**
	FIGURE 3.1

Reference: ESRI ArcGIS Online Base Layers

I. Cultural Meadow- Dry-Moist Old Field Meadow (CUM1-1)

The cultural meadows at the Site appear to be fallow agricultural fields, overgrown apple orchards or maintained (manicured) grassed areas.

Cultural Meadow- CUM1-1(A)

Cultural Meadow CUM1-1(A) is located south of Barton Street and east of McNeilly Road. At the time of the Site visits, it was partly mowed close to the backyard fences of the residences along McNeilly Road and Barton Street. The reminder of the cultural meadow is not managed and is vegetated with sumac (*Rhus typhina*), buckthorn (*Rhamnus cathartica*), goldenrod (*Solidago canadensis*), Queen Anne's Lace (*Daucus carota*), yellow hawkweed (*Hieracium caespitosum*), teasel (*Dipsacus fullonum*), buttercup (*Ranunculus acris*), thistle (*Cirsium canadensis*, *C. vulgare*), red and white clover (*Trifolium pratense* and *T. repens*), dandelion (*Taraxacum officinale*), vetch (*Vicia gracca*), milkweed (*Asclepias syriaca*), Virginia creeper (*Parthenocissus quinquefolia*), orchard grass (*Dactylis glomerata*), timothy (*Phleum pratense*) and other grasses (*Poa* spp.)

Cultural Meadow- CUM1-1(B)/AG and CUM1-1(C)/AG

Both cultural meadows are located on the south side of Barton Street. They have been left fallow for a number of years and have been recently been turned back to agricultural land use to grow cash crops. Soybean (*Glycine max*) was grown in 2016. Mature hedgerows are present along the boundaries and one remnant is present in the north eastern section of CUM1-1(B). On both cultural meadows remnants of the old cultural meadow are present along the edges and along Barton Street. Vegetation includes sumac, buckthorn, goldenrod, Queen Anne's Lace, wild mustard (*Sinapsis arvense*), yellow hawkweed, teasel, chicory (*Cichorium intybus*), curled dock (*Rumex crispus*), buttercup, thistle, red and white clover, vetch, milkweed, prickly lettuce (*Lactuca serriola*), Philadelphia fleabane (*Erigeron philadelphicus*), New England aster (*Symphyotrichum novae-angliae*), Virginia creeper, reed canary grass (*Phalaris arundinacea*), orchard grass and grasses. Purple loosestrife (*Lythrum salicaria*) is resent in the drainage ditch that runs along the south side of Barton Street.

The cultural meadows/soybean fields likely provide habitat for smaller mammals and birds and may be used as linkage to other fields or orchards.

Cultural Meadow- CUM1-1(D)

Cultural meadow CUM1-1(D) is located adjacent to the Winona Elementary School property, south of the parking lot on Lewis Road. The cultural meadow consists of meadow grasses with oxeye daisy (*Leucanthemum vulgare*), dandelion, milkweed and Dame's rocket (*Hesperis matronalis*). The meadow appears to be regularly maintained though cutting. The cultural meadow is likely to provide habitat to small mammals. Because it is fenced with only a small area for access from Lewis Road, it is unlikely to be used as corridor and it doesn't provide linkage to other natural environment features.

Cultural Meadow- CUM1-1(E)

Cultural meadow CUM1-1(E) is located northeast corner of Lewis Road and Highway 8. Access was restricted to one partial site walk in November of 2016, so the ELC was completed from the road side. The cultural meadow appears to be a farrow agricultural field, possibly a former orchard. Vegetation present consists of small shrubs, weeds and grasses, including briar rose (*Rosa eglanteria*) and buckthorn. The cultural meadow likely provides habitat for smaller mammals and birds and may be used as linkage to other fields.

Cultural Meadow- CUM1-1(F)

Cultural meadow CUM1-1(F) is located northeast corner of Barton Street and McNeilly Road. Access was not granted, so the ELC was completed from the road side. The cultural meadow appears to be a vacant lot, over grown with shrubs, weeds and grasses such as sumac, teasel, goldenrod, dandelion, wild mustard, vetch, orchard grass, timothy, annual bluegrass (*Poa annua*) and creeping bentgrass (*Agrostis stolonifera*). The cultural meadow likely provides habitat for smaller mammals and birds and may be used as linkage to other fields.

Cultural Meadow- CUM1-1(G)

Parcel CUM1-1(G) is located on the northwest side of Barton Street and Lewis Road. It is flat with a couple of small, vegetated soil mounds. A well maintained orchard is located on the west side and a small hedgerow with a drainage ditch along Lewis Road. This cultural meadow is vegetated with manicured lawn and appears to be cut and maintained regularly. This cultural meadow provides only limited wildlife habitat as there is no shelter present on this parcel.

II. Orchard- OR

Orchard- OR is not an ELC category but has been used at the Site for orchards. Numerous orchard and grape vine plantations are present in the Block 3 area. Two are located east of McNeilly Road. The orchards are planted with fruit trees, including cherry (*Prunus* sp.), peach (*P. persica*), pear (*Pyrus* sp.) and grape vine (*Vitis* sp.). Groundcover consists of weeds and grasses, including goldenrod, thistle, dandelion, red and white clover.

III. Hedgerow- HR

Hedgerows are as such not a distinct category in the ELC system, however, to facilitate land classification at the Site, this vegetation community was added. At the Site, mature hedgerows line agricultural fields and orchards and are characterized by vegetation that is influenced by anthropogenic activities such as agriculture. Composition of hedgerows varies, but includes sumac, sugar maple (*Acer saccharum ssp. saccharum*), Manitoba maple (*Acer negundo*), burr oak (*Quercus macrocarpa*), red oak (*Q. rubra*), white oak (*Q. alba*), white mulberry, black locust (*Robinia pseudoacacia*), white ash (*Fraxinus americana*), black willow (*Salix nigra*), willow (*Salix* spp.), buckthorn, grey dogwood (*Cornus racemosa*), common lilac (*Syringa* *vulgaris*), domestic pear, domestic cherry, common apple (*Malus pumila*), briar rose, red-osier dogwood (*C. stolonifera*), riverbank grape (*Vitis riparia*) and Virginia creeper. The understorey consists of weeds and grasses, including dandelion, goldenrod, red and white clover and thistle.

IV. Cattail Mineral Shallow Marsh- MAS2-1

Cattails (*Typha latifolia*) were found growing in approximately 50 m of the drainage ditch on the southern boundary of cultural meadow CUM1-1(D). The area is relatively small and confined to the drainage ditch area. Vegetation in the area includes common reed (*Phragmites australis*), teasel, thistle, goldenrod, Philadelphia fleabane, aster and grasses.

V. Cultural Savannah- CUS1

A cultural savannah is present on the west side of Lewis Road. It consists of an open cultural meadow with grasses and weeds and a tree cover of white ash (*Fraxinus americana*).

3.2.2 Plant Species of Significance

Plant surveys were completed in the spring, summer and fall on lands where access was permitted by the landowner. A plant species list is shown in Table C-1. Species significance rankings were obtained from MNRF (S Rank), COSEWIC (2018), ESA (2007), SARA (2002) and the City of Hamilton Natural Areas Inventory Species Checklist (2014).

Plant species of significance on a local, provincial or national level were not identified and no plant Species at Risk were encountered during the surveys. A total of 92 species were recorded and the percentage of introduced, non-native species is 70%. The relatively high percentage of non-native species present at the Site is an indication of heavily managed lands (agricultural lands, orchards) and other anthropogenic influences and disturbances from residences and infrastructure.

Milkweed which is an important plant for the Monarch butterfly (*Daunus plexippus*), a Species at Risk (Special Concern) was observed on the Site. Monarch is considered to be a common butterfly in the Hamilton area according to the City of Hamilton Natural Areas Inventory Species Checklist (2014) and milkweed is abundant in Southern Ontario.

3.3 Wildlife Surveys

3.3.1 Breeding Birds

All birds seen or heard during site visits were recorded. The breeding bird survey was carried out in accordance with the Ontario Breeding Bird Atlas protocols and consisted of 5 minute long Point Counts. Six (6) breeding bird surveys were carried out: May 28, 2015; July 7, 2015; June 1, 2016 and July 13, 2016, June 5 and July 7, 2017. Survey locations are shown in Figure 3.1. In addition, bobolink (*Dolichonyx oryzivorus*) and Eastern meadowlark (*Sturnella magna*) specific surveys were conducted on June 26, 2019, July 3, 2019 and July 10, 2019 following the MNRF Bobolink Survey Protocol provided by the City of

Hamilton. Bobolink and Eastern meadowlark were no heard or observed during any breeding bird surveys. Survey locations and GPS coordinates can be found in Appendix D.

Species significance was evaluated based on national, provincial and local level published literature and current status lists, including the Hamilton Natural Areas Inventory Project 3rd Edition (2014) Species Checklist.

Barn swallow (*Hirundo rustica*), a Species at Risk was observed foraging over open areas. Carolina wren (*Thryothorus ludovicianus*), a locally rare species was noted during breeding bird surveys.

3.3.2 Incidental Wildlife

Incidental observations of wildlife were recorded based on sightings and/or indirect evidence such as tracks, scat and dens (Table 3-1). Species significance ranking was based on the provincial rank (S Rank), listing on the Endangered Species Act (ESA, 2007), the Committee on the Status of Wildlife in Canada, COSEWIC (2017), the Species at Risk Act (SARA, 2002) and the local status in the City of Hamilton as recorded in the Hamilton Natural Areas Inventory Project species check list (2014).

Wildlife species observed during the natural environment surveys were species commonly found in urban and agricultural settings close to residential areas. Monarch, a Species at Risk was observed feeding on milkweed.

Table 3-1 Incidental Wildlife Observations

Common Name	Scientific Name	S Rank	ESA	COSEWIC	SARA	City of Hamilton*
Mammals						
White-tailed Deer	*Odocoileus virginianus*	S5				C
Raccoon	*Procyon lotor*	S5				C
Eastern Grey Squirrel	*Sciurus carolinensis*	S5				C
Eastern Cottontail	*Sylvilagus floridanus*	S5				C
Lepidoptera						
Monarch Butterfly	*Daunus plexippus*	S2N, S4B	SC	END	SC	C
Tiger Swallowtail	*Papilio canadensis*	S5				ND
Cabbage White	*Pieris rapae*	SNA				I, C

Legend:
* HCA (2014) Hamilton Natural Areas Inventory Project, 3rd Edition. Species Checklist Document. Hamilton Conservation Authority

C: Common
I: Introduced (non native)
ND: Status not determined
SRank: Provincial Conservation Status (NHIC)
S2N: Imperiled
S4: Apparently secure
S5: Secure
B: Breeding
N: Non-breeding

COSEWIC: Committee on the Status of Wildlife in Canada
ESA: Endangered Species Act
SARA: Species at Risk Act
END: Endangered
SC: Special Concern
SNA: Conservation status not applicable

3.4 Species at Risk Screening

Arcadis completed a Species at Risk screening. Records of Species at Risk were obtained from the Ministry of Natural Resources and Forestry (MNRF) and the Natural Heritage Information Centre (NHIC), Species at Risk Ontario (SARO, 2018) and Hamilton Natural Areas Inventory Project 3rd Edition (2014) Species Checklist (Table 3-2).

Two SAR were observed on the Site, barn swallow and monarch. Although bobolink and Eastern meadowlark have been reported in the vicinity of the Site and potential habitat is present, neither species was recorded during the breeding bird surveys of the Site (2015 to 2019).

Arcadis contacted the Ministry of Environment, Conservation and Parks (MECP) with regards to SAR, in particular records of bobolink and Eastern meadowlark. MECP response can be found in Appendix F. No additional information was received from MECP regarding SAR.

3.5 Significant Wildlife Habitat

Habitat for Species of Conservation Concern (Not including Endangered or Threatened Species)

Significant Wildlife Habitat (SWH) screening was completed for habitat of Species of Conservation concern (other than endangered and threatened species) (MNRF, 2015). Monarch has been observed on Site and milkweed on which monarch depends on for their life cycle is scattered throughout the general area.

According to the Natural Heritage Information Centre (NHIC) Monarch is listed provincially (S-Rank) as S2N, S4B, which is imperiled, non-breeding (S2N) and apparently secure, breeding (S4B). In Hamilton, monarch is listed as common which indicates that there is no concern in the Hamilton area with monarch occurrences. Milkweed is present on the Site, however, not in notably high abundance and only single individuals of monarch were observed, therefore, the Site is not considered SWH.

Seasonal Concentration Areas of Animals

Seasonal concentration areas are areas where wildlife species such as migratory species occur annually in spring and fall in aggregations using areas as stopover. These stopover areas are used by congregations of large numbers of individuals of a species for resting and feeding along the migratory routes, e.g., in certain areas along the shores of the Great Lakes before and after crossing the lakes.

Monarch stopover areas are present along Lake Erie and Lake Ontario where butterflies stop over before and after crossing the Great Lakes during spring and fall migration. Certain criteria are required for stopover areas, including the presence of meadows and forests within 5 km of either Lake Erie or Lake Ontario. Although the Site is within 5 km of Lake Ontario, other criteria are not fulfilled, e.g., forest is not present and only single monarch have been observed, and there is no overabundance of milkweed and other nectar plants. Therefore, the Site is not considered SWH.

Table 3-2 Species at Risk

Common Name	Scientific Name	SARA	ESA	Srank	City of Hamilton	Habitat Requirement	Habitat present on Site
Plants							
Green Dragon	*Arisaema dracontium*	SC	SC	S3	Rare	Wet deciduous forests along streams.	No. Forest not present on Site.
False Hop Sedge	*Carex lupuliformis*	END	END	S1	N/A	Riverine swamps and marshes.	No. Riverine wetlands not present on Site.
American Chestnut	*Castanea dentata*	END	END	S2	Uncommon	Dryer upland deciduous forests with sandy, acidic to neutral soils.	No. Forest not present on Site.
Eastern Flowering Dogwood	*Cornus florida*	END	END	S2?	Uncommon	Thickets, stream banks, shaded forests.	No. Thickets, stream banks and forest not present on Site.
American Columbo	*Frasera caroliniensis*	END	END	S2	Rare	Open, moist deciduous forests, dense shrub thickets, grasslands and swamps.	No. Forest not present on Site.
Cucumber Tree	*Magnolia acuminata*	END	END	S2	N/A	Rich, deciduous forest	No. Forest not present on Site.
Red Mulberry	*Morus rubra*	END	END	S2	Rare	Rich woods, flood plains	No. Forest/ floodplain not present on Site.
Broad Beech Fern	*Phegopteris hexagonoptera*	SC	SC	S3	Rare	Rich, deciduous forests	No. Forest not present on Site.
Few-flowered Club-Rush	*Trichophorum planifolium*	No Status	END	S1	Rare	Dry open wooded slopes	No. Open wooded slope not present on Site.
Mammals							
Woodland Vole	*Microtis pinetorum*	SC	SC	S3?	Rare	Deciduous Forest	No. Forest not present on Site.
Insects							
Rusty-patched Bumble Bee	*Bombus affinis*	END	END	S1	N/A	Open habitats, urban settings, open woods	Potential, flowering weeds present. However, Site not known occurrence location on SARO distribution map.
Monarch	*Danaus plexippus*	SC	SC	S2N, S4B	Common	Open habitats with milkweed present.	Yes. Milkweed present. Observed on Site.
Amphibians							
Jefferson Salamander	*Ambystoma jeffersonianum*	END	END	S2	Rare	Deciduous forests, breeds in vernal pools	No. Forest and vernal pools not present on Site.
Turtles							
Spiny Softshell	*Apalone spinifera spinifera*	THR	END	S3	Rare	Rivers, lakes ponds.	No. Waterbodies not present on Site.
Snapping Turtle	*Chelydra serpentine*	SC	SC	S3	Common	Wetlands, ponds and lakes	No. Waterbodies not present on Site.
Blanding's Turtle	*Emydoidea blandingii*	THR	THR	S3	Rare	Large wetlands and shallow lakes.	No. Large wetlands or lake not present on Site.
Northern Map Turtle	*Graptemys geographica*	SC	SC	S3	Rare	Rivers and lakeshores	No. Rivers or lakes not present on Site.
Eastern Musk Turtle	*Sternotherus odoratus*	SC	SC	S3	Rare	Ponds, lakes, marshes and rivers.	No. Waterbodies not present on Site.

Common Name	Scientific Name	SARA	ESA	Srank	City of Hamilton	Habitat Requirement	Habitat present on Site
Snakes							
Eastern Ribbonsnake	*Thamnophis sauritus*	SC	SC	S4	Rare	Close to water, especially in marshes	No. Waterbodies not present on Site.
Birds							
Henslow's Sparrow	*Ammodramus henslowii*	END	END	SHB	Extirpated	Farm fields, tall grass pastures, and wet meadows.	Potential. Farm fields and pasture present on Site. Not observed on Site or recorded during breeding bird surveys. Site not known occurrence location on SARO distribution map.
Eastern Whip-poor-will	*Antrostomas vociferus*	THR	THR	S4B	Rare	Open woodlands or openings in mature, deciduous, coniferous and mixed forests.	No. Forest not present on Site.
Short-eared Owl	*Asio flammeus*	SC	SC	S2N,S4B	Rare	Large, open areas with low vegetation, including grasslands, meadows, marshes and agricultural areas	Potential, as open areas are present. Not observed on Site or recorded during breeding bird surveys. Site not known occurrence location on SARO distribution map.
Black Tern	*Chlidonias niger*	No Status	SC	S3B	Extirpated	Shallow cattail marshes with or near open water.	No. Shallow cattail wetlands with open water not present on Site.
Cerulean Warbler	*Dendroica cerulea*	END	THR	S3B	Rare	Mature, deciduous forests.	No. Mature forest not present on Site.
Bobolink	*Dolichonyx oryzivorus*	THR	THR	S4B	Uncommon	Open hay fields	Potential. Open fields present on Site. Not observed on Site or recorded during breeding bird surveys.
Acadian Flycatcher	*Empidonax virescens*	END	END	S2S3B	Rare	Mature, shady forests with ravines, forested swamps.	No. Mature forest or forested swamp not on Site
Peregrine Falcon	*Falco peregrinus*	SC	SC	S3B	Rare	Tall, steep cliff ledges close to large bodies of water. In urban areas on tall buildings.	No. Cliff ledges or tall buildings not present on Site.
Bald Eagle	*Haliaeetus leucocephalus*	No Status	SC	S2N, S4B	Rare	Variety of habitats and forest types, near major lake or river.	No. Forest not present on Site.
Barn Swallow	*Hirundo rustica*	THR	THR	S4B	Common	Man-mad structures, near open grasslands and wetlands	Yes, observed foraging by adjacent residents on Site, agricultural buildings present offsite.
Yellow-breasted Chat	*Icteria virens*	END	END	S1B	Rare	Dense shrubbery, including abandoned farm fields, clearcuts, powerline corridors, fencerows, forest edges and openings, swamps, and edges of streams and ponds	Potential, forest edge and open areas present on Site. Not observed on Site or recorded during breeding bird surveys. Site not known occurrence location on SARO distribution map.
Least Bittern	*Ixobrychus exilis*	THR	THR	S4B	Rare	Cattail wetlands.	Potential. Small cattail wetland area present on Site. Not observed on Site or recorded during breeding bird surveys. Site not known occurrence location on SARO distribution map.
Loggerhead Shrike	*Lanius ludovicianus*	END	END	S2B	Extirpated	Grasslands with scattered low trees and shrubs.	Potential. Grasslands with scattered low trees/shrubs present on Site. Not observed on Site or recorded during breeding bird surveys. Site not known occurrence location on SARO distribution map.
Prothonotary Warbler	*Protonotaria citrea*	END	END	S1B	Rare	Flooded woodlands or swamps	No. Flooded areas or swamps not present on Site.
Eastern Meadowlark	*Sturnella magna*	THR	THR	S4B	Uncommon	Pastures, hayfields, agricultural fields	Potential. Pasture, hayfield/ agricultural fields present on Site. Not observed on Site or recorded during breeding bird surveys. Recorded offsite in the vicinity of the Site.
Barn Owl	*Tyto alba*	END	END	S1	Extirpated	Farmlands, fallow fields and meadows with barns and old farm buildings.	Potential. Farm fields present on Site, farm buildings present off site. Not observed on Site or recorded during breeding bird surveys. Site not

Common Name	Scientific Name	SARA	ESA	Srank	City of Hamilton	Habitat Requirement	Habitat present on Site
							known occurrence location on SARO distribution map.
Fish							
Redside Dace	*Clinostomus elongatus*	END	END	S2	Rare, possibly extirpated	Pools and slow-moving areas of small streams with a gravel bottom.	No. Natural watercourses not present on Site.

Legend:

ESA: Endangered Species Act	SRank: Provincial Conservation Status (NHIC)	B: Breeding
SARA: Species at Risk Act	S1: Critically imperilled	N: Non-breeding
END: Endangered	S2: Imperiled	NA: Not available
NAR: Not at Risk	S3: Vulnerable	
SC: Special Concern	S4: Apparently secure	
THR: threatened	S5: Secure	
SNA: Conservation Rank not applicable	S2?: Rank uncertain	
SZN: Non-breeding migrants/vagrants	SHB: Possibly extirpated, historic breeder	

3.6 Other Ecological Features

3.6.1 Linkages and Corridors

Wildlife corridors are important features which allow wildlife to move between natural environment features. Corridors provide shelter from harsh weather conditions, protection from predators and allow wildlife to move safely across the landscape.

At the Site wildlife can move freely across agricultural fields, orchards and along hedgerows. Movement to the north is limited by the highway, fenced commercial properties and private residences. Forested areas along and on the nearby Niagara Escarpment to the south allow for suitable east west movement.

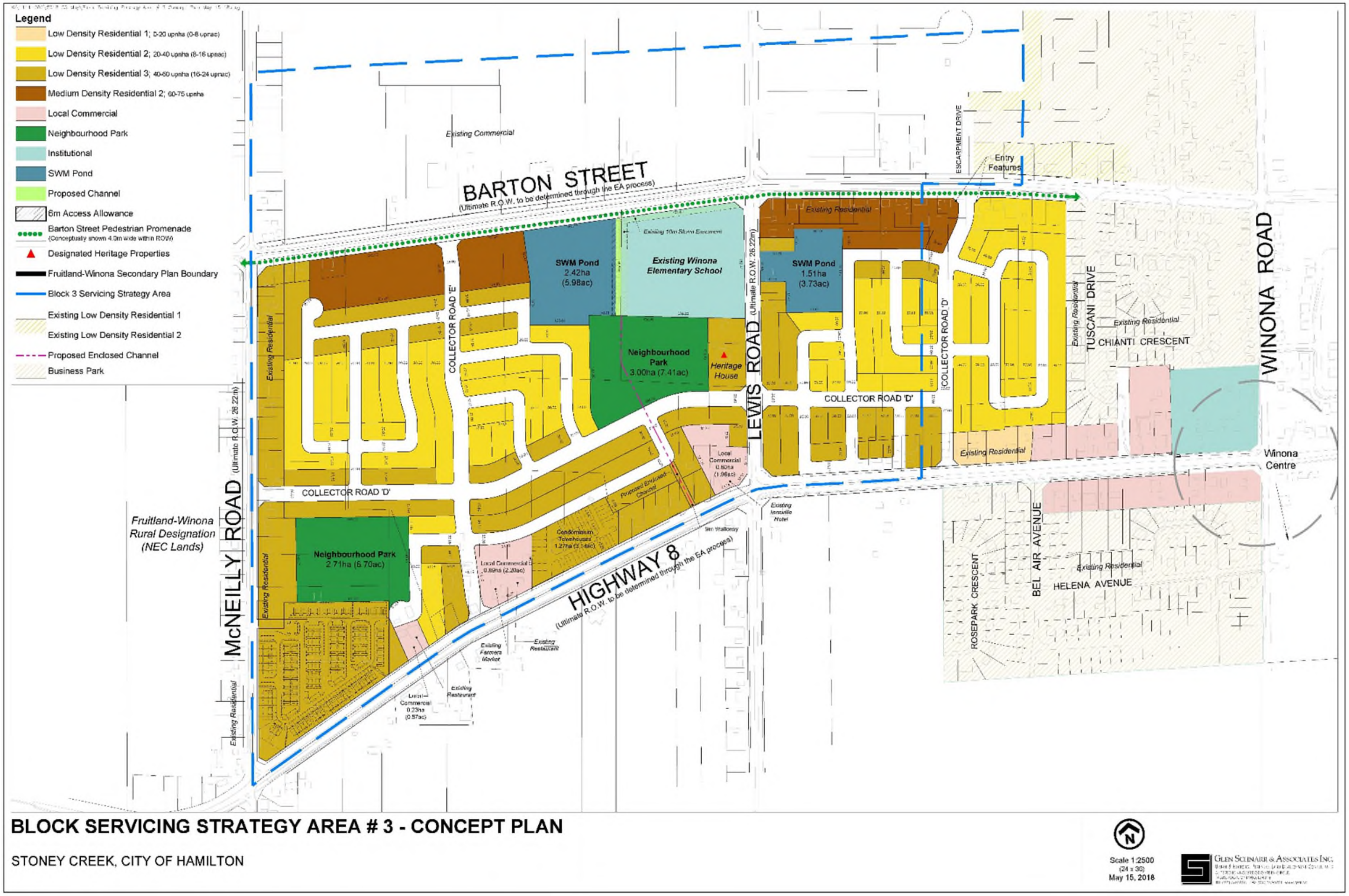
3.6.2 Deer Yards

There are no known deer yards at the Site. However, there was evidence that deer use the Site (sightings).

4 DESCRIPTION OF PROPOSED DEVELOPMENT

It is proposed to develop Block 3 with a subdivision, including low and medium density homes, parks, commercial space, stormwater ponds and access roads (Figure 4-1).

Figure 4.1: Proposed Development



5 IDENTIFICATION AND ASSESSMENT OF IMPACTS

All natural environment features on the Site have been heavily influenced and/or managed by anthropogenic activities such as agriculture and orchard management. They consist of agricultural fields that are planted with cash crops, fallow fields which over time turned into cultural meadows, planted and abandoned fruit orchards and grape plantations and planted hedgerows. Vegetation throughout the Site consists of common native and non-native species, none of which are considered Species at Risk or locally rare. The relatively high percentage of non-native species indicates historic disturbance from agriculture. None of the vegetation communities identified on the Site are considered rare, uncommon or sensitive.

The hedgerows and orchard trees provide some nesting opportunities for breeding birds and it is expected that trees and shrubs that will be removed as part of the grading and development will be replaced. The hedgerows and orchards are not considered significant or sensitive to disturbance and similar habitat is available in the immediate vicinity south of Highway 8 and will be available again in green spaces, parks and backyards once Block 3 is developed.

Although there are man-made drainage ditches present, none are considered fish habitat or potential fish habitat as they are seasonally dry. A small patch of wetland plants is present in the drainage ditch that runs along the school property. Because of the small size and the presence of non native, invasive plants, it is not considered significant or sensitive. Although these watercourses and ditches are not considered fish habitat, there is some surface water conveyance to downstream sections that do comprise fish habitat and therefore, there is potential for impacts to fish or fish habitat as part of the development. Decrease in water quality e.g., through increased sedimentation, introduction of chemicals into the watercourses from project activities and/or increases in water quantity may have a negative impact on fish habitat downstream (indirect impacts). Effects may include decrease in fish health, reproduction and loss of spawning and feeding habitats. Therefore, activities involving these watercourses should consider potential impacts of water quality of these watercourses on downstream fish habitat.

The natural environment surveys did not identify any development constraints in accordance with the PPS. Development will have no impact on PSWs, significant wetlands, valleylands, wildlife habitat or woodlands or ANSIs. However, it should be noted that prior to removal of trees in the hedgerows, mitigation measures should be implemented (see Section 6).

One SAR, barn swallow was found to use the Site for foraging, however, no breeding habitat was identified on Site as no buildings are present that may be used for nesting. It was not possible to locate nests on buildings offsite during natural environment surveys. Some foraging areas will be lost due to the development. However, extensive areas for feeding are available in the immediate vicinity of the Site, e.g., south of Highway 8 and within Block 3, e.g., on the school playing fields. In addition, mitigation measures recommended in Section 6 include plantings which may attract flying insects on which barn swallow feed. Significant impacts to barn swallow are therefore not expected.

Monarch, a Species at Risk (Special Concern) was observed feeding on milkweed. Monarch depends on milkweed for its life cycle, and some potential habitat will be lost in the development area. However, milkweed is common and plentiful in the Stoney Creek area, along roadsides, edges of agricultural fields and orchards as well as on vacant lots and fallow fields. Monarch is considered common in the Hamilton area. Impact to monarch is not expected, however, mitigation plantings are recommended to compensate for loss of milkweed and other flowering plants (Section 6).

One locally rare species, Carolina wren was recorded. Carolina wren feeds on insects and spiders, including moths, beetles, grasshoppers and caterpillars. Habitat includes brushy thickets, shrubby residential areas and backyards and overgrown farmlands. There may be some temporary loss of habitat as Block 3 is being developed, however, since Carolina wren doesn't require specialized habitat and green space and vegetated backyards are part of the development, the impact to Carolina wren is not considered significant.

During construction wildlife species may be temporarily displaced but will re-establish to the available habitat once the new development is completed. Overall, temporary habitat loss will not have any significant long term effects on the existing populations as individuals will adapt and become tolerant of the new conditions. However, disturbance and removal of trees and shrubs during the breeding bird season can have a direct adverse effects on nesting birds which have to be mitigated.

6 MITIGATION MEASURES

In accordance with the Migratory Birds Convention Act, mitigation measures for the protection of migratory birds and their nests have to be implemented before trees and shrubs can be removed and development begins. This applies for tree nesting as well as ground nesting species of breeding birds, e.g., in cultural meadows. Tree, shrub and vegetation removal should occur outside of the breeding bird season, which in Stoney Creek runs from the end of March to the end of August.

A tree preservation and protection plan is recommended to identify trees that should be retained. This should include a detailed evaluation of trees in hedgerows which consist of native species. The tree preservation plan should be developed by a certified arborist. Wherever possible, hedgerow like plantings using native species should be incorporated in landscape plans for green spaces.

It is recommended to include pollinator (butterfly, moth and bee) friendly plantings of native trees, shrubs and flowering plants in green spaces in Block 3 to provide habitat for birds and insects, including caterpillars. Recommended native tree and shrub species include maple (*Acer* spp.), American basswood (*Tilia americana*), cherry (*Prunus* spp.), oak (*Quercus* spp.), poplar (*Populus* spp.), willow (*Salix* spp.), viburnum (*Viburnum* spp.), dogwood (*Cornus* spp.), elderberry (*Sambucus canadensis*), sumac (*Rhus* spp.), serviceberry (*Amelanchier* spp.), rose (*Rosa* spp.) and raspberry (*Rubus* spp.). Flowering plant species should include native milkweed (*Asclepias* spp.), aster (*Aster* spp.), goldenrod (*Solidago* spp.), sunflower (*Helianthus* spp.), wild bergamot (*Monarda fistulosa*), Joe-Pye weed (*Eutrochium* spp.) and echinacea (*Echinacea* spp.). In addition, planting of native grasses and sedges such as big bluestem grass (*Andropogon gerardii*), bottlebrush grass (*Elymus hystrix*), Bebb's sedge (*Carex bebbii*), ebony sedge (*C. ebenea*) and stellate sedge (*C. rosea*) should be included in the landscape design, wherever possible.

Carolina wren, a locally rare species was noted during breeding bird surveys. In order to mitigate loss of habitat, including old orchard and hedgerows, nest boxes could be provided in green spaces, although it is acknowledged that implementation may be difficult as part of the development. Plantings of native plant species will attract the insects Carolina wren feeds on and will provide nesting opportunities.

Mitigation measures are recommended for general earthworks such as grading and construction. It is recommended to install silt fencing to prevent excessive run off entering drainage ditches to avoid sedimentation and to regularly inspect the integrity and effectiveness of the silt fencing as a barrier.

Development of a residential subdivision with paved surfaces and roofs may result in indirect effects such as increased sediment transport, diversion of water, changes in volumes of surface runoff. Stormwater will be directed to two stormwater ponds which will be located south of Barton Street, one will be constructed west of the existing school and one east of Lewis Street.

It is recommended that the functions of the watercourses (i.e., surface water conveyance) should be maintained (e.g., with stormwater management), and any potential disruptions should be properly mitigated (e.g., silt fencing to limit sediment loading). Consistent with the recommendations of the approved subwatershed study, the proposed stormwater management plan will replace the water quality and quantity function of the drainage features in the study area.

Provided that mitigation measures are implemented, long term or residual effects on natural environment features in the vicinity of Block 3 are not expected.

7 RECOMMENDATIONS

The Arcadis work program was completed in accordance with the EIS Terms of Reference as compiled in consultation with the City of Hamilton and HCA.

The EIS was prepared with consideration of applicable policies of the PPS, UHOP, Fruitland-Winona Secondary Plan and HCA in which natural features and functions are to be maintained or enhanced and potentially negative direct, indirect and/or cumulative effects have to be mitigated.

In order for the proposal to proceed as planned, the following recommendations are made to mitigate potential impacts:

- Complete tree and shrub and cultural meadow vegetation removal outside of breeding bird season (trees and shrubs should be removed between September to March);
- Complete a Tree Preservation Plan;
- Use native tree, shrub and flowering plant species, including milkweed for green spaces;
- Install nest boxes for Carolina wren in green spaces, where feasible; and
- Install silt fencing during earthworks, grading and construction to avoid excessive sedimentation in drainage ditches.

8 REFERENCES

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9 LIMITATIONS

An EIS is designed to identify existing natural environment conditions based upon a physical Site inspection of the property and an evaluation of readily available information. Natural environment inventories and the nature of the work dictates that findings and conclusions may not be definitive, but rather qualitative statements based on the observations made and research data accessed.

Achieving the study objectives stated in this report has required us to arrive at conclusions based on the best information presently known to us. No investigative method can completely eliminate the possibility of obtaining partially imprecise or incomplete information; it can only reduce this possibility to an acceptable level. Professional judgment was exercised in gathering and analyzing the information obtained. Professional judgment was also exercised in the formulation of recommendations. Like all professional persons rendering advice, we cannot act as absolute insurers of the conclusions we reach; we commit ourselves to care and competence in reaching those conclusions.

Our undertaking, therefore, is to perform our work, within the limits prescribed by our client, with the usual thoroughness and competence of our profession. No other warranty or representation, expressed or implied, is included or intended in this report.

This report was prepared by Arcadis Canada Inc. (Arcadis) exclusively for the account of the Landowners Group (the Client). Other than the Client, copying or distribution of this report or use of or reliance on the information contained herein, in whole or in part, is not permitted without the express written permission of Arcadis. Nothing in this report is intended to constitute or provide a legal opinion. Arcadis accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

The conclusions presented represent the best judgment of the assessors based on current environmental standards and on the Site conditions observed between May 2015 and November 2019. Due to the nature of the
investigation and the limited data available, the assessors cannot warrant against undiscovered environmental liabilities.
Respectfully submitted,

ARCADIS Canada Inc.

APPENDIX A: TERMS OF REFERENCE AND REVIEW COMMENTS

Arcadis Response to City of Hamilton Comments, dated September 12, 2019

No.	City of Hamilton Comment	Arcadis Response
1	A Comment Response table has not been provided with the revised Block 3 Servicing Strategy. This would be helpful to ensure that all previous comments have been addressed.	Comment response table is now provided.
2a i	Policy Review: A policy review has been provided within Section 1.1 of the EIS. There is concern that a comprehensive discussion has not been provided. Natural Heritage System: Based on mapping within Volumes 1 and 2 of the Urban Hamilton Official Plan (UHOP), a Natural Heritage System has not been identified within Block 3. It was identified within previous comments (April 3, 2019) that there are features within the Natural Heritage System that are not mapped. These features include habitat for Species at Risk (SAR) and Significant Wildlife Habitat (SWH). There is concern that this has not been discussed within the EIS.	Section 1.1 has been updated.
2a ii	Fruitland Winona Secondary Plan: Block 3 is located within the Fruitland Winona Secondary Plan. There is concern with Section 1.1.4 (Fruitland Winona Secondary Plan) of the revised EIS. Discussions focus on the Stoney Creek Urban Boundary Expansion Subwatershed Study and not on policies of the Secondary Plan.	Section 1.1.4 has been updated.
2b i	Field Surveys: Generally, field surveys were undertaken according to approved protocols. Watercourses: Within Table 2-1 (Summary of Natural Environment Surveys Completed), it has been identified that aquatic habitat assessments were completed June 26, July 3, and July 10, 2019. Since these watercourses may exhibit ephemeral conditions, there is concern that the field surveys were not completed in spring or fall.	An additional fall survey of the watercourses was completed on November 22, 2019.
2c i	Watercourses: A Fish Habitat Assessment has been included within Appendix E; however, there is concern that discussions have not been provided within the main EIS. Further clarification is required.	The discussion on fish habitat has been revised.
2c ii	The Fish Habitat Assessment focuses on the field survey that was undertaken on July 10, 2019. Within Table 2-1 (Summary of Natural Environment Surveys Completed), it was identified that assessments were completed June 26, July 3 and	The Fish Habitat Assessment has been updated and includes the fall visit. Findings from all other assessments were the same at each Site visit.

No.	City of Hamilton Comment	Arcadis Response
	July 10, 2019. Further clarification is required on why the other assessments have not been discussed.	
2c iii	Discussions within the Fish Habitat Assessment are focused on direct fish habitat. There is concern that indirect habitat has not been thoroughly considered. Further clarification is required.	Additional discussion has been provided.
2d	Locally Rare Species: Carolina Wren, a locally rare species has been observed breeding within the study area. Within previous comments (April 3, 2019), there was concern that the impact of development on this species was not considered. Based on review of the revised EIS, there is concern that this comment has not been adequately addressed. Discussions with regards to this species are missing from Sections 3.3.1 (Breeding Bird Surveys) and 5 (Identification and Assessment of Impacts). In addition, there is concern with the limited discussion that has been provided within Sections 6 (Mitigation Measures) and 7 (Recommendations). Further discussion is required.	Additional discussion has been provided.
2e i	SAR: SAR is under the jurisdiction of the Ministry of Environment, Conservation and Parks (MECP) (formerly Ministry of Natural Resources and Forestry (MNRF)). In previous comments (April 3, 2019), there was concern that correspondence from MECP/MNRF was not included in the report. While correspondence has been provided from MECP in Appendix F (Communications), there is concern that this does not adequately address the previous comment.	No additional communication with MECP is available.
2e ii	Eastern Meadowlark/Bobolink: Surveys were undertaken to determine if these species (“threatened”) were found within the Block 3 study area. The locations of the survey sites have been provided on Figure D-1 (Appendix D: Breeding Bird Surveys); however, this figure is very difficult to read. Further clarification is required.	The format of Figure D-1 has been changed to make it clearer.
2e iii	Barn Swallow: Within Appendix D (Breeding Bird Surveys), Barn Swallow, a “threatened” species was identified as possibly breeding within the study area. There is concern that this species has not been considered in the development of this area.	Barn swallow would be breeding offsite as they attach their nest on or in buildings and no buildings (or any other suitable structures) are present on Site. Barn swallow prefer barns or sheds for nesting, they attach nests either inside on walls or beams or on the outside of those types of buildings where there is an overhang. They generally return to their old nests.
2e iv	Within Section 5 (Identification and Assessment of Impacts) it has been identified that there is extensive feeding areas available in the vicinity of the area for Barn Swallow and Monarch and impacts on these species are not expected. There is	Section 5 has been revised.

No.	City of Hamilton Comment	Arcadis Response
	concern with this statement. Additional habitat within the vicinity does not recognize the potential habitat that will be lost as a result of development of this area.	
2f	SWH: Monarch, a species of "Special Concern" has been observed within the study area. Based on the Ministry of Natural Resources and Forestry (MNRF) SWH Criteria Schedules for Ecoregion 7E (January 2015), habitat for Species of Conservation Concern (not including Endangered or Threatened Species) has been identified as SWH. Included in this category are all Special Concern and Provincially Rare (S1-S3; SH) plant and animal species. Within previous comments (April 3, 2019), there was concern that this had not been discussed within the report. Based on review of the revised EIS, there is concern that this comment has not been adequately addressed. The discussion in Section 3.4.1 (Significant Wildlife Habitat) focusses on Monarch stopover areas and does not discuss this species as a Species of Conservation Concern.	Additional discussion has been provided in Section 3.4.1.
2g	Opportunities for Enhancement: In previous comments (April 3, 2019) there was concern that opportunities to retain hedgerows should be included within the development concept. While it has been identified that a tree preservation plan should be completed, there is concern that the incorporation of hedgerows has not been considered within the development concepts.	In Section 6 Mitigation Measures- it is recommended to incorporate hedgerow like plantings in the landscape design wherever possible.

Memorandum

Hamilton

Planning and Economic
Development Department

To: Margaret Fazio
Project Manager
Growth Management

From: Melissa Kiddie
Natural Heritage Planner
Development Planning, Heritage and Design, Suburban Team

Phone: 905-546-2424 Ext. 1290 **Fax:** 905-546-4202

Date: September 12, 2019 **File:** N/A

Subject: **Block 3 Servicing Strategy-Second Submission August 2019 Natural Heritage Planning Comments**

Natural Heritage Planning staff has reviewed the revised Block 3 Servicing Strategy that has been prepared by Urbantech West August 2019.

1. A Comment Response table has not been provided with the revised Block 3 Servicing Strategy. This would be helpful to ensure that all previous comments have been addressed.
2. The focus of these comments is on Appendix C (Terrestrial Data; C-1 Updated Environmental Impact Statement (EIS) Block 3 prepared by Arcadis July 2019)
    a) Policy Review: A policy review has been provided within Section 1.1 of the EIS. There is concern that a comprehensive discussion has not been provided.
        i. Natural Heritage System: Based on mapping within Volumes 1 and 2 of the Urban Hamilton Official Plan (UHOP), a Natural Heritage System has not been identified within Block 3. It was identified within previous comments (April 3, 2019) that there are features within the Natural Heritage System that are not mapped. These features include habitat for Species at Risk (SAR) and Significant Wildlife Habitat (SWH). There is concern that this has not been discussed within the EIS.
        ii. Fruitland Winona Secondary Plan: Block 3 is located within the Fruitland Winona Secondary Plan. There is concern with Section 1.1.4 (Fruitland Winona Secondary Plan) of the revised EIS. Discussions focus on the Stoney Creek Urban Boundary Expansion Subwatershed Study and not on policies of the Secondary Plan.
    b) Field Surveys: Generally, field surveys were undertaken according to approved protocols.
        i. Watercourses: Within Table 2-1 (Summary of Natural Environment Surveys Completed), it has been identified that aquatic habitat

assessments were completed June 26, July 3, and July 10, 2019. Since these watercourses may exhibit ephemeral conditions, there is concern that the field surveys were not completed in spring or fall.

c) Watercourses:
   i. A Fish Habitat Assessment has been included within Appendix E; however there is concern that discussions have not been provided within the main EIS. Further clarification is required.
   ii. The Fish Habitat Assessment focuses on the field survey that was undertaken on July 10, 2019. Within Table 2-1 (Summary of Natural Environment Surveys Completed), it was identified that assessments were completed June 26, July 3 and July 10, 2019. Further clarification is required on why the other assessments have not been discussed.
   iii. Discussions within the Fish Habitat Assessment are focused on direct fish habitat. There is concern that indirect habitat has not been thoroughly considered. Further clarification is required.

d) Locally Rare Species: Carolina Wren, a locally rare species has been observed breeding within the study area. Within previous comments (April 3, 2019), there was concern that the impact of development on this species was not considered.

   Based on review of the revised EIS, there is concern that this comment has not been adequately addressed. Discussions with regards to this species are missing from Sections 3.3.1 (Breeding Bird Surveys) and 5 (Identification and Assessment of Impacts). In addition, there is concern with the limited discussion that has been provided within Sections 6 (Mitigation Measures) and 7 (Recommendations). Further discussion is required.

e) SAR:
   i. SAR is under the jurisdiction of the Ministry of Environment, Conservation and Parks (MECP) (formerly Ministry of Natural Resources and Forestry (MNRF)). In previous comments (April 3, 2019), there was concern that correspondence from MECP/MNRF was not included in the report.

      While correspondence has been provided from MECP in Appendix F (Communications), there is concern that this does not adequately address the previous comment.
   ii. Eastern Meadowlark/Bobolink: Surveys were undertaken to determine if these species ("threatened") were found within the Block 3 study area. The locations of the survey sites have been provided on Figure D-1 (Appendix D: Breeding Bird Surveys); however this figure is very difficult to read. Further clarification is required.

iii. Barn Swallow: Within Appendix D (Breeding Bird Surveys), Barn Swallow, a "threatened" species was identified as possibly breeding within the study area. There is concern that this species has not been considered in the development of this area.

iv. Within Section 5 (Identification and Assessment of Impacts) it has been identified that there is extensive feeding areas available in the vicinity of the area for Barn Swallow and Monarch and impacts on these species are not expected. There is concern with this statement. Additional habitat within the vicinity does not recognize the potential habitat that will be lost as a result of development of this area.

f) SWH: Monarch, a species of "Special Concern" has been observed within the study area. Based on the Ministry of Natural Resources and Forestry (MNRF) SWH Criteria Schedules for Ecoregion 7E (January 2015), habitat for Species of Conservation Concern (not including Endangered or Threatened Species) has been identified as SWH. Included in this category are all Special Concern and Provincially Rare (S1-S3; SH) plant and animal species. Within previous comments (April 3, 2019), there was concern that this had not been discussed within the report.

Based on review of the revised EIS, there is concern that this comment has not been adequately addressed. The discussion in Section 3.4.1 (Significant Wildlife Habitat) focusses on Monarch stopover areas and does not discuss this species as a Species of Conservation Concern.

g) Opportunities for Enhancement: In previous comments (April 3, 2019) there was concern that opportunities to retain hedgerows should be included within the development concept. While it has been identified that a tree preservation plan should be completed, there is concern that the incorporation of hedgerows has not been considered within the development concepts.

If you have any questions, please contact me at (905) 546-2424 ext. 1290.

Melissa

MK:mk

Memo

To:	Melissa Kiddie, M.E.S (Pl), ERPG, Natural Heritage Planner, City of Hamilton
	Jaime Tellier, Conservation Planner, Hamilton Conservation Authority
From:	Barbara Hard, Ph.D., Senior Ecologist
cc:	Jason Mosdell, MCIP, RPP, Project Manager, Branthaven Development Corp.
Date:	May 5, 2015
Re:	Proposed Terms of Reference, Scoped Environmental Impact Statement (EIS) Block 3, Block Servicing Strategy, Fruitland-Winona Secondary Plan, City of Hamilton

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It is our understanding that Block 3 of the Fruitland-Winona Secondary Plan requires a Block Servicing Strategy as per Amendment 17 to the Urban Hamilton Official Plan from May 14, 2014. The City of Hamilton prepared Terms of Reference for the Block Servicing Strategy in consultation with the Conservation Authority which includes the requirement for a Scoped Environmental Impact Statement (EIS).

Specific natural heritage requirements for the Block Servicing Strategy for Block 3 are outlined in the City of Hamilton "Terms of Reference for Fruitland-Winona Block Servicing Strategy" document, dated October 15, 2013.

They include:

- Ecological Land Classification and Vegetation Surveys
  - Update SCUBE East Subwatershed Study Phase 1 & 2
- Define limits of natural heritage feature boundaries
- Review the width of the preliminary vegetation protection zone (VPZ) that have been established within the Subwatershed Study
- Drainage and Infrastructure improvement works:
  - Identification of design measures to avoid/mitigate the potential negative effects of the proposed channel improvements on existing natural heritage features and functions.

The completion of the Scoped EIS report will follow the City of Hamilton Draft *Environmental Impact Statement (EIS) Guidelines* (revised November 2013) and will include a description of the proposed development, mapping and aerials, a description of the surrounding environment (biophysical inventory), impact identification and assessment and mitigation and monitoring plans (as needed). If the newly revised EIS guidelines (January 2015) are ratified by Council while work to support the EIS is ongoing, changes, if applicable, will be incorporated in the EIS report.

The following are the proposed Terms of Reference for the EIS field inventories for the Site for review and comments by the City of Hamilton and Hamilton Conservation Authority (HCA):

1. Vegetation

Vegetation communities that are found will be described in accordance with Ecological Land Classification (ELC) for southern Ontario (Lee et al., 1998 and Lee, 2008) and mapped. A two season survey will be carried out and species lists will be compiled. The spring survey will be carried out between the beginning of May and June, the summer survey will be carried out in late August/early September. The species list will include federal, provincial rankings and local status. Non-native species will be identified.

2. Breeding Bird Survey

All birds seen or heard during site visits will be recorded. A breeding bird survey will be carried out in accordance with the Ontario Breeding Bird Atlas protocols. Two surveys will be carried out, the first one between May 24 and June 6 and the second between June 16 and July 10, 2015.

Species significance will be evaluated based on national, provincial and local level published literature and current status lists.

3. Species at Risk

ARCADIS will carry out a Species at Risk screening. Records of Species at Risk will be obtained from the Ministry of Natural Resources and Forestry (MNRF) and the Natural Heritage Information Centre (NHIC). The presence of Species at Risk, if any, will be noted and included in the EIS report.

4. Wildlife

Incidental observations of mammals, amphibians, reptiles and insects during the site visits will be recorded. Observations will include direct sightings and indirect evidence such as calls, tracks, scat, burrows, dens and browse. The species list will include federal, provincial rankings and local status.

5. Draft Outline of EIS Report

The following is the proposed draft outline of the EIS Report:

- 1.0 Introduction
  - 1.1 Policy Review
    - 1.1.1 Provincial Policy Statement
    - 1.1.2 Hamilton Official Plan
    - 1.1.3 Hamilton Conservation Authority Policies
  - 1.2 Background Information Review
- 2.0 Field Inventories Methodology
- 3.0 Existing Conditions
  - 3.1 Site description
  - 3.2 Vegetation Surveys

Hamilton
Conservation
Authority

A Healthy Watershed for Everyone

BY EMAIL

September 30, 2019

Margaret Fazio, Senior Project Manager
Infrastructure Planning
Growth Management, Planning & Economic Development Department
City of Hamilton
71 Main St. West, 6th Floor
Hamilton, ON L8R 4Y5

Dear Ms. Fazio,

Re: Block Servicing Strategy, Fruitland-Winona Secondary Plan Area, Block 3, Second Submission, August 2019

Thank you for providing the Hamilton Conservation Authority (HCA) with the *Block Servicing Strategy, Fruitland Winona Secondary Plan, Block 3* (Urbantech West, Second Submission, August 2019). HCA staff have reviewed the report and August 14/19 Urbantech comment response letter, and offer the following comments for consideration.

Environmental Impact Assessment

1. Natural Heritage Features and Watercourses

In Section 3, Existing Conditions, it is noted that discussions between the City of Hamilton (City) and HCA resulted in the determination that regulated watercourse features 1, 2, 3 and 4 did not require protection and could be enclosed. With respect to feature 1 (Watercourse 9), it is indicated enclosure was allowed given downstream infrastructure constraints. In Section 3.6, it is further noted enclosure was allowed given City concerns related to flooding and safety. In addition to this, the City's preference for an enclosed system was also related to concerns over consistency with the Secondary Plan, parkland requirements and useable recreational space, as well as anticipated long-term maintenance costs associated with an open watercourse feature. HCA suggests these additional considerations raised by the City should be identified in the report.

HCA staff continue to note there was insufficient fisheries sampling work completed to determine if fish may be present at certain times or to support the conclusions made in the report that the drainage features within the block do not provide or support fish habitat (Section 3.7 and App C, EIS, Section 3.1.2.3). Appendix E of the EIS (Arcadis, Updated July 2019) provides a DFO fish habitat self-assessment, which acknowledges there may be some surface water conveyance from the block to downstream sections that do comprise fish habitat.

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HCA suggests this should be noted in the body of the EIS and main report, along with the limitations of the assessment work completed. In HCA staff's opinion, based on the work completed, the report should note the on-site intermittent streams likely provide some form of contributory function as fish habitat, which will need to be considered at the time of development. While the report has completed a DFO self-assessment, HCA staff notes recent changes to the *Fisheries Act* will likely require further review to determine the potential for impacts and need for an authorization from DFO at the time of development. HCA suggest this should be noted in the final report.

Table 9-1 states fish rescue permits and/or a LOA will not be required. In the absence of more detailed information or staging plan to identify when construction/enclosure will occur, HCA suggests this statement in Table 9-1 is potentially misleading.

Survey work completed as part of the EIS recorded Barn swallow foraging on site. Monarch was also recorded as part of survey work completed for the study. HCA staff suggest that indicating there is additional habitat for these species in the surrounding area does not recognize the considerable area of potential habitat that will be lost as a result of development of the block (as well as the surrounding blocks), nor is it clear which surrounding habitat areas are being referred to.

While the EIS has included some correspondence with the MECP regarding species at risk, there is nothing included to indicate all issues have been resolved to MECP's satisfaction. If additional information/correspondence is available HCA suggests it should be included in the final report.

The EIS includes a limited discussion regarding Significant Wildlife Habitat (SWH). This section could be expanded to address all potential categories/types of SWH. For example, while Monarch are discussed in terms of the site's function as a migratory stop over (seasonal concentration areas), the site is not reviewed as potential habitat for a species of conservation concern.

HCA staff support the limited recommendations made in Section 6 (Mitigation Measures) and 7 (Recommendations) of the EIS. Further consideration could be given to retaining hedgerows in the development concept (e.g. in association with the SWM pond, school and neighbourhood parks).

Hydrology and Hydraulics Assessments

2. Lack of Model Calibration, Validation or Parameter Sensitivity Analysis

Given the significant revisions to the original MIKE 11 modeling (and the considerable changes in peak flow rates), HCA staff had previously suggested that some form of model calibration or validation is warranted. Due to the lack of available flow observations in Watercourse 9, this review was expected to focus on a fulsome comparison of peak flow rates under existing conditions and future uncontrolled conditions (at all key comparison locations) to peak flow rates determined by previous approved modeling studies (SCUBE SWS 2013, FDRP, etc.). Also, a sensitivity analysis of key model parameters was suggested, to further validate the revised modeling results.

The intended sensitivity analysis was not provided in the revised submission. HCA staff had expected a review of changes in peak flow rates resulting from changes in the values selected for key parameters (within justified ranges). It was staff's expectation that this review would help address concerns regarding the accuracy and confidence in the peak flow rates modelled by the Block Servicing Study.

Due to the errors found in the original SCUBE Subwatershed Study 2013 MIKE 11 model, a peak flow comparison to this study was not relied on.

Table 5-12 and 5-13, compares the existing and future uncontrolled peak flows determined by the updated MIKE 11 design event model, SCUBE 2013, and FDRP 1989. However, there appears to be errors in the tables. The FDRP future uncontrolled drainage areas do not appear consistent with the FDRP report. Although not relied upon, it was also observed that the SCUBE 2013 peak flows are not consistent with the 1st submission report.

HCA staff completed a comparison of the design event model peak flows to FDRP 1989 results. Given the magnitude of the increases, HCA staff have concerns regarding the accuracy and confidence in the peak flow rates modelled by the Block Servicing Study.

The existing condition peak flows determined using the single event (design event) modelling are significantly greater than the peak flows previously determined by the FDRP. At the downstream crossings of CNR and QEW (Nodes 11 & 13), the current study 100-year existing conditions peak flows are 40 and 65 % larger than the FDRP results (when normalizing for drainage area differences).

The future uncontrolled condition peak flows determined using the single event (design event) modelling are also significantly greater than the peak flows previously determined by the FDRP. At the downstream crossings of CNR and QEW (Nodes 11 & 13), the current study 100-year peak flows are 50 and 30% larger than the FDRP results (when normalizing for drainage area differences).

Some differences between the peak flows was expected given the different modelling approach (design event versus continuous), different model software and differing parametrization choices. However, significantly higher existing conditions peak flows (with respect to previous assessments) would result in greater allowable release rates from the development. Without further confirmation as to the accuracy and confidence in the modelled results, there is concern about the potential for an increase in actual peak flow rates downstream (compared to current in-field conditions).

In addition to the above, the continuous model peak flows (from the 1st submission) were also compared to FDRP results. It was noted that the 100-year existing conditions peak flow rates determined using the continuous modelling were -45% and -5% smaller than the FDRP results (when normalizing for drainage area differences), at the downstream crossings of CNR and QEW. The 100-year future uncontrolled conditions peak flow rates determined using the continuous modelling (as presented in the 1st submission), were -25% and -15% smaller than the FDRP results (when normalizing for drainage area differences), at the downstream crossings of CNR and QEW.

As detailed in Review Comment 4 below, the unexpectedly large increases in peak flow rates (for both existing and future uncontrolled conditions) between the design event and continuous versions of the Block Servicing Study model increases HCA staff's concern regarding the accuracy and confidence in the peak flow rates modelled.

As further review, HCA staff intend to compare the Block Servicing Study peak flow results to our ongoing Flood Plain Mapping Update study, and will provide further comment once this review is completed. Once this review has been completed, HCA staff may request additional justifications / reviews to address any outstanding accuracy and confidence concerns.

3. Corrected Errors from the Original SCUBE SWS 2013 MIKE 11 Modeling

HCA had suggested that the report provide further detail regarding the errors that were found and corrected in the original SCUBE SWS 2013 MIKE 11 modeling, as this information forms another aspect of the validation of the revised peak flows.

It is HCA staff's suggestion that the details provided in the DHI memo dated June 12, 2018 (Subject: Scube East Model Update – Corrected Slopes) be included in the report, as this memo describes the key error (considerably low values for urban catchment slope) found and corrected from the original SCUBE Subwatershed Study 2013 MIKE 11 model.

The DHI memo dated June 12, 2018 also identifies significant differences in peak flows when the original SCUBE Subwatershed Study 2013 MIKE 11 model (using 2007 version of MIKE 11) was re-run using the 2017 version of MIKE 11. Although it is acknowledged that the 2017 re-run produced lower peak flows, the magnitude of differences and lack of understanding of reasons for the differences increases HCA staff's concern regarding the accuracy and confidence in the peak flow rates modelled by the Block Servicing Study.

4. Recommend the Use of Design Storm Assessments, given Statistical Issues with the Frequency Flow Analysis

Given the Frequency Flow Analysis concerns, HCA had suggested that further consideration be given to the use of a design storm / single event modeling approach for all required assessments (SWM pond design, impacts of Proposed Conditions with SWM Controls on downstream Existing Condition peak flow rates, revised Future Uncontrolled Conditions), and that appropriate validation / sensitivity analysis of the adopted design event modeling would be necessary.

In reviewing the revised submission, HCA notes the peak flows determined using the single event (design event) modelling are significantly greater than the peak flows determined using the continuous modelling (as presented in the 1st submission).

HCA staff had suggested the design event approach given the expected inaccuracies in the frequency flow analysis. However, HCA staff had not expected such large increases in peak flow rates. For example, at Nodes 1, 10, 11, and 13, the 100-year existing conditions peak flows determined using the design event modelling were 65%, 32%, 55%, and 74% greater than the continuous modeling results. Also, the 100-year future uncontrolled conditions peak flows at Nodes 10, 11, and 13 increased by 101%, 105%, and 53%, respectively.

4(a). Flood Storage and Flow Attenuation Within Feature 1

Further discussions are suggested regarding how (or if) the flood storage and flow attenuation of Drainage Area 300 within the existing onsite Feature 1 should be accounted for, if the Block Servicing Study continues to propose enclosure of this feature with external flows re-routed to the downstream Venetian Meats channel.

4(b). Assessing the Potential Effects of Enlarging the Highway 8, Lewis Road and Barton Street Culvert Crossings

The proposed upgrades to culvert crossings may reduce flow attenuation, and possibly increase flows, water levels and velocities downstream of the crossings. Depending on the proposed upgrades, a downstream impact assessment may be required, and would be based on a comparison of the following scenarios:

- Existing land use, with existing SWM (if any), existing conditions at all hydraulic structures, and accounting for the flow attenuation at the crossings.
- Proposed site land use, existing land use offsite, with proposed site SWM and existing offsite SWM (if any), proposed crossing details, existing conditions at all offsite hydraulic structures and downstream channel sections, and accounting for the flow attenuation at ALL hydraulic structures.
- The review is requested to include the range of storms evaluated in the overall study.

This recommended assessment differs from the assessments undertaken to date to support this study, where flow attenuation at hydraulic structures appears to have been ignored.

5. Comparison of Peak Flows under Proposed Conditions with SWM Controls to Existing Conditions for Four Storm Events

This previous HCA review comment has been addressed.

6. Peak Flow Comparison Locations Downstream of the Site for the Various Pond Rating Curve Scenarios

The previous HCA review comment has been addressed.

7. Channel Capacity in the Venetian Meats Channel

The previous HCA review comment has been addressed.

8. Comparison of Peak Flows under Proposed Conditions with SWM Controls to Existing Culvert & Channel Capacities

HCA had recommended that a table be included comparing the peak flow rates under Proposed Conditions with SWM Controls to the existing flow capacities of culverts and channel sections downstream of the site.

It is expected that the previous HCA review comment will be addressed at the Detailed Design stage.

9. Comparison of Peak Flows under Future Uncontrolled Conditions to Existing Culvert & Channel Capacities

As an update to the same evaluation from the SCUBE 2013 study, HCA had recommended that there be a comparison of peak flow rates under Future Uncontrolled Conditions (Regional and 100 year event) to the existing flow capacities of culverts and channel sections at the QEW and CNR crossings downstream of the site.

It is expected that the previous HCA review comment will be addressed at the Detailed Design stage.

10. Reduced Peak Flow Rates between Node 1 and Node 5 under Existing Conditions

The previous HCA review comment has been addressed.

11. Lack of Change in 100 year Storm Event Peak Flow Rate between Node 5 and Node 8 under Existing Conditions

The previous HCA review comment has been addressed.

12. Reduced Peak Flow Rates between Node 13 and Node 14 under Existing Conditions

The previous HCA review comment has been addressed.

13. Drainage of Catchments 200 & 201A

The previous HCA review comment has been addressed.

14. External Conveyance Sewer System:

The previous HCA review comment has been addressed.

15. Statistical Distribution Selection – Appendix F

This previous HCA review comment has been addressed.

16. Proposed Condition with SWM Control Peak Flows for Node 1

This previous HCA review comment has been addressed.

17. Final Hydrology and Hydraulics Modeling Files to be Provided

Once finalized, HCA would request that a copy of all modelling files be provided.

SWM Pond Design

All previous HCA review comments related to SWM pond design (comments #18-23) have been addressed.

Additional Comments

24. Proposed % Imperviousness Values

HCA had suggested it should be confirmed the proposed imperviousness values are consistent with the Fruitland Winona Secondary Plan and SCUBE SWS 2013.

In reviewing the revised report and responses, HCA notes the proposed % imperviousness (approximately 70%) are considerably larger than that which was assumed in the SCUBE 2013 Subwatershed Study (50%). Notwithstanding the on-going review of the modelling, it is noted the proposed increase in imperviousness could potentially increase the regulatory floodplain downstream.

25. Recommended Runoff Coefficients by Land Use

See comment #24 above.

26. Available Topography Data Used in the Study

HCA had requested additional details regarding the topographic data used for this study, including source, date created, contour interval, etc.

The previous HCA review comment has been addressed.

That said, it is expected that there is a typo, and that the contour interval of the GTA Mass Points and Breaklines 2002 data is 1.0m, not 10.0m. It is also expected that the 2017 McLaren topographic survey was the primary source of topographic data for the study.

27. Recommendations for Future Study

The report contains a number of recommendations for additional study, assessment and design work at subsequent stages of development planning (e.g. SWM design, water balance, infiltration and LID, etc.). Additional recommendations have been provided in the comments above. It is recommended that these items be summarized in a separate section in the final report to ensure all recommendations and future work requirements are adequately captured.

Thank you for the opportunity to review and comment on the draft report. HCA staff are available to meet to discuss these comments in more detail if that would be helpful.

Kind regards,

Mike Stone MCIP, RPP
Manager, Watershed Planning Services
MS/JB

Memorandum

Hamilton

Planning and Economic
Development Department

To: Margaret Fazio
Project Manager
Growth Management

From: Melissa Kiddie
Natural Heritage Planner
Development Planning, Heritage and Design, Suburban Team

Phone: 905-546-2424 Ext. 1290 **Fax:** 905-546-4202

Date: April 3, 2019 **File:** N/A

Subject: Block 3 Servicing Strategy
Natural Heritage Planning Comments

Natural Heritage Planning staff has reviewed the Block 3 Servicing Strategy that has been prepared by Urbantech West January 2019. The focus of these comments is on Appendix C (Terrestrial Data-Environmental Impact Statement prepared by Arcadis December 2018).

1. Natural Heritage System: Based on the Fruitland Winona Secondary Plan, the Natural Heritage System has not been identified within Block 3. It is important to note that there are features associated with the Natural Heritage System that are not mapped. These features include habitat for Species at Risk and Significant Wildlife Habitat.
2. Field Surveys: Generally, field surveys were undertaken according to approved protocols.
   a) Vegetation: Within the Plant List, Hawthorn sp. have been identified. Since there are locally uncommon/rare species, there is concern that this species was only identified to genus. Further clarification is required.
   b) Breeding Birds: It is important to note that one of the breeding bird surveys (July 13, 2016) was completed outside of the timing window (the end date of surveys is July 10).
3. Locally Rare Species: Carolina Wren, a locally rare species has been observed breeding within the study area. There is concern that the impact of development on this species has not been considered. Further clarification is required.
4. Species at Risk (SAR): Within the Provincial Policy Statement, UHOP and Fruitland Winona Secondary Plan, policies are provided that affords protection to “threatened” and “endangered” species. These policies include:

   - Development and site alteration shall not be permitted in habitat of endangered species and threatened species except in accordance with provincial and federal requirements (PPS 2.1.7);

- New development and site alteration shall not be permitted within significant habitat of threatened and endangered species (UHOP policy C.2.5.2); and,
- All development shall comply with the Endangered Species Act, 2007 or its successor legislation (Fruitland-Winona Secondary Plan policy 7.4.11.1).

a) SAR is under the jurisdiction of the Ministry of Environment, Conservation and Parks (MECP) (formerly Ministry of Natural Resources and Forestry (MNRF)). There is concern that correspondence from MECP/MNRF has not been included within the report.

b) Bobolink: Based on background information, it was identified that Bobolink, a "threatened" species could potentially be located within the study area. There is concern that appropriate surveys to identify this species were not undertaken. Surveys are to be undertaken as per MNRF Bobolink Survey Methodology. This methodology indicates that transects are to be determined with point counts completed along transects. Three (3) sets of point counts are to be completed in June or the first week of July. These surveys are to start 30 minutes after dawn and continue to no later than 9 am. Further clarification is required.

c) Barn Swallow: Barn Swallow, a "threatened" species was identified as breeding within the study area. There is concern that this species has not been considered in the development of this area.

5. Significant Wildlife Habitat (SWH) Screening: Monarch, a species of "Special Concern" has been observed within the study area. Based on the MNRF SWH Criteria Schedules for Ecoregion 7E (January 2015), habitat for Species of Conservation Concern (not including Endangered or Threatened Species) has been identified as SWH. Included within this category are all Special Concern and Provincially Rare (S1-S3; SH) plant and animal species. There is concern that this has not been discussed within the report. Further discussion is required.
6. Opportunities for Enhancement:

   a) Hedgerows: Hedgerows have been identified within the study area. These features contain native trees such as Sugar Maple, Bur Oak, Red Oak and White Oak. Since the City recognizes the importance of trees and woodlands to the health and quality of life in the community, the protection and restoration of trees and forests is encouraged (policy C.2.11.1). There is concern that this has not been discussed. Opportunities to retain trees within these hedgerows should be included within the development concepts.

   b) Enhancement of Special Concern Species Habitat: Common Milkweed is used by Monarch, a 'Special Concern' species. Since this area is proposed to be developed, there is concern that this species will be removed. Opportunities to include Milkweed and other native species that support butterfly habitat should be integrated into development. Further discussion is required.

If you have any questions, please contact me at (905) 546-2424 ext. 1290.

Melissa

MK:mk

Hamilton
Conservation
Authority

A Healthy Watershed for Everyone

BY EMAIL

April 17, 2019

Margaret Fazio, Senior Project Manager
Infrastructure Planning
Growth Management, Planning & Economic Development Department
City of Hamilton
71 Main St. West, 6th Floor
Hamilton, ON L8R 4Y5

Dear Ms. Fazio,

Re: Block Servicing Strategy, Fruitland-Winona Secondary Plan Area, Block 3, January 2019

Thank you for providing the Hamilton Conservation Authority (HCA) with the *Block Servicing Strategy, Fruitland Winona Secondary Plan, Block 3* (Urbantech West, January 2019). HCA staff have reviewed the report and offer the following comments for consideration.

Environmental Impact Assessment

1. Natural Heritage Features and Watercourses

In Section 3, Existing Conditions, it is noted that discussions between the City of Hamilton (City) and HCA resulted in the determination that regulated watercourse features 1, 2, 3 and 4 did not require protection and could be enclosed. With respect to feature 4 (Watercourse 9), it is indicated enclosure was allowed given downstream infrastructure constraints. In Section 3.6, it is further noted enclosure was allowed given City concerns related to flooding and safety. In addition to this, the City's preference for an enclosed system was also related to concerns over consistency with the Secondary Plan, parkland requirements and useable recreational space, as well as anticipated long-term maintenance costs associated with an open watercourse feature. HCA suggests these additional considerations raised by the City should be identified in the report.

HCA staff note there was insufficient fisheries sampling work completed to determine if fish may be present at certain times. With respect to watercourse enclosure, HCA suggests it should be noted in Section 3.7, Environmental Impact Assessment, that consultation with the Department of Fisheries and Oceans (DFO) may be required to determine the potential impacts to fish or fish habitat. While this is noted in Table 9-1, it is suggested that a further reference in section 3.7 be included.

Table 9-1 states fish rescue permits and/or a LOA will not be required. In the absence of more detailed information or staging plan to identify when construction/enclosure will occur, HCA suggests this statement in Table 9-1 is potentially misleading.

The Environmental Impact Statement (EIS) provided in Appendix C indicates that Eastern Meadowlark and Bobolink have been reported previously from the vicinity of the site and that potential habitat is present, but that neither species was recorded during survey work; survey work did however record Barn swallow foraging on site. HCA staff note earlier surveys have documented each of these species on site. Monarch was also recorded as part of survey work completed for the study. HCA suggests that these species, the potential impacts to their habitat as a result of development of the block, and mitigation measures should be discussed further.

HCA staff suggest that indicating there is additional habitat for these species in the surrounding vicinity/Stoney Creek area does not recognize the considerable area of potential habitat that will be lost as a result of development of the block (as well as the surrounding blocks). If consultation with the MECP regarding these species at risk and potential Endangered Species Act requirements has occurred, HCA suggests this information should also be included.

HCA staff suggest Section 6 (Mitigation Measures) and 7 (Recommendations) of the EIS could be clarified to indicate that all vegetation types, including cultural meadows, must be considered in relation to the Migratory Bird Convention Act, and that any vegetation removal should only occur outside the migratory and breeding bird timing windows.

HCA staff note the mitigation measures section is very minimal. While there may be few environmental features in the block, HCA suggest the section could be expanded to be more robust, for example to include discussion regarding tree preservation plans, measures for Monarchs, etc.

Hydrology and Hydraulics Assessments

2. Lack of Model Calibration, Validation or Parameter Sensitivity Analysis

Given the significant revisions to the original MIKE 11 modeling (and the considerable changes in peak flow rates), HCA staff suggest that some form of model calibration or validation is warranted. Due to the lack of available flow observations in Watercourse 9, this review is expected to focus on a fulsome comparison of peak flow rates under existing conditions and future uncontrolled conditions (at all key comparison locations) to peak flow rates determined by previous approved modeling studies (SCUBE SWS 2013, FDRP, etc.). Also, a sensitivity analysis of key model parameters is suggested, to further validate the revised modeling results.

3. Corrected Errors from the Original SCUBE SWS 2013 MIKE 11 Modeling

The existing condition and future uncontrolled condition peak flows in Table 5-4 are considerably larger than those determined in the SCUBE SWS 2013 study, at available comparison locations (Nodes 12, 13 and 14). It is suggested that the report further detail the errors that were found and corrected in the original SCUBE SWS 2013 MIKE 11 modeling, as this information forms another aspect of the validation of the revised peak flows.

4. Recommend the Use of Design Storm Assessments, given Statistical Issues with the Frequency Flow Analysis

Given the Frequency Flow Analysis concerns, it is suggested that further consideration be given to the use of a design storm / single event modeling approach for all required assessments (SWM pond design, impacts of Proposed Conditions with SWM Controls on downstream Existing Condition peak flow rates, revised Future Uncontrolled Conditions). Further review / discussion of the adopted design storm details and validation / sensitivity analysis of the design event modeling would be necessary.

5. Comparison of Peak Flows under Proposed Conditions with SWM Controls to Existing Conditions for Four Storm Events

It was HCA staff's understanding, based on previous discussions, that the assessment was to include a comparison of peak flows for Proposed Conditions with SWM Controls to Existing Conditions for four discrete storm events, in addition to the comparison of peak flows determined by Flood Frequency Analysis of the continuous modeling results. The completion of this assessment would become more important in the absence of the assessments requested under item #4 above.

6. Peak Flow Comparison Locations Downstream of the Site for the Various Pond Rating Curve Scenarios

Given HCA's focus on ensuring that downstream flow regimes are maintained, it is recommended that peak flows for Proposed Conditions with SWM Controls be compared to Existing Conditions, at Nodes 7 – 14 for each of the various pond rating curve scenarios.

Furthermore, it is recommended that Table 5-18 also compare peak flows for Proposed Conditions with SWM Controls (Preferred Pond Rating Curve Scenario) to Existing Conditions, at Nodes 7 – 14.

7. Channel Capacity in the Venetian Meats Channel

It is HCA staff's understanding that the Venetian Meats constructed channel has a flow capacity of 5.3 m^3/s for the reach between Node 7 and 8, and a flow capacity of 8.1 m^3/s for the reach between Node 8 and 10. It is suggested that this be confirmed, and be considered within the pond design as necessary.

8. Comparison of Peak Flows under Proposed Conditions with SWM Controls to Existing Culvert & Channel Capacities

It is recommended that a table be included comparing the peak flow rates under Proposed Conditions with SWM Controls to the existing flow capacities of culverts and channel sections downstream of the site.

9. Comparison of Peak Flows under Future Uncontrolled Conditions to Existing Culvert & Channel Capacities

As an update to the same evaluation from the SCUBE 2013 study, it is recommended that there be a comparison of peak flow rates under Future Uncontrolled Conditions (Regional and 100 year event) to the existing flow capacities of culverts and channel sections at the QEW and CNR crossings downstream of the site.

10. Reduced Peak Flow Rates between Node 1 and Node 5 under Existing Conditions

Based on Table 3-2, there is a reduction in existing condition peak flow rates between Node 1 and Node 4 or 5 for the various return period events. Given the increase in drainage area, it was expected that the peak flow rates would have increased between Node1 and Node 5. It is suggested that the modeling / Flood Frequency Analysis be reviewed for possible errors. If no errors are evident, it is suggested that the report discuss the rationale for these findings.

11. Lack of Change in 100 year Storm Event Peak Flow Rate between Node 5 and Node 8 under Existing Conditions

Based on Table 3-2, there is no change in existing condition peak flow rates between Node 5 and Node 8 for the 100 year storm event. However, there are 35 to 20 % increases in peak flow rates between these two Nodes for the 2 to 50 year storm events, respectively. It was expected that the 100 year storm event peak flow rates would have increased between Node 5 and Node 8. It is suggested that the modeling / Flood Frequency Analysis be reviewed for possible errors. If no errors are evident, it is suggested that the report discuss the rationale for these findings.

12. Reduced Peak Flow Rates between Node 13 and Node 14 under Existing Conditions

Based on the existing condition peak flows in Table 3-2, there is a reduction in peak flow rates between Node 13 and Node 14 for the various return period events up to 50. Given the increase in drainage area, it was expected that the peak flow rates would have increased between Node 1 and Node 5. It is suggested that the modeling / Flood Frequency Analysis be reviewed for possible errors. If no errors are evident, it is suggested that the report discuss the rationale for these findings.

13. Drainage of Catchments 200 & 201A

Text on Page 24 states "A total of approximately 123.4 ha has been determined to drain to the culvert crossing Barton Street on the west side of Lewis Road (Flow Node 5 with characteristics shown in Table 3-1)". However, it is HCA staff's understanding that Catchments 200 and 201A also drain to the upstream side of this culvert via an existing 900 mm diameter storm sewer.

Based on the consultant's review and site observations, it would be appreciated if it could be confirmed whether the 900 mm diameter storm sewer draining Catchments 200 and 201A ends at the upstream side of the culvert crossing Barton Street on the west side of Lewis Road (Culvert ID 3), or if the 900 mm diameter storm sewer ends at the downstream side Culvert ID 3.

14. External Conveyance Sewer System

Text on Page 27 states "As such, the Regulatory storm event, or 100-year storm, is to be conveyed through an external conveyance storm sewer. For this reason, there will no longer be a floodplain issue for the site. The storm sewer has been sized to accommodate an external peak flow of 1.88 m^3/s from the lands west of Lewis Road and south of Highway 8 based on calculations provided in the storm sewer design sheet included in Appendix G".

Based on the existing condition peak flows in Table 3-2, the 100-year peak flow rate at Node 1 (which represents this drainage area (DA 300)) is 2.40 m^3/s. It is suggested that the hydrologic modeling and storm sewer flow estimates be reviewed to ensure that consistency has been maintained. However, it is acknowledged that the full flow capacity at the upstream end of the External Conveyance Sewer System is a minimum of 2.75 m^3/s.

15. Statistical Distribution Selection – Appendix F

HCA staff were not completely clear what the orange dots shown on Figure 1 - 4 of Appendix F represent. Clarification would be appreciated.

16. Proposed Condition with SWM Control Peak Flows for Node 1

In Table 5-4, for Node 1 the peak flows for Proposed Conditions with SWM Control are the same as that for Future Uncontrolled Conditions. This is expected to be a clerical error, as the Node 1 peak flows for Proposed Conditions with SWM Control are expected to be the same as those under existing conditions, given this drainage area is upstream of the proposed Block 3.

17. Final Hydrology and Hydraulics Modeling Files to be Provided

Please provide a final copy of all modelling files, including output files, for future reference.

SWM Pond Design

18. Summary of Tasks for Detailed Design

Throughout the report, text identifies SWM pond design and assessment aspects to be addressed during subsequent stages of development planning. It is recommended that these items be summarized in a separate section for clarity. Also, is would be appreciated if the summary addressed all recommended actions and design criteria as per the Terms of Reference for Fruitland – Winona Block Servicing Strategy (Nov 2013).

19. SWM Pond Volume Requirements

It is suggested that pond volume requirements be based on design event modeling of the proposed conditions, rather than using SCUBE 2013 flow – volume relationships, which may not be accurate given the revised drainage patterns and imperviousness.

20. Proposed Development Areas Not Serviced by the Two Proposed SWM Ponds

It is suggested that the report text more clearly highlight the areas that will not be serviced by the two proposed SWM Ponds, as well as the fact that for these areas on-site storm water management will need to be evaluated and accounted for during subsequent development planning stages.

21. Table 5-5 Pond 9-2 (West) Release Rates

It was HCA staff expectation that the 2-year and 100-year release rates shown in Table 5-5 for Pond 9-2 (West) would be similar to the peak flows for Proposed Conditions with SWM Control for Node 4 shown in Table 5-4, however the peak flows are considerably different. It is suggested that the report be reviewed and discussion text be included to clarify this matter.

22. Required Storage Volumes for Pond 2 (West) in Table 5-14

The required storage volumes were expected to be consistent with Scenario 2 Table 5-8 values. It is suggested that the report be reviewed and discussion text be included to clarify this matter.

23. What Does Pre-development Flows Represent in Tables 5-7 to 5-9

HCA staff were unclear what drainage area and location the Pre-development Flows in these tables represented. Clarification would be appreciated.

Additional Comments

24. Proposed % Imperviousness Values

It would be appreciated if the report could confirm that the proposed values are consistent with the Fruitland Winona Secondary Plan and SCUBE SWS 2013.

25. Recommended Runoff Coefficients by Land Use

It would be appreciated if the report could confirm that the proposed values are consistent with the Fruitland Winona Secondary Plan and SCUBE SWS 2013.

26. Available Topography Data Used in the Study

Please include in Section 3.1 (Existing Topography) the details of the topographic data used for this study, including source, date created, contour interval, etc.

27. Recommendations for Future Study

The report contains a number of recommendations for additional study, assessment and design work at subsequent stages of development planning (e.g. SWM design, water balance, infiltration and LID, etc.). Additional recommendations have been provided in the comments above. It is recommended that these items be summarized in a separate section in the final report to ensure all recommendations and future work requirements are adequately captured.

Thank you for the opportunity to review and comment on the draft report. HCA staff are available to meet to discuss these comments in more detail if that would be helpful.

Kind regards,

Mike Stone MCIP, RPP
Manager, Watershed Planning Services
MS/JB

Hamilton
Conservation
Authority

A Healthy Watershed for Everyone

BY EMAIL

February 12, 2020

Margaret Fazio, Senior Project Manager
Infrastructure Planning
Growth Management, Planning & Economic Development Department
City of Hamilton
71 Main St. West, 6th Floor
Hamilton, ON L8R 4Y5

Dear Ms. Fazio,

Re: Block Servicing Strategy, Fruitland-Winona Secondary Plan Area, Block 3, Third Submission, January 2020

Thank you for providing the Hamilton Conservation Authority (HCA) with the *Block Servicing Strategy, Fruitland Winona Secondary Plan, Block 3* (Urbantech West, Third Submission, January 2020). HCA staff have reviewed the report and offer the following comments for consideration.

Summary and Significant Outstanding Issues

While the third submission report has addressed some of HCA's September 30, 2019 natural heritage and engineering review comments, as well as subsequent follow-up engineering comments (email dated November 4, 2019), a number of comments/requested assessments have not been completed. The outstanding items are described below, with the more significant issues summarized here for quick reference.

The requested evaluation to confirm negligible potential erosion impacts resulting from the significantly increased downstream peak flow rates, under the proposed development which includes the bypass of upstream external flows, does not seem to have been completed.

The proposed upgrades to culvert crossings at Barton, Lewis and Highway 8 have not been detailed and may reduce flow attenuation and possibly increase flows, water levels and velocities downstream of the crossings. Depending on the proposed upgrades, a downstream impact assessment may be required.

Staff note the existing condition peak flow rates have changed considerably at some key locations, when compared to the first submission results. Given the lack of changes to the existing conditions assessment this was not expected, and staff suggest further comment regarding the changes should be included in the report.

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Office Fax: 905-648-4622 ◆ Shop Fax: 905-525-2214 ◆ E-mail:nature@conservationhamilton.ca ◆ Website: www.conservationhamilton.ca

In addition, HCA staff request that future uncontrolled peak flow results be provided in the main report, as the information is not easily abstracted from the provided Appendices. It is HCA staff's intention to compare the peak flow results to our ongoing Flood Plain Mapping Update study, and will provide further comment once this review is completed. Once this review has been completed, HCA staff may request additional justifications / reviews to address any outstanding accuracy and confidence concerns.

Environmental Impact Assessment

1. Natural Heritage Features and Watercourses

HCA provided natural heritage related comments dated September 30, 2019 regarding the second submission report. In reviewing the third submission staff note that ARCADIS has not provided a direct response to these comments. While Urbantech's comment response table included in Appendix M indicates HCA's natural heritage requested revisions have been included in the EIS and main body of the revised report, in reviewing the third submission staff note this generally does not appear to be the case as it relates to HCA's species at risk, significant wildlife habitat and fisheries comments.

HCA notes not all of the EIS's recommended mitigation measures are noted in the main report. It may be helpful for the report to refer to the EIS for the complete list of recommended mitigation measures.

In Section 3, Existing Conditions, it is noted that discussions between the City of Hamilton (City) and HCA resulted in the determination that regulated watercourse features 1, 2, 3 and 4 did not require protection and could be enclosed. With respect to feature 1 (Watercourse 9), it is indicated enclosure was allowed given downstream infrastructure constraints. In Section 3.6, it is further noted enclosure was allowed given City concerns related to flooding and safety. In addition to this, the City's preference for an enclosed system was also related to concerns over consistency with the Secondary Plan, parkland requirements and useable recreational space, as well as anticipated long-term maintenance costs associated with an open watercourse feature. HCA continues to suggest that these additional considerations raised by the City and its preference for an enclosed system should be identified in the report.

Hydrology and Hydraulics Assessments

2. Lack of Model Calibration, Validation or Parameter Sensitivity Analysis

The intended sensitivity analysis has not been provided. HCA staff had expected a review of changes in peak flow rates resulting from changes in the values selected for key parameters (within justified ranges). It was staff expectation that this review would help address concerns regarding the accuracy and confidence in the peak flow rates modelled by the Block Servicing Study. HCA suggests this analysis should be completed as part of the final report.

As per HCA email correspondence dated November 4, 2019, staff note the third submission BSS designs and assessments have been based on the continuous modeling (as per the First Submission).

HCA staff have compared the third submission existing conditions peak flow results to our ongoing Flood Plain Mapping Update study. The unit peak flow rates are similar between the two studies at the CNR crossing and at Lake Ontario. However, it should be noted that the BSS unit peak flow rates are considerably higher at the Highway 8 crossing.

Also, it was noted that the third submission existing condition peak flow rates have changed considerably at some key nodes, when compared to the first submission results. Given the lack of changes to the existing conditions assessment, this was not expected. Please provide an explanation for the revised peak flow rates.

It was further noted that the main report tables and tables within the figures were inconsistent with regards to peak flow rates. It appears that the figures are still based on second submission results.

In addition, HCA staff request that future uncontrolled peak flow results be provided in the main report, as the information is not easily abstracted from the information provided. It is HCA staff's intention to compare the peak flow results to our ongoing Flood Plain Mapping Update study, and will provide further comment once this review is completed. Once this review has been completed, HCA staff may request additional justifications / reviews to address any outstanding accuracy and confidence concerns.

3. Corrected Errors from the Original SCUBE SWS 2013 MIKE 11 Modeling

The DHI memo dated June 12, 2018 has now been included in the report Appendices. This memo identifies significant differences in peak flows when the original SCUBE Subwatershed Study 2013 MIKE 11 model (using 2007 version of MIKE 11) was re-run using the 2017 version of MIKE 11. Although it is acknowledged that the 2017 re-run produced lower peak flows, the magnitude of differences and lack of understanding of reasons for the differences increases HCA staff's concern regarding the accuracy and confidence in the peak flow rates modelled by the Block Servicing Study. While this continues to be a concern, no action is required at this time.

4. Recommend the Use of Design Storm Assessments, given Statistical Issues with the Frequency Flow Analysis

As per HCA email correspondence dated November 4, 2019, the third submission BSS designs and assessments have been based on the continuous modeling (as per the first submission).

As per HCA email correspondence dated November 4, 2019, an assessment was to be completed confirming that the resultant peak flow rates, under the scenario of proposed development with SWM and Catchment 300 flows bypassing the site, will not result in any adverse flooding or erosion impacts on downstream channel sections or culverts (Nodes 5 – 14). The third submission includes a comparison of peak flows at key culverts, as well as within the Venetian Meats channel.

It does not appear that an evaluation has been completed to confirm negligible potential erosion impacts resulting from the significantly increased downstream peak flow rates under the proposed development. HCA suggests this assessment should be completed.

Furthermore, it had been expected that all channel sections downstream of the proposed development would be reviewed to confirm that the increased peak flow rates are expected to have no flooding impacts. It appears that only the Venetian Meat channel section was assessed in this regard.

In addition, a similar comparison has not yet been provided for the future uncontrolled conditions scenario.

The proposed upgrades to culvert crossings at Barton, Lewis and Highway 8 have not been detailed and may reduce flow attenuation and possibly increase flows, water levels and velocities downstream of the crossings. Depending on the proposed upgrades, a downstream impact assessment may be required.

5. Comparison of Peak Flows under Proposed Conditions with SWM Controls to Existing Culvert & Channel Capacities

As discussed in above, the third submission provides some, but not a full comparison of peak flow rates under Proposed Conditions with SWM Controls to the existing flow capacities of culverts and channel sections downstream of the site.

6. Comparison of Peak Flows under Future Uncontrolled Conditions to Existing Culvert & Channel Capacities

As an update to the same evaluation from the SCUBE 2013 study, HCA had recommended that there be a comparison of peak flow rates under Future Uncontrolled Conditions (Regional and 100 year event) to the existing flow capacities of culverts and channel sections at the QEW and CNR crossings downstream of the site. As discussed in above, the third submission has not provided this comparison.

Thank you for the opportunity to review and comment on the third submission report. HCA staff are available to meet to discuss these comments in more detail if that would be helpful towards addressing key outstanding issues and ensuring timelines are met for completion of the study.

Kind regards,

Mike Stone MCIP, RPP
Manager, Watershed Planning Services
MS/JB

City of Hamilton Comments to Final Draft Report - Block 3 Servicing Strategy - Urbantech

January 16-Feb 14, 2020 Comment period).

Comment No.	Report Reference	Comment Details	Commentor's Name	Staff's Area of work - Department, Division, Area
SMW - Engineering Comments				
1		The final Block Servicing Strategy Report (BSS) should be signed and stamped by a Qualified Professional Engineer.		
2	MIKE 11 Hydrologic Analysis	The current BSS SWM strategy is based on continuous modelling using MIKE 11. However, the report included the flow results for design storm event simulation from the 2nd BSS submission in several sections, which are outdated. Please ensure that during final submission, the relevant report sections, appendices and engineering drawings are including the flow assessment results based on the latest DHI memo (Jan 15, 2020). Some examples of inconsistencies are: Table 5-9, SWM pond target scenario tables for ponds 2 and 3 in Appendix H, Drawings SWM-5 and SWM-6.		
3	LIDs	***Previous comment 18:*** table 5-15 should revise the topsoil depth to a minimum 200mm and include the option of rear yard swales with 150mm perforated pipe with granular materials.		
4	Table 5.12-Section 5.7	Please verify the unitary volume calculations for Pond 3. The storage volumes should be "m3/imp-ha" to be consistent with that of Pond-2.		
5	Hydro-G Report (Appendix B)	**a)** The Hydrogeological Investigation Report (Landtek, July, 2019) included sections for water taking evaluation and impact assessment, monitoring and mitigation plans during construction. Please clarify why these sections are removed from the Jan, 2020 report.		
		b) The water balance assessment results in Appendix I are not consistent with report section 3.2 and the July, 2019 report. Please verify.		
6	Sanitary Sewer Design Sheet (Appendix I)	**a)** Please note that as per City standards sanitary sewers should be maximum 75% full. The proposed sewer from MH15A-W to MH12A-W should be upsized, which is shown to be 81% full. This sewer leg has an intermediate manhole, MH 24A-W, which should be added in the design sheet.		
		b) In sanitary-west option 2 design sheet, please verify the population densities for West condo, EX5, EX6, EX7, EX8; and ensure consistency with sanitary drainage area plans.		
		c) In sanitary sewer design sheets for the west area, the flows from MH 24A-W to MH12A-W and MH 24A-W(1) to MH12A-W are not added downstream. Please revise.		
		d) Please clarify the outlet of catchment 16 (1.42 ha) in the sanitary drainage area plans. Is it going to Street D or Street E?		
		e) For option 2, the existing McNeilly Road sanitary sewer north of Barton Street is shown to be 97% full. Please note that during detailed design stage (for higher population densities) , sewer upgrade may trigger based on flow monitoring of the existing sewer along McNeilly Road.		
7	DWG GR-1	***Previous comment 4g*** : based on section A-A, it appears that partial drainage from existing lots fronting McNeilly Road currently goes through the Block 3 lands and the proposed fill will block this drainage. During detailed design, a temporary/interim ditch inlet should be considered to pick up the external drainage from the existing lots.		
	DWGs SAN-1 to	**a)** During detailed design, please ensure that additional manholes are provided at locations, where currently two pipes are shown leaving from the same manhole at different directions, therefore the conveyance systems should be separated to avoid any interaction.		
		b) DWGs SAN-1 and SAN-1A: the proposed sanitary sewer from MH 25A-W to MH 7A-W is going through private lands. Please note that a suitable block should be dedicated to the City for this proposed sewer. The land owner should acknowledge in writing, about the proposed sanitary sewer through his lands.	Zakia Sultana	Project Manager, Infrastructure Planning, Growth Management Division, Planning &

8	SAN-4, SAN- 1A to SAN-4A	**c)** DWGs SAN-1 and SAN 1-A: please verify the top and inverts at MH 33 A-W and MH 31A-W. During detailed design, please ensure that minimum 2.75m cover is provided for all sanitary sewers as per City standards. **d)** A note should be added in the drainage plans for the external drainage from HWY-8 to EX.MH 10 (20.45 ha in sanitary sewer design sheet). **e)** Please show the north limit of catchment 1, immediately south-east of Barton Street and Lewis Road. **f)** ***Previous comment 20g*** : catchment 3 should divided to separate areas north and south of Barton Street.		Economic Development, City of Hamilton
9	DWG STM-1	***Previous comment 11h*** : please clarify the park servicing strategy. We understand that the minor flows will be captured by the proposed park stub connection to Street D storm sewer. Please clarify whether major flows will be conveyed overland to public streets.		
10	DWG-STM3 (External Bypass Pipe)	Please provide MIKE 11 flow results for catchment 300 and 200, the 2nd submission BSS included the 100-year hydrographs showing the 100-year peak flows for these catchments, which is removed from this submission. Based on the continuous simulation results (BSS, Jan 2020), 100-year peak flows for catchments 300 and 200 are 2.648 m^3/s and 1.474 m^3/s respectively. Based on single event modeling (BSS 2nd submission), 100-year peak flows for catchments 300 and 200 were 4.017 m^3/s and 1.5 m^3/s respectively. While for both modelling scenarios, catchment 200 flows are in good agreement, catchment 300 flows are significantly different. Based on the reduced flows for catchment 300, the sewer size from MH 7C to MH6C is reduced to 1350mm in the storm sewer design sheet; however the drainage area plans are still showing a 1500mm sewer. The external bypass sewer design should be kept same as the BSS 2nd submission scenario 2a, therefore sewer from MH7C to MH6C should be kept as 1500mm. Please revise the storm sewer design sheet accordingly.		
11	DWG STM-4	**Previous comments 6c,10b,11f**: please verify the drainage area of catchments EXT 4.1 and EXT 4.2, there appears to be typo. The BSS should include discussions about the SWM/drainage strategy for the external areas north-east of Barton Street and McNeilly Road. Drainage to the venetian meat channel, Arvin Avenue storm sewer and existing watercourse should be documented. A note should be added that the option of extending the existing 1950mm storm sewer from McNeilly Road to Arvin Avenue may be considered during detailed design stage, which may allow EXT 4.1 lands to drain to Arvin Avenue storm sewer.		
12	DWGs SWM-1 to SWM-4	**a)** During detailed design, major overland flow route for both ponds should be directed to the wet cell. If 100-year flows are captured in storm sewers, a split manhole may be required to divert the major flows to the wet cell, or the forebay may be upsized considering the additional flows. **b)** DWG SWM-1(***Previous comment 14.2b***): the drawings are still showing pond 2 access road from Barton Street. During detailed design stage access road should be provided from internal streets as noted in the response letter. **c)** DWG SWM-2 (***Previous comment 4i***): during detailed design stage, the proposed berm design at Barton Street should be confirmed. **d)** DWG SWM-3: the drawings are not showing any connection of internal streets to Pond 3 access Road. During detailed design, access should be provided from internal streets, not Lewis Road.		
13	DWG SWM-7	Please verify the drainage area of catchment 101A, which is 1.98 ha in other drawings.		
Natural Heritage				
14	Appendix C-Section 1.1.2 (page2)	**Previous comment (Sept. 12, 2019) 2 a) i)** has not been addressed. On page 2 it is stated "Schedule B of the UHOP shows the Hamilton Natural Heritage System which does not identify Core Areas on and adjacent to the site". As identified in previous comments, there are features within the Natural Heritage System that have not been mapped. These features incude habitat for Species at Risk (SAR) and Significant Wildlife Habitat (SWH). The statement needs to be revised to include this caveat.		
15	Appendix C-Section 1.1.4 (page 3)	**Previous comment (Sept. 12, 2019) 2 a) ii)** has not been addressed. On page 3, the discussion within Section 1.1.4 (Fruitland Winona Secondary Plan) focuses on the Stoney Creek Urban Boundary Expansion Subwatershed Study and not on policies of the Secondary Plan (policies 7.4.2.5-natural heritage principles; 7.4.11-Natural Heritage System general policies and 7.4.14-Block Servicing Strategy). This section is to be revised to include these policies.		Natural Heritage Planner: Development Planning, Heritage and Design, Planning and Economic
16	Appendix C-Section 3.4 (page 15)	On page 15, Section 3.4 has been labelled as "Species at Risk Screening". While this label describes the first three paragraphs, section 3.4.1 describes Significant Wildlife Habitat. Significant Wildlife Habitat should be its own section.	Melissa Kiddie	
17	Appendix C-Section 5 (page 22)	**Previous comment (Sept. 12, 2019) 2 e) iv)** has not been addressed: On page 22 it has been stated that "Monarch depends on milkweed for its life cycle, however milkweed is common and plentiful in the Stoney Creek area". It is important to note that additional habitat within the vicinity does not recognize the potential habitat that will be lost as a result of development within this area.		

18	Appendix C- Section 6 (page 24)	**Previous comment (Sept. 12, 2019) 2 d)**: As a measure to mitigate the impacts on the locally rare Carolina Wren, it has been identified that nest boxes could be provided within green spaces. It is important to note that this may be difficult to implement as part of development of this area.		Development, City of Hamilton
19	Appendix C- Appendix D: Breeding Birds	**Previous comment (Sept. 12, 2019) 2 e) ii)**: The locations of Eastern Meadowlark/Bobolink surveys have been provided on Figure D-1. The stations have been labelled in red and are very difficult to read. This figure needs to be revised to clearly identify the station numbers.		
20	Appendix C- Appendix D: Breeding Birds	**Previous comment (Sept. 12, 2019) 2 e) iii)** has not been addressed: Within the breeding bird table provided within Appendix D, Barn Swallow, a "threatened" species has been identified as possibly breeding within the study area. There is concern with this evaluation. Within the text of Appendix C, it has been noted that Barn Swallow was only found foraging within the area and that no breeding habitat was available for this species (page 22). This table needs to be revised to reflect this information.		
Public Consultation /Administrative				
21	Appendix N - 1, Public Stakeholder List	Remove staff names' rows, down to Councillors. Remove last 2 columns for the entire list - not needed and some of these are internal - City directions. Replace staff names with my name - Margaret Fazio - Liaison to City staff/Project Team and internal communications.	M.Fazio	Growth Management Division, Infrastructure Planning.
22	Appendix N - 2	Change title from "Notice of Public Comment" to "Notice of 30 day Public Review"		
23	Appendix N-4	Leave the notice but need to add your PIC panels - preferably in colour here. Feb 23, 2016 Returned letters/Landowner Inquiries - this list shows peoples names and addresses, and if you wish to follow City's privacy protection best practices, we suggest removing this list. You may wish to just mention in numbers, in the main body of the report, how many people registered letters were sent to, include your mailing list map/refer to the study map, how many were returned and how many provided comments. This is the kind of information Coucil would be interested in. By the Way, Council Members are treated as the rest of the public.		
24	Appendix N - 3	Out of order with N-3 in hard copy - please check the e copy as well. Title says PIC but there are no panels, but where the N-3 says there are letters, there are maps in that section?...May just be out of order. If providing the sign in sheet, please either provide a blank (which we don't have, I know), or black out attendee names & contact information to protect their privacy.		
25	Executive Summary	Provide long form of EIS. Also, discussions with transportation staff indicated - as per concept map, that further intersection control measures are to be determined at Application submission/Detailed Design stage. Therefore, we woudd like to suggest to reword to the following: " If changes are made to the road network the City has the right to ask for Traffic Impact Studies, if found to be required. As development proceeds, the determination of intersection controls (stop-control or mini-roundabout), within each development area will be required."	M. Fazio & Mohan Philip	Growth Management & Transportation Planning
26	Introduction, fourth paragraph	Suggest changing last sentence to" This study pertains to the Block 3 area within the Secondary Plan.		
27	Introduction - Overall Comment	Please use an accronym for Block 3 SS consistently. Currently there are BSS, Block 3, Block 3 SS in use. Suggest sticking to just one for clarity.		
28	Purpose	NHS - introduce the long form before using the accronym		
29	Official Public Comment	Please reword the first sentence - it is repetitive. Please reword the tense of this section into past tense, rather than future. Thiurd sentence please change to: "The hard copy of the study report was made available at City Hall - Clerk's Dest, and 6th Floor - front counter..."		

30	SCUBE Subwatershed Study	Second Paragraph - last sentence - suggest removing. Not sure it's needed? When you are describing Phases does Phase 3 mean this current study? Sorry - not clear. Perhaps it should be stated earlier in this Section 1.7, that SCUBE Subwatershed Studies followed a Municipal Class Environmental Assessment process, which fulfilled the requirements of Phases 1 & 2, - at teh bottom of the second paragraph? It would provide more process clarity. You refer to Phase 3 for this study (third paragraph - page 10), but we are not technically carrying out Phase 3 EA process, so would suggest refraining from using thatPhase 3 reference here. Just state that ...."this BSS provides an implementation strategy for the Block 3 area".... Last paragraph - top line mentions "SWMF" - please provide long form. - I don't know what it is? Could you please use Pond 2 & 3 naming consistently, and always mention "East" and "West" when referring to POnds by number. Also, please add a statement which talks about SCUBE Subwatershed Study East establishing the numbering system for the Ponds. Just so nobody is wondering what happened to Pond 1.	M.Fazio	Growth Management Division, Infrastructure Planning.
31	Section 4.2 Roadworks; pg 29	Please place the first setence of the first paragraph below the first paragraph - under the bullers. Otherwise the sentence doesn't feel like it's pertaining to roadworks, but is speaking to general grading for the entire site...we know it's dependent on roads, so moving it will make that relationship clearer. Second Paragraph - it is likely that cycling will also be included on the east-west collector, so the bottom sentence should also include a statement		
32	Roadworks continued	Please reword the bottom paragraph to indicate that Barton and Fifty Road Phases 3 & 4 Municipal Class EA (EA) , as well as Highway 8 Phases 3 & 4 EA are ongoing at the time of writing of this report. McNeilly and Lewis were not identified in SCUBE TMP (sub-set of the Secondary PLan), to trigger a need for further study. All roads which are rural will become urbanized within BLock 3 SS. Until Barton and Highway 8 EA are completed the ROW width is determined by the Secondary Plan policies. Barton Road is classified as a major arterial roadway, currently identified in the Secondary Plan to require 40.576m ROW, which is 36.576 m from centre line, with additional off set of 4m to the south. Highway 8 is an arterial roadway with the ROW of 36.576m, however. The ongoing EAs may amend these ROW widths. McNeilly and Lewis Roads will remain classified as collector roads, with ROW width 26.213m. Please note that local road ROW is not 20m exactly but 20.117m.		
33	4.3 STORM DRAINAGE, pg 30	Second Paragraph - fourth sentence suggest rewording to "The ponds are not intended to accommodate additional drainage.....controls need to ensure that downstream exceedances don't occu". Currently the sentence feels disjointed and hard to follow.		
34	4.3.2 External Storm Drainage Requirements	Bottom of second paragraph..."...Mike 11 model results are greater than those determined using the rational method"...suggest putting "rational method" in quotation marks, because to a non-specialist this sounds like Mike 11 is irrational, therefore shouldn't be used?:) ALso, suggest putting in brackets after "rational method" (standard calculation used to determine flows).		
35	5.3 SWM Targets & Design Criteria, pg. 34	Replace MOE, with MECP, in this section and throughout the document.		
36	5.7.1 Extended Detention Storage, pg 56	Please remove the reference to Meander Belt calculations, and the associated Appendix, except for Erosion analyses - downstream. Meander belt is no longer applicable.		
37	5.7.3 Sediment Forebay pg. 58	Please make references to SWM Ponds consistent with the rest of the Report...SWM West (Pond 2), SWM East (Pond 3).		
38	5.9.1 LID BMPS for GROUNDWATER RECHARGE	Second Paragraph - second sentence. Please replace "will" with "were".		
39	8 TRAFFIC/ TRANSPORTATIO N	Not sure if this needs to be repeated from Roadworks? If yes see pg. 30 comments provided above.		
40	8.2 FUTURE BACKGROUND TRAFFIC CONDITIONS	First sentence - please add "at full build out scenario" in brackets after 2024 or add the number 2024 after the bottom sentence...so that whoever is reading it can connect the dots.		

41	8.3 FUTURE TOTAL TRAFFIC CONDITIONS pg. 82	Please remove the last sentence of the bottom paragraph. Barton street EA, at intersections with Lewis and McNeilly has identified a need for signalized intersections. If we can just leave it out we're covered. Also, please see above for wording on intersection control - comments on Executive Summary.		
42				
43				
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45				
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47				

APPENDIX B: SITE PHOTOGRAPHS

<table>
<tr><td>PHOTO 1</td><td rowspan="4"></td></tr>
<tr><td>Date: August 20, 2015</td></tr>
<tr><td>Direction: South</td></tr>
<tr><td><u>Description:</u>
Agricultural land/Cultural meadow, view from Barton Street</td></tr>
</table>

<table>
<tr><td>PHOTO 2</td><td rowspan="4"></td></tr>
<tr><td>Date: August 20, 2015</td></tr>
<tr><td>Direction: North</td></tr>
<tr><td><u>Description:</u>
Cultural meadow, view from Barton Street</td></tr>
</table>

PHOTO 3	
Date: June 1, 2016	
Direction: West	
Description: Meadow adjacent to school on Lewis Road.	

PHOTO 4	
Date: June 5, 2017	
Direction: South	
Description: Orchard adjacent to cultural meadow.	

PHOTO 5	
Date: June 5, 2017	
Direction: South	
Description: Agricultural field and meadow.	

PHOTO 6	
Date: June 5, 2017	
Direction: West	
Description: Cultural savannah adjacent to Lewis Road.	

APPENDIX C: VEGETATION INVENTORY

Table C-1: Vascular Plant Species List

Common Name	Scientific Name	S Rank	COSEWIC	ESA	SARA	City of Hamilton*
Manitoba Maple	*Acer negundo*	S5				N
Norway Maple	*Acer platanoides*	SNA				I
Silver Maple	*Acer saccharinum*	S5				N
Sugar Maple	*Acer saccharum ssp. saccharum*	S5				N
Common Yarrow	*Achillea millefolium*	S5				I
Creeping Bentgrass	*Agrostis stolonifera*	SNA				I
Garlic Mustard	*Alliaria petiolata*	SNA				I
Common Ragweed	*Ambrosia artemisiifolia*	S5				N
Corn Chamomile	*Anthemis arvensis*	SNA				I
Common Buckthorn	*Rhamnus cathartica*	SNA				I
Common Burdock	*Arctium minus*	SNA				I
Common Milkweed	*Asclepias syriaca*	S5				N
Garden Asparagus	*Asparagus officinalis*	SNA				I
Common Wintercress	*Barbarea vulgaris*	SNA				I
Lamb's Quarters	*Chenopodium album*	SNA				I
Chicory	*Cichorium intybus*	SNA				I
Canada Thistle	*Cirsium canadensis*	SNA				I
Bull Thistle	*Cirsium vulgare*	SNA				I
Field Bindweed	*Convolvulus arvensis*	SNA				I
Grey Dogwood	*Cornus racemosa*	S5				N
Red-osier Dogwood	*Cornus stolonifera*	S5				N
Common Hawthorn	*Crataegus monogyna*	N/A				N/A
Orchard Grass	*Dactylis glomerata*	SNA				I
Queen Ann's Lace	*Daucus carota*	SNA				I
Deptford Pink	*Dianthus armeria*	SNA				I
Teasel	*Dipsacus fullonum*	SNA				I
Field Horsetail	*Equisetum arvense*	S5				N
Philadelpia Fleabane	*Erigeron philadelphicus*	S5				N
Meadow Fescue	*Festuca pratensis*	SNA				I
White Ash	*Fraxinus americana*	S4				N
Honey-Locust	*Gleditsia triacanthos*	SNA				I
Soybean	*Glycine max*	SNA				I
Dame's Rocket	*Hesperis matronalis*	SNA				I
Yellow Hawkweed	*Hieracium caespitosum*	SNA				I
Foxtail Barley	*Hordeum jubatum*	S5				N
St. John's Wort	*Hypericum perforatum*	SNA				I
Spotted Jewelweed	*Impatiens capensis*	S5				N
Prickly Lettuce	*Lactuca serriola*	SNA				I
Sweet Pea	*Lathyrus odoratus*	SNA				I
Butter-and-Eggs	*Linaria vulgaris*	SNA				I
Oxeye Daisy	*Leucanthemum vulgare*	SNA				I
Tartarian Honeysuckle	*Lonicera tatarica*	SNA				I
Common Apple	*Malus pumila*	SNA				I
Black Medick	*Medicago lupulina*	SNA				I
Alfalfa	*Medicago sativa*	SNA				I

Common Name	Scientific Name	S Rank	COSEWIC	ESA	SARA	City of Hamilton*
Sweet White Clover	*Melilotus albus*	SNA				I
White Mulberry	*Morus alba*	SNA				I
Virginia Creeper	*Parthenocissus quinquefolia*	S4?				N
Reed Canary Grass	*Phalaris arundinacea*	S5				N
Timothy	*Phleum pratense*	SNA				I
Common Reed	*Phragmites australis*	SNA				I
Scots Pine	*Pinus sylvestris*	SNA				I
English Plantain	*Plantago lanceolata*	SNA				I
Common Plantain	*Plantago major*	S5				N
Annual Bluegrass	*Poa annua*	SNA				I
Kentucky Bluegrass	*Poa pratensis*	S5				I
Grass spp.	*Poa spp.*	N/A				N/A
Sulphur Cinquefoil	*Potentilla recta*	SNA				I
Peach sp.	*Prunus persica*	N/A				I
Cherry sp.	*Prunus* sp.	N/A				I
Pear sp.	*Pyrus* sp.	N/A				I
White Oak	*Quercus alba*	S5				N
Bur Oak	*Quercus macrocarpa*	S5				N
Red Oak	*Quercus rubra*	S5				N
Tall Buttercup	*Ranunculus acris*	SNA				I
Buckthorn	*Rhamnus cathartica*	SNA				I
Rhubarb	*Rheum rhabarbarum*	SNA				NL
Poison Ivy	*Rhus radicans*	S5				N
Staghorn Sumac	*Rhus typhina*	S5				N
Black Locust	*Robinia pseudoacacia*	SNA				I
Briar Rose	*Rosa eglanteria*	SNA				I
Black Raspberry	*Rubus occidentalis*	S5				N
Curled Dock	*Rumex crispus*	SNA				I
Black Willow	*Salix nigra*	S4?				N
Willow	*Salix* spp.	N/A				N/A
Wild Mustard	*Sinapsis arvensis*	SNA				I
Bittersweet Nightshade	*Solanum dulcamara*	SNA				I
Canada Goldenrod	*Solidago canadensis*	S5				N
Perennial Sow-thistle	*Sonchus arvensis*	SNA				I
New England Aster	*Symphyotrichum novae-angliae*	S5				N
Common Lilac	*Syringa vulgaris*	SNA				I
Common Tansy	*Tanacetum vulgare*	SNA				I
Common Dandelion	*Taraxacum officinale*	SNA				I
Field Pennycress	*Thlaspi arvense*	SNA				I
American Basswood	*Tilia americana*	S5				N
Goat's Beard	*Tragopogon dubius*	SNA				I
Red Clover	*Trifolium pratense*	SNA				I
White Clover	*Trifolium repens*	SNA				I
Broad-leaved Cattail	*Typha latifolia*	S5				N
Stinging Nettle	*Urtica dioica*	SNA				I
Cow Vetch	*Vicia gracca*	SNA				I
Riverbank Grape	*Vitis riparia*	S5				N

Common Name	Scientific Name	S Rank	COSEWIC	ESA	SARA	City of Hamilton*
Grape sp.	*Vitis* sp.	N/A				N/A

Legend:

* HCA (2014) Hamilton Natural Areas Inventory Project, 3rd Edition. Species Checklist Document. Hamilton Conservation Authority

I: Introduced (non native)

N; Native

NA: Not applicable

NL: Not listed

U: Uncommon

S4: Apparently secure

S5: Secure

SNA: Conservation status not applicable

ESA: Endangered Species Act

APPENDIX D: BREEDING BIRD SURVEYS

Table D-1: Breeding Birds

Common Name	Scientific Name	Habitat	Survey Location (BB#)	ELC/ Location	S Rank	COSEWIC	SARA Status	ESA Status	City of Hamilton	Breeding Status
Canada Goose	*Branta canadensis*	I	2, 4, 8	CUM1-1, AG	S5B				C	POSS
Turkey Vulture	*Cathartes aura*	O/AG	2, 3, 10	CUM1-1, AG	S5B				UC	POSS
Killdeer	*Charadrius vociferus*	O/AG	2, 3, 11	CUM1-1	S5B/S5N				A	POSS
Rock Pigeon	*Columba livia*	U	2, 8, 10, 12, 20, 21	CUM1-1, U	SNA				A	POSS
American Woodcock	*Scolopax minor*	AG/O/MW	3, 6	CUM1-1, AG	S4B				C	POSS
Ring-billed Gull	*Larus delawarensis*	I	1, 12	CUM1-1	S5B/S4N				A	POSS
Barn Swallow	*Hirundo rustica*	AG/U	3, 6	CUM1-1, AG	S4B	THR	THR	THR	C	
Tree Swallow	*Tachycineta bicolor*	O/WL	14, 15, 16	West of Lewis Road	S4B					POSS
Mourning Dove	*Zenaida macroura*	ES/U	2, 4, 10, 13, 15, 16, 17, 18, 19, 20	Urban	S5				A	POSS
Northern Flicker	*Colaptes auratus*	AG/U/W	5, 6, 14, 20	CUM1-1, AG, U	S4B				C	POSS
Willow Flycatcher	*Empidonax traillii*	T	2, 3, 5, 6, 9, 10	CUM1-1, HR, AG	S5B				C	POSS
Eastern Kingbird	*Tyrannus*	O/AG/U	1, 2, 3, 6, 8,	CUM1-1, AG	S4B				A	POSS
Red-eyed Vireo	*Vireo olivaceus*	W/U	4, 8, 13, 17, 19	CUM1-1, AG, HR, U	S5B				C	POSS
Blue Jay	*Cyanocitta cristata*	W/U	4, 5, 6, 7, 9, 11, 13, 17, 18, 19, 20, 21	CUM1-1, U, OR, AG	S5				A	POSS
American Crow	*Corvus brachyrhyncos*	AG/W/O	1, 6, 10, 12, 17, 18, 19, 20, 21	CUM1-1, U, OR, AG	S5B				C	POSS
Black-capped Chickadee	*Poecile atricapillus*	MW	1, 2, 3, 4, 7, 9, 11, 12, 15, 17,19, 21	CUM1-1, U, OR, AG, HR	S5				A	POSS
White-breasted Nuthatch	*Sitta carolinensis*	W	1, 3, 5, 7, 8, 10, 18, 21	CUM1-1, U, OR, AG, HR	S5				C	POSS
Carolina Wren	*Thryothorus ludovicianus*	W	3, 5, 6, 9, 10, 15, 16	CUM1-1, U, HR	S3S4				R	POSS
House Wren	*Troglodytes aedon*	AG/U/WL/W	2, 3, 7, 8, 11, 14, 18, 20	CUM1-1, U, AG	S5B				C	POSS
American Robin	*Turdus migratorius*	U	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21	CUM1-1, U, OR, AG	S5B				A	POSS
Gray Catbird	*Dumetella carolinensis*	T/AG/U	3, 4, 5, 6, 10, 16	CUM1-1, AG	S4B				A	POSS
European Starling	*Sturnus vulgaris*	AG/U	1, 2, 3, 4, 5, 6, 7, 8, 9, 12, 13, 15, 18, 19, 21	CUM1-1, AG, HR, U	SNA				A	POSS
Cedar Waxwing	*Bombycilla cedrorum*	W/AG/U	5, 6, 7, 8	CUM1-1, AG, U	S5B				C	POSS
Yellow Warbler	*Setophaga petechia*	T	2, 3, 5, 6, 9, 14	CUM1-1, AG	S5B				A	POSS
Chipping Sparrow	*Spizella passerina*	CW	1, 5, 7, 9, 14,	CUM1-1, AG,	S5B				A	POSS

Common Name	Scientific Name	Habitat	Survey Location (BB#)	ELC/ Location	S Rank	COSEWIC	SARA Status	ESA Status	City of Hamilton	Breeding Status
			15, 18, 19	U						
Song Sparrow	*Melospiza melodia*	ES	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 13, 15, 18, 19, 21	CUM1-1, AG, U, HR	S5B				A	POSS
Northern Cardinal	*Cardinalis*	U	1, 2, 4, 10, 11, 13, 15, 16, 17, 18, 19, 20, 21	CUM1-1, U	S5				A	POSS
Red-winged Blackbird	*Agelaius phoeniceus*	WL	2, 5, 14, 16	WL, CUM1-1	S4				A	POSS
Common Grackle	*Quiscalus quiscula*	W/U	1, 5, 7, 9, 14, 15, 18, 19	CUM1-1, AG, U	S5B				A	POSS
Brown-headed Cowbird	*Molothrus ater*	W	4, 5, 10, 14	OR, AG, CUM1-1	S4B				A	POSS
House Finch	*Haemorhous mexicanus*	U	1, 2, 8, 13, 15, 16, 17	U, CUM1-1, AG	SE				A	POSS
American Goldfinch	*Spinus tristis*	ES	3, 4, 7, 11, 12, 13, 14, 15, 16, 17, 18, 19	CUM1-1, AG, OR, U	S5B				A	POSS
House Sparrow	*Passer domesticus*	U	2, 4, 13, 15, 19, 21	CUM1-1, AG, U	SE				A	POSS

Legend:

S Ranks:
S3: Vulnerable
S4: Apparently secure
S5: Secure
B: Breeding
E: Exotic (non-native)
POSS: Possible Breeding
SNA: No S Rank assigned (non-native species)
NAR: Not at Risk

AG: Agricultural
CW: Coniferous Woodlands
DW: Deciduous Woodlands
ES: Early Successional
I: Islands
MW: Mixed Woodlands
O: Open Lands
T: Thickets
U: Urban
W: Woodlands
WL: Wetlands

A: Abundant
C: Common
UC: Uncommon
R: Rare
THR: Threatened

Table D-2: Bobolink Survey Locations

Location Number	Survey Location	Dates Completed	GPS Location (17 T)	Comment
1	250 m north of Barton, east of McNeilly Road	June 5, 2017, July 7, 2017, June 26, 2019, July 3, 2019, July 10, 2019	608292.51 mE 4785803.21 mN	Bobolink and Eastern meadowlark not heard or observed
2/BB1	Barton Street, 170 m east of McNeilly Road	May 28, 2015, July 7, 2015, August 20, 2015, June 1, 2016, July 13, 2016, June 5, 2017, July 7, 2017, June 26, 2019, July 3, 2019, July 10, 2019	608214.83 mE 4785803.21 mN	Bobolink and Eastern meadowlark not heard or observed
3/BB3	250 m south of Barton, in soybean field	May 28, 2015, July 7, 2015, August 20, 2015, June 1, 2016, July 13, 2016, June 5, 2017, July 7, 2017, June 26, 2019, July 3, 2019, July 10, 2019	608166.64 mE 4785305.81 mN	Bobolink and Eastern meadowlark not heard or observed
4	250 m north of Highway 8 in old orchard	June 5, 2017, July 7, 2017, June 26, 2019, July 3, 2019, July 10, 2019	608041.62 mE 4785042.36 mN	Bobolink and Eastern meadowlark not heard or observed
5	Highway 8, 150 m east of McNeilly Road	June 5, 2017, July 7, 2017, June 26, 2019, July 3, 2019, July 10, 2019	607984.96 mE 4784794.10 mN	Bobolink and Eastern meadowlark not heard or observed
6/BB20	Highway 8 at McNeilly Road	May 28, 2015, July 7, 2015, August 20, 2015, June 1, 2016, July 13, 2016, June 5, 2017, July 7, 2017, June 5, 2017, July 7, 2017, June 26, 2019, July 3, 2019, July 10, 2019	607831.25 mE 4784751.45 mN	Bobolink and Eastern meadowlark not heard or observed
7/BB8	Barton Street, 285 m east of McNeilly	May 28, 2015, July 7, 2015, August 20, 2015, June 1, 2016, July 13, 2016, June 5, 2017, July 7, 2017, June 26, 2019, July 3, 2019, July 10, 2019	608335.35 mE 4785533.27 mN	Bobolink and Eastern meadowlark not heard or observed
8/BB7	250 m south of Barton, in soybean field	May 28, 2015, July 7, 2015, August 20, 2015, June 1, 2016, July 13, 2016, June 5, 2017, July 7, 2017, June 26, 2019, July 3, 2019, July 10, 2019	608280.36 mE 4785280.83 mN	Bobolink and Eastern meadowlark not heard or observed
9/BB6	180 m north of Highway 8	May 28, 2015, July 7, 2015, August 20, 2015, June 1, 2016, July 13, 2016, June 5, 2017, July 7, 2017, June 26, 2019, July 3, 2019, July 10, 2019	608248.85 mE 4785044.52 mN	Bobolink and Eastern meadowlark not heard or observed
10/BB9	Barton Street, 305 m west of Lewis Road	May 28, 2015, July 7, 2015, August 20, 2015, June 1, 2016, July 13, 2016, June 5, 2017, July 7, 2017, June 26, 2019, July 3, 2019, July 10, 2019	608581.30 mE 4785488.21 mN	Bobolink and Eastern meadowlark not heard or observed
11/BB10	250 m south of Barton Street, in soybean field	May 28, 2015, July 7, 2015, August 20, 2015, June 1, 2016, July 13, 2016, June 5, 2017, July 7, 2017, June 26, 2019, July 3, 2019, July 10, 2019	608520.71 mE 4785244.56 mN	Bobolink and Eastern meadowlark not heard or observed
12	150 m north of Highway 8	June 5, 2017, July 7, 2017, June 26, 2019, July 3, 2019, July 10, 2019	608489.43 mE 4785060.72 mN	Bobolink and Eastern meadowlark not heard or observed
13/BB14	205 m west of Lewis Road	June 5, 2017, July 7, 2017, June 26, 2019, July 3, 2019, July 10, 2019	608638.64 mE 4785326.27 mN	Bobolink and Eastern meadowlark not heard or observed

Location Number	Survey Location	Dates Completed	GPS Location (17 T)	Comment
14/BB11	Lewis Road, 210 m north of Barton Street	June 5, 2017, July 7, 2017, June 26, 2019, July 3, 2019, July 10, 2019	608951.57 mE 4785657.89 mN	Bobolink and Eastern meadowlark not heard or observed
15	Lewis Road, 50 m north of Barton Street	June 5, 2017, July 7, 2017, June 26, 2019, July 3, 2019, July 10, 2019	608883.89 mE 4785484.57 mN	Bobolink and Eastern meadowlark not heard or observed
16	Lewis Road, south of school property	May 28, 2015, July 7, 2015, August 20, 2015, June 1, 2016, July 13, 2016, June 5, 2017, July 7, 2017, June 26, 2019, July 3, 2019, July 10, 2019	608831.86 mE 4785255.73 mN	Bobolink and Eastern meadowlark not heard or observed
17/BB15/BB16	Lewis Road, 150 m north of Highway 8	May 28, 2015, July 7, 2015, August 20, 2015, June 1, 2016, July 13, 2016, June 5, 2017, July 7, 2017, June 26, 2019, July 3, 2019, July 10, 2019	608786.10 mE 4785084.96 mN	Bobolink and Eastern meadowlark not heard or observed
18/BB17	Highway 8 and Lewis Road	May 28, 2015, July 7, 2015, August 20, 2015, June 1, 2016, July 13, 2016, June 5, 2017, July 7, 2017, June 26, 2019, July 3, 2019, July 10, 2019	608805.49 mE 4784958.67 mN	Bobolink and Eastern meadowlark not heard or observed
19	75 m south of Barton Street	June 5, 2017, July 7, 2017, June 26, 2019, July 3, 2019, July 10, 2019	609265.75 mE 4785263.38 mN	Bobolink and Eastern meadowlark not heard or observed

MNRF-Guelph District
Bobolink Survey Methodology

Bobolink Survey Methodology (also applicable to Eastern Meadowlark)

Qualifications: Observers should be familiar with Bobolink identification by sight and sound. This includes being able to separate males from females and knowledge of Bobolink behaviour during breeding to allow it to be categorized (e.g. singing, carrying food or nesting material, foraging, territorial displays).

Pre-Survey: Set up parallel transects crossing the fields lengthwise at approximately 250 m intervals and locate point counts along the transects, at 250 m intervals. Point counts should be located to give a good view of the surrounding fields.
Create GPS locations for each point count.

Conditions: Surveys need to be done under field conditions with no rain, no or low wind speed and good visibility. In the course of the surveys if a nest or probable nest is encountered, the surveyor is advised not to disturb it or search an area for nests. Surveys rely on observations of birds while walking along transects through the fields.

Survey: Materials needed for the survey include binoculars, notebook, GPS, compass, watch and camera.
Surveys should start 30 minutes after dawn and continue until no later than 9 am. The observer will walk the transect stopping at each point count. Undertake ten minutes of observations and listening at each point count. Record information on all Bobolink observed or heard, their sex, direction, distance, behaviour and interactions with other Bobolink or other species. On transit between point counts, record any Bobolink observed or heard if not also seen on the point counts.

Repeat visits: Complete at least three sets of point count surveys. These should take place in June or the first week of July with each survey separated by a week or more from previous surveys.

Habitat: From the transects, make notes on the general conditions of the fields that are surveyed. These would include broad habitat descriptors (type of meadow/ field/ crop), estimated height of the vegetation, general vegetation type (including predominate species if known), estimated percentage of grass versus broad-leaved plants, presence of hedgerows & fence lines, and presence of litter (i.e. thatch). Photos should be taken.

Legend

Ecological Land Classification (ELC)

CUM1-1= Dry-Moist Old Field Meadow
CUS1= Cultural Savannah
HR= Hedgerow
MAS2-1= Cattail Mineral Shallow Marsh
OR= Orchard
BB= Breeding Bird Survey location
= Bobolink Survey location

Title: Bobolink Survey Locations	
Project: Environmental Impact Statement, Block 3	
Client: Landowners Group	
ARCADIS	Date: July 12, 2019
	FIGURE D-1

Reference: ESRI ArcGIS Online Base Layers

APPENDIX E: FISH HABITAT ASSESSMENT

MEMO

To:
Fruitland-Winona BSS3 Landowners Group
c/o Rob Merwin

Copies:

From:
Sean McKee, Barbara Hard

Tel 905.764.9380

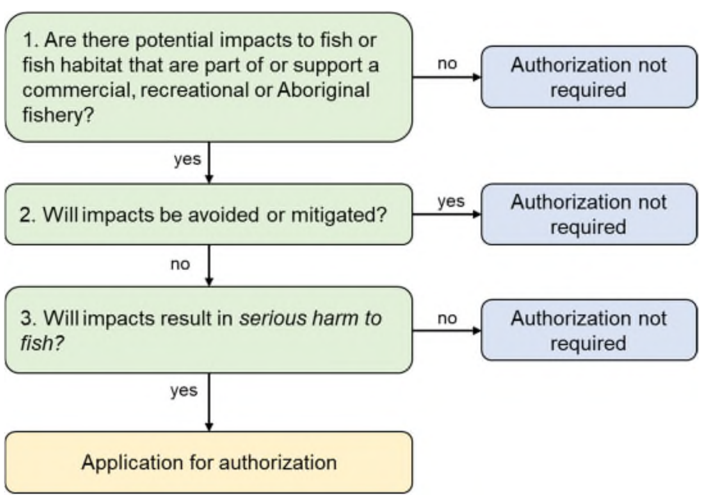
Date:
December 6, 2019

ARCADIS Project No.:
10366146

Subject:
Fruitland-Winona Secondary Plan – Block 3 – Updated Fish Habitat Self-Assessment

This memo documents the fish habitat assessment conducted as part of the Environmental Impact Statement (EIS) update in support of the Draft Plan applications for lands in Block 3 of the Fruitland-Winona Secondary Area Plan in Stoney Creek (Figure 1).

The City of Hamilton identified a requirement for a “DFO Fish Habitat Screening”, therefore, prior to undertaking this assessment, Arcadis contacted Megan Lay of Fisheries and Oceans Canada (DFO), where it was clarified that compliance with the provisions of the *Fisheries Act* (1985) in regard to particular waterbodies is made on a case-by-case basis through a self-assessment tool. The self-assessment should consider the project extent (e.g., location, activities/works, size) to determine impacts to fish and fish habitat and identify appropriate mitigation measures. This habitat assessment was developed to follow the Fisheries and Oceans Canada (DFO) Self-Assessment Tool for Projects Near Water for watercourses in Block 3. The self-assessment follows these steps to determine whether authorization is required:



Fish and fish habitat are protected under the *Fisheries Act* (1985), and harm to fish and fish habitat is prohibited under the Act. Accordingly, there are a number of waterbody types where DFO authorization is not required, including:

- artificial waterbodies that are not connected to a waterbody that contains fish at any time during any given year, and
- any other waterbody that does not contain fish at any given time during any given year.

An approved subwatershed study was previously conducted for the watercourses in this block (Aquafor Beech 2012). This study involved stream classification, which determined that watercourses in Block 3 are either piped, altered by agricultural tile drainage, or incorporated into roadside ditches, and are ephemeral and do not comprise fish habitat. However, watercourses 7.2 and 9 were deemed to be indirect fish habitat, in that they contribute surface water to downstream sections.

Therefore, this fish habitat assessment was undertaken to verify the findings of the approved subwatershed study and to determine whether an authorization or review is required as part of the DFO Self-Assessment. Arcadis conducted fish habitat assessments for the following sites in the study area (Figure 2):

- Watercourse 7.2;
- Watercourse 9;
- Three (3) watercourses between McNeilly Road and Lewis Road;
- Ditches along Barton Street, Lewis Road, and Highway 8.

The habitat assessment was conducted based on shoreline observations of physical characteristics of the watercourse, such as: size (width and depth), flow, habitat types (pool, run, riffle), in-stream cover, degree of disturbance and modification, and substrate. The field surveys were undertaken on June 26, July 3, July 10 and November 22, 2019.

A desktop review of historic fish data was conducted using the Ministry of Natural Resources and Forestry (MNRF) Fish ON-Line tool (MNRF 2019). No fish have been reported or observed in any of the watercourses included in this fish habitat assessment. However, the nearby Fifty Creek supports a tolerant warmwater fish community consisting of golden shiner, white sucker and fathead minnow. These species were captured downstream of the QEW by Hamilton Conservation Authority. Upstream of the QEW, only fathead minnows were captured (Aquafor Beech 2012). The MNRF Fish ON-Line tool also states that pumpkinseed have been confirmed in Fifty Creek. Although not applicable to the watercourses in Block 3, Watercourses 9 or 7.2 may support a similar tolerant warmwater fish community downstream of the QEW.

Figure 1: Site Location

Background Reference: First Base Solutions, 2017

{BH\mzarei} V:\GISProjects_ENV\CDN_GTA\10366146_StoneyCreek_BartonLewis\000_UEIS_B3\SiteLocation.mxd

Figure 2: Fish Habitat Assessment Locations

Background Reference: First Base Solutions, 2017

{BH\mzarei} V:\GISProjects_ENV\CDN_GTA\10366146_StoneyCreek_BartonLewis\000_UEIS_B3\SitePlan.mxd

1.0 WATERCOURSE 7.2

Figure 3 Watercourse 7.2, looking north

Watercourse 7.2 is north of Barton Street and East of McNeilly Road. It is a small channel (~0.2 m wide) with a narrow riparian zone, with a driveway and a lawn on either side. At the time of observation, the channels were dry, i.e., no water or flow. The watercourse is highly modified and channelized, running north along the property boundary. Watercourse 7.2 does not comprise direct fish habitat. Based on observations, any indirect habitat (i.e., surface water conveyed to downstream sections) provided by Watercourse 7.2 is limited and seasonal.

2.0 WATERCOURSE 9

Figure 4 Watercourse 9, looking east

Watercourse 9 is immediately south of the railroad tracks and east of Lewis Road, and west of Winona Road. It is a small channel with wide sloped berms on each side. The watercourse is modified, and appears to be channelized, with rip rap along the corner near Lewis road. It is bordered by railroad tracks to the north, with various land uses to the south. At the time of observation, the west end of the channel was dry, i.e., no water or flow, however further east, there were standing water sections with a wetted width of 2 m. Watercourse 9 does not comprise direct fish habitat. Based on observations, any indirect habitat (i.e., surface water conveyed to downstream sections) provided by Watercourse 9 is limited and seasonal.

3.0 DRAINAGE DITCH 1

Figure 5 Drainage Ditch 1, channel bed and substrate

Drainage Ditch 1 is south of Barton Street and east of McNeilly Road, with a western arm that branches out towards McNeilly Road. There appeared to be no connection (no culvert observed) to the north side of Barton, except at Lewis Road. At the time of observation, there was no water throughout the ditch, however the substrate was damp in some areas. The average bankfull width of the channel is roughly 0.8 m. There is a wide (~8 -25 m wide) treed riparian area, providing shade and cover. There is a vehicle crossing partway up the reach, with a culvert spanning underneath. The west arm of Drainage Ditch 1 had no wetness. Drainage Ditch 1 does not comprise fish habitat.

4.0 DRAINAGE DITCH 2

Figure 6 Drainage Ditch 2 looking south

Drainage Ditch 2 is south of Barton, approximately halfway between McNeilly Road and Lewis Road. There appeared to be no connection (no culvert observed) to the north side of Barton, except at Lewis Road. The flow in this watercourse is ephemeral, and contained no water at the time of observation, although the substrate was damp in some sections. The bankfull width was ~ 0.4 m. The riparian area is a 12 m wide treed strip with agricultural land on either side. Due to the lack of water and connection to downstream sections, this watercourse does not comprise fish habitat.

5.0 DRAINAGE DITCH 3

Figure 7 Drainage Ditch 3

Drainage Ditch 3 is south of Barton and borders the Winona Elementary Public School to the west. This watercourse was dry at the time of observation. The riparian area is treed and ranges from 7-14 m wide for most of its length. Drainage Ditch 3 does not comprise fish habitat.

Standing water in Drainage Ditch 3 in November 2019 following days of snowmelt and rainfall.

6.0 ROADSIDE DITCH (NORTH SIDE OF HWY 8)

Figure 8 Roadside ditch, North of Hwy 8

This roadside ditch runs along the north side of Highway 8. The riparian area varies, and includes landscaped grass, tall grasses and trees. The channel was dry at the time of observation and is expected to have seasonal and/or transient flow. Although the channel may exhibit seasonal/transient flow, it is expected that this roadside ditch does not comprise fish habitat or appreciable surface water conveyance to downstream sections.

7.0 ROADSIDE DITCH (SOUTH SIDE OF BARTON STREET AND EAST SIDE OF MCNEILLY)

Figure 9 Roadside ditch, south of Barton St. looking west

This roadside ditch runs along the south side of Barton Street and the east side of McNeilly Road. At the time of observation, there was no water or wetness in the ditch, and no riparian zone. The bankfull width of the channel is approximately 0.4 m. Although the channel may exhibit seasonal/transient flow, it is expected that this roadside ditch does not comprise fish habitat or appreciable surface water conveyance to downstream sections.

8.0 ROADSIDE DITCH (NORTH OF BARTON STREET AND WEST OF LEWIS ROAD)

Figure 10 Roadside ditch, north of Barton St. looking north

This roadside ditch contained water with minimal flow. This roadside ditch receives flow from across Barton Street (Section 9) via a culvert. The watercourse ranged from 0.4 to 1 m in width, with a maximum depth of 10 cm. The riparian area consists of tall grasses and some smaller wooded vegetation. There was abundant algal growth observed throughout. Under higher flow conditions, this watercourse would eventually feed into watercourse 9, however at the time of observation the watercourse was not continuous. This roadside ditch does not comprise fish habitat. Based on observations, any indirect habitat (i.e., surface water conveyance to downstream sections) provided to downstream sections is limited.

9.0 ROADSIDE DITCH (SOUTH AND WEST OF BARTON STREET AND LEWIS ROAD)

Figure 11 Roadside ditch, south of Barton St. looking west

The roadside ditch on the south and west of Barton Street and Lewis road borders Winona Public Elementary School. The ditch is connected to the roadside ditch to the north via a culvert crossing Barton Street. At the time of observation, there was some flow present, however the watercourse was generally narrow (~5 cm) and shallow (<2 cm) with some wider, deeper sections. In some sections the channel substrate is comprised of gravel and rip rap from the road grade. The ditch is connected to the roadside ditch to the north via a culvert under Barton Street. This watercourse also appears to receive direct stormwater runoff from the school parking areas. In some stretches, there is emergent and floating vegetation, and other sections contain thick algae. This roadside ditch does not comprise fish habitat. Based on observations, any indirect habitat (i.e., surface water conveyance to downstream sections) provided to downstream sections is very limited.

10.0 CONCLUSION

As part of this DFO Fish Habitat Self-Assessment in support of the Draft Plan applications for lands in Block 3 of the Fruitland-Winona Secondary Area Plan in Stoney Creek, a total of nine sites were assessed for fish habitat. Of these, it was determined that no sites comprise direct fish habitat. As noted previously (Aquafor Beech 2013), Watercourses 7.2 and 9 provide indirect habitat (i.e., surface water conveyance) to downstream sections, however there are barriers to fish passage to the watercourses in Block 3. At the time of the Site visits, the conveyance of surface water was limited and deemed to be seasonal and/or transient in nature. In general, the watercourses in the area are seasonal and have been modified/channelized, and have been incorporated into roadside drainage, built-up areas, or agricultural drainage. More water in the ditches was observed during the fall, following snow melt and rain fall.

Although these sites do not comprise fish habitat, since some locations provide surface water conveyance to downstream sections that do comprise fish habitat, there is potential for impacts to fish or fish habitat as part of the project activities. Therefore, works involving these watercourses should consider the project extent and potential impacts to the role of these watercourses in supporting downstream fish habitat. The functions of these watercourses (i.e., surface water conveyance) should be maintained (e.g., with stormwater management), and any potential disruptions should be properly mitigated (e.g., silt fencing to limit sediment loading). Consistent with the recommendations of the approved subwatershed study, the proposed stormwater management plan will replace the water quality and quantity function of the drainage features in the study area. As long as these functions are maintained, no DFO authorization is required.

REFERENCES

Aquafor Beech Limited. 2013. *Stoney Creek Urban Boundary Expansion Area (SCUBE) East – Subwatershed Study,* s.1.:s.n.

Fisheries Act 1985 (Canada). c. F-14. https://laws-lois.justice.gc.ca/eng/acts/f-14/.

Ontario Ministry of Natural Resources and Forestry (MNRF). 2019. Fish ON-Line. Website: https://www.gisapplication.lrc.gov.on.ca/FishONLine/Index.html?site=FishONLine&viewer=FishONLine&locale=en-US. Accessed July 09, 2019.

APPENDIX F: COMMUNICATIONS

From: Species at Risk (MECP) <SAROntario@ontario.ca>
Sent: Monday, July 15, 2019 12:37 PM
To: Hard, Barbara <Barbara.Hard@arcadis.com>
Subject: RE: SAR in Stoney Creek

Hello Dr. Hard.

Thank you for your email.

As you may know, the Ministry of the Environment, Conservations and Parks (MECP) has accepted responsibility for the administration of the Endangered Species Act (ESA). Work associated with ESA authorizations has been centralized from 25 Ministry of Natural Resources and Forestry district offices into one, newly formed Permissions and Compliance team within the new Species at Risk Branch in MECP. This branch is staffed by former MNRF employees with experience in the ESA.

To facilitate communications with our clients, the MECP has established a one-window e-mail account, SAROntario@ontario.ca, for applications, report submissions and other communications relating to applications and authorizations under the ESA. SAROntario@ontario.ca will also be the primary contact for clients who wish to determine whether their proposed activity is likely to contravene the ESA. Staff in this new branch will continue to be available to provide advice to you.

To support our new centralized model, we have been working on the attached guide to help clients work through the preliminary screening process, including providing advice to clients on how they can gather the information you have requested from publicly available information sources. Please feel free to contact us at SAROntario@ontario.ca if you think your activity is likely to contravene the ESA and if you would like further advice on authorization options.

Please see the attached guide for your use.
Thank you,
Kristina Hubert
for Permissions and Compliance Section
Species at Risk Branch
Ministry of the Environment, Conservation and Parks

From: Hard, Barbara <Barbara.Hard@arcadis.com>
Sent: July-15-19 2:23 PM
To: Species at Risk (MECP) <SAROntario@ontario.ca>
Subject: SAR in Stoney Creek

Hi there,
I am looking for information on SAR in Stoney Creek (Block 3, map attached).
Of particular interest are bobolink and meadowlark sightings.

Thanks,

Barbara

Barbara Hard, PhD, PBiol, RPBio, QP(RA) | Senior Biologist, Discipline Lead, Natural Sciences |
Barbara.Hard@arcadis.com
Arcadis | Arcadis Canada
155 Frobisher Dr Suite J-101 Waterloo ON | N2V 2E1| Canada
M. +1 905 516 5976 | F. +1 519 886 8398

Client's Guide to Preliminary Screening for Species at Risk

Ministry of the Environment, Conservation and Parks

Species at Risk Branch, Permissions and Compliance

DRAFT - May 2019

Table of Contents

1.0 Purpose, Scope, Background and Context

1.1 Purpose of this Guide

This guide has been created to:

- help clients better understand their obligation to gather information and complete a preliminary screening for species at risk before contacting the ministry,
- outline guidance and advice clients can expect to receive from the ministry at the preliminary screening stage,
- help clients understand how they can gather information about species at risk by accessing publicly available information housed by the Government of Ontario, and
- provide a list of other potential sources of species at risk information that exist outside the Government of Ontario.

It remains the client's responsibility to:

- carry out a preliminary screening for their projects,
- obtain best available information from all applicable information sources,
- conduct any necessary field studies or inventories to identify and confirm the presence or absence of species at risk or their habitat,
- consider any potential impacts to species at risk that a proposed activity might cause, and
- comply with the *Endangered Species Act* (ESA).

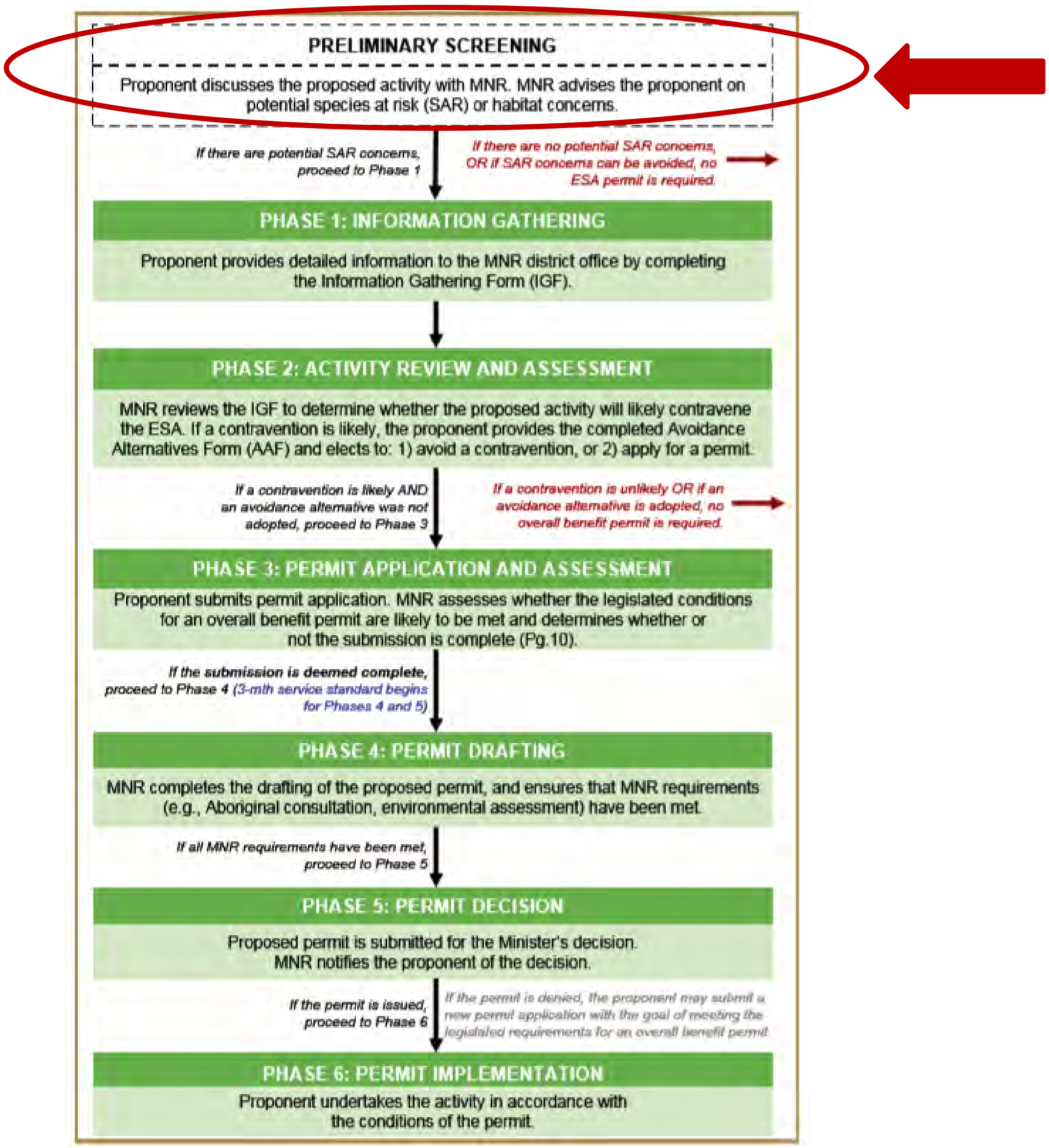
To provide the most efficient service, clients should initiate species at risk screenings and seek information from all applicable information sources identified in this guide, at a minimum, prior to contacting Government of Ontario ministry offices for further information or advice.

1.2 Scope

This guide is a resource for clients seeking to understand if their activity is likely to impact species at risk or if they are likely to trigger the need for an authorization under the ESA. It is not intended to circumvent any detailed site surveys that may be necessary to document species at risk or their habitat nor to circumvent the need to assess the impacts of a proposed activity on species at risk or their habitat. This guide is not an exhaustive list of available information sources for any given area as the availability of information on species at risk and their habitat varies across the province. This guide is intended to support projects and activities carried out on Crown and private land, by private landowners, businesses, other provincial ministries and agencies, or municipal government.

1.3 Background and Context

To receive advice on their proposed activity, clients must first determine whether any species at risk or their habitat exist or are likely to exist at or near their proposed activity, and whether their proposed activity is likely to contravene the ESA. Once this step is complete, client may contact the ministry at SAROntario@ontario.ca to discuss the main purpose, general methods, timing and location of their proposed activity as well as information obtained about species at risk and their habitat at, or near, the site. At this stage, the ministry can provide advice and guidance to the client about potential species at risk or habitat concerns, measures that the client is considering to avoid adverse effects on species at risk or their habitat and whether additional field surveys are advisable. This is referred to as the "Preliminary Screening" stage. For more information on additional phases in the diagram below, please refer to the *Endangered Species Act Submission Standards for Activity Review and 17(2)(c) Overall Benefit Permits* policy available online at https://www.ontario.ca/page/species-risk-overall-benefit-permits



2.0 Roles and Responsibilities

To provide the most efficient service, clients should initiate species at risk screenings and seek information from all applicable information sources identified in this guide prior to contacting Government of Ontario ministry offices for further information or advice.

Step 1: Client seeks information regarding species at risk or their habitat that exist, or are likely to exist, at or near their proposed activity by referring to all applicable information sources identified in this guide.

Step 2: Client reviews and consider guidance on whether their proposed activity is likely to contravene the ESA (see section 3.4 of this guide for guidance on what to consider).

Step 3: Client gathers information identified in the checklist in section 4 of this guide.

Step 4: Client contacts the ministry at SAROntario@ontario.ca to discuss their preliminary screening. Ministry staff will ask the client questions about the main purpose, general methods, timing and location of their proposed activity as well as information obtained about species at risk and their habitat at, or near, the site. Ministry staff will also ask the client for their interpretation of the impacts of their activity on species at risk or their habitat as well as measures the client has considered to avoid any adverse impacts.

Step 5: Ministry staff will provide advice on next steps.

Option A: Ministry staff may advise the client they can proceed with their activity without an authorization under the ESA where the ministry is confident that:

- no protected species at risk or habitats are likely to be present at or near the proposed location of the activity; or
- protected species at risk or habitats are known to be present but the activity is not likely to contravene the ESA; or
- through the adoption of avoidance measures, the modified activity is not likely to contravene the ESA.

Option B: Ministry staff may advise the client to proceed to Phase 1 of the overall benefit permitting process (i.e. Information Gathering in the previous diagram), where:

- there is uncertainty as to whether any protected species at risk or habitats are present at or near the proposed location of the activity; or
- the potential impacts of the proposed activity are uncertain; or
- ministry staff anticipate the proposed activity is likely to contravene the ESA.

3.0 Information Sources

Land Information Ontario (LIO) and the Natural Heritage Information Centre (NHIC) maintain and provide information about species at risk, as well as related information about fisheries, wildlife, crown lands, protected lands and more. This information is made available to organizations, private individuals, consultants, and developers through online sources and is often considered under various pieces of legislation or as part of regulatory approvals and planning processes.

The information available from LIO or NHIC and the sources listed in this guide should not be considered as a substitute for site visits and appropriate field surveys. Generally, this information can be regarded as a starting point from which to conduct further field surveys, if needed. While this data represents best available current information, it is important to note that a lack of information for a site does not mean that species at risk or their habitat are not present. There are many areas where the Government of Ontario does not currently have information, especially in more remote parts of the province. The absence of species at risk location data at or near your site does not necessarily mean no species at risk are present at that location. On-site assessments can better verify site conditions, identify and confirm presence of species at risk and/or their habitats.

Information on the location (i.e. observations and occurrences) of species at risk is considered sensitive and therefore publicly available only on a 1km square grid as opposed to as a detailed point on a map. This generalized information can help you understand which species at risk are in the general vicinity of your proposed activity and can help inform field level studies you may want to undertake to confirm the presence, or absence of species at risk at or near your site.

Should you require specific and detailed information pertaining to species at risk observations and occurrences at or near your site on a finer geographic scale; you will be required to demonstrate your need to access this information, to complete data sensitivity training and to obtain a Sensitive Data Use License from the NHIC. Information on how to obtain a license can be found online at https://www.ontario.ca/page/get-natural-heritage-information.

Many organizations (e.g. other Ontario ministries, municipalities, conservation authorities) have ongoing licensing to access this data so be sure to check if your organization has this access and consult this data as part of your preliminary screening if your organization already has a license.

3.1 Make a Map: Natural Heritage Areas

The Make a Natural Heritage Area Map (available online at http://www.gisapplication.lrc.gov.on.ca/mamnh/Index.html?site=MNR_NHLUPS_NaturalHeritage&viewer=NaturalHeritage&locale=en-US provides public access to natural heritage information, including species at risk, without the user needing to have Geographic Information System (GIS) capability. It allows users to view and identify generalized species at risk information, mark areas of interest, and create and print a custom map directly from the web application. The tool also shows topographic information such as roads, rivers, contours and municipal boundaries.

Users are advised that sensitive information has been removed from the natural areas dataset and the occurrences of species at risk has been generalized to a 1-kilometre grid to mitigate the risks to the species (e.g. illegal harvest, habitat disturbance, poaching).

The web-based mapping tool displays natural heritage data, including:

- Generalized Species at risk occurrence data (based on a 1-km square grid),
- Natural Heritage Information Centre data.

Data cannot be downloaded directly from this web map; however, information included in this application is available digitally through Land Information Ontario (LIO) at https://www.ontario.ca/page/land-information-ontario.

3.2 Land Information Ontario (LIO)

Most natural heritage data is publicly available. This data is managed in a large provincial corporate database called the LIO Warehouse and can be accessed online through the LIO Metadata Management Tool at https://www.javacoeapp.lrc.gov.on.ca/geonetwork/srv/en/main.home. This tool provides descriptive information about the characteristics, quality and context of the data. Publicly available geospatial data can be downloaded directly from this site.

While most data are publicly available, some data may be considered highly sensitive (i.e. nursery areas for fish, species at risk observations) and as such, access to some data maybe restricted.

3.3 Additional Species at Risk Information Sources

- The Breeding Bird Atlas can be accessed online at http://www.birdsontario.org/atlas/index.jsp?lang=en
- eBird can be accessed online at https://ebird.org/home
- iNaturalist can be accessed online at https://www.inaturalist.org/
- The Ontario Reptile and Amphibian Atlas can be accessed online at https://ontarionature.org/programs/citizen-science/reptile-amphibian-atlas
- Your local Conservation Authority. Information to help you find your local Conservation Authority can be accessed online at https://conservationontario.ca/conservation-authorities/find-a-conservation-authority/

  Local naturalist groups or other similar community-based organizations
- Local Indigenous communities
- Local land trusts or other similar Environmental Non-Government Organizations
- Field level studies to identify if species at risk, or their habitat, are likely present or absent at or near the site.
- When an activity is proposed within one of the continuous caribou ranges, please be sure to consider the caribou Range Management Policy. This policy includes figures and maps of the continuous caribou range, can be found online at https://www.ontario.ca/page/range-management-policy-support-woodland-caribou-conservation-and-recovery

3.4 Information Sources to Support Impact Assessments

- Guidance to help you understand if your activity is likely to adversely impact species at risk or their habitat can be found online at https://www.ontario.ca/page/policy-guidance-harm-and-harass-under-endangered-species-act and https://www.ontario.ca/page/categorizing-and-protecting-habitat-under-endangered-species-act
- A list of species at risk in Ontario is available online at https://www.ontario.ca/page/species-risk-ontario. On this webpage, you can find out more about each species, including where is lives, what threatens it and any specific habitat protections that apply to it by clicking on the photo of the species.

4.0 Check-List

Please feel free to use the check list below to help you confirm you have explored all applicable information sources and to support your discussion with Ministry staff at the preliminary screening stage.

- ✓ Land Information Ontario (LIO)
- ✓ Natural Heritage Information Centre (NHIC)
- ✓ The Breeding Bird Atlas
- ✓ eBird
- ✓ iNaturalist
- ✓ Ontario Reptile and Amphibian Atlas
- ✓ List Conservation Authorities you contacted:____________________________________

  ____
- ✓ List local naturalist groups you contacted:______________________________________

  ____
- ✓ List local Indigenous communities you contacted:_________________________________

  ____
- ✓ List any other local land trusts or Environmental Non-Government Organizations you contacted:____

  ____
- ✓ List and field studies that were conducted to identify species at risk, or their habitat, likely to be present or absent at or near the site: ___________________________________

  ____
- ✓ List what you think the likely impacts of your activity are on species at risk and their habitat (e.g. damage or destruction of habitat, killing, harming or harassing species at risk):____

  ____

APPENDIX D
AIR DRAINAGE

D-1 Air Drainage Analysis (Amec Foster Wheeler, May 2018)

1312733 Ontario Inc. Submission to the City of Hamilton, Fruitland-Winona Tertiary Plan Area

Air Drainage Analysis

To:	1312733 Ontario Inc. 720 Oval Court, Burlington, ON, L7L 6A9
Date	March 9, 2016
From:	Dr. Diar Hassan, Ron Bianchi, and Gaëtan Beauchesne (P. Eng.) Amec Foster Wheeler, Ottawa
	Dr. Kevin Ker Research Associate and Prof. Affiliate, Brock University

Executive Summary – Air Drainage Analysis for 1312733 Ontario Inc.

The City of Hamilton requires an Air Drainage Analysis for the Block 3 Servicing Strategy Area, Urban Hamilton Official Plan, Fruitland-Winona Tertiary Plan (hereafter referred as to the PLAN) area located within the City of Hamilton in southern Ontario, Canada.

The desktop analysis consisted in the review of the topography and the analysis of the climatology of the region.

The objective of this analysis was to study the effect of the proposed development within the PLAN to the micro-climate in the region.

The archived climate data for three nearby weather stations revealed that the predominant winds will be from the west and southwest direction. Furthermore, the data have shown December and February being the months with the highest number of fog occurrences while February is the month with the highest number of reported freezing fog.

The two types of low temperature that can cause injury conditions are advection frost and radiation frost. Such conditions occur during the growing season and advection freeze and radiation freeze during the dormant period. Advection frost is a regional frost event and it occurs when low temperature air masses which originate from northern regions move into the area. This kind of event can be understood through the analysis of climatological data and the topography of the region. Radiation frost is a micro-scale climate event and is generally site specific. Radiation frost is typically caused by cold air accumulation near the ground surface, which can occur in the spring or fall. Low temperature freeze events occur during the winter months when plants are not actively growing but are in a dormant state to survive winter conditions.

Tender fruit trees and wine grapes can be damaged in the winter due to very low temperatures that go below their acclimation points. The damage often includes cracking of trunks and branches, the death of flower and leaf buds or total death of trees and vines.

Following the desktop analysis of the microclimate and the topography in the Fruitland-Winona area, the proposed development inside the PLAN area is not expected to block the southwesterly-to-northeasterly direction air flow. The new development is not expected to impede the natural air movement and may assist in mixing the boundary air layer (a layer near the ground) by creating eddies (turbulences), thus aid in streaming any cold air descending from the Niagara Escarpment, i.e. prevent air stagnation. Meanwhile, the existing and proposed local roads and the natural open spaces outlines in the PLAN will help to channel the air downstream toward Lake Ontario.

CONTENTS

Reviewer:

Gaëtan Beauchesne, P. Eng.

1. INTRODUCTION

The City of Hamilton requires an Air Drainage Analysis for the Block 3 Servicing Strategy Area, Urban Hamilton Official Plan, Fruitland-Winona Tertiary Plan (hereafter called the PLAN) area in Ontario, Canada. The subject lands are shown in Figure 1 and are generally bounded by Barton Street to the north, Highway 8 to the south, McNeily Road to the west, and Collector Road 'D' to the east.

Amec Foster Wheeler was retained by 1312733 Ontario Inc. to conduct a desktop Air Drainage Analysis for a proposed development within the PLAN area. The analysis evaluates the effect of the proposed development on the micro-climate in the region.

Topography influences the air flow movement and microclimatology of any area. Nocturnal cooling caused by radiation (emission of longwave radiation from the ground) is the main reason for cold air draining from mountains or higher elevations into valleys or lower ground under the influence of gravity. A katabatic wind is a term used for downslope air movement. Solar et al. (2002) found that within an hour after sunset, larger variations in surface temperature developed with localized cooling were found in wind sheltered locations. The authors also found that stronger stratification conditions and weaker air flow produce deeper drainage current.

Downward heat fluxes and intermittent turbulences are expected to break down the air drainage flow few times during each night. Boundary layer flow acceleration and the reduction of Richardson number (buoyancy to flow shear ratio) are likely to increase mixing of the air near the ground with the air several meters higher (Solar et al. 2002).

New urban developments can alter the natural airflow pattern by blocking and/or affecting the air mixing and turbulence in the area. Such changes can, therefore, affect the micro-climate in that area. To study such effects, it is important to analyze the topography, current air flow, and climate conditions of the area.

Data from three nearby weather stations, namely Vineland, Burlington Piers, and Hamilton Airport, were collected for this purpose. Based on the archived data availability, the Burlington Piers and Vineland data were compiled for the period of January 2003 through the end of December 2015, whereas the Hamilton Airport data was compiled for the period of December 2011 through the end of December 2015.

The following sections will provide a geographical overview of the area, the PLAN, climatological maximum and minimum temperatures, prevailing winds, topography, and summary and conclusions of the air drainage analysis.

2.0 FRUITLAND-WINONA AREA

The Fruitland-Winona area is located in the city of Hamilton in southern Ontario, Canada, situated between Lake Ontario to the north, the Niagara Escarpment to the south, the Hamilton city center to the west, and the Town of Grimsby to the east as shown in Figure 1 below. Due to its unique location in Ontario, the unique climate and rich soil conditions in the area are favorable for the cultivation of fruits and vegetables.

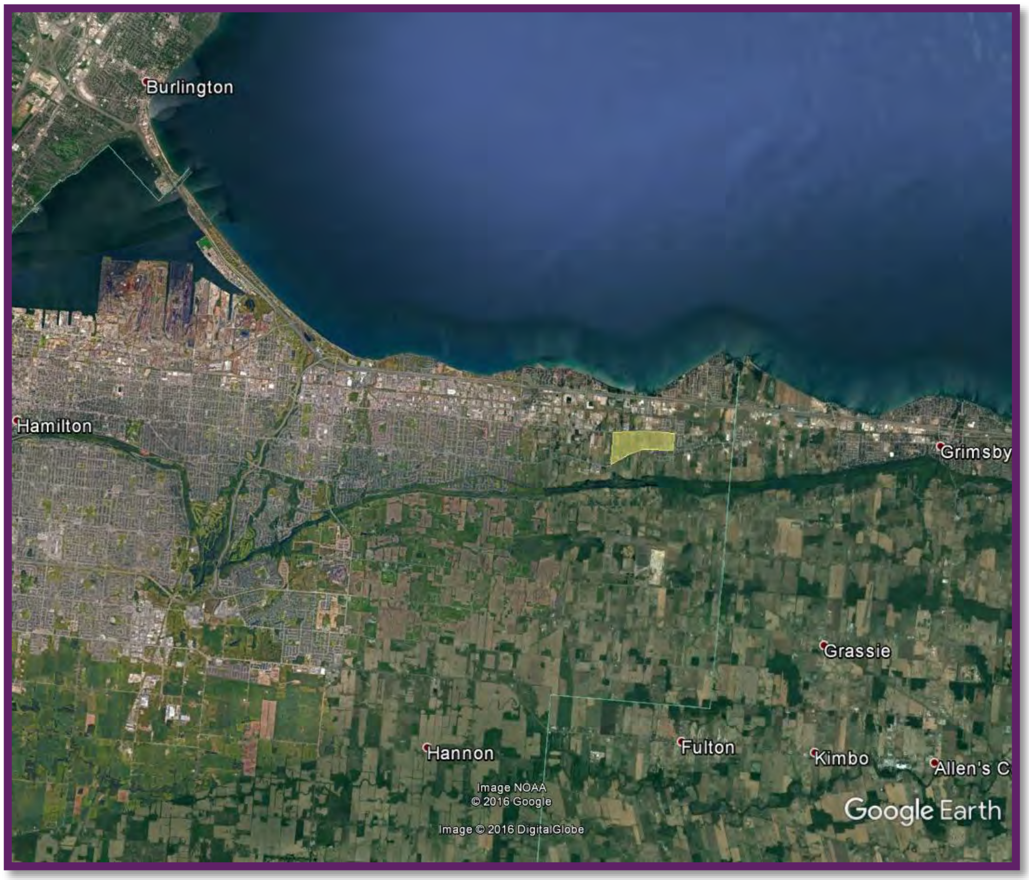


Figure 1. Fruitland-Winona area in light shaded yellow. © Google Earth.

The Niagara Escarpment and Lake Ontario play a major role in moderating the temperature during winter and summer and help in producing the almost-ideal climate conditions for wine and ice wine production in the area. In addition to the wine industry, the area is also famous for a variety of fruit and vegetable production like peaches, cherries, grapes, apples, pears, and strawberries. Figure 2 below shows the proposed development area in relation to the 2005 Greenbelt Area (dark green) produced by the Ministry of Agriculture and Food, Ministry of Municipal Affairs and Housing and Ministry of Natural Resources.

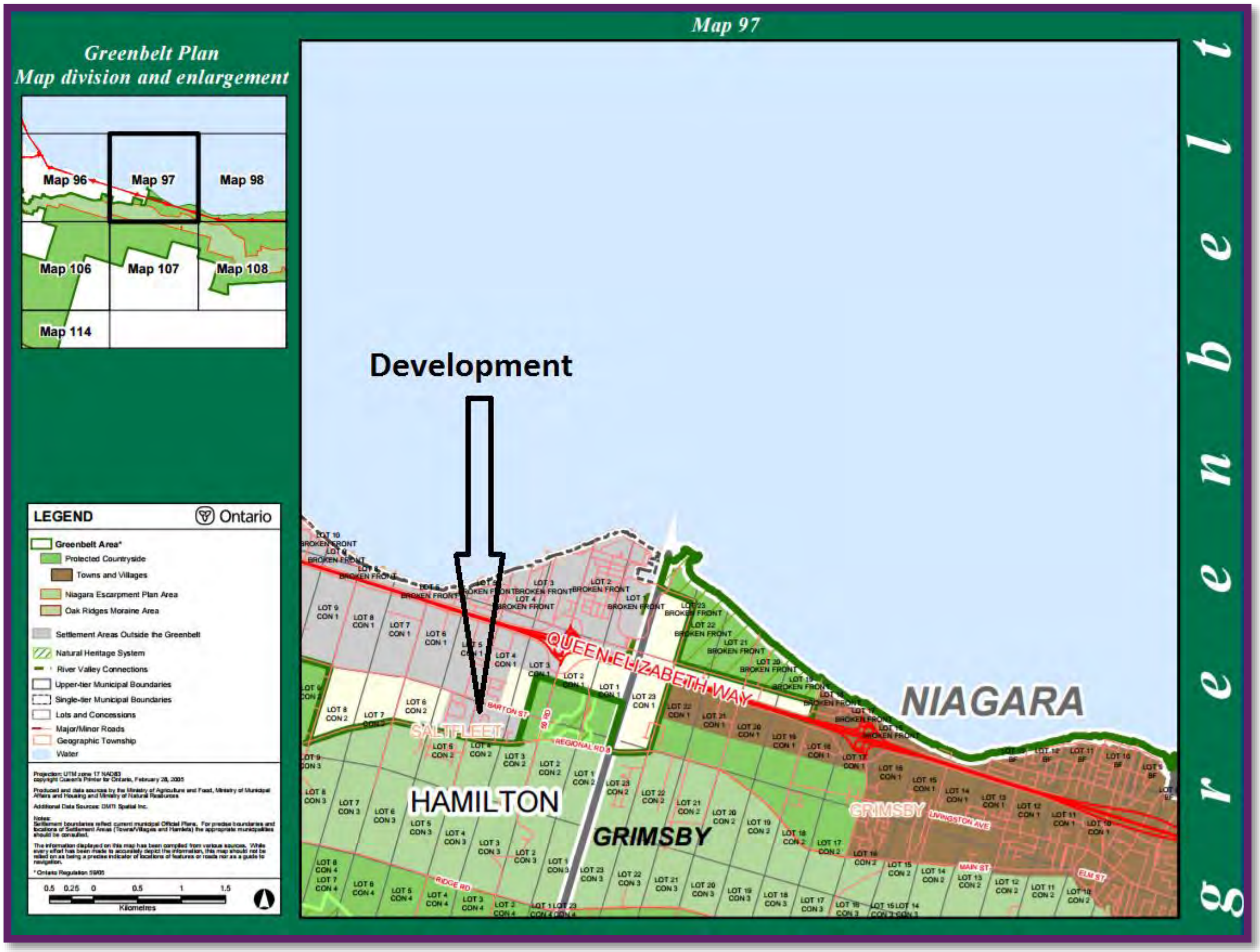


Figure 2. Map showing the Greenbelt Plan produced by the Ministry of Agriculture and Food, Ministry Affairs and Housing and Ministry of Natural Resources (2005).

3.0 HAMILTON FRUITLAND-WINONA TERTIARY PLAN

The proposed development inside the PLAN consists of dwelling development in the area bounded between Barton Street to the north, Highway 8 to the south, McNeilly Road to the west, and Collector Road 'D' to the east. The Fruitland-Winona Tertiary Plan is given in Figure 3. The major roads have a north-north-east to south-south-west alignment.

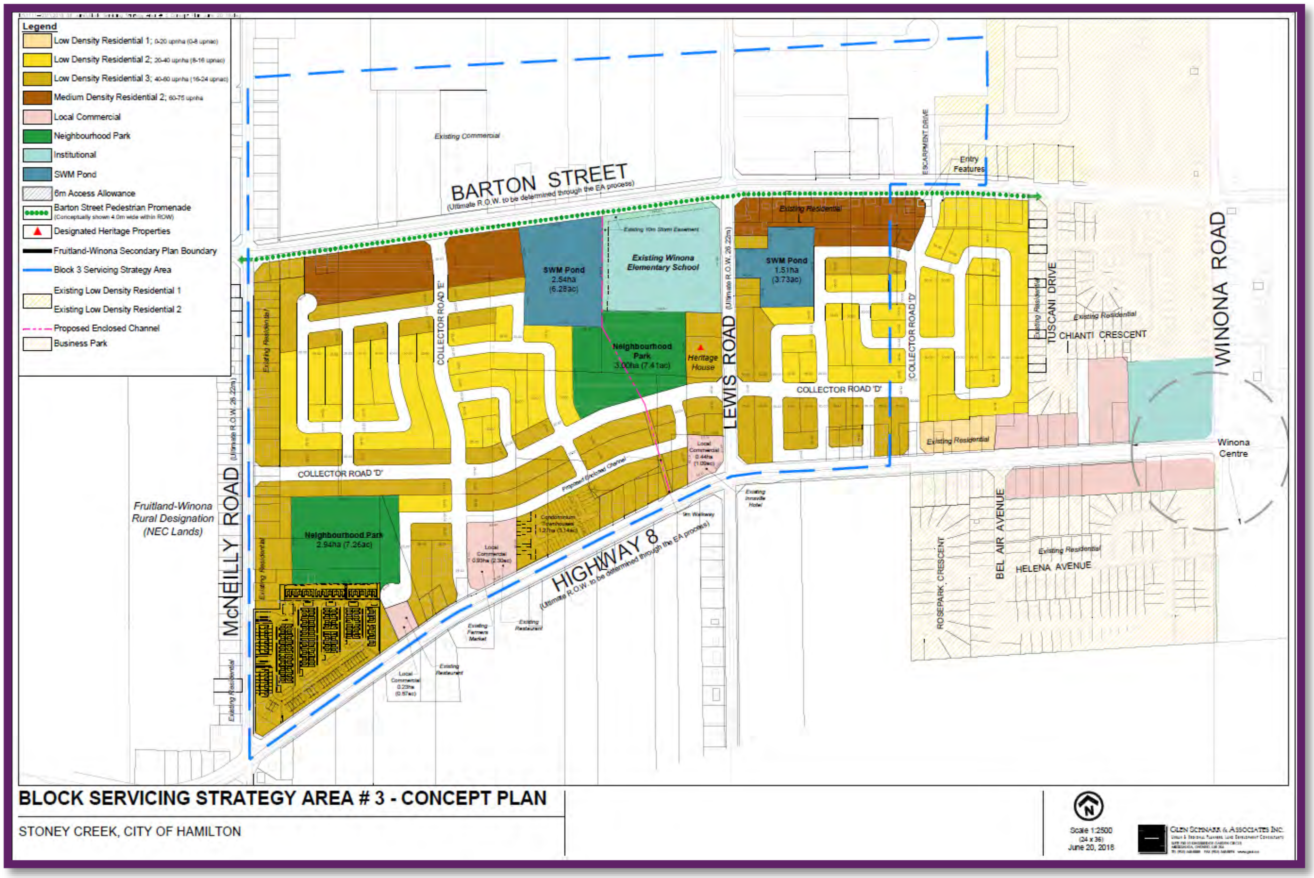


Figure 3. The Fruitland-Winona Tertiary Plan.

The proposed features to be built within the PLAN are a majority of mixed low residential density units, a small area of medium residential density units on the north side, local commercial buildings, recreational parks, institutional buildings, and Strom Water Management (SWM) ponds.

4. TEMPERATURE DISTRIBUTION

Climatological data from Environment Canada and Climate Change (ECCC) from the three weather station were used in this analysis. An Internal software was used to quality check the validity of the data and produce the several figures that are used in the analysis and presented in this document.

The landscape (the Niagara Escarpment) and the nearby large waterbody (Lake Ontario) within this region are two among several contributing factors that affect spatial temperature variation in the area. Figure 4 below depicts such spacial temperature variation during fall, winter, and spring. When comparing the data from Vineland weather station (WS) with the data from the Hamilton Airport WS, one can notice the effect of the warmer marine environment and topography on the Vineland area such that the Maximum and Minimum temperatures from the Vineland WS are, in general, warmer than those observed at the Hamilton Airport WS.

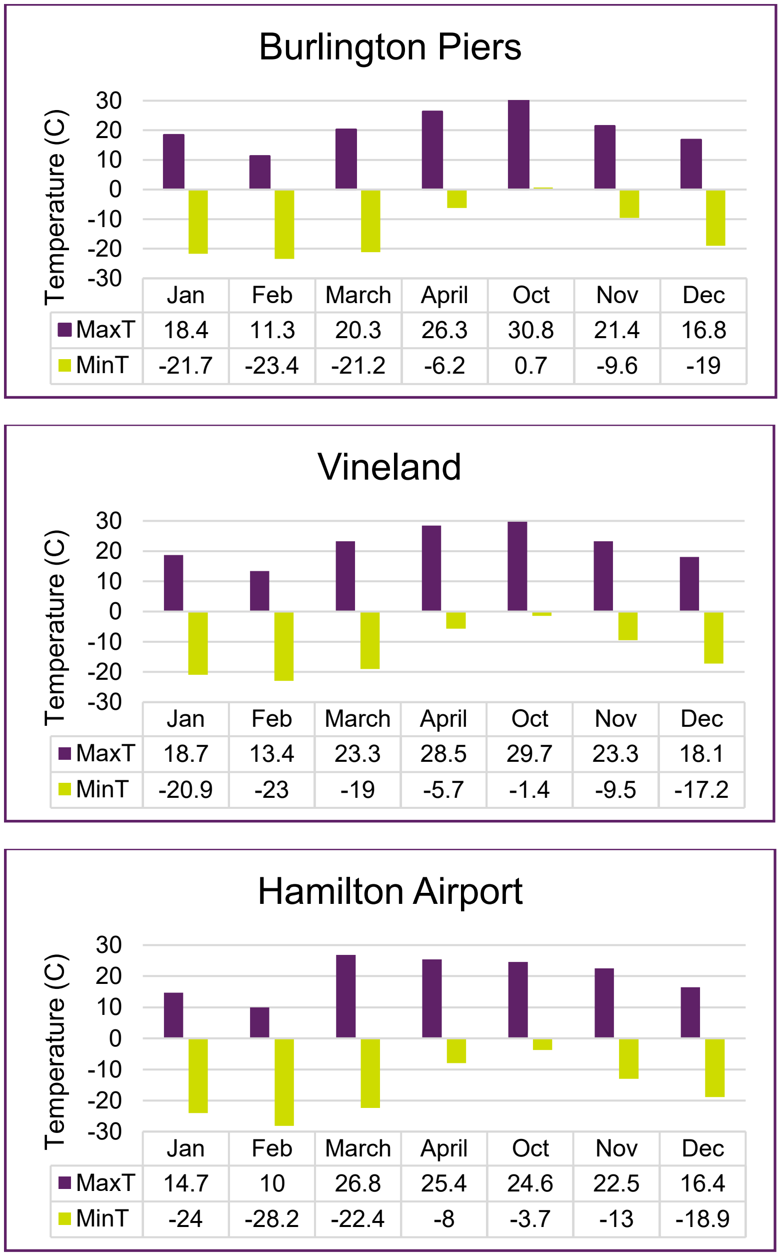
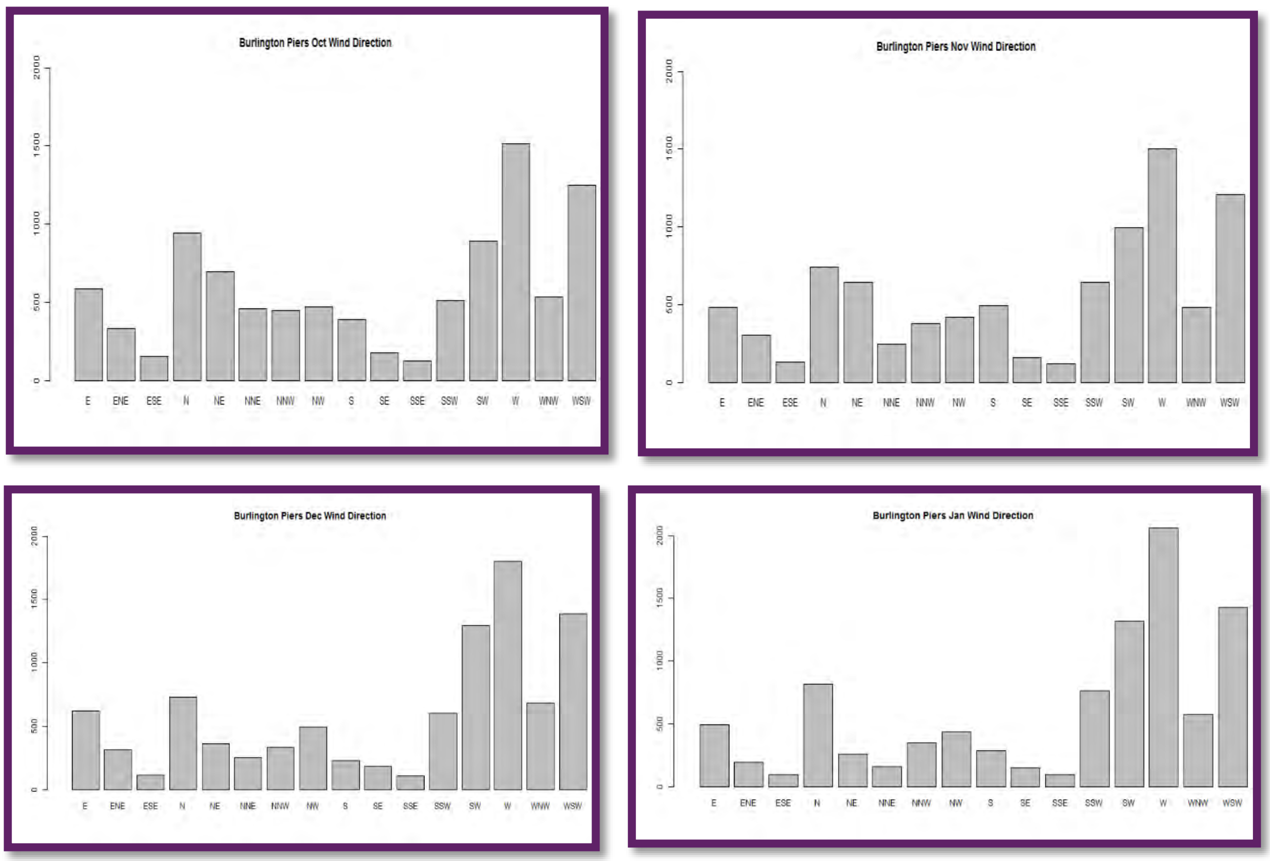


Figure 4. Maximum and Minimum Temperatures from the three weather station for the period starting January 2003 and ending December 2015.

5. WINDS

A. PREVAILING WINDS

To determine the prevailing orientation of the wind in the area, hourly data of wind direction collected from the three weather stations were plotted for the months of October through April. Figures 5 to 7 show the prevailing winds on a monthly basis at the three locations. The prevailing winds at Burlington Piers are westerly and southwesterly, while the north to northeast is considered the second most common wind direction (Figure 5). Similarly, the Vineland prevailing winds are from the west and southwest during the winter season, while a north-to-east component of the winds become as prevalent during spring (Figure 6). The Hamilton station data also show that the prevailing winds are from the west and southwest direction (Figure 7).



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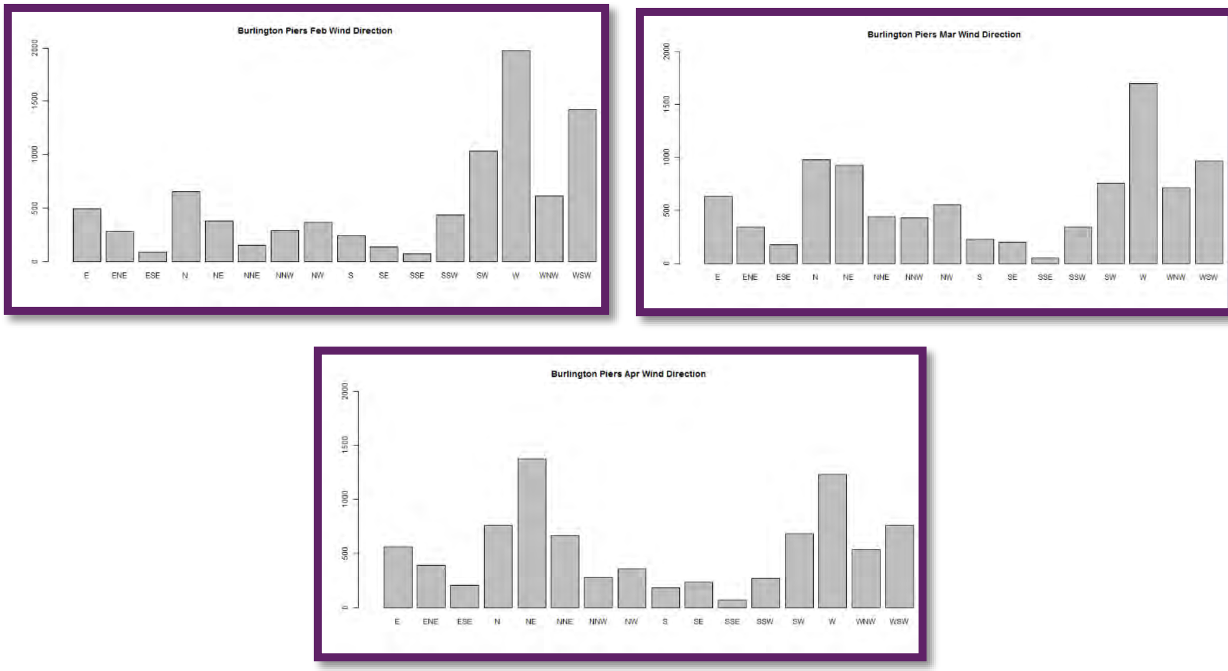
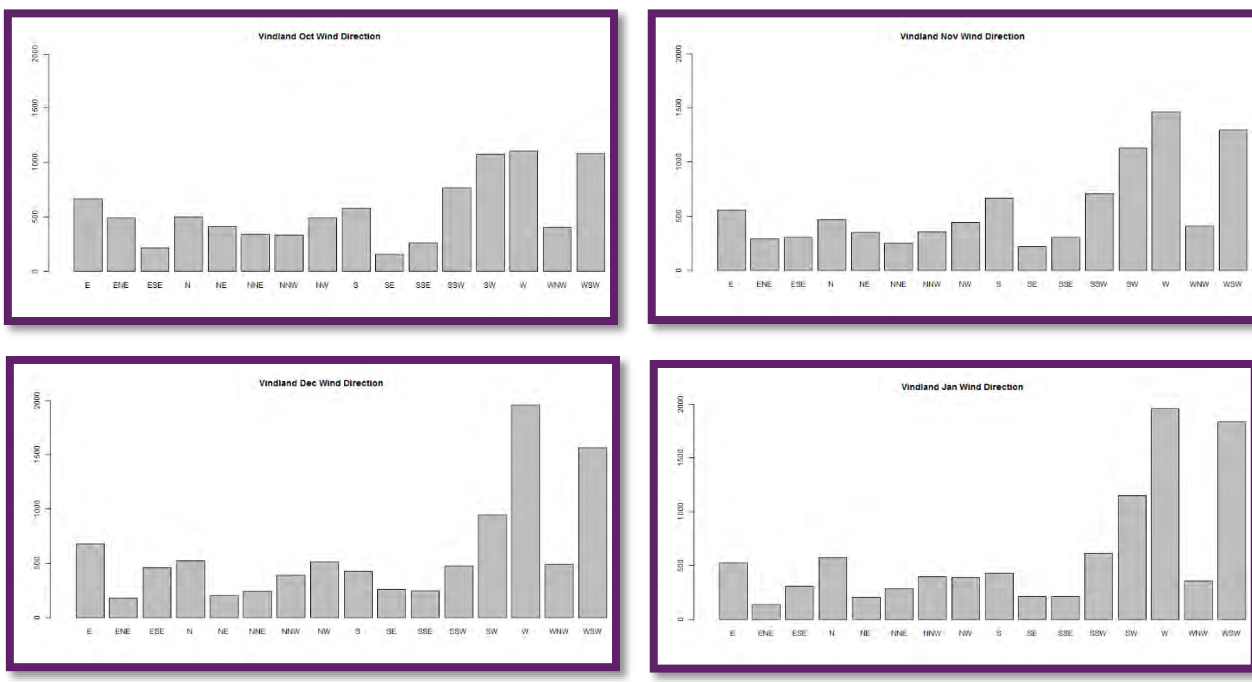


Figure 5. The prevailing winds from Burlington Piers weather station for the months of October through April (2003-2015).



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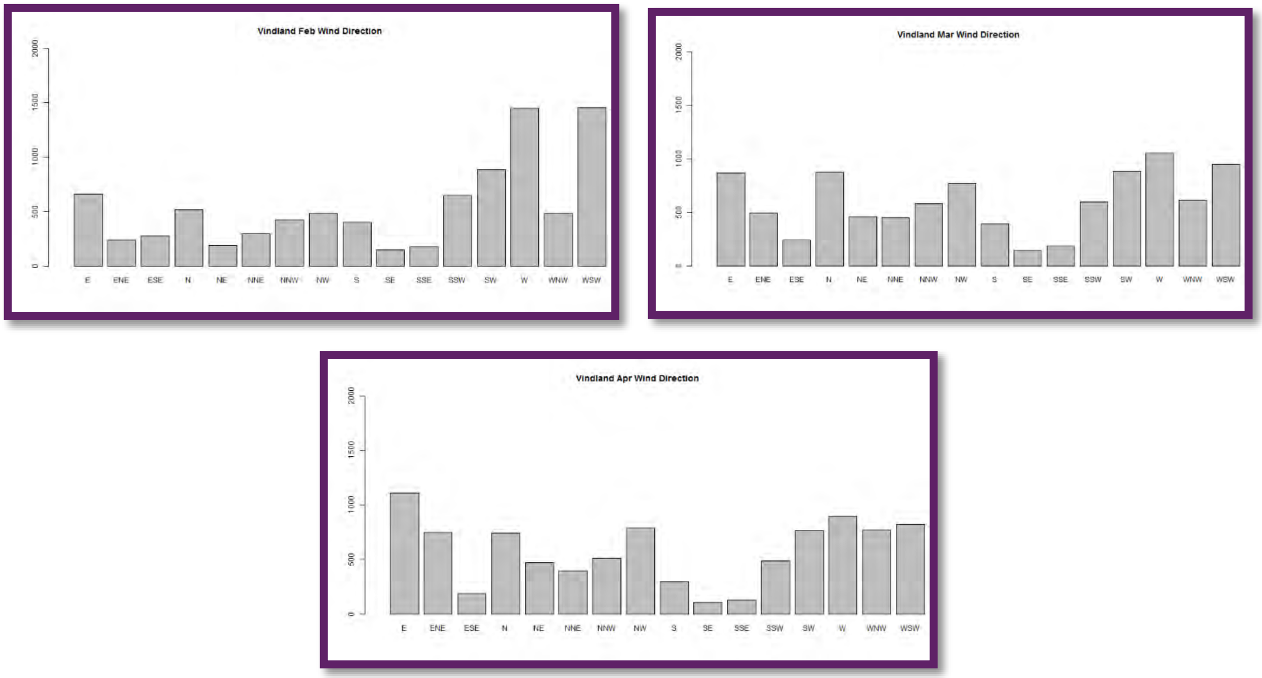
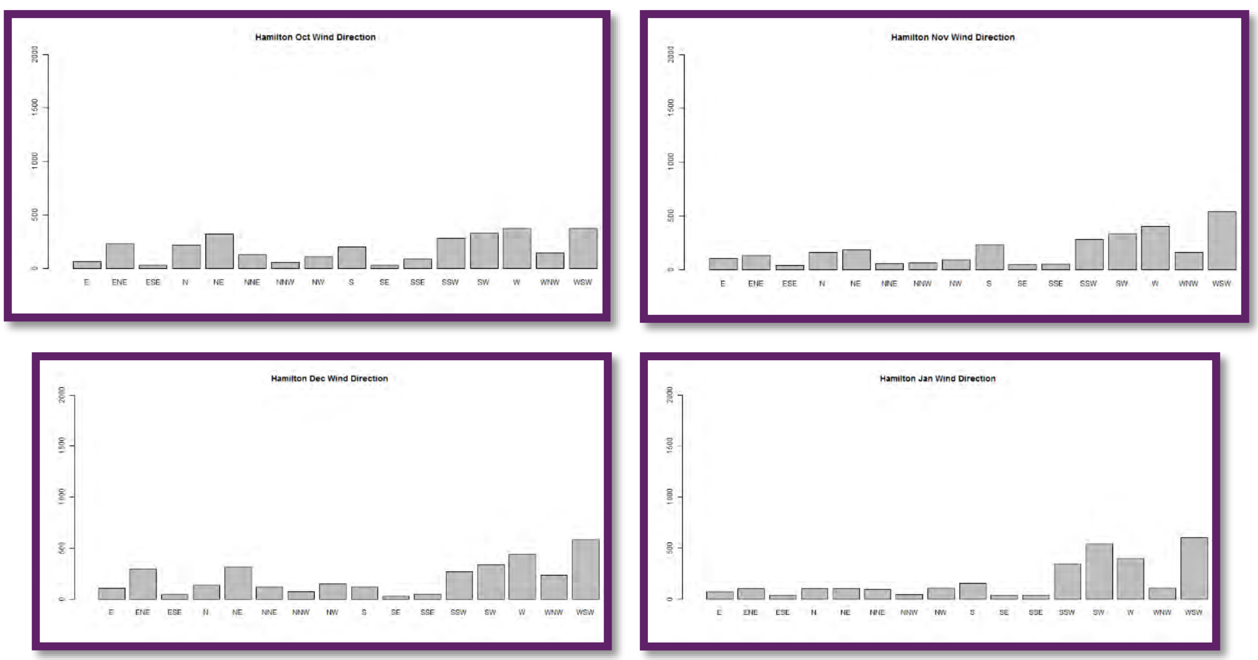


Figure 6. The prevailing winds from Vineland weather station for the months of October through April (2003-2015)



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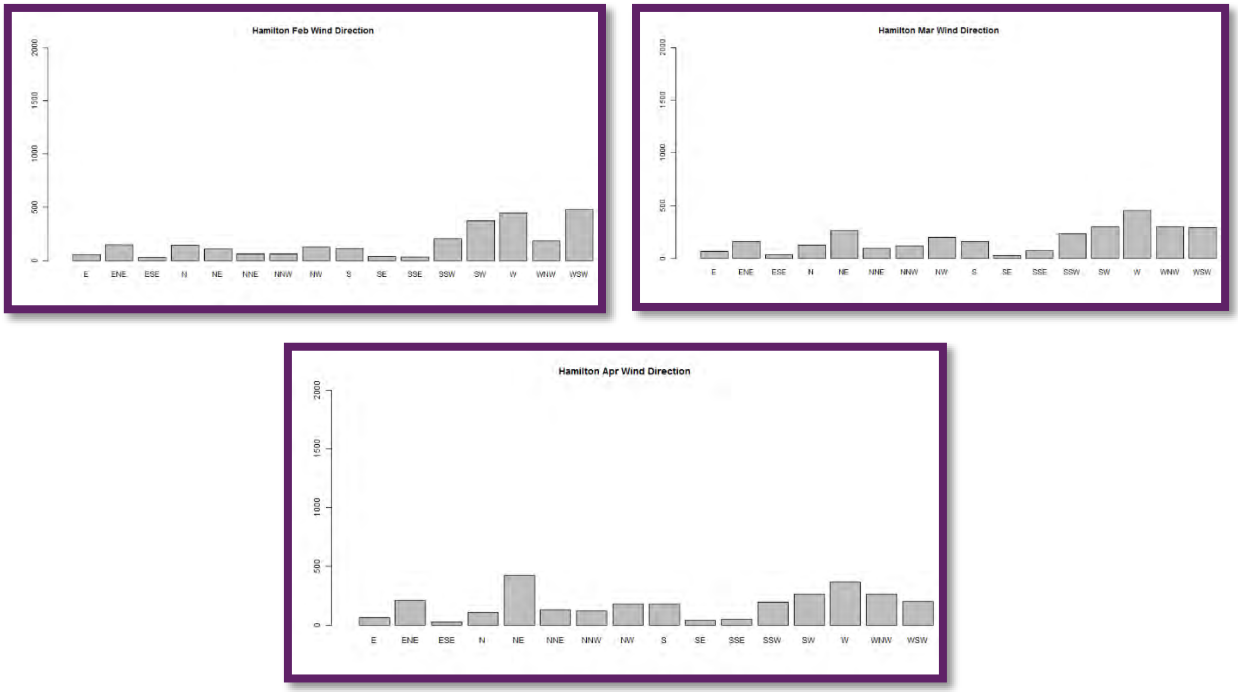
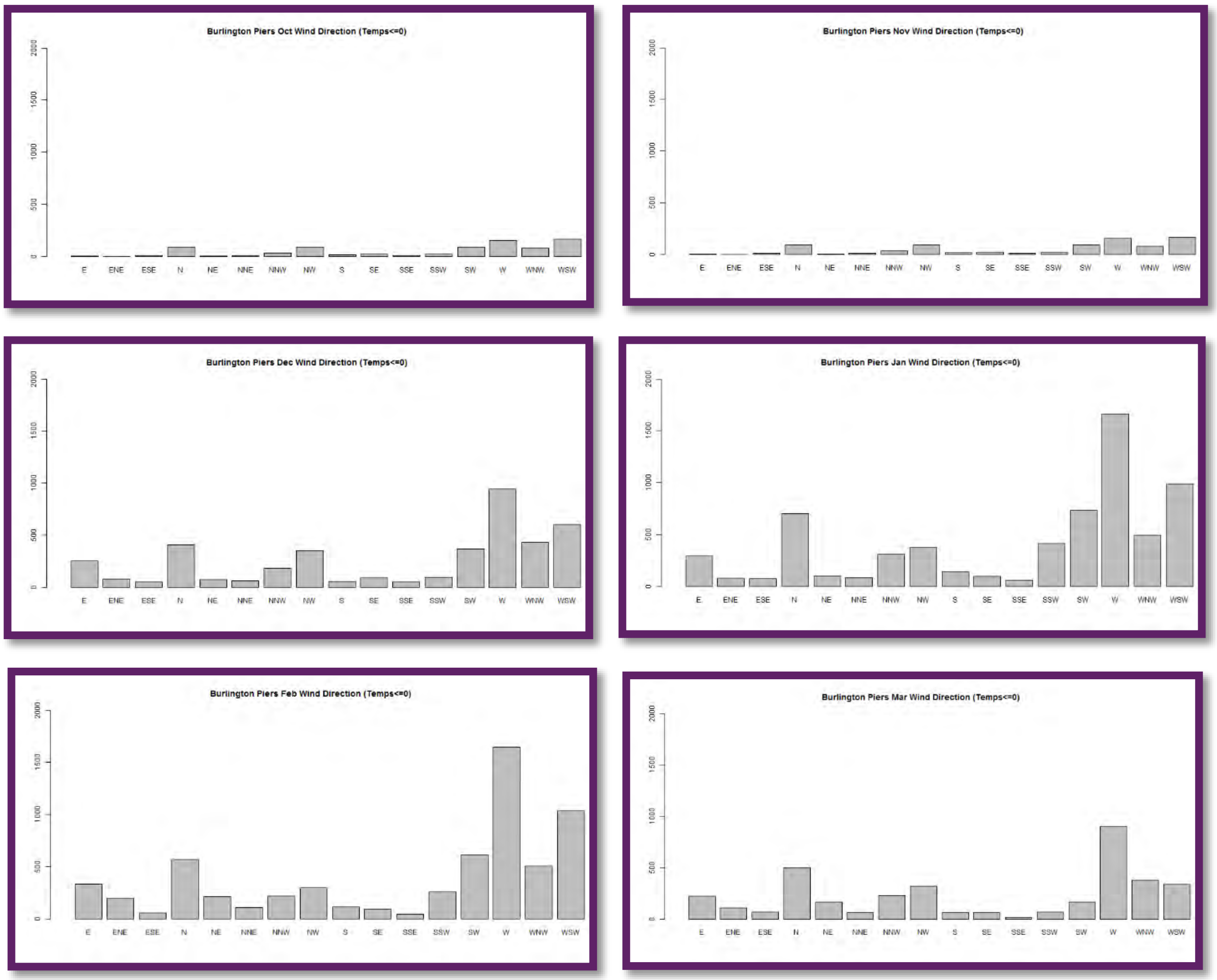


Figure 7. The prevailing winds from Hamilton Airport weather station for the months of October through April (2011-2015).

B. PREVAILING WINDS UNDER FREEZING AND SUB-FREEZING TEMPERATURES

The tender fruits in the area are mostly affected by sub-freezing temperatures. Thus, the database used in the section above were filtered for temperatures at or below freezing to show the prevailing winds during such conditions.

The monthly prevailing wind direction at or below freezing point is shown in Figure 8 below. Westerly to southwesterly winds are prevailing at Burlington Piers and Hamilton during such conditions. Meanwhile, winds from the west to west-south-west are prevailing in the Vineland area during late fall and through early spring under freezing and sub-freezing temperatures.



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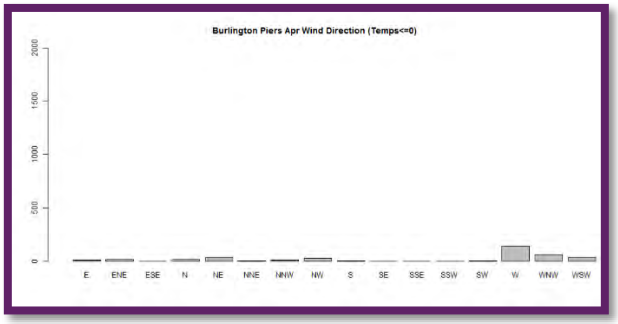

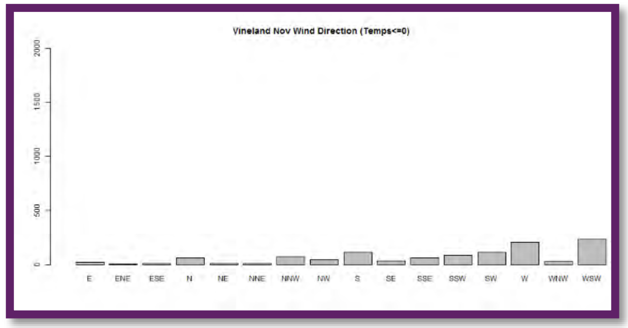

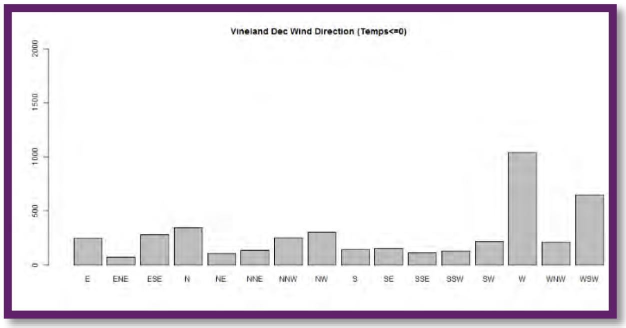

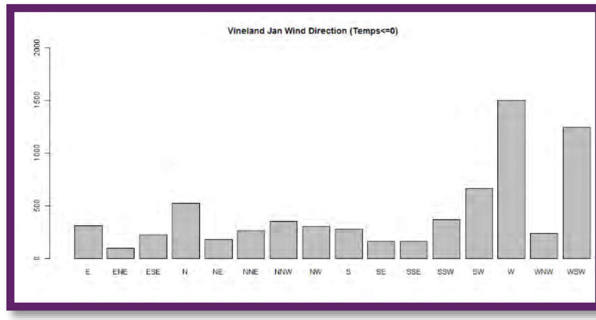

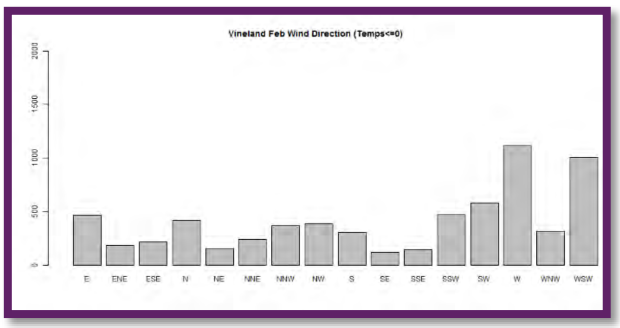

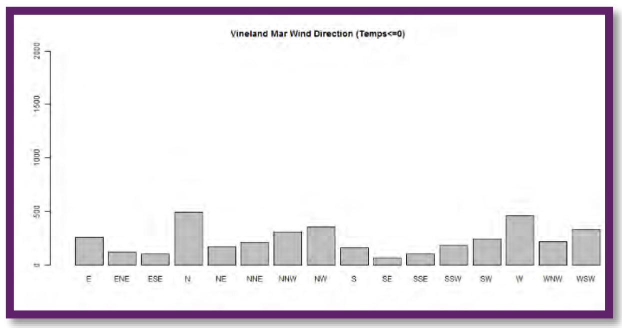

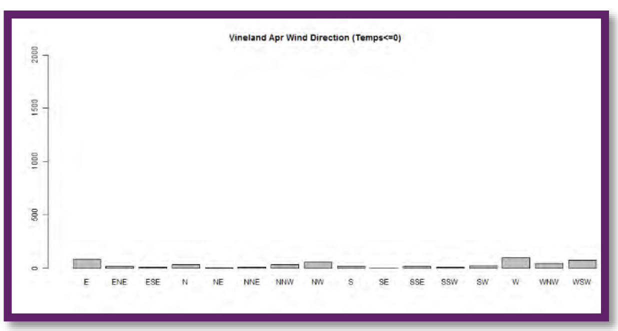

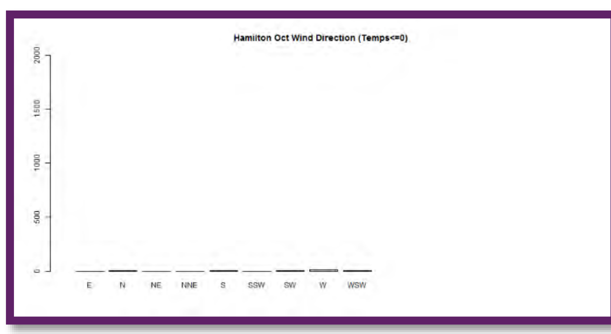

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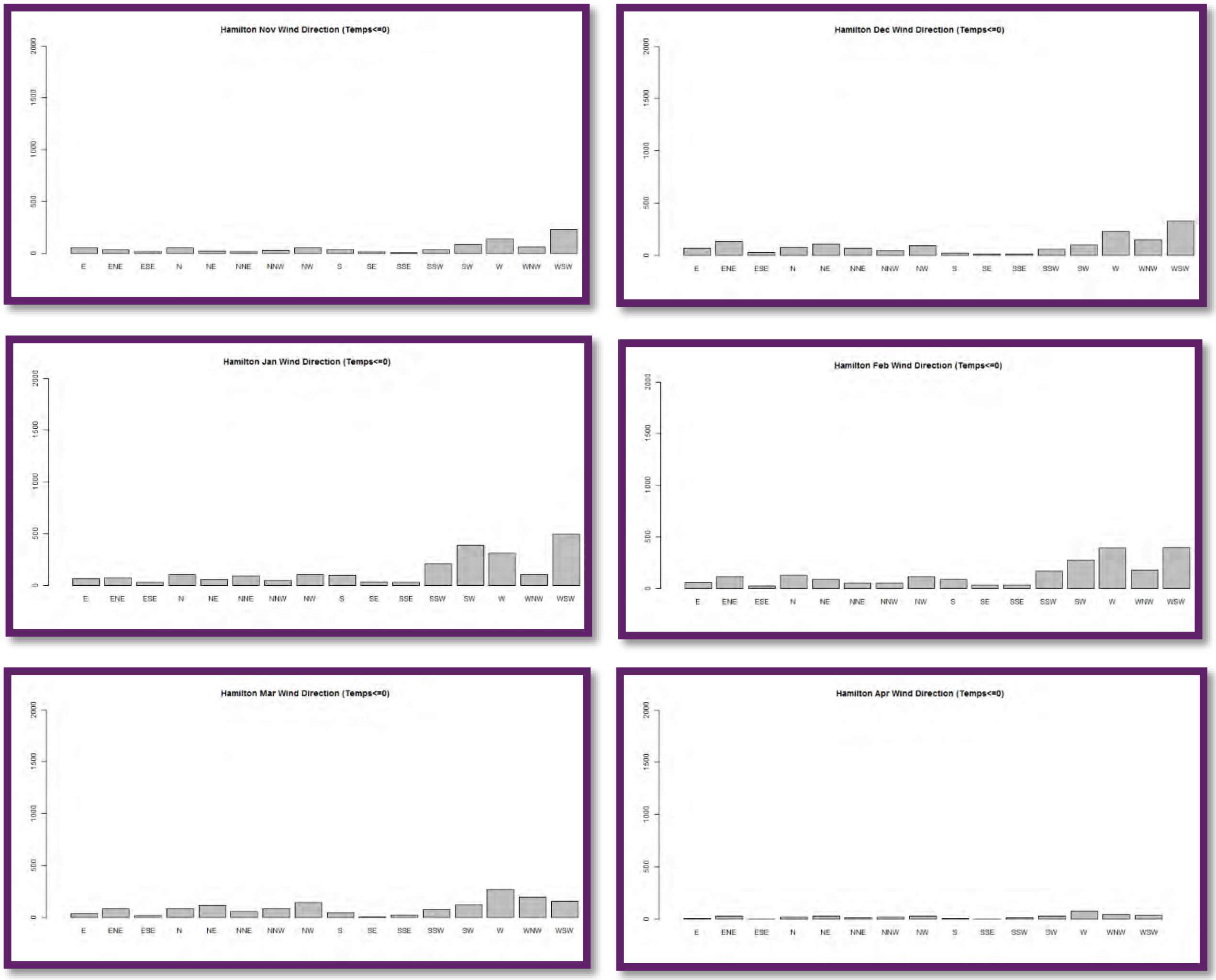
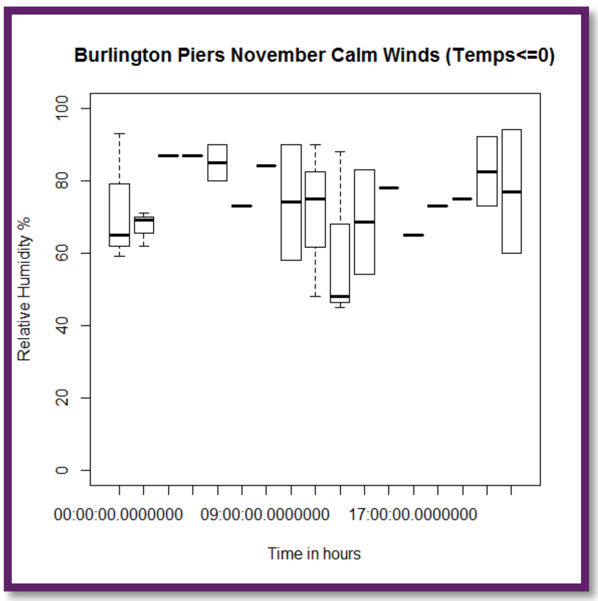


Figure 8. Late fall, winter, and mid-spring prevailing winds from the Burlington Piers weather station (Nov-Apr), the Vineland weather station (Oct-Apr), and Hamilton Airport weather station (Oct-Apr) at or below freezing temperatures.

C. PROBABILITY OF FROST OCCURRENCE

Frost is considered one of the main causes of significant losses to fruit crops. Cloud cover plays a major role in frost development besides other weather parameters. The Burlington Piers and Vineland weather stations are automatic reporting stations and lack any reports of cloud cover or weather condition reports (e.g. precipitation type, fog, freezing fog). To draw a generalized idea about the frequency of frost occurrence in the area, data from the three weather stations were filtered using relative humidity (equal or higher than 90%), air temperature (equal or below freezing), and calm wind conditions (less or equal to 4 km h^{-1}). The database from the Hamilton Airport weather station contains hourly weather reports which will be discussed later.

Figures 9 through 11 show the time in hours versus the relative humidity at the Burlington Piers, Vinland, and Hamilton Airport weather stations. Although the results in the three figures below show that the area is prone to frost event, the Vineland region can be considered more susceptible to frost events due to its low elevation and geographical location in relation to the other sites (the median of the box and whisker plot of the Vineland area have higher frequency at or near the 90% relative humidity during evening and overnight hours). The figures also show that the frost potential extends longer at the Vineland region at the end of fall and early spring (i.e. November and March).



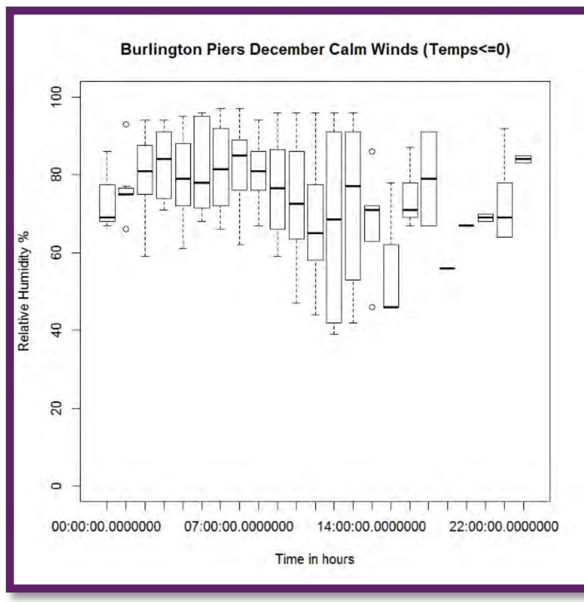


Figure 9 continues to the next page

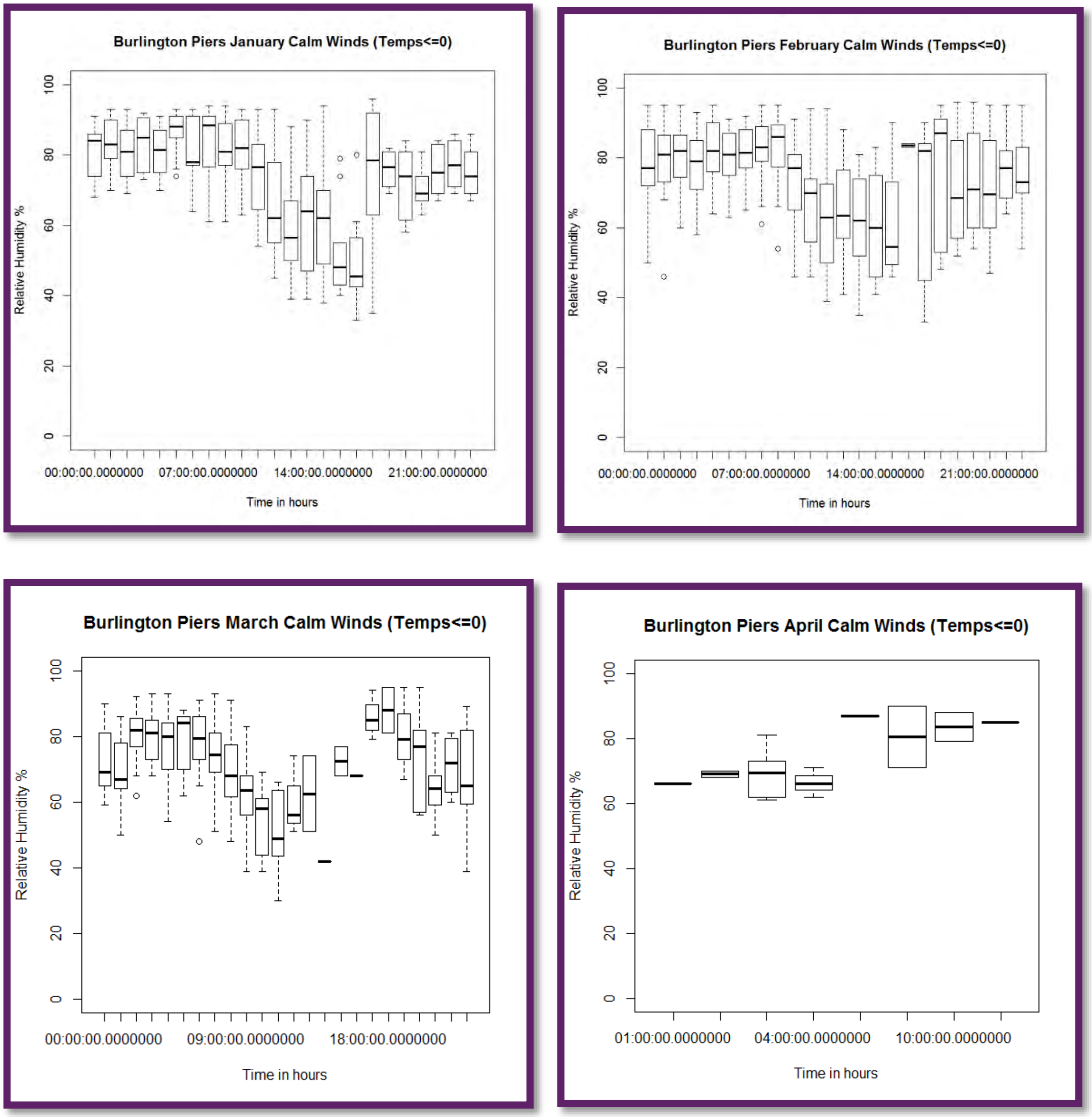


Figure 9. The temporal probability of frost occurrence for the Burlington Piers weather station (Nov-Apr) with calm winds and at or below freezing temperatures conditions.

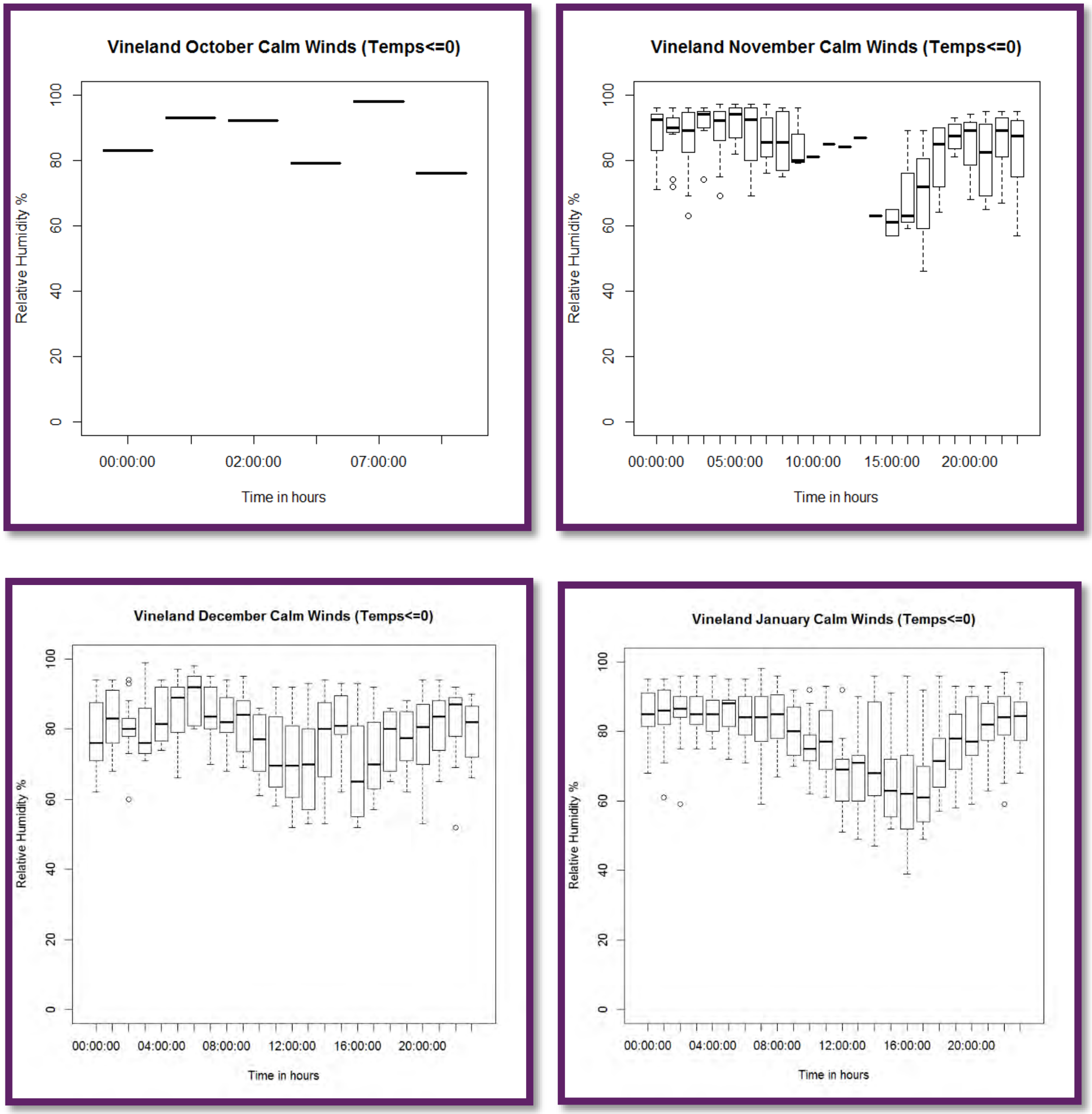


Figure 10 continues to the next page

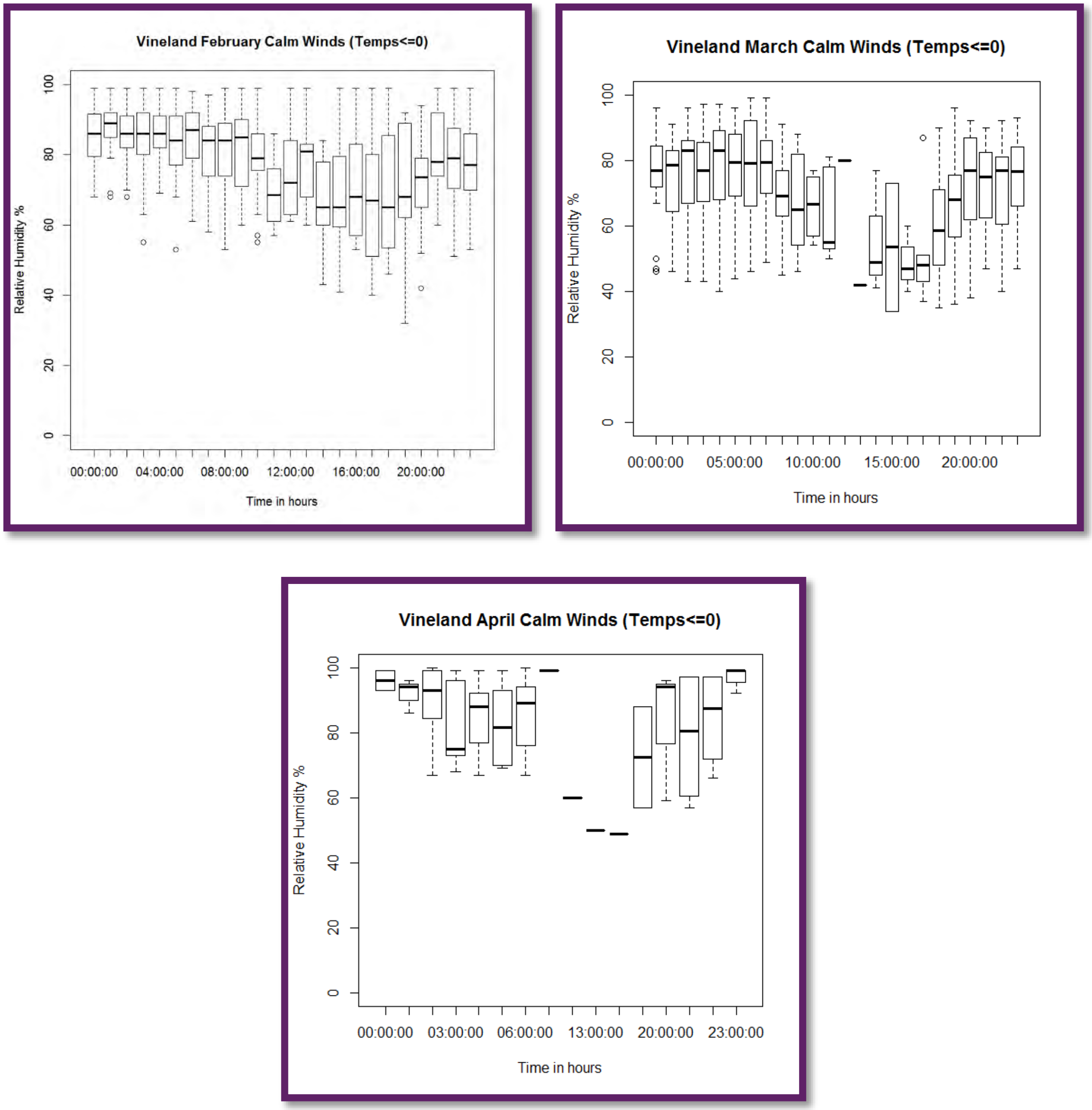


Figure 10. The temporal probability of frost occurrence for the Vineland region (Nov-Apr) with calm winds and at or below freezing temperatures conditions.

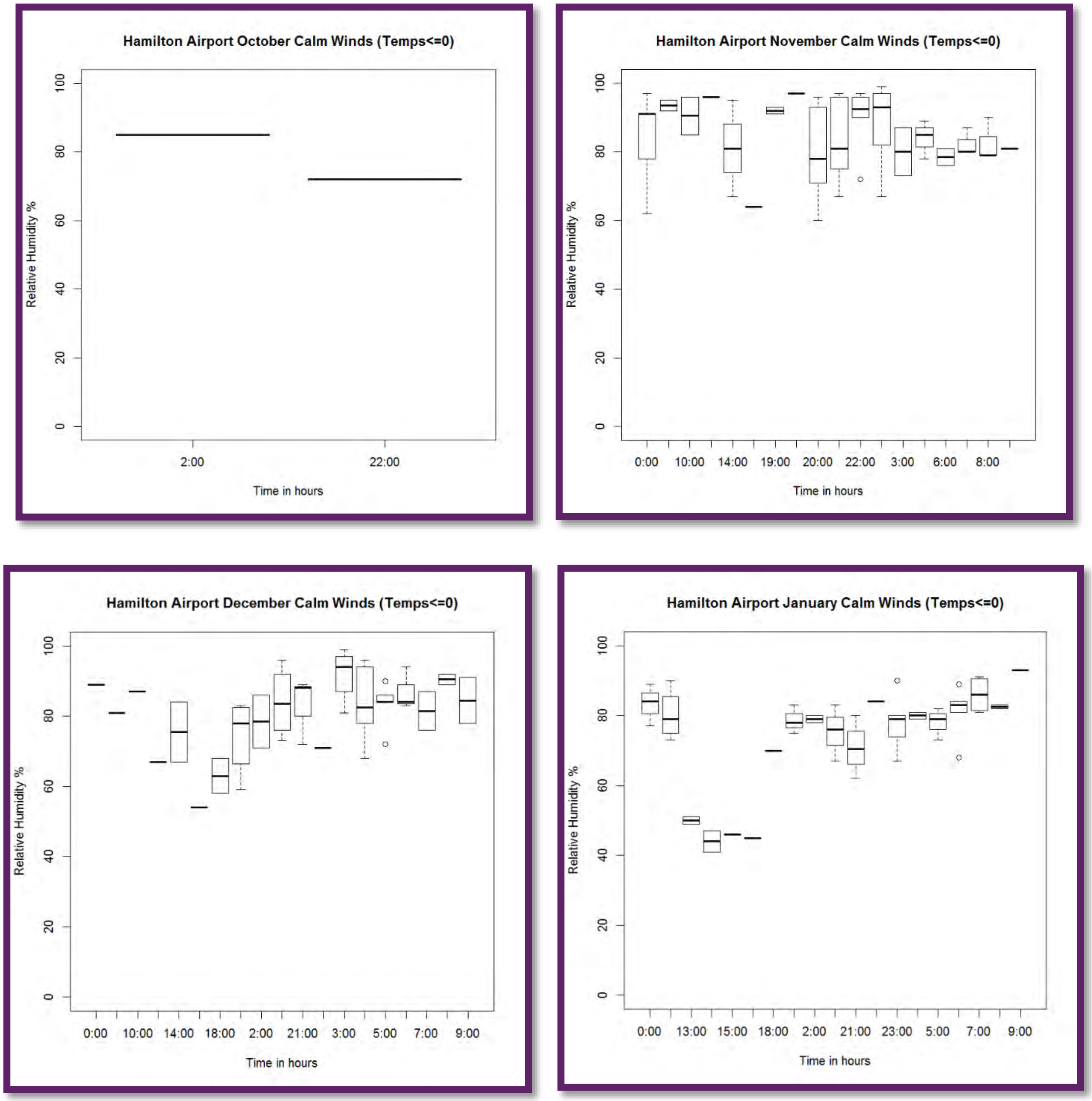


Figure 11. continues to the next page

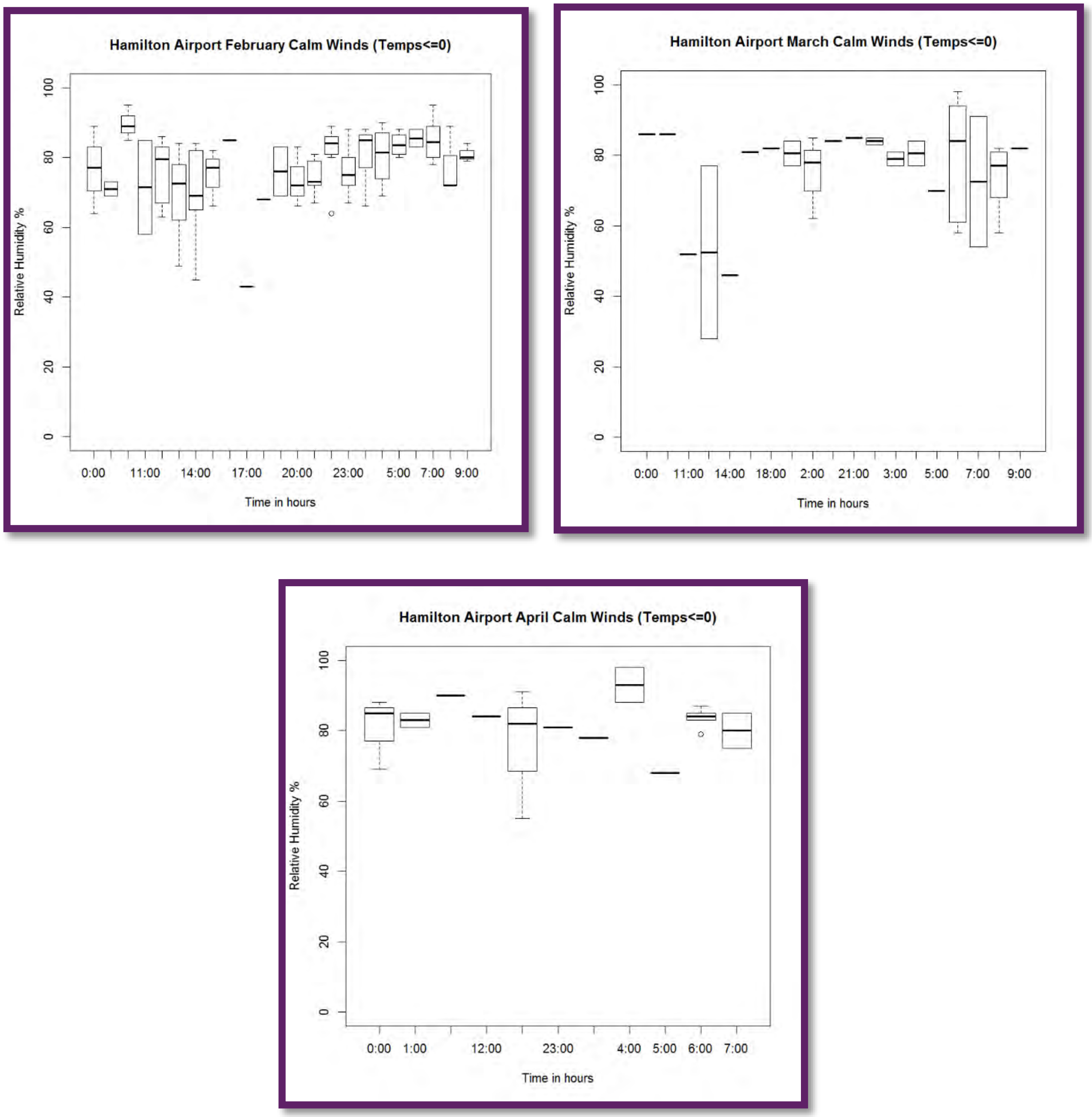


Figure 11. The temporal probability of frost occurrence for the Hamilton Airport weather station (Nov-Apr) with calm winds and at or below freezing temperatures conditions.

D. FOG AND FREEZING FOG

As mentioned earlier, the Hamilton Airport weather station reports hourly weather conditions. Figure 12 shows the westerly and southwesterly winds are more common during fog incidences. In addition to the southwesterly to west-south-west wind component, the northeasterly winds are also common during freezing fog cases as seen on the figure to the left. Higher frequency of fog was reported during December and February, then followed by November and January with lesser reports during March, April, and October, respectively, as seen in figure 13. Whereas, higher occurrences of freezing fog were recorded in February, with lesser reports during November, January, and December, respectively. The historical weather data also show that the majority of the reported fog and freezing fog incidences were associated with movement of larger weather systems and distinct air masses as indicated by the higher wind speed.

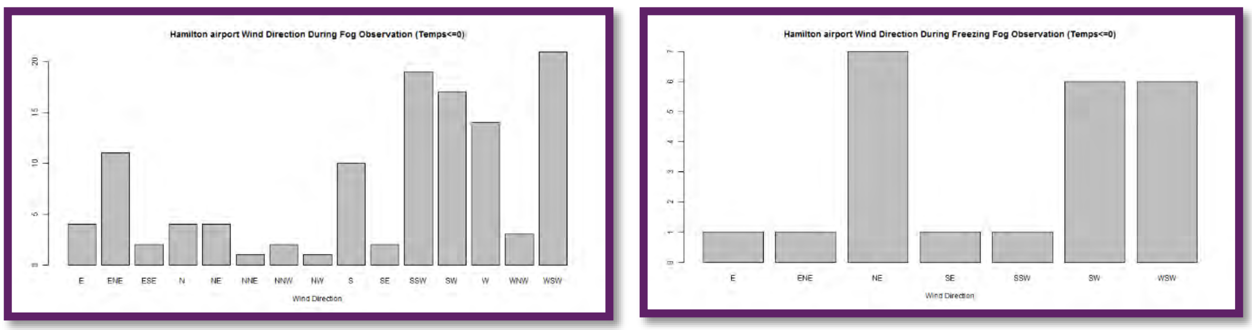


Figure 12. Wind directions during fog (right) and freezing fog (left) observations at the Hamilton Airport weather station (2011-2015).

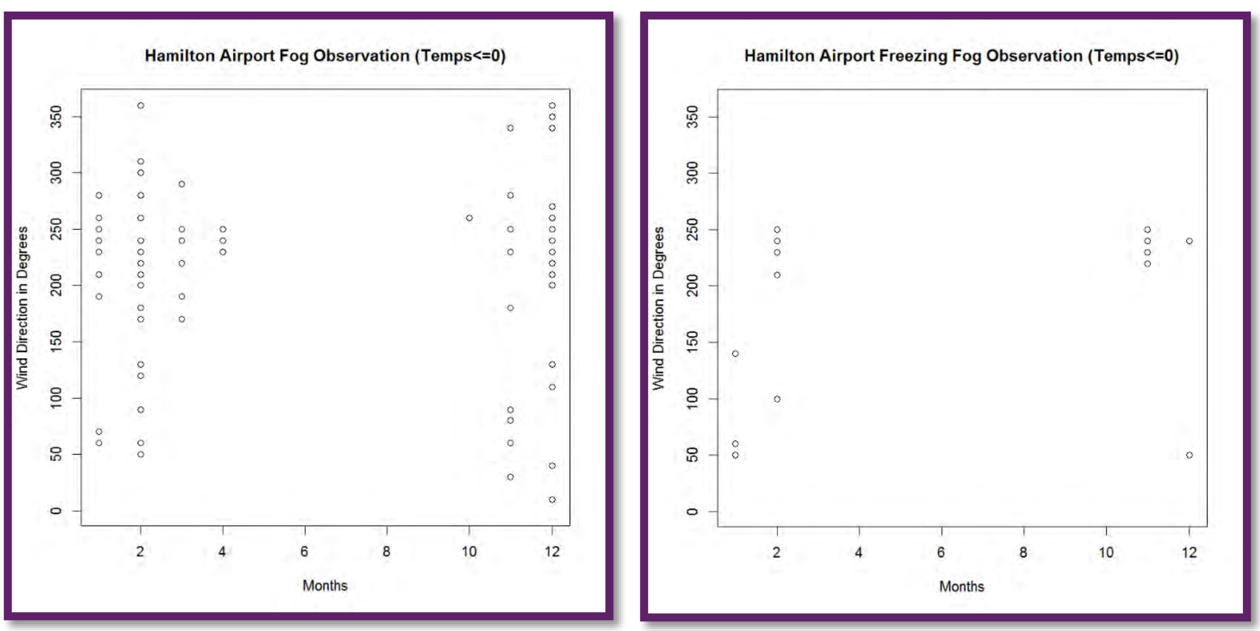


Figure 13. Fog (right) and freezing fog (left) observation during each month at the Hamilton Airport weather station (2011-2015).

6. TOPOGRAPHY

The area under proposed development in the PLAN is approximately 1 km^2 as shown in the grey shaded region below in Figure 14. The area is located between the Niagara Escarpment to the south and Lake Ontario to the north. The area bounded by the Niagara Escarpment and the PLAN is much steeper than the area between the development and Lake Ontario. The ground at the top of the Niagara Escarpment is standing at ~200 m above mean sea level (MSL) and the ground elevation descends steeply northward towards the PLAN area. The ground elevations within the PLAN are ranging between 89 to 98 m above MSL, whereas the steepest gradient of the landscape lies on the eastern part of the PLAN area. There is a gradual decrease in the landscape elevation starting from the northern boundary of the PLAN with heights reaching ~86 m above MSL at the railway track, and ending at ~80 m above MSL at the shorelines of Lake Ontario.

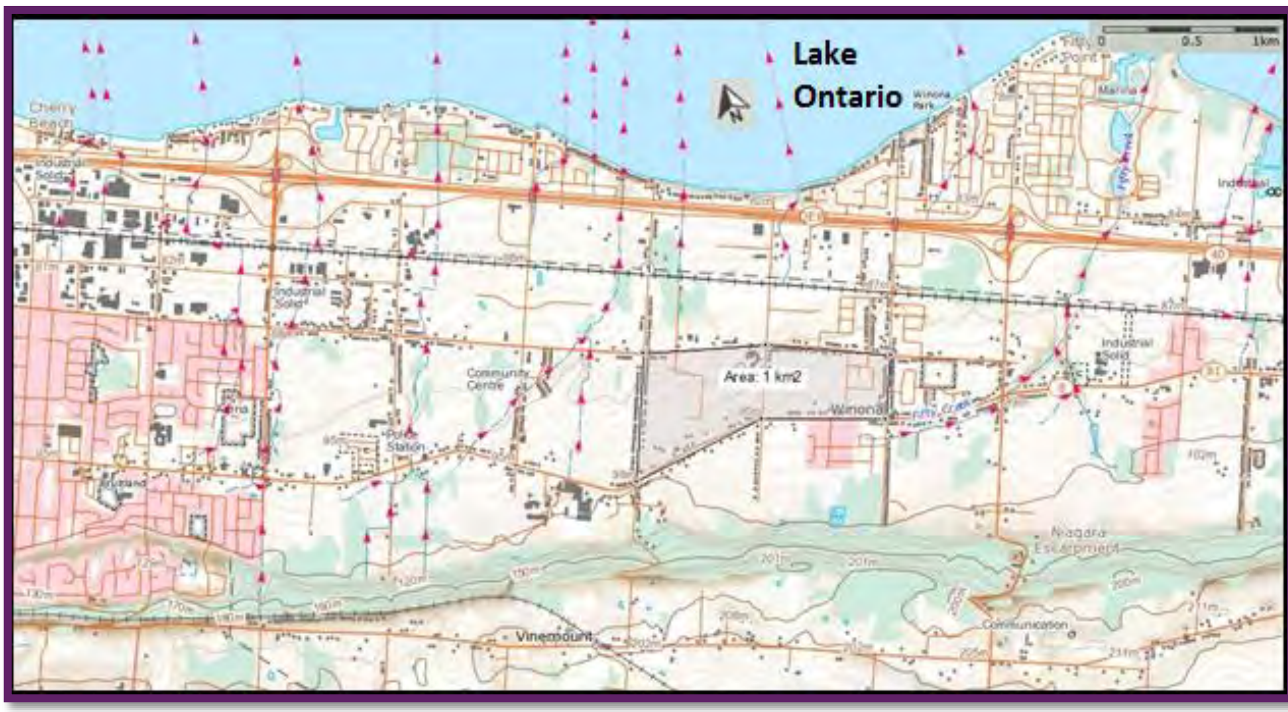


Figure 14. Topographical map of the area. ©Natural Resources Canada.

7. WINTER INJURY

As mentioned earlier in the document, damage to plants from frost events is an important factor for consideration. Due to the unique mesoclimate of the Niagara Peninsula below the escarpment, production of tender fruit and wine grapes is possible in this region of Hamilton. These types of plants are also prone to injury from severe low winter temperatures or winter freeze events.

As with frost events that may occur while the plants are actively growing, advective and radiative freeze events can occur while the plants are dormant. If the temperature reaches low enough values, bud and wood injury can occur at different times of the dormant period (from leaf fall until bud break the following spring). Plants become hardier to cold temperatures throughout the fall (acclimation) and then lose hardiness as they approach bud break in the spring (deacclimation). Ongoing information on plant hardiness status for grapes can be found at www.ccovi.ca/vine-alert and for tender fruit at www.tenderfruitalert.ca.

The location of this development should not impact the natural katabatic movement or ground flow of air during the winter months (Section 5B). The elevation drop from south to north will continue to allow for natural drainage of cold air towards Lake Ontario as has naturally occurred over time (Section 6). Road orientation will allow for ongoing natural airflow and structures should not impede natural air movement nor create new cold air pockets or pools during the winter months.

8. SUMMARY AND CONCLUSION

The requirement of the Block 3 Servicing Strategy Area (the PLAN) outlines the developed with a majority of low to medium density dwelling units, Neighbourhood Parks, SWM facilities, institutional, and local commercials.

The analysis of weather data obtained from the three nearby weather stations (Vineland, Burlington Piers, and Hamilton Airport) concluded that the prevailing winds are from the west and southwest direction and the analysis of the temperature observations obtained showed the Vineland area as the most moderate temperature-wise among the three stations. The archived observations from the Hamilton Airport weather station showed that highest fog incidences happened during December and February, while February was found to be the month with the highest number of reported freezing fog. The westerly and southwesterly winds were the dominant direction during fog events whereas northeasterly, southwesterly, and west-south-west winds were dominant during freezing fog events.

Following the desktop analysis of the microclimate in the Fruitland-Winona area, the proposed development inside the PLAN area (Figure 3) is not expected to block the southwesterly-to-northeasterly direction air flow. The development inside the PLAN area may assist in mixing the boundary air layer (a layer near the ground) by creating eddies (turbulences), thus aid in streaming any cold air descending from the Niagara Escarpment. This process would prevent air stagnation and facilitate air flow into Lake Ontario. Meanwhile, the existing and proposed local roads (McNeily Road, Collector Road “E”, Lewis Road, and Collector Road “D”) and the natural open spaces outlines in the PLAN will further help to channel the air downstream toward Lake Ontario.

9. REFERENCES

- Soler, M. R., C. Infante, P. Buenestado, and L. Mahrt, 2002. Observations of nocturnal drainage flow in a shallow gully, Boundary-Layer Meteorology V.105. pp. 253–273, doi:10.1023/A:1019910622806.
- Fraser, H., K. Slingerland, K. Ker, K. Fisher, and R. Brewster. 2009. Reducing cold injury to grapes through the use of wind machines, Final report: CanAdvance Project # ADV-161. Nov. 2005 - Nov. 2009. 30 pp.
- Historical Climate Data (http://climate.weather.gc.ca/)
- Natural Resources Canada (http://atlas.gc.ca/toporama/en/)
- Ontario Ministry of Municipal Affairs-Ministry of Housing (http://www.mah.gov.on.ca/Page13785.aspx)
- Google Earth (https://www.google.ca/earth/)

APPENDIX - RESUMES

DIAR HASSAN, PH.D., P.MET.

ATMOSPHERIC SCIENTIST

CORE SKILLS

- Dual-polarimetric and conventional Radar-based Rainfall Algorithms
- Dual-polarimetric and conventional Radar-based Snow-Water Equivalent Algorithms
- Dual-polarimetric and conventional Radar-based Solid Snowfall Algorithms
- Meteorological Consultation and tailored weather forecast for an array of commercial clients
- Weather observation field campaigns
- Weather Forecasting
- Seasonal forecasting

PROFESSIONAL SUMMARY

Dr. Hassan is an accredited Professional Meteorologist with a decade of experience. He has served as a consultant meteorologist for an array of clients such as energy, transportation, airport ground operation, school boards, municipalities, film Industry, consultant Engineering companies, and sport and social events.

As a seasonal forecaster, Dr. Hassan possesses nine years of experience in producing and briefing the North American seasonal outlook. He was presented as an expert subject matter on different media platforms.

Challenged by the low radar-based estimation of snow-water equivalent, Dr. Hassan focused his Ph.D. project on improving such estimation through the use of conventional and dual-polarimetric weather radars. He established an algorithm that better estimate snow-water equivalent than the currently employed one by the Canadian Radar Network. Furthermore, he established a new algorithm that directly estimates solid snowfall rates. The latter algorithm provides crucial information to different industries, particularly to the transportation sector.

The decision to gradually upgrade the Canadian Radar Network and equip them with dual polarimetric capabilities intrigued Dr. Hassan, and he, therefore, establish new polarimetric-based algorithms that estimate rainfall rates. Moreover, he devised a logic tree that optimizes on rainfall estimation by selecting a specific algorithm based on the polarimetric radar variables.

Dr. Hassan has a wide range of academic experience as a lecturer at different academic levels up to the graduate level. He held the position of an academic supervisor for six years, during which he was responsible for the management and liaison of a wide range of academic activities.

PROFESSIONAL QUALIFICATIONS/REGISTRATION(S)

Professional Meteorologist Accreditation (Operation), ECO Canada, 2018

Professional Meteorologist Accreditation (Research), ECO Canada, 2018

EDUCATION

Ph.D. Dual and Conventional Weather Radar-Based Precipitation Algorithms, Dept. of Earth Science and Space, York University, Toronto, Ontario, 2015

Project Management Certificate, Sheridan College, Oakville, Ontario, 2009

M.Sc. Dual-polarimetric radars, Dept. Of Meteorology, Al-Mustansiriya University, Baghdad, 1998

B.Sc. Physics/Meteorology, Dept. Physics, Al-Mustansiriya University, Baghdad, 1996

MEMBERSHIPS/AFFILIATIONS

Canadian Meteorological and Oceanographic Society (CMOS)

American Meteorological Society (AMS)

LANGUAGES

English, Kurdish, Arabic, and fair knowledge of French

Employment History

Amec Foster Wheeler, Ottawa, Ontario, Atmospheric Scientist, Dec 2015 to present.

York University, Toronto, Ontario, Research Associate, Nov 2015.

Pelmorex/The Weather Network, Oakville, Ontario, Consultant Meteorologist, 2006 to 2015.

Pelmorex/The Weather Network, Oakville, Ontario, Seasonal Forecaster, 2007 to 2015.

A private entity, Abu Dhabi, UAE, Academic Supervisor, 2001 to 2006.

AIS, Abu Dhabi, UAE, Lecturer, 1999 to 2001.

Al-Mustansiriya University, Baghdad, Lecturer, 1998 to 1999.

Publications and Conferences

- Hassan, D., P. A. Taylor, G. A. Isaac, 2017: “Snowfall Rate Estimation Using C-Band Polarimetric Radars”, Meteorol. Appl. Accepted.
- Hassan, D., P. A. Taylor, G. A. Isaac, 2017: “C-Band Polarimetric-Based Rainfall Estimation”, Submitted.
- Hassan, D., P. A. Taylor, G. A. Isaac, 2017: “Solid Snowfall Rate Estimation Using a C-Band Radar”, to be submitted.
- Hassan, D., G. Isaac, and P. Taylor, 2013: “Snow Liquid Water Equivalent Estimation from Polarimetric Weather Radar Perspective”, Eastern Snow Conf., Huntsville, Ontario.
- Hassan, D., G. Isaac, and P. Taylor, 2012: “Estimating Snowfall Rate Using WKR Polarimetric Radar Data”, CMOS Montreal, Quebec.
- Boodoo, S., D. Hudak, M. Leduc, A. Ryzhkov, N. Donaldson and D. Hassan, 2009: "Hail detection with a C-Band dual Polarization radar in southern Canada." AMS 34th Conference on Radar Meteorology, Williamsburg, VA, USA.
- Hassan, D., R. Al-Naimi, and K. Al-Jumaily, 2001: “Depolarization effects due to some atmospheric constituents”. Al-Mustansiriya J. Sci., vol. 12, No. (2), pp 171-178.

Project

- **Air Drainage Analysis City of Hamilton: Fruitland-Winona (2017)**
  Study the effect of the new development of the microclimate and their subsequent effect on the tender fruits in the area.
- **Borden Gold Project, Chapleau, Ontario (2017)**
  A comprehensive climate study for the area, including Temperature, Precipitation, IDF curves, Evapotranspiration, and Windrose.
- **Maintenance Decision Support System (MDSS) (2016-2017)**
  Upgrade the current MDSS Maritimes client pavement treatment.
- **Votgle Plant Local Intense Precipitation and Warning Time Evaluation, Southern Nuclear, United States (2016)**
  Investigate into extreme precipitation events in the southeastern United States, including storm identification, data collection, storm typing, and reporting.

RON BIANCHI, BSC (HON) BCERT FRMETS

SENIOR ASSOCIATE – DIRECTOR OF STRATEGIC DEVELOPMENT CLIMATE AND TERRESTRIAL WEATHER - MET-OCEAN SERVICES

CORE SKILLS

- Project Management and Application Development
- Client Relationship Development
- Expert in Meteorological Sciences and Climate Change Analysis
- Meteorological applications in Mining, Energy/Power, Insurance, Infrastructure, Aviation and Environmental Assessment

PROFESSIONAL SUMMARY

Ron Bianchi is a senior associate specializing in the fields of meteorology, atmospheric sciences, and climate change. Ron has over twenty-five years' experience managing clients and projects in many verticals including meteorological forecasting, energy, power, insurance, infrastructure, aviation, environmental assessments, air permitting, and mining. Ron specializes in developing unique meteorological services, such as technical/scientific reports and studies, specific weather forecast products, atmospheric modeling with various in-house models, baseline climate and climate change analysis reports. Additional services such as meteorological instrumentation installation and training Ron specializes in the area of applied industrial meteorology via meteorological operations, project execution, business development, and strategic planning, in both the public and private sectors.

- Over twenty-five years of forecasting experience in the private and government sectors;
- Expert knowledge of meteorological production and dissemination methods;
- Reputation for leadership within organizations and within the meteorology profession;
- Able to bridge government and private sectors to exchange technology, training, and business plans;
- A deep understanding and proficient with all meteorological models;
- Extensive experience with various meteorological monitoring observing systems and their specific applications;
- Able to quickly put new meteorological technology into operation;
- Exceptional communication and interpersonal skills that clients and internal staff;
- In-depth knowledge of principles and methods for curriculum and training design;
- Highly sophisticated analytical skills, and strong ability to assimilate complex concepts and translate them into real-world results.

Ron's position at Amec Foster Wheeler as a senior associate and Director of Strategic Development for the Met Oceans group will provide guidance to the group's growth and new business opportunities, along with applying his expertise within the Met-Ocean group and internal and external clients.

PROFESSIONAL QUALIFICATIONS/REGISTRATION(S)

Certified Project Manager, 2010

EDUCATION

BSc (Hon) in Physics and Meteorology – University of Toronto, (1987)

Ivey School of Business, University of Western Ontario, Executive Management Program (2000)

Canada School of Public Service- Federal Service (2005)

MEMBERSHIPS/AFFILIATIONS

American Meteorological Society-Professional Member

Royal Meteorological Society – Professional Member and Fellow

Canadian Meteorological and Oceanographic Society- Past President, current member

Australian Meteorological Society-Professional Member

National Weather Association –Professional Member

American Geophysical Union-Member

LANGUAGES
English

EMPLOYMENT HISTORY
Senior Associate, Director of Strategic Development - Climate and Terrestrial Weather - Met-Ocean Services - current

PANAM Lead Meteorologist, Sailing Venue RCYC at Toronto 2015 Pan/Parapan American Games

February 2015 to July 2015

Director of Meteorology, Atmospheric Group Manager at Golder Associates - Environmental Sciences

Division, 2007 to 2015

Vice President of Meteorology and Executive Meteorologist at The Weather Network/MeteoMedia,

1997 to 2007

Operations Manager, Ontario Storm Prediction Centre at Environment Canada - Meteorological

Service of Canada (Federal Government), 2005 to 2006
Primary Load Forecast Meteorologist - Weather Services Operations Planning & Interconnections at

Independent Electricity System Operator (IESO) 1996 to 1997

REPRESENTATIVE PROJECTS
Weather Forecasting

PANAM TO2015 Games - Toronto, Ontario, Canada

Lead meteorologist - providing detailed meteorological forecasts specifically geared to competitive sailing. Designing state-of-the-art meteorological workstation and WRF Modelling for advanced forecasting and warning capabilities. Daily briefings with venue operators, race committee, coaches, and athletes. Ensuring all involved are provided with the most accurate weather forecasts and warning system that ensured their safety and security during the games.

Chase Energy Canada Limited - Alberta, Canada

Provide weekly rolling temperature forecasts for all of Canada. The forecasts consisted of a graphical product displaying trends of warmer to cooler than normal conditions for all regions of Canada. Along with a brief commentary on current Meteorological trends that might impact energy production across the country.

City Oakville Storm Water Monitoring

Weather tracking/ high-resolution precipitation forecasts. Oakville, Ontario, Canada. Provide high-resolution precipitation forecasts specific to the city of Oakville to enable storm monitoring teams to capture stormwater and provide analysis. Forecasts were provided via email and telephone consultation along with weather briefings to provide "go-no-go" on weather events that met various City of Oakville criteria.

National Pre Olympic Qualifiers – Vancouver, Canada

Provided the Ontario provincial sailing team with high-resolution WRF model wind data (hourly and 1 km resolution) over the race area of the event. Daily weather briefings and tactical wind strategy consultation via the internet and telephone.

Canada Summer Games - PEI, Canada

Provide the Ontario provincial sailing team with high-resolution WRF model wind data (hourly and 1 km resolution) over the race area of the event. Daily weather briefings and tactical wind strategy consultation via the internet and telephone.

Alaska North Slope Liberty Geotechnical Project (Repsol) – Alaska, USA

Provided meteorological support for drilling operations. Daily weather forecasts (short and long-term), daily climatological data, atmospheric forecasted pressure trend, ice thickness and movement, tidal periods beneath the sea ice, specific surface weather forecast maps, and maintaining a continuous weather watch for warnings for a safe and secure working environment

Cliffs Natural Resources - Ontario, Canada

Provided biological survey teams (winter track count) with local aviation forecasts for low flying helicopter surveys. Along with wind, QPF, and visibility forecasts in designated areas, defined by the client.

Sir Adam Beck, OPG Niagara Fall, Ontario, Canada

Provided daily forecasts, with special attention to QPF (rainfall) during a construction phase for major repairs at Sir Adam Beck site. The forecast is used for planning of daily construction and safety of the crew. On-call briefings were also provided on active weather days.

Mining

Adriana Resources Inc. - Lac Otelnuk Mining Ltd. - Northern Quebec, Canada

Installed weather station and set up a monitoring program. Analysis and quarterly reports were produced and provided to various disciplines in hydrology, geology, geotechnical working groups. Provided baseline regional climate summary and analysis, and climate change work for Environmental Assessment.

Aurora Energy Ltd. Newfoundland, Canada

Installed weather station and set up a monitoring program. Analysis and quarterly reports were produced and provided to various disciplines in hydrology, geology, geotechnical working groups. Provided baseline regional climate summary and analysis, and climate change work for Environmental Assessment.

AREVA Resources - Nunavut, N.W.T., Canada

Provided the Probable Maximum Precipitation (PMP) for the Kiggavik project located west of Baker Lake, Nunavut. The objective of the report is to provide a precipitation value that will serve as a conservative basis of design for various engineered structures such as tailings management areas and water treatment ponds.

Trelawney Mining and Exploration Inc.-Northern Ontario, Canada

Installed on-site weather station is to capture the local weather effects. Set up a monitoring program. Analysis and quarterly reports were produced and provided to various disciplines in hydrology, geology, geotechnical working groups. Provided baseline regional climate summary and analysis, and climate change work for future Environmental Assessment.

Cliffs Natural Resources - Ontario, Canada

Installed on-site weather station for baseline data collection and providing maintenance of the station. Responsible for continued QA/QC and analysis of the recorded meteorological fields. Conducted MM5 and CALMET modeling northern Ontario and ferrochrome production facility. Climate baseline and climate change work for Environmental Assessment.

Focus Graphite – Quebec, Canada

Installed on-site weather station for baseline data collection and providing maintenance of the station. Responsible for continued QA/QC and analysis of the recorded meteorological fields. Conducted MM5 and CALMET modeling western Quebec. Climate baseline and climate change work for Environmental Assessment

Ivaco Rolling Mills – Quebec, Canada

Installed on-site weather station for baseline data collection and providing maintenance of the station. Responsible for continued QA/QC and analysis of the recorded meteorological fields. Conducted MM5 and CALMET modeling southern Quebec. Climate baseline and climate change work for Environmental Assessment

Globestar Moblan – Northern Quebec, Canada

Installed on-site weather station for baseline data collection and providing maintenance of the station. Responsible for continued QA/QC and analysis of the recorded meteorological fields. Conducted MM5 and CALMET modeling northern Quebec. Climate baseline and climate change work for Environmental Assessment.

Walker Aggregates- Ontario, Canada

Duntron Weather station repair and calibration. Conducted micro climate study of possible effects due to expansion of the aggregate pit on a specific and rare fern plant species.

Focus Graphite – Quebec, Canada

Installed on-site weather station for baseline data collection and providing maintenance of the station. Responsible for continued QA/QC and analysis of the recorded meteorological fields. Conducted MM5 and CALMET modelling western Quebec. Climate baseline and climate change work for Environmental Assessment

Cliff Mine Site and Cliffs FPF Site – Northern Ontario, Canada

Installed on-site weather station for baseline data collection and providing maintenance of the station. Responsible for continued QA/QC and analysis of the recorded meteorological fields. Conducted MM5 and CALMET modelling northern Ontario and ferrochrome production facility. Climate baseline and climate change work for Environmental Assessment

Walker Aggregates- Ontario, Canada

Duntron Weather station repair and calibration. Conducted micro climate study of possible effects due to expansion of the aggregate pit on a specific and rare fern plant species.

Hammond Reef – NW Ontario, Canada

Installed on-site weather station for baseline data collection and providing maintenance of the station. Responsible for continued QA/QC and analysis of the recorded meteorological fields. Conducted MM5 and CALMET modelling northern Quebec. Climate baseline and climate change work for Environmental Assessment.

Barrie Landfill – Barrie, Ontario, Canada

Installed on-site weather station for baseline data collection and providing maintenance of the station. Responsible for continued QA/QC and analysis of the recorded meteorological fields. Developed a dust and odor mitigation process.

Prodigy Gold – NW Ontario, Canada

Installed on-site weather station for baseline data collection and providing maintenance of the station. Responsible for continued QA/QC and analysis of the recorded meteorological fields. Climate baseline and climate change work for Environmental Assessment

Morelos Mining Operations – Mexico

Installed on-site weather station for baseline data collection and providing maintenance of the station. Responsible for continued QA/QC and analysis of the recorded meteorological fields. Climate baseline and climate change work for Environmental Assessment

Kabanga Nickel – Africa

Installed on-site weather station for baseline data collection and providing maintenance of the station. Responsible for continued QA/QC and analysis of the recorded meteorological fields. Climate baseline and climate change work for Environmental Assessment. Particular attention to the boundary layer winds and production of wind-roses for each day and month for air dispersion modelling.

Climate Studies and Climate Change Analysis

Region of Waterloo- Ontario, Canada

Provide an overall objective of the climate analysis is to prepare a summary of climate data for the Region of Waterloo that will help it understand the current climate conditions, how this climate has changed over the past 30 years or so, and how the climate is projected to change in the near future. This detailed analysis will provide the basis for initiating discussion of an adaptation strategy; and discussion of the possible need for an improved assessment of short term weather forecasting. The focus of the report was for the hydrology group in the Region of Waterloo.

Onca Puma Microclimate Assessment - Puma, Brazil

Technical report in a micrometeorological assessment of the possible effects of the molten slag dump on the local meteorology and climate. Responsibilities included meteorological data analysis, development of several meteorological data sets for heat transfer models, local climate data analysis and assessment of potential microclimate impacts.

Town of Sombra, Ontario, Canada

Technical Memorandum will describe the severe precipitation event recorded in Sombra Ontario. The Technical memorandum described the synoptic large scale event that led to the severe precipitation event.

NWMO - Nuclear Waste Management Organization (NWMO), Ontario, Canada

Several locations (14) studies and technical memorandums regarding baseline climate and climate change possibilities

And long term effects for the various project sites.

PIEVEC – Infrastructure Ontario Climate Change Vulnerability Assessment – Ontario, Canada

Provide an overall objective of the climate analysis is to prepare a summary of climate data that will help it understand the current climate conditions, how this climate has changed over the past 30 years or so, and how the climate is projected to change in the near future. Then developed working training sessions with various internal PIEVEC members.

Walker Aggregates – Microclimate study on plant species

Technical report in a micrometeorological assessment of the possible effects expansion on the local meteorology and climate. Responsibilities included meteorological data analysis, development of several meteorological data sets local climate data analysis and assessment of potential microclimate impacts on various plant species.

POWER/Energy

Wind Energy Inc. Galetta, Quebec

Preliminary analysis of a potential wind energy project in the Quebec region. Used existing data to assess the physical and wind characteristics of the site and forecast wind energy potential based on historical and modelled MM5 data. Responsible for CALMET modelling to downscale RUC model output, conducting wind analysis on refined spatial resolution to locate the maximum wind potential energy and comparison study using on-site surface station data.

Windfield Energy Inc. Ontario, Canada

Provided Windfield Energy Inc. to carry out a preliminary analysis of a potential wind energy project in the Ottawa region. Used existing data to assess the physical and wind characteristics of the site and forecast wind energy potential based on historical and modelled MM5 data. Responsible for CALMET modelling to downscale RUC model output, conducting wind analysis on refined spatial resolution to locate the maximum wind potential energy and comparison study using on-site surface station data.

Teck Coal - Alberta, Canada

Provided Teck Coal Limited Cardinal River (Teck Coal) to carry out a preliminary analysis of a potential wind energy project at the Cardinal River site. Used existing on-site captured data to assess the physical and wind characteristics of the site and forecast wind energy potential based on historical and modelled MM5 data. Report included forecast wind energy potential based on historical data; Develop an energy production model based on installation scenarios, and Provide a financial analysis based on estimated project costs and energy generation.

Nanticoke New Nuclear Plant Build Project – Nanticoke, Ontario, Canada

Responsible for the completion of the air quality component of the EIS for Bruce Power - Nanticoke New Build. Responsibilities included installing meteorological on-site station, data analysis, development of several meteorological data sets for dispersion modelling, climate data trend analysis and assessment of climate change on the possible project.

Westcoast Connector Gas Transmission Project – B.C. Canada

Installed on-site weather station for baseline data collection and providing maintenance of the station. Responsible for continued QA/QC and analysis of the recorded meteorological fields. Conducted MM5 and CALMET modelling. Climate baseline and climate change work for Environmental Assessment. Provided Technical Report on the verification of on-site weather data to Environment Canada forecast weather data.

Modeling

Halton Region - Ontario, Canada

Conducted meteorological modelling using MM5 and CALMET for Halton Region air-shed study. The process in verifying and validating the quality of the meteorological data includes comparing with local surface stations, presenting annual, seasonal and day/night wind-roses, atmospheric stability, annual and seasonal mixing height, and average wind flow in the computational domain during Ontario smog days advisory.

Kinross Gold Operation - Chukotka Region, Russia

Conducted MM5 and CALMET modelling and provided detail analysis of MM5 and CALMET output. The analysis illustrates the model output capability to simulate down-slope and up-slope wind flows which usually occurs in mountainous region.

Air Drainage Analysis (Fruitland-Winona Tertiary Plan)

1312733 Ontario Inc.

Aurora Energy Ltd- Newfoundland, Canada

Installed on-site weather station for baseline data collection and providing maintenance of the station. Responsible for continued QA/QC and analysis of the recorded meteorological fields. Climate baseline and climate change work for Environmental Assessment.

Covanta/Green Island Energy – BC, Canada

Conducted MM5 and CALMET modelling and provided detail analysis of MM5 output. The analysis includes presentation of thermal induced wind flow in coastal region during high pressure system, model output verification using four surface stations in the region and wind pattern comparison to CMC model output presented by Canadian Wind Energy Atlas. The meteorological data provided to Covanta Energy to be used for air dispersion modelling has been peer reviewed by Dr. Joseph S. Scire of TRC and Dr. Li Huang of British Columbia Ministry of Environment. The reviewers have expressed great confidence for the data provided.

Xstrata - Sudbury, Ontario, Canada

The meteorological data set development to generate a three dimensional meteorological fields for 2008 to 2010 periods. The Calmet model is initialized by RUC (Rapid Update Cycle) model output and surface meteorological fields recorded at Sudbury Airport. Dr. Robert Bloxam and Dr. John Liu of Ontario Ministry of Environment reviewed and approved the use of the meteorological data for air dispersion modelling.

ExxonMobil – Halifax, Nova Scotia, Canada

Prepared meteorological dataset for air dispersion modelling and managed the air quality study for two ExxonMobil gas plants in Nova Scotia. The report of the study was well received during the presentation by ExxonMobil.

Health Canada Ottawa, Ontario, Canada

Conducted and MM5 and CALMET modelling for three Iron and Steel industries located in Ontario, Manitoba, and Alberta.

Diavik Diamond Mine- N.W.T.,Canada

Responsible for MM5 modelling, conducting wind analysis on refined spatial resolution to locate the maximum wind potential energy, and developing verification methodology to increase client's confidence in modelling output

Burnco – Ontario, Canada

Conducted MM5 and CALMET modelling and provided detail analysis of MM5 and CALMET output for air dispersion modelling.

Madawaska – Ontario, Canada

Conducted meteorological modelling using MM5, CALMET, and Aermod. The process in verifying and validating the quality of the meteorological data includes comparing with local surface stations, presenting annual, seasonal and day/night wind-roses, atmospheric stability, annual and seasonal mixing height, and average wind flow in the computational domain.

Insurance

Frank Cowan Company – Princeton, Ontario, Canada

Provide technical due diligence for weather forecasting needs and possible use for website for all their insurance clients. Provided final approval of certified government forecasts for website use.

Various Client members of Frank Cowan Company – Princeton, Ontario, Canada

Several Client of FCC were referred to complete several technical memorandums and weather/climate summaries for the various municipalities that are members of FCC.

PMP

Barrick Gold Corporation- Ontario, Canada

Estimated the Probable Maximum Precipitation for Barrick Gold - Hemlo property.

Areva Resources Canada Inc. - Nunavut, N.W.T., Canada

Estimated the Probable Maximum Precipitation for the area of proposed uranium mining and milling operation at Kivallik region. The probable maximum precipitation value will be used for tailing pond and dam design.

urbantech
west

APPENDIX E
FLUVIAL GEOMORPHOLOGY

E-1 Erosion Threshold Analysis (GEO Morphix, February 2020)

Urbantech West, A Division of Leighton-Zec West Ltd.
2030 Bristol Circle Suite 105   Oakville, Ontario   L6H 0H2
TEL: 905.829.8818
www.urbantech.com

APPENDIX E-1
Erosion Threshold Analysis (GEO Morphix, February 2020)

12-062 Block Servicing Strategy #3
Erosion Threshold Assessment

Unnamed Tributary of Lake Ontario
Hamilton, Ontario

Prepared for:
Block 3 Landowners Group
c/o Rob Merwin
720 Oval Court
Burlington, ON L7L 5K2

February 27, 2020
PN18099

GEO MORPHIX

Geomorphology
Earth Science
Observations

Report Prepared by:	GEO Morphix Ltd. PO Box 205, 36 Main St. N. Campbellville, ON L0P 1B0
Report Title:	12-062 Block Servicing Strategy #3 Erosion Threshold Assessment Reach LOT-1
Project Number:	PN18099
Status:	Final
Version:	1.1
Prepared by:	Andre-Marcel Baril, M.Sc.
Approved by:	Paul Villard, Ph.D., P.Geo.
Approval Date:	February 27, 2020

Table of Contents

Appendices

1 Introduction

This report summarizes an erosion assessment completed for an unnamed tributary in support of the 12-062 Block Servicing Strategy (BSS) #3 in the City of Hamilton, Ontario. An unnamed tributary of Lake Ontario was identified by the Hamilton Conservation Authority as requiring an evaluation of its erosion threshold. To do so, three reaches located downstream of the development were evaluated, and an erosion threshold and post- to pre- erosion exceedance analysis was completed for the most sensitive reach in order to understand the potential impact of development on the watercourse. The modelling approach documented here is consistent with previously completed erosion analyses for the Toronto and Region Conservation Authority, Credit Valley Conservation Authority and Conservation Halton.

The assessment included the following components:

- Desktop analysis for determining the potential zone of impact, which is the extent of the channel reaches to be assessed
- Review of relevant background materials, including existing watershed data
- Field assessments to determine the overall stability of the drainage feature on a reach-by-reach basis
- Reach-scale habitat sketch maps based on Newson and Newson (2000) outlining channel substrate, flow behaviour, geomorphological units, and riparian vegetation on the day
- A detailed geomorphological field assessment, the primary objective of which is to determine the critical flow or erosion threshold for the most sensitive reach
- Analysis of post- to pre-development time of exceedance, number of exceedances, cumulative excess discharge, and cumulative excess work index associated with the most sensitive reach.

2 Existing Conditions

2.1 Geology

Channel morphodynamics are largely governed by the flow regime and the availability and type of sediments (i.e., surficial geology) within the stream corridor. These factors are explored as they not only offer insight into existing conditions, but also potential changes that could be expected in the future as they relate to a proposed activity.

The study area is located within the Iroquois Plain physiographic region, which extends from the South Slope to the north to Lake Ontario. Specifically, the study area is characterized as Shale Plains, while areas upstream (north) of QEW are located on the Niagara Escarpment (Chapman and Putnam, 1984). Local surficial geology along the tributary consists of clay- to silt-textured till composed of sand, gravel, minor silt and clay (OGS, 2010).

The sediments which compose the unnamed tributary are dominated by cohesive clay materials. These materials, while small, are relatively resistant to erosion due to their cohesiveness.

3 Watercourse Characteristics

3.1 Reach Delineation

Reaches are homogeneous segments of channel used in geomorphological investigations. Reaches are studied semi-independently as each is expected to function in a manner that is at least slightly different from adjoining reaches. This method allows for a meaningful characterization of a watercourse as the aggregate of reaches, or an understanding of a particular reach, for example, as it relates to a proposed activity.

Reaches are typically delineated based on changes in the following:

- Channel planform
- Channel gradient
- Physiography
- Land cover (land use or vegetation)
- Flow, due to tributary inputs
- Soil type and surficial geology
- Historical channel modifications

Three reaches located downstream of the subject site were evaluated to determine their potential sensitivity to erosion. The criteria used to delineate the relevant reaches for our study, Reaches 1, 2 and 3 are described in Table 1. A reach map is provided within Appendix A, field observations are available within Appendix B, and a photo record is available within Appendix C.

Table 1: Reaches of the Unnamed Lake Ontario Tributary

Reach	Reach Extent	Length	Reach-defining Characteristics
1	Queen Elizabeth Way to Via Rail Crossing	470 m	Reinforced engineered channel with su-pavement composed of concrete blocks, rooted emergent aquatic vegetation
2	Via Rail Crossing upstream to culvert spanning Lewis Road	210 m	Rooted emergent aquatic, straight feature, roadside ditch.
3	Culvert spanning Lewis Road to crossing at Barton Street	250 m	Lack of aquatic vegetation, roadside ditch, narrow riparian buffer, hydromodification from additional roadside drainage inputs.
4	Lewis Road and Barton Street to the woodlot west of Winona Public School	225 m	Encroachment of riparian buffer into watercourse, no channel development, roadside ditch.

3.1.1 Reach Observations

Because the reaches in question were straightened roadside-ditch featured, the Rapid Geomorphic Assessment (RGA) and Rapid Stream Assessment Technique (RSAT) were not applied as these are designed for naturalized watercourses. However, detailed observations of channel features were documented during field visits in July of 2018 to determine channel stability and identify potentially sensitive areas.

Reach 1 is a straight engineered channel conveying flows between a commercial center and an industrial site. The reach showed minimal morphological diversity, having a poor riffle and pool development. Minimal erosion was observed within the channel, which had well vegetated banks and predominantly gravel bed materials which overlaid cement blocks. The channel had a narrow riparian buffer which was composed of herbaceous vegetation, with occasional immature trees. Average channel bankful width was 3.4 m and the average channel bankfull depth was 0.58 m.

Reach 2 is characterized as a straight-suspended load channel occupying an unconfined valley and is best described as a straightened ditch. The channel's narrow riparian buffer is continuous and dominated by established grasses and herbaceous vegetation which encroaches the channel for most of its length. The channel is heavily vegetated predominantly by rooting-emergent plants, specifically cattails and reed canary grass. The channel is intermittent, as in it is expected to go through periods in which no water is present within the feature. The channel has a low gradient and lacks a riffle pool sequence. Substrate for both bed and banks was predominantly clay. Average bankfull width was 2.22 m, and average maximum bankfull depth was 0.2 m at the time of assessment. No localized erosion was observed within the feature, nor were there any distinct areas of sediment deposition.

Reach 3 conveyed flow along the west side of Lewis Road within the Venetian Meats Lands north of Barton Avenue. The channel is a straight-suspended load channel which acts as a roadside ditch. The feature has gravel throughout its length on the bed, a low gradient and lacks a riffle-pool sequence. Herbaceous vegetation was present within the watercourse and the adjacent riparian area, and the surrounding land use was agricultural and industrial. Average bankfull width of the channel was 1.66 m and its average bankfull depth was 0.16 m. Erosion was noted at one location, in which a gabion basket at the upstream extent of the reach near Barton Avenue had been outflanked. Erosion or sedimentation was not observed elsewhere within the reach which can be considered stable.

Reach 4 is another straight-suspended load intermittent feature conveying flow eastward along the north side of Barton Avenue. No riffle-pool sequence was observed within the reach, which had a low gradient and bed material composed of clay and silt. Surrounding land-use was predominantly agricultural and residential, and the feature lacked a riparian buffer. Terrestrial vegetation was present within the channel throughout the reach, providing some reinforcement to the channel bed and banks. Average bankfull width of the feature was 2.65 m, and its average bankfull depth was 0.4 m. No localized erosion was observed within the feature, nor were there any distinct areas of sediment deposition. At the downstream extent of the reach, at Lewis Avenue, the feature received flows from roadside ditches to the west and east.

3.1.2 Detailed Geomorphological Assessment

A detailed geomorphological assessment of the channel at Reach 1 was completed to determine average bankfull channel characteristics, including cross-sectional geometry and hydraulics, for the purpose of informing erosion thresholds. Representative cross sections were surveyed in Reach 1, and a modified Wolman (1954) pebble count was completed at each cross section to characterize the bed materials. A longitudinal survey of the bed was also completed to determine slope. The channel measurements were then used to calculate bankfull flow characteristics such as discharge, average velocity, and erosion or sediment transport sensitivity. A summary of measured and computed values is presented in Table 2.

Table 2: Bankfull channel parameters for the study reaches

Channel Parameter	Reach 1
Average bankfull channel width (m)	2.22
Average bankfull channel depth (m)	0.25
Average channel gradient (m/m)	0.0073
Calculated bankfull discharge (m^3/s)	0.43

Bankfull Shear Stress	17.85
D_{50} (mm)	2

4 Erosion Threshold Assessment

4.1 Methodology

Erosion thresholds are used to determine the magnitude of flow required to potentially entrain and transport bed and/or bank materials. As such, they may be used to inform erosion reduction strategies in channels influenced by conceptual flow management plans. The erosion threshold analysis provides a depth, velocity, or discharge at which sediment of a particular size may potentially be entrained.

The erosion threshold is the theoretical point at which entrainment of sediment would occur based on bed and bank materials. Due to the variability between bed and bank composition and structure, erosion thresholds are determined for both bed and bank materials.

Threshold targets are determined using different methods that are dependent on channel and sediment characteristics. For example, thresholds for non-cohesive sediments are commonly estimated using a shear stress approach, similar to that of Miller et al. (1977), which is based on a modified Shield's curve. A velocity approach could also be applied. For cohesive materials, a method such as that described by Komar (1987), or empirically-derived values such as those compiled by Fischenich (2001), Chow (1959) or Julien (1998), could be applied.

An erosion threshold is quantified based on the bed and bank materials and local channel geometry, in the form of a critical discharge. Theoretically, above this discharge, entrainment and transport of sediment can occur. The velocity, *U* is calculated at various depths, until the average velocity in the cross section slightly exceeds the critical velocity of the bed material. The velocity is determined using a Manning's approach, where the Manning's *n* value is visually estimated through a method described by Arcement and Schneider (1989) or calculated using Limerinos's (1970) approach. The velocity is mathematically represented as

$$U = \frac{1}{n} d^{2/3} S^{1/2} \qquad \text{[Eq. 1]}$$

where, *d* is depth of water, *S* is channel slope, and *n* is the Manning's roughness. The discharge is then calculated using the area of a typical cross section at that depth.

For the bank materials, following Chow (1959) in a simplified cross section, 75% of the bed shear stress acts on the channel banks. In a similar approach, the depth of flow is increased until the shear stress acting on the banks exceeds the resisting shear strength of the bank materials.

4.2 Results

Erosion thresholds were determined for the bed materials within Reach 1, as it was determined to be the most sensitive reach within the watercourse to erosion based on the field observations. It was also taken into consideration that the reach is located downstream of the confluence of both channels proposed to convey flow from the development site. This field-based methodology to identify these thresholds provides a more tailored approach to the receiving watercourse than the desktop-based approach completed in the previous Subwatershed Study (Aquafor Beech Limited, 2013).

Bed materials were selected for the erosion threshold given that bed and bank materials were equivalent based on a review of the sediment samples retrieved from the field. The critical shear stress and velocity for the materials were subsequently determined, and used to determine the threshold discharge, the point at which sediment entrainment begins to occur.

The results of the erosion assessment are provided in Table 3. The critical discharge to entrain materials within Reach 1 was determined to be 0.609 m^3/s based on a permissible velocity adapted from Chow's (1959) threshold for non-cohesive silt-loam. This erosion threshold was selected for post- to pre-development comparisons outlined in Section 5.

Table 3: Erosion threshold

Parameter	Reach 1
D_{50} (mm)	2
Critical velocity (m/s)	0.61
Critical discharge (m^3/s)	0.609

5 Erosion Modelling

5.1 Model Overview

Using the results of the erosion threshold analysis, continuous hydrological modelling analyses were applied to produce hydrographs for use in the exceedance analyses. These exceedance analyses were completed using our own in-house model, based on four indices:

1) Cumulative time of exceedance
2) Number of exceedance events
3) Cumulative effective discharge
4) Cumulative effective work index (i.e., cumulative effective stream power)

They, as a product, provide an evaluation of the number of events, period of transport, and magnitude. We note that the most relevant index is the cumulative effective stream power.

Time of exceedance and number of exceedances can be simply calculated from the discharge record. For more relevant indicators, hydraulic information is required. As such, our model applies the discharge to a characteristic cross-section. Using a Manning's approach, the discharge at each time step in the continuous hydrological model provided by Urbantech is converted into a velocity, depth of flow, shear stress, and/or stream power. These parameters are calculated based on field measurements of slope, cross section and channel roughness. This provides analysis that is site appropriate and specific.

The post- and pre-development hydrological modelling reflects changes to the hydrological regime resulting from SWM measures being implemented within the catchment. Continuous flow data provided the results in 60-minute increments for the years of 1962-1992. The hydrological modeling was analyzed to calculate the various erosion indices noted above to identify potential changes in the erosive potential of the watercourse following development.

To calculate work terms for pre- and post-development scenarios, both velocity and shear stress were calculated at each time step. Through an iterative process, water depth and velocity were calculated for each discharge passing through a representative cross-section. The cross-section is divided into floodplain and bankfull sections. The cross-section is further broken into panels.

Velocity, U is calculated for each panel using the Manning's approach (equation 2). This is a conservative approach as it allows dissipation of flood energy in the floodplain.

The total discharge, Q_T at each time step is based on the summation of the discharge of all panels, Q_i, such that:

$$Q_{T=} \sum Q_i \qquad \text{[Eq. 2]}$$

Q_i is discharge through a panel (which is set at 10 percent of the cross-section). Qi is defined as:

$$Q_i = U_i w_i d_i \qquad \text{[Eq. 3]}$$

where, w_i and d_i are width and depth for each panel. The discharge for each panel was then summed to give a total discharge. This is more accurate than using average cross-sectional dimensions of a simple trapezoidal channel, as the bed is usually irregular, and a panel approach more accurately represents the true cross-sectional area.

For each event, the discharge is converted into a maximum depth and average velocity. The maximum depth is used to calculate a maximum bed shear stress, $\tau_{o_{max}}$ based on:

$$\tau_{o_{max}} = d_{max} \rho g S_{bed} \qquad \text{[Eq. 4]}$$

where, d_{max} is the maximum water depth, ρ is water density, g is acceleration due to gravity, and S_{bed} is the channel bed slope.

Cumulative total work, ϖ_{tot} is defined as:

$$\varpi_{tot} = \sum \tau_{0_{max}} . U_{avg} . \Delta t \qquad \text{[Eq. 5]}$$

where, U_{avg} is average velocity (Q_{tot}/A_{tot}, where A_{tot} is wetted area), while cumulative effective work index (ϖ_{eff}) is defined by:

$$\varpi_{eff} = \sum \tau - \tau_{cr} . U . \Delta t, \varpi < 0 = 0 \qquad \text{[Eq. 6]}$$

where, τ_{cr} is the critical shear stress.

Time of exceedance t_{ex} defined as:

$$t_{ex} = \sum \Delta t \text{ (for } Q_T > Q_{threshold}) \qquad \text{[Eq. 7]}$$

where, $Q_{threshold}$ is the discharge at the erosion threshold.

5.2 Model Results

The full series of post- to pre-development hydrographs are included in Appendix D, and include the erosion threshold based on discharge, for reference. Table 4 provides the results of the assessment based on the hydrographs provided by Urbantech.

Table 4: Erosion targets based on post- and pre-development continuous modelling

	CD (m^3/s)	CED (m3/s)	ω_{eff} (N/m)	CTW (N/m)	t_{ex} (hours)	Exceedance #
R-2 (PRE)	7292	149.2	2,350,250	1221926387	150	79.00
R-2 (POST)	7936	238.9	3,299,507	1290006655	254	134.00
Percent Change (%)	8.8	60.0	40.4	5.6	69.3	69.6

Changes to the hydrological regime resulting from the stormwater design and contributing drainage areas have increased the potential for erosion within the drainage channel. However, given the existing condition of the drainage channel this is not expected to cause extensive erosion within the watercourse. In its current state, this channel is heavily vegetated with rooted vegetation and no typical evidence of erosion such as scouring, bank slumping or undercutting was observed. The model has predicted an increase of 60% in cumulative effective discharge, the cumulative discharge which exceeds the erosion threshold, and 40% in cumulative effective work index (ω_{eff}), which represents cumulative shear stress exceeding the erosion threshold. While these increases appear significant on a relative scale, we do not expect their impacts to be significant given the minimal duration of these events. For example, a typical stream is expected to experience sediment entrainment for 2 to 3 days within a year. However, in the proposed scenario there are only anticipated to be cumulatively 10.6 days in which erosion occurs during the 30 year record assessed. As well, we note that there are negligible changes to the cumulative discharge (CD), and the cumulative total work (CTW), which is the total amount of work applied to the channel over the 30 year record. This points to the difference between the existing and proposed scenario's erosion potential is tied to infrequent short duration high frequency flow events, which are not expected to cause substantial changes to the drainage feature. This is shown graphically within Appendix D.

6 Summary and Recommendations

An erosion threshold in the form of a critical discharge was defined for Reach 2 as being 0.61 m^3/s based on detailed field observations, an analysis of the channel's sediment's and its bankfull geometry. This erosion threshold, and the selection of Reach 2 provide the most conservative estimates as the most sensitive reach within the watercourse from which a comparison can be made for post- to pre-development scenarios.

The work conducted in this assessment provides a site-specific strategy that incorporates a 2-year over control, with erosion thresholds defined based on field observations collected using standard geomorphological techniques. The erosion threshold was used to compare pre- and post-development exceedances based on standard erosion indices. Pre- to post-development comparisons were based on instream flows. As such, this technique accounts for cumulative inputs from associated ponds and other external sources.

Results indicate that the changes to the hydrological regime resulting from development have caused the erosive potential of Reach 2, and by proxy the entire unnamed tributary of Lake Ontario, to slightly increase. However, given the minimal duration and infrequency of erosion events in the post-development scenario, and the existing condition of the channel being a well vegetated environment, we do not foresee the requirement for systemic erosion mitigation measures to be undertaken and expect the channel to remain stable in the post-development condition.

We trust this report meets your requirements. Should you have any questions please contact the undersigned.

Respectfully submitted,

Paul Villard, Ph.D., P.Geo., CAN-CISEC
Director, Principal Geomorphologist

André-Marcel Baril, M.Sc.
River Scientist

7 References

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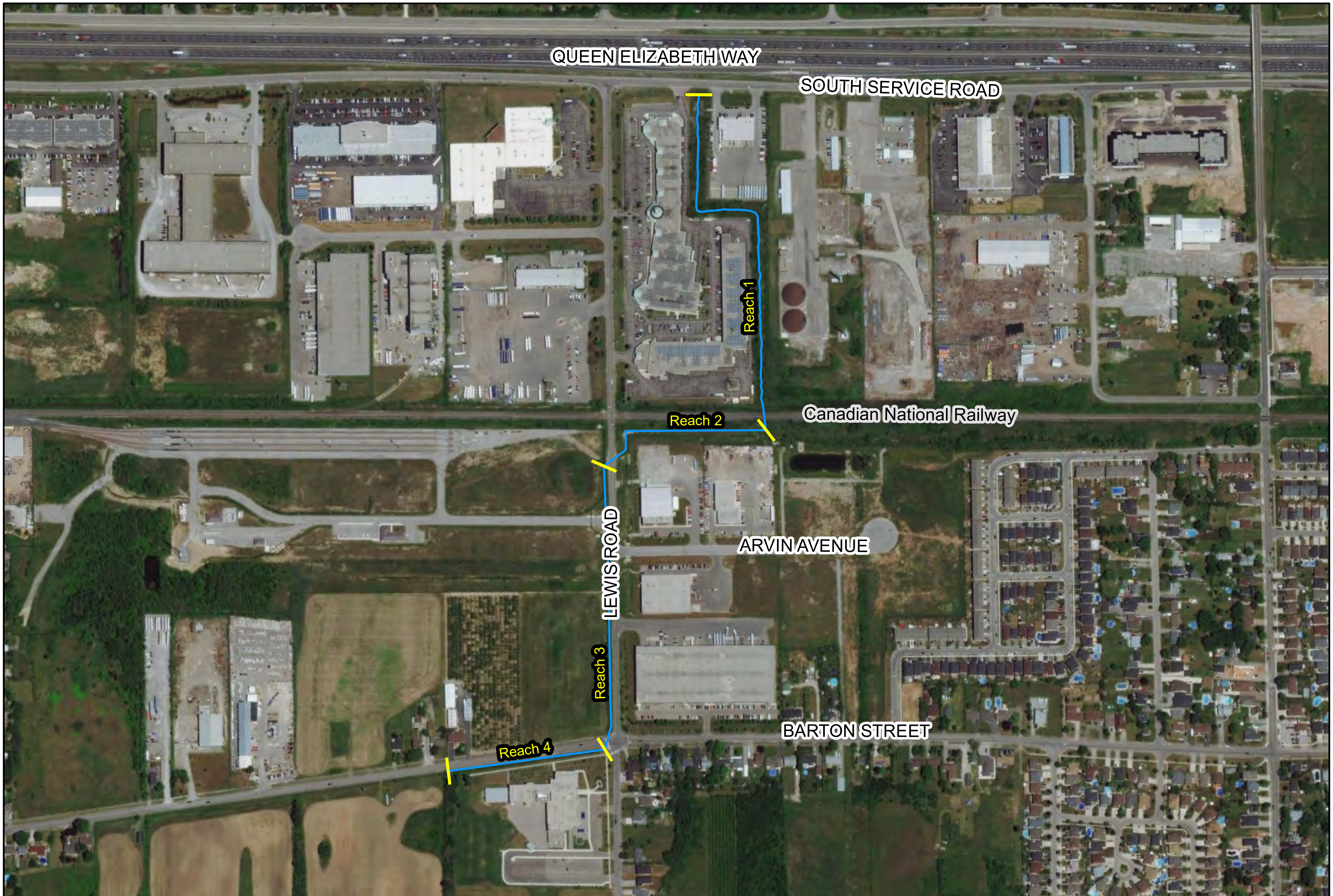
Appendix A
Reach Map



Legend

- Reach Break and ID
- Detailed Assessment
- Watercourse

Unnamed Tributary of Lake Ontario

Reach Delineation

Hamilton, Ontario

N

0 50 100 200
Metres

GEO MORPHIX

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community Imagery: May, 2018.
Reach Break and Reach ID and Detailed Assessment: GEO Morphix Ltd., 2019. Watercourse: GEO Morphix Ltd. and MNRF, 2019.
Print Date: February, 2020. PN18099. Drawn By: W.B., A.M.B.

Appendix B
Field Sheets

GEO | MORPHIX
Geomorphology Earth Science Observations

R1

Reach Characteristics

Project Code: 18099

Date:	2020-02-20	**Stream/Reach:**	Stoney Creek Tributary
Weather:	-4°C Sun & cloud	**Location:**	Stoney Creek
Field Staff:	AMB JT	**Watershed/Subwatershed:**	
UTM (Upstream)		**UTM (Downstream)**	

Land Use (Table 1): 4 | **Valley Type** (Table 2): 2 | **Channel Type** (Table 3): 11 | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 1 | ☐ Groundwater | Evidence: ______

Riparian Vegetation

Dominant Type: (Table 6) 3/2

Species: Reed canary grass

Coverage:
- ☐ None
- ☐ Fragmented
- ☒ Continuous

Channel widths
- ☐ 1-4
- ☒ 4-10
- ☐ > 10

Age Class (yrs):
- ☐ Immature (<5)
- ☒ Established (5-30)
- ☐ Mature (>30)

Encroachment: (Table 7) 2

Aquatic/Instream Vegetation

Type (Table8) 6 | Coverage of Reach (%) 5

Woody Debris
- ☐ Present in Cutbank
- ☐ Present in Channel
- ☒ Not Present

Density of WD:
- ☒ Low
- ☐ Moderate
- ☐ High

WDJ/50m: 0

Water Quality

Odour (Table 16): 1

Turbidity (Table 17): 2

Channel Characteristics

Sinuosity (Type) (Table 9): 1 | **Sinuosity (Degree)** (Table 10): 1 | **Gradient** (Table 11): 1 | **Number of Channels** (Table 12): 1

Entrenchment (Table 13): 1 | **Type of Bank Failure** (Table 14): 1 | **Downs's Classification** (Table 15): 5

	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Riffle Substrate	☐	☒	☒	☒	☐	☐	☐
Pool Substrate	☒	☒	☒	☐	☐	☐	☐
Bank Material	☒	☐	☐	☐	☐	☐	☒

↳ cable blocks

Bankfull Width (m)	3.5	3.7	3.1	**Wetted Width (m)**			
Bankfull Depth (m)	0.70	0.45	0.60	**Wetted Depth (m)**			

Riffle/Pool Spacing (m) ______ **% Riffles:** 20 **% Pools:** 80 **Meander Amplitude:** N/A

Pool Depth (m) ______ **Riffle Length (m)** ______ **Undercuts (m)** 0

Velocity (m/s) ______ ______ ______ **Wiffle ball / ADV / Estimated**

Comments: Straight constructed channel, minor riffle pool development, minimal geomorphic activity noted

Bank Angle
- ☒ 0 – 30
- ☐ 30 – 60
- ☐ 60 – 90
- ☐ Undercut

Bank Erosion
- ☒ < 5%
- ☐ 5 – 30%
- ☐ 30 – 60%
- ☐ 60 – 100%

Notes: Cable blocks reinforcing channel banks and bed throughout. Minimal evidence of erosion. No erosion at 90° bend following constructed riffle. Stable constructed channel.

Completed by: JT   Checked by: ______

GEO | MORPHIX

General Site Characteristics

Project Code: PN18099

Date:	July 24, 2018	**Stream/Reach:**	~~R1~~ R2
Weather:	Sun + 25°C	**Location:**	Lewis Rd + Barton St
Field Staff:	CH	**Watershed/Subwatershed:**	Stoney Crk

Features

- Reach break
- Cross-section
- Flow direction
- Riffle
- Pool
- Medial bar
- Eroded bank
- Undercut bank
- Rip rap/stabilization/gabion
- Leaning tree
- Fence
- Culvert/outfall
- Swamp/wetland
- Grasses
- Tree
- Instream log/tree
- Woody debris
- Station location
- Vegetated island

cattails

Flow Type

H1	Standing water
H2	Scarcely perceptible flow
H3	Smooth surface flow
H4	Upwelling
H5	Rippled
H6	Unbroken standing wave
H7	Broken standing wave
H8	Chute
H9	Free fall

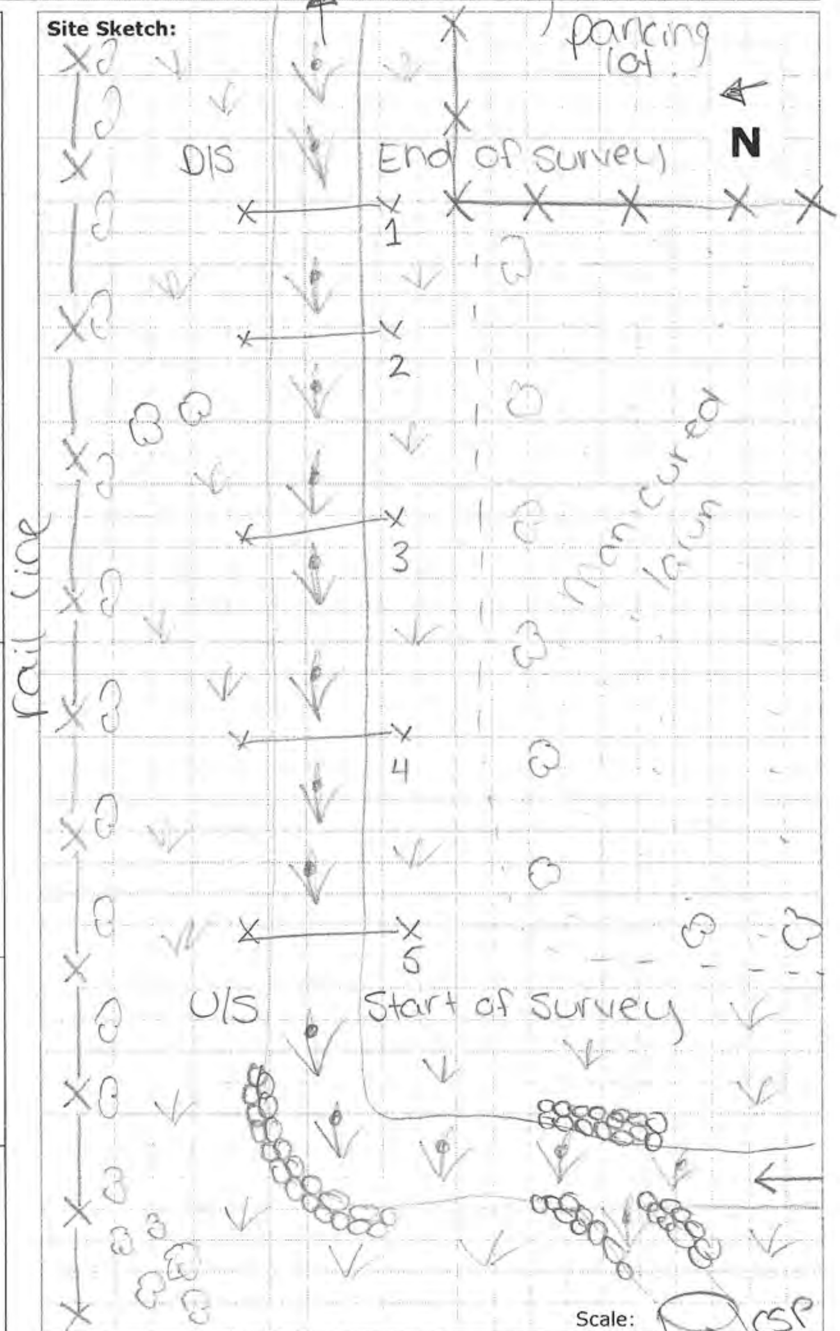
Substrate

S1	Silt	S6	Small boulder
S2	Sand	S7	Large boulder
S3	Gravel	S8	Bimodal
S4	Small cobble	S9	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	EP	Erosion pin
BS	Backsight	RB	Rebar
DS	Downstream	US	Upstream
WDJ	Woody debris jam	TR	Terrace
VWC	Valley wall contact	FC	Flood chute
BOS	Bottom of slope	FP	Flood plain
TOS	Top of slope	KP	Knick point

Site Sketch:



Scale: CSP

Additional Notes:

Lewis Rd R1

Completed by: CH Checked by: ________

GEO | MORPHIX
Geomorphology Earth Science Observations

Reach Characteristics

Project Code/Phase: PN18099

Date:	July 24, 2018	**Stream/Reach:**	~~R1~~ R2
Weather:	Sun + 25°C	**Location:**	Lewis Rd + Barton St
Field staff:	CH	**Watershed/Subwatershed:**	Stoney Crk
UTM (Upstream)		**UTM (Downstream)**	

Land Use (Table 1): 9 | **Valley Type** (Table 2): 1 | **Channel Type** (Table 3): 11 | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 2 | ☐ Groundwater | Evidence: None

Riparian Vegetation

Dominant Type: (Table 6) 3
Species: ______

Coverage:
☐ None
☐ Fragmented
☒ Continuous

Channel widths
☒ 1-4
☐ 4-10
☐ > 10

Age Class (yrs):
☒ Immature (<5)
☐ Established (5-30)
☐ Mature (>30)

Encroachment: (Table 7) 4

Aquatic/Instream Vegetation

Type (Table8) 1 | Coverage of Reach (%) 90

Woody Debris
☐ Present in Cutbank
☐ Present in Channel
☒ Not Present

Density of WD: N/A
☐ Low
☐ Moderate
☐ High
WDJ/50m: None

Water Quality

Pockets of standing water

Odour (Table 16): 1
Turbidity (Table 17): 1

Channel Characteristics

Sinuosity (Type) (Table 9)	1	**Sinuosity (Degree)** (Table 10)	1	**Gradient** (Table 11)	1	**Number of Channels** (Table 12)	1
Entrenchment (Table 13)	2	**Type of Bank Failure** (Table 14)	1	**Downs's Classification** (Table 15)	S		

	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Riffle Substrate	☐	☐	☐	☐	☐	☐	☐
Pool Substrate	☐	☐	☐	☐	☐	☐	☐
Bank Material	☐	☐	☐	☐	☐	☐	☐

Bankfull Width (m): see detailed | **Wetted Width (m)**: Pockets of
Bankfull Depth (m): assessment | **Wetted Depth (m)**: standing water
Riffle/Pool Spacing (m): NA | **% Riffles:** NA | **% Pools:** NA | **Meander Amplitude:** NA
Pool Depth (m): NA | **Riffle Length (m)**: NA | **Undercuts (m)**: None
Velocity (m/s): NA | | | Wiffle ball / ADV / Estimated

Comments: No riffles + Pools
Straight

Bank Angle
☐ 0 – 30
☐ 30 – 60
☒ 60 – 90
☐ Undercut

Bank Erosion
☐ < 5%
☒ 5 – 30%
☐ 30 – 60%
☐ 60 – 100%

Notes:
Straightened ditch along rail line.

Completed by: CH
Checked by: ______

GEO | MORPHIX

Geomorphology
Earth Science
Observations

General Site Characteristics

Project Code: PH18099

Date:	July 13/18	**Stream/Reach:**	~~R2~~ R3
Weather:	Sun + 25°C	**Location:**	Barton + Lewis
Field Staff:	CH + CVM	**Watershed/Subwatershed:**	Stoney Crk.

Features
- Reach break
- Cross-section
- Flow direction
- Riffle
- Pool
- Medial bar
- Eroded bank
- Undercut bank
- Rip rap/stabilization/gabion
- Leaning tree
- Fence
- Culvert/outfall
- Swamp/wetland
- Grasses
- Tree
- Instream log/tree
- Woody debris
- Station location
- Vegetated island

Flow Type

H1	Standing water
H2	Scarcely perceptible flow
H3	Smooth surface flow
H4	Upwelling
H5	Rippled
H6	Unbroken standing wave
H7	Broken standing wave
H8	Chute
H9	Free fall

Substrate

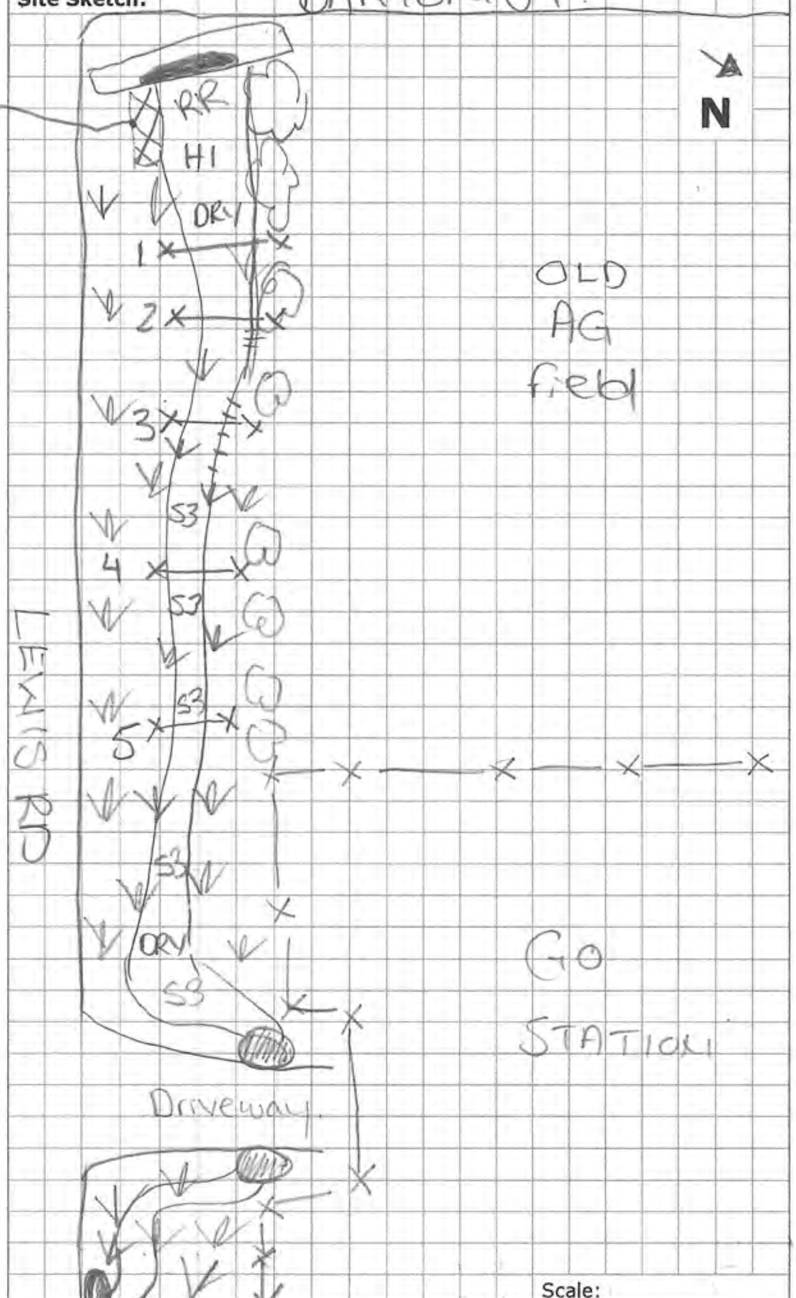
S1	Silt	S6	Small boulder
S2	Sand	S7	Large boulder
S3	Gravel	S8	Bimodal
S4	Small cobble	S9	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	EP	Erosion pin
BS	Backsight	RB	Rebar
DS	Downstream	US	Upstream
WDJ	Woody debris jam	TR	Terrace
VWC	Valley wall contact	FC	Flood chute
BOS	Bottom of slope	FP	Flood plain
TOS	Top of slope	KP	Knick point

RR- riprap

Site Sketch: BARTON ST.



Scale:

Additional Notes:

see detailed assessment

Completed by: CH Checked by: ________

GEO | MORPHIX
Geomorphology Earth Science Observations

Reach Characteristics

Project Code: PN18099

Date:	July 13 2018	**Stream/Reach:**	~~R2~~ R3
Weather:	Sun + 28°C	**Location:**	Barton St + Lewis Rd
Field Staff:	CH + CVM	**Watershed/Subwatershed:**	Stoney Crk
UTM (Upstream)		**UTM (Downstream)**	

Land Use (Table 1): 3/9 | **Valley Type** (Table 2): 1 | **Channel Type** (Table 3): 6 | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 3 | ☐ Groundwater | Evidence: None

Riparian Vegetation

- Dominant Type: (Table 6) 1/3
- Species: ______
- Coverage: ☐ None; ☒ Fragmented; ☐ Continuous
- Channel widths: ☒ 1-4; ☐ 4-10; ☐ > 10
- Age Class (yrs): ☐ Immature (<5); ☒ Established (5-30); ☐ Mature (>30)
- Encroachment: (Table 7) 3

Aquatic/Instream Vegetation

- Type (Table8) None; Coverage of Reach (%) 0
- Woody Debris: ☐ Present in Cutbank; ☐ Present in Channel; ☒ Not Present
- Density of WD: ☐ Low; ☐ Moderate; ☐ High — NA
- WDJ/50m: 0

Water Quality

DRY

- Odour (Table 16): NA
- Turbidity (Table 17): NA

Channel Characteristics

- Sinuosity (Type) (Table 9): 1
- Sinuosity (Degree) (Table 10): 1
- Gradient (Table 11): 2
- Number of Channels (Table 12): 1
- Entrenchment (Table 13): 1
- Type of Bank Failure (Table 14): 1
- Downs's Classification (Table 15): S

	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Riffle Substrate	☐	☒ (coarse)	☒	☐	☐	☐	☐
Pool Substrate (struck out)	☐	☐	☐	☐	☐	☐	☐
Bank Material	☒ Si	☐	☐	☐	☐	☐	☐

- Bankfull Width (m): see detailed assessment
- Bankfull Depth (m):
- Wetted Width (m): DRY
- Wetted Depth (m):
- Riffle/Pool Spacing (m): NA
- % Riffles: NA
- % Pools: NA
- Meander Amplitude: NA
- Pool Depth (m): NA
- Riffle Length (m): NA
- Undercuts (m):
- Velocity (m/s): DRY
- Wiffle ball / ADV / Estimated

Bank Angle: ☐ 0 – 30; ☒ 30 – 60; ☒ 60 – 90; ☐ Undercut

Bank Erosion: ☐ < 5%; ☒ 5 – 30%; ☐ 30 – 60%; ☐ 60 – 100%

Comments: Roadside ditch. No R-P. Pooled water @ u/s Xing

Notes:

Completed by: CH Checked by: ______

GEO | MORPHIX
Geomorphology Earth Science Observations

General Site Characteristics

Project Code: PN18099

Date:	July 13/18	**Stream/Reach:**	~~R3~~ R4
Weather:	Sun + 25°C	**Location:**	Barton + Lewis
Field Staff:	CH + CVM	**Watershed/Subwatershed:**	Stoney Crk.

Features	
(symbol)	Reach break
(symbol)	Cross-section
(symbol)	Flow direction
(symbol)	Riffle
(symbol)	Pool
(symbol)	Medial bar
(symbol)	Eroded bank
(symbol)	Undercut bank
(symbol)	Rip rap/stabilization/gabion
(symbol)	Leaning tree
(symbol)	Fence
(symbol)	Culvert/outfall
(symbol)	Swamp/wetland
(symbol)	Grasses
(symbol)	Tree
(symbol)	Instream log/tree
(symbol)	Woody debris
(symbol)	Station location
(symbol)	Vegetated island

Flow Type

H1	Standing water
H2	Scarcely perceptible flow
H3	Smooth surface flow
H4	Upwelling
H5	Rippled
H6	Unbroken standing wave
H7	Broken standing wave
H8	Chute
H9	Free fall

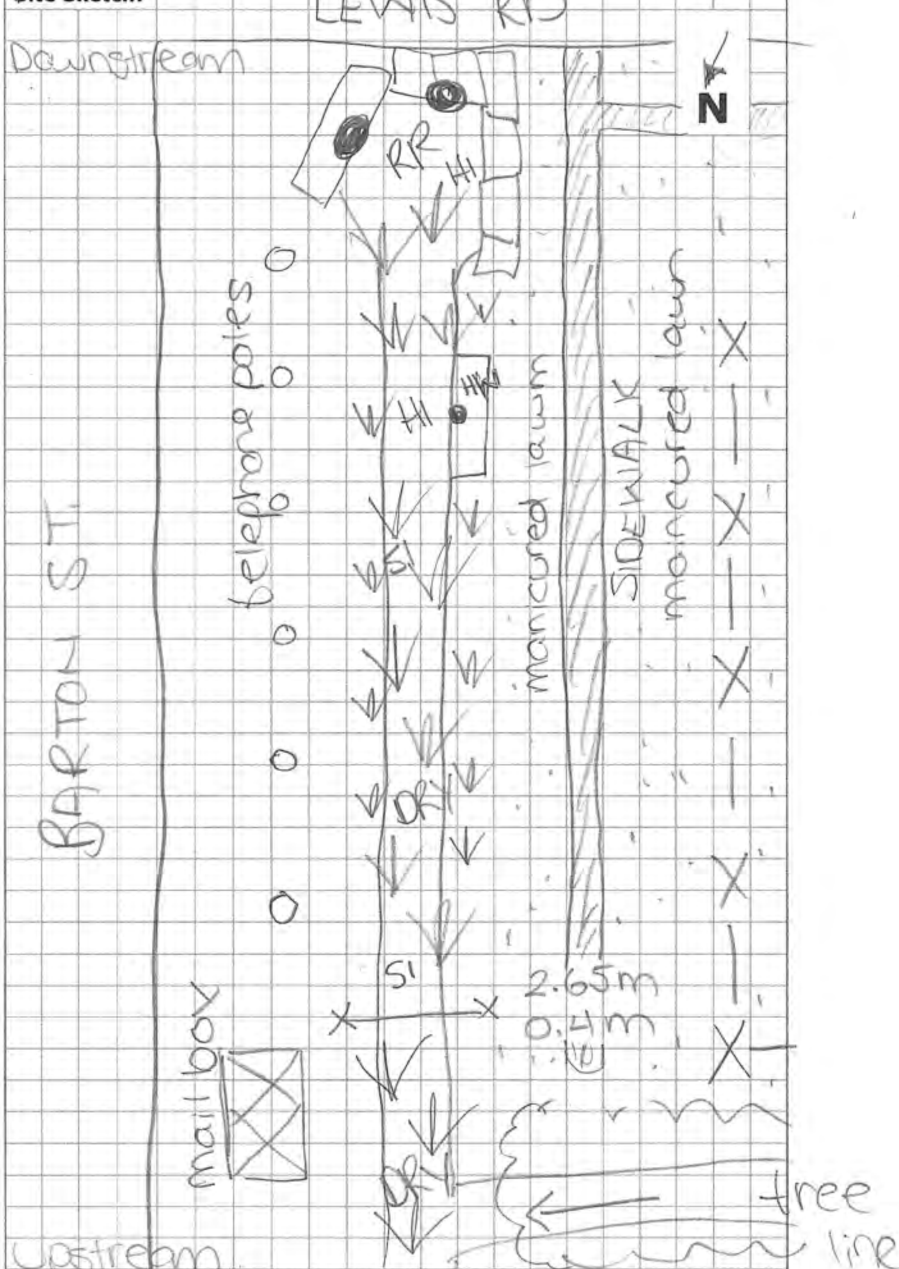
Substrate

S1	Silt	**S6**	Small boulder
S2	Sand	**S7**	Large boulder
S3	Gravel	**S8**	Bimodal
S4	Small cobble	**S9**	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	**EP**	Erosion pin
BS	Backsight	**RB**	Rebar
DS	Downstream	**US**	Upstream
WDJ	Woody debris jam	**TR**	Terrace
VWC	Valley wall contact	**FC**	Flood chute
BOS	Bottom of slope	**FP**	Flood plain
TOS	Top of slope	**KP**	Knick point

Site Sketch:



Scale: 1 ~ 1m

Additional Notes: No R-Ps
No areas of erosion

HW - head wall
RR - riprap

Completed by: CH Checked by: ________

GEO MORPHIX
Geomorphology Earth Science Observations

Reach Characteristics

Project Code: PN18099

Date:	July 13/18	**Stream/Reach:**	~~3~~ R4
Weather:	Sun + 25°C	**Location:**	Burton Rd + Lewis St
Field Staff:	CH + CVM	**Watershed/Subwatershed:**	Storey Crk
UTM (Upstream)		**UTM (Downstream)**	

Land Use (Table 1): 3/6 **Valley Type** (Table 2): 1 **Channel Type** (Table 3): 11 **Channel Zone** (Table 4): 2 **Flow Type** (Table 5): 3 ☐ Groundwater **Evidence:** None

Riparian Vegetation

Dominant Type: (Table 6) 3

Species: ______

Coverage:
- ☐ None
- ☑ Fragmented
- ☐ Continuous

Channel widths
- ☑ 1-4
- ☐ 4-10
- ☐ > 10

Age Class (yrs):
- ☑ Immature (<5)
- ☐ Established (5-30)
- ☐ Mature (>30)

Encroachment: (Table 7) 4

Aquatic/Instream Vegetation

Type (Table8) None **Coverage of Reach (%)** 0

Woody Debris
- ☐ Present in Cutbank
- ☐ Present in Channel
- ☑ Not Present

Density of WD:
- ☐ Low
- ☐ Moderate
- ☐ High

WDJ/50m: /

Water Quality

Dry

Odour (Table 16) /

Turbidity (Table 17) /

Channel Characteristics

Sinuosity (Type) (Table 9) 1 **Sinuosity (Degree)** (Table 10) 1 **Gradient** (Table 11) 1 **Number of Channels** (Table 12) 1

Entrenchment (Table 13) 1 **Type of Bank Failure** (Table 14) None **Downs's Classification** (Table 15) 5

	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Riffle Substrate	☑	☐	☐	☐	☐	☐	☐
Pool Substrate	☐	☐	☐	☐	☐	☐	☐
Bank Material	☑	☐	☐	☐	☐	☐	☐

Bankfull Width (m) 2.65 | — | — **Wetted Width (m)** Dry | — | —

Bankfull Depth (m) 0.4 | — | — **Wetted Depth (m)** — | — | —

Riffle/Pool Spacing (m) NA **% Riffles:** NA **% Pools:** NA **Meander Amplitude:** NA

Pool Depth (m) NA **Riffle Length (m)** NA **Undercuts (m)** None **Comments:** Roadside ditch

Velocity (m/s) Dry | / | / **Wiffle ball / ADV / Estimated**

Bank Angle
- ☐ 0 – 30
- ☑ 30 – 60
- ☐ 60 – 90
- ☐ Undercut

Bank Erosion
- ☑ < 5%
- ☐ 5 – 30%
- ☐ 30 – 60%
- ☐ 60 – 100%

Notes:

Completed by: CH Checked by: ______

Appendix C
Photo Record

Photo 1 Reach 1: Crossing at CN Rain Line upstream to Crossing at Lewis Road	
	Photo taken near the downstream extent of the reach. Note the dense rooted emergent aquatic vegetation stabilizing the channel. Yellow arrow denotes flow direction.
Photo 2 Reach 1: Crossing at CN Rain Line upstream to Crossing at Lewis Road	
	The reach had a wide corridor adjacent to Lewis Road. No erosion to the bank reinforcements was observed.

Photo 3 Reach 1: Crossing at CN Rain Line upstream to Crossing at Lewis Road	 The channel was well vegetated throughout its length, and had a riparian buffer composed of herbaceous vegetation and grasses
Photo 4 Reach 1: Crossing at CN Rain Line upstream to Crossing at Lewis Road	 Photo taken at the upstream extent of Reach 1. No significant scour or erosion was observed at the confluence of Reach 2 and the small ditch which conveyed flow northwardly from Arvin Avenue.

Photo 5

Reach 2: Crossing at Lewis Road to Crossing at Barton Street

Reach 2 conveyed flow northwards along the west side of Lewis Road from the crossing to Barton Street. The majority of the reach was colonized by terrestrial herbaceous plants and grass from the riparian zone.

Photo 6

Reach 2: Crossing at Lewis Road to Crossing at Barton Street

Within the vicinity of Barton Street, some channel development was observed which has locally reduced the coverage of vegetation within the feature but not developed banks.

Photo 7
Reach 2: Crossing at Lewis Road to Crossing at Barton Street

Standing water was occasionally observed within the intermittent watercourse which showed no evidence of significant erosion or sediment deposition.

Photo 8
Reach 2: Crossing at Lewis Road to Crossing at Barton Street

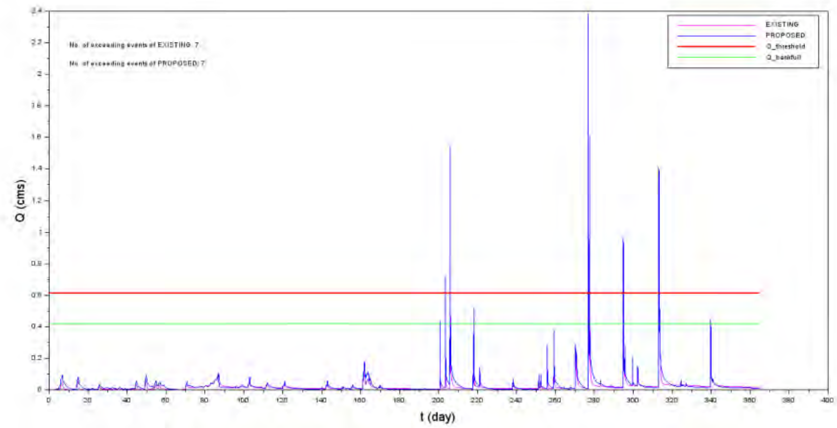
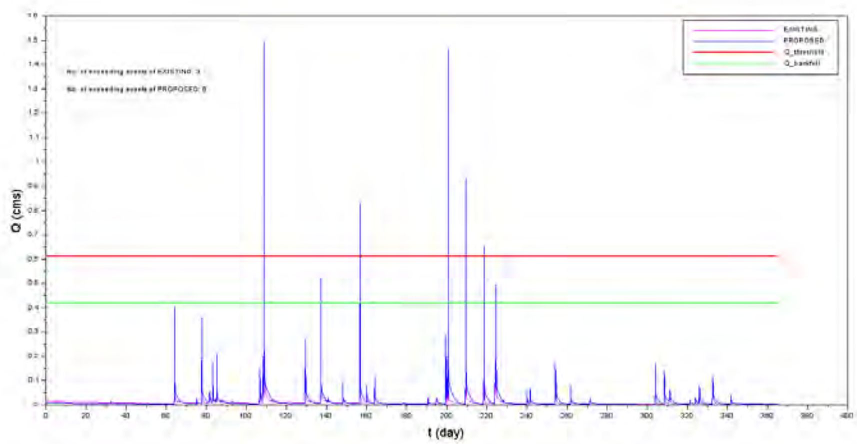
The crossing at Barton Street was a circular concrete culvert which had been partially blocked by riparian vegetation which had colonized the channel.

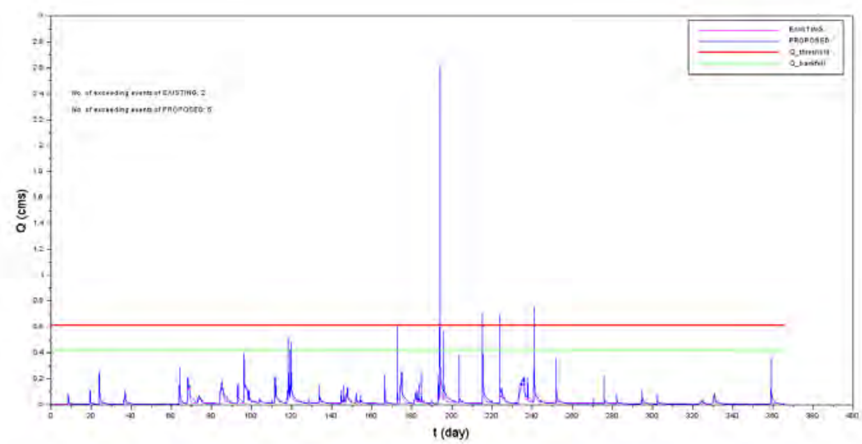
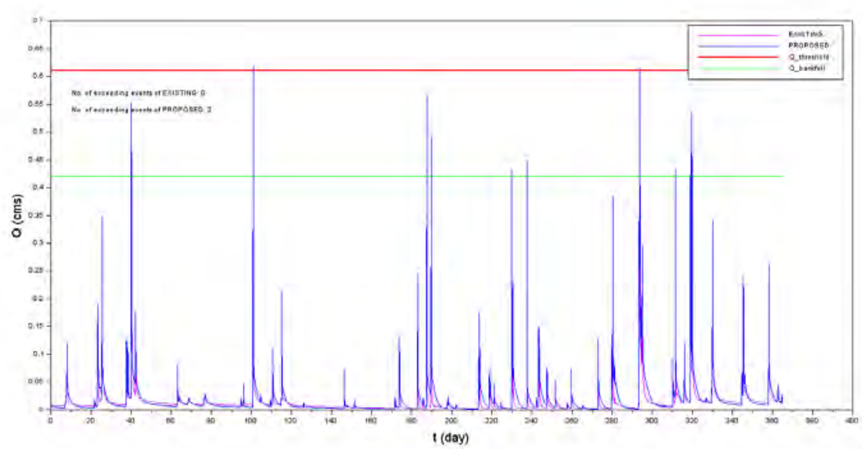
Reach 3: From the crossing at Lewis Street upstream to the woodlot west of Winona Public School Photo 9	
	At the downstream extent of Reach 3, a culvert conveying flow from the west side of Lewis Road and a small ditch from the north formed a confluence.
Reach 3: From the crossing at Lewis Street upstream to the woodlot west of Winona Public School Photo 10	
	The Barton Street crossing appeared to be causing a slight backwater, as evidenced by the standing water upstream of the structure.

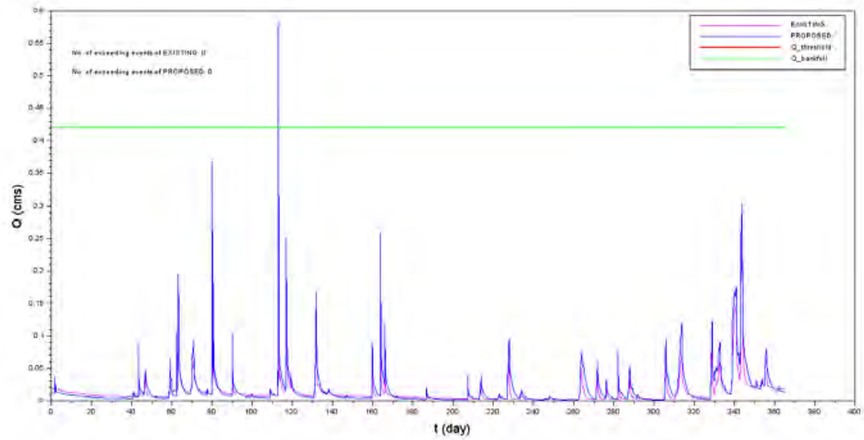
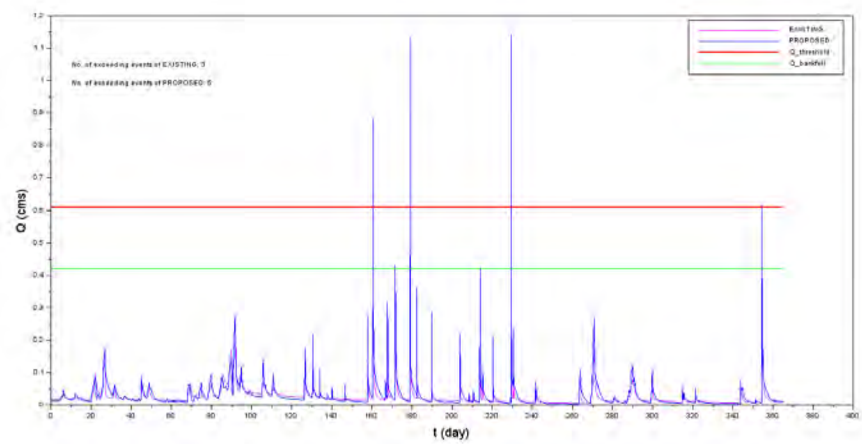
Photo 11
Reach 3: From the crossing at Lewis Street upstream to the woodlot west of Winona Public School

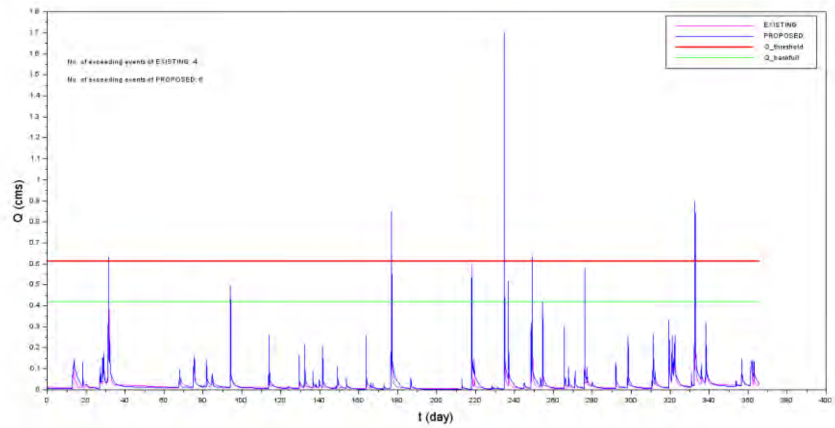
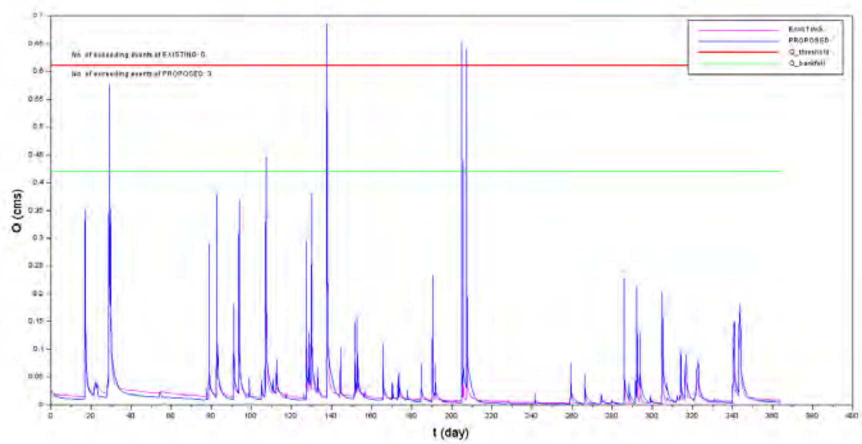
The channel was predominantly colonized by riparian vegetation, with some aquatic species such as reed canary grass also noted within the reach.

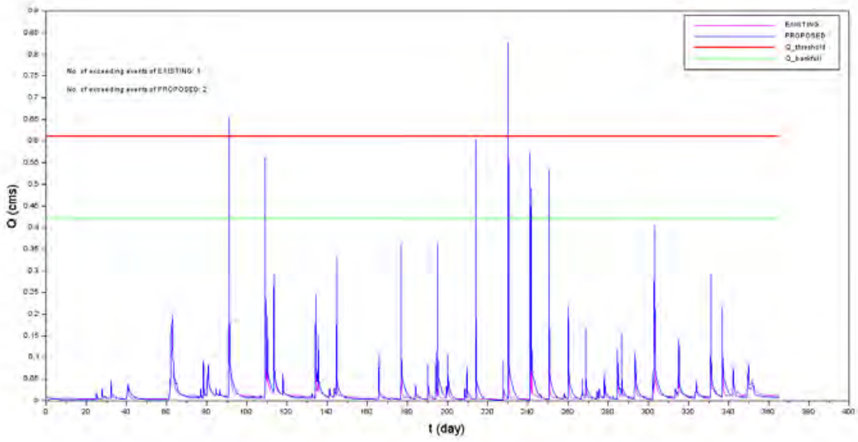
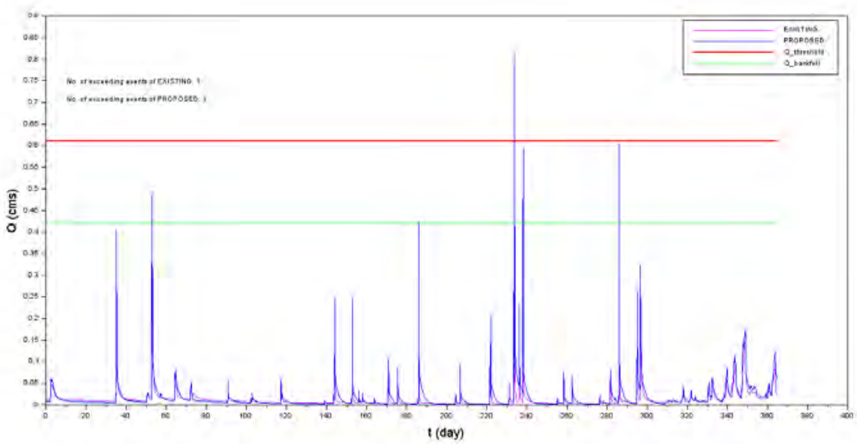
Appendix D
Hydrographs

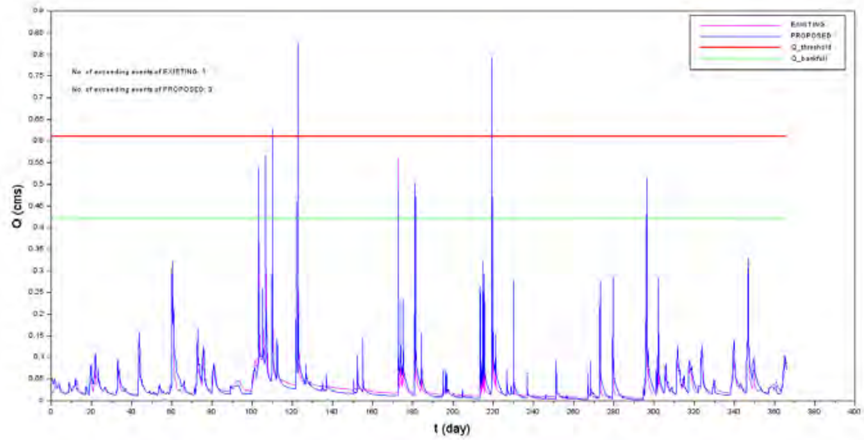
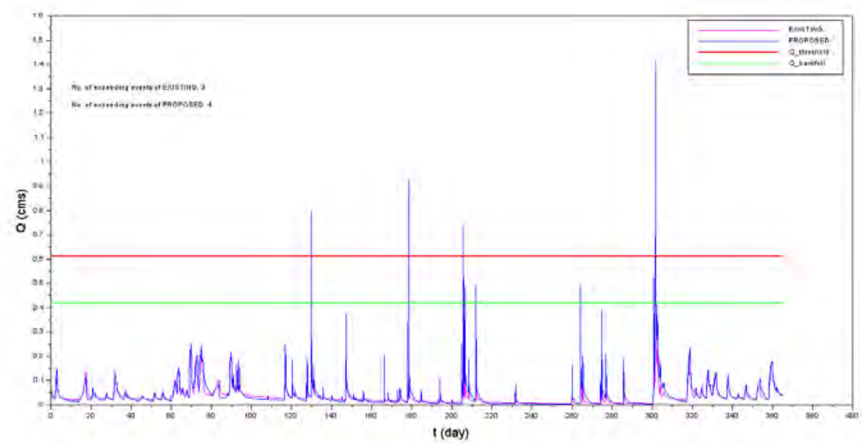
Reach 1 - 1962	
Reach 1 - 1963	

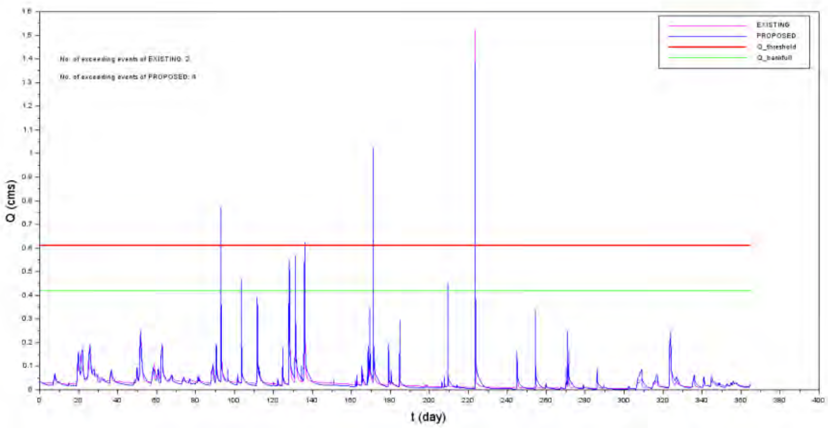
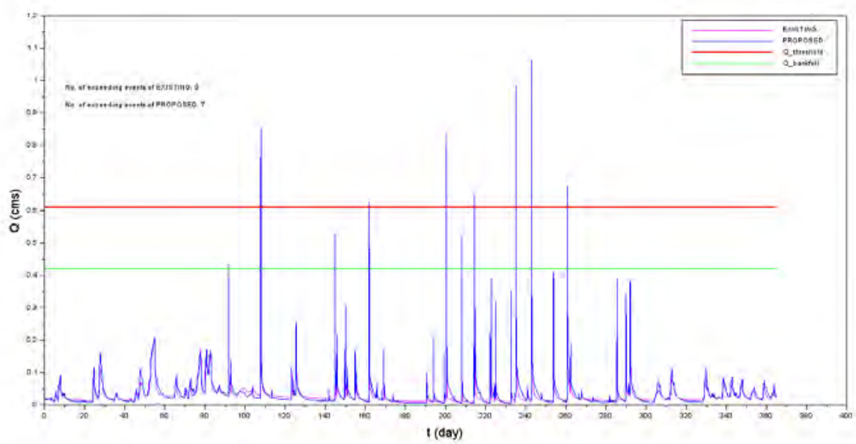
Reach 1 - 1964	
Reach 1 - 1965	

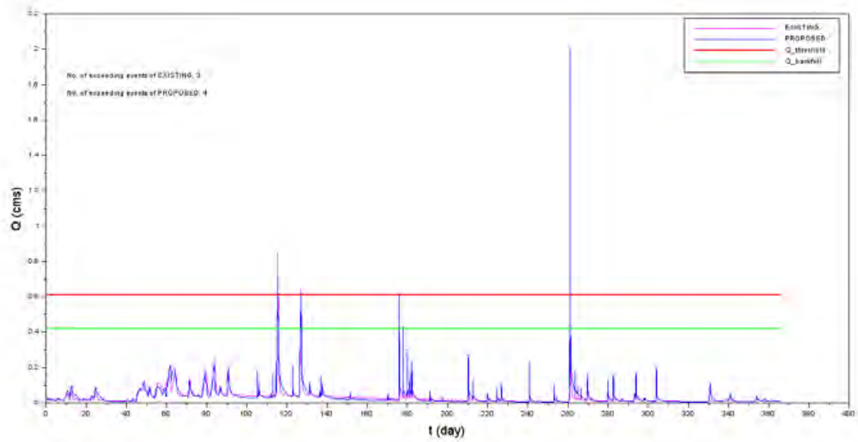
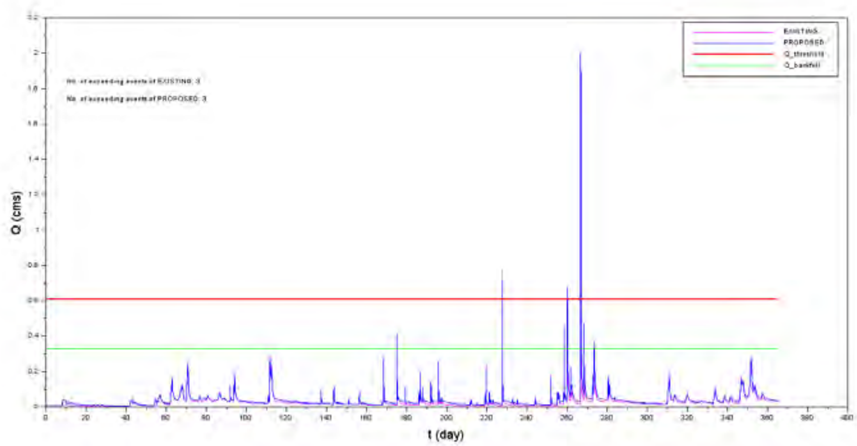
Reach 1 - 1966	
Reach 1 - 1967	

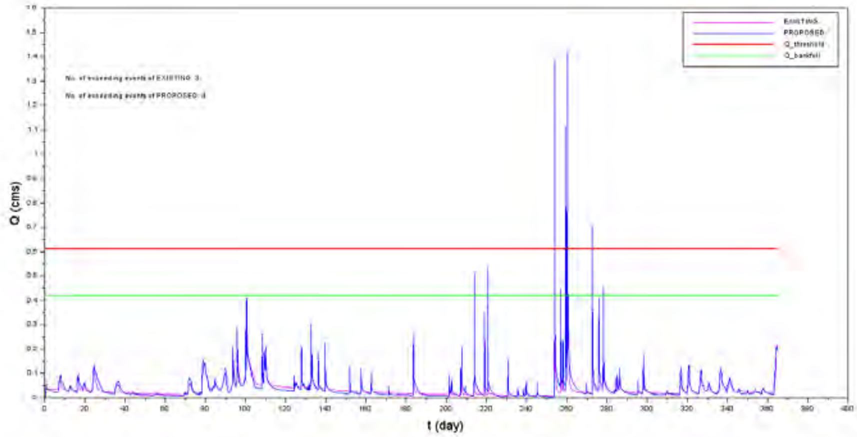
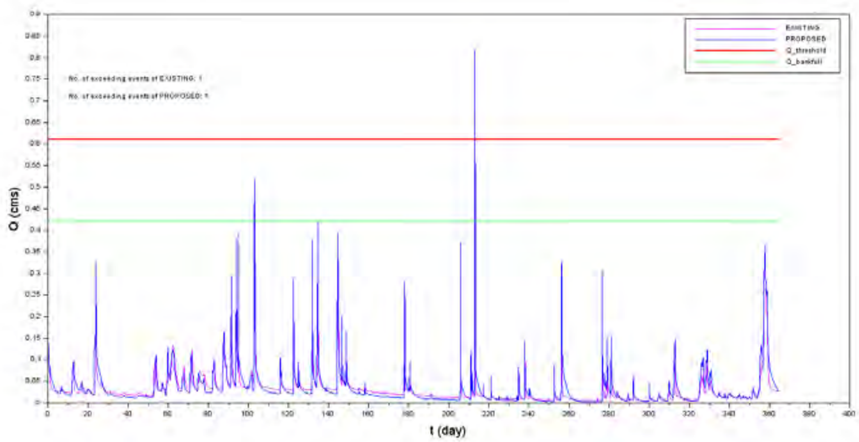
Reach 1 - 1968	
Reach 1 - 1969	

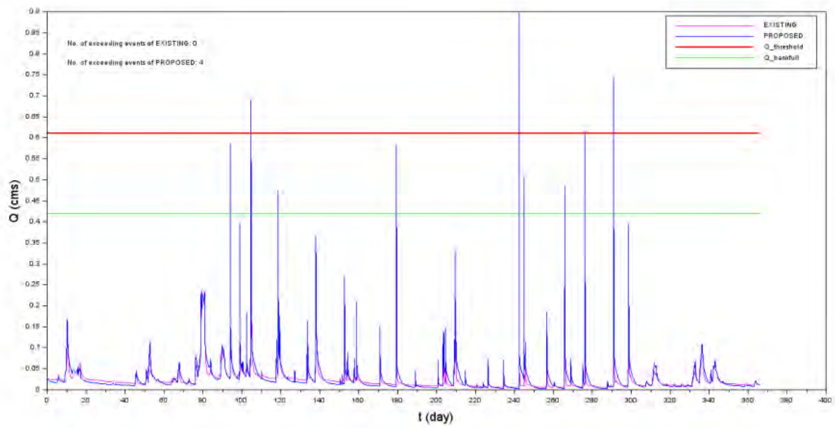
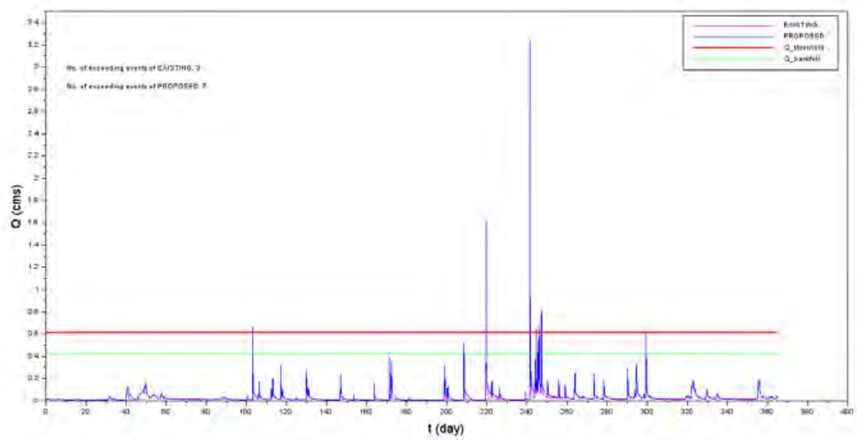
Reach 1 - 1970	
Reach 1 - 1971	

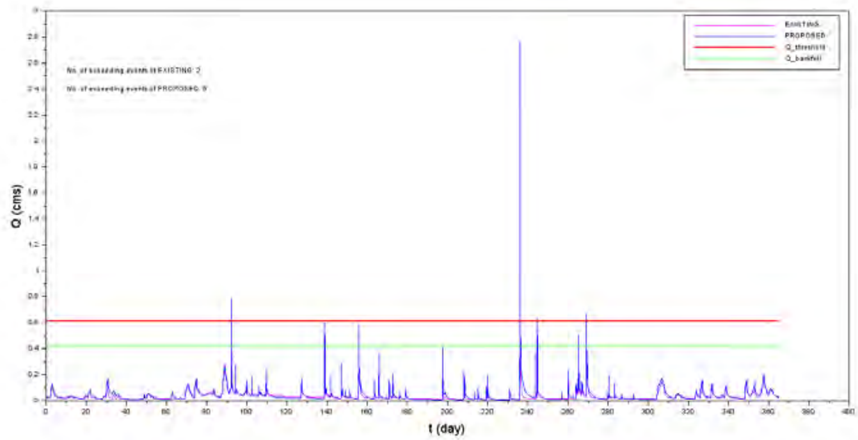
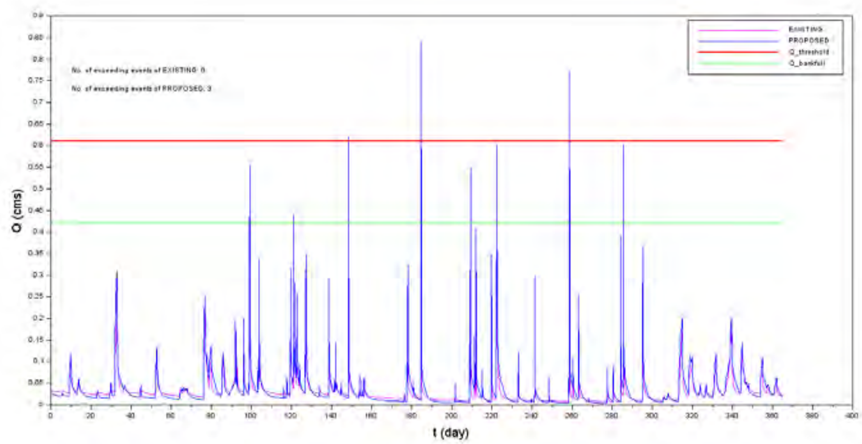
Reach 1 - 1972	
Reach 1 - 1973	

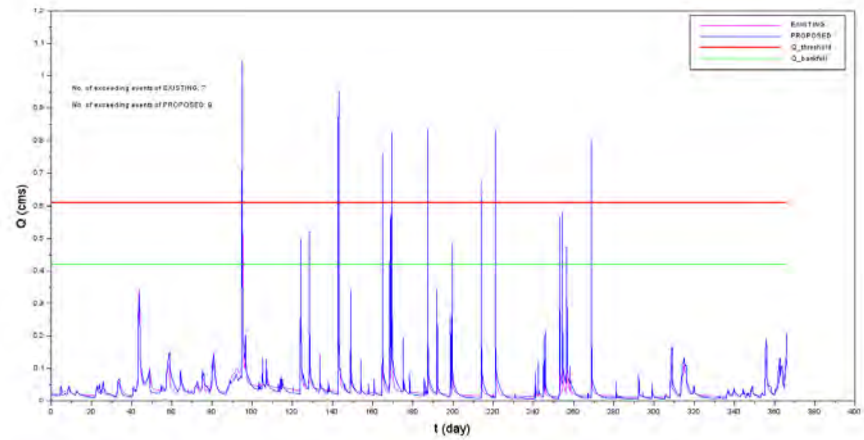
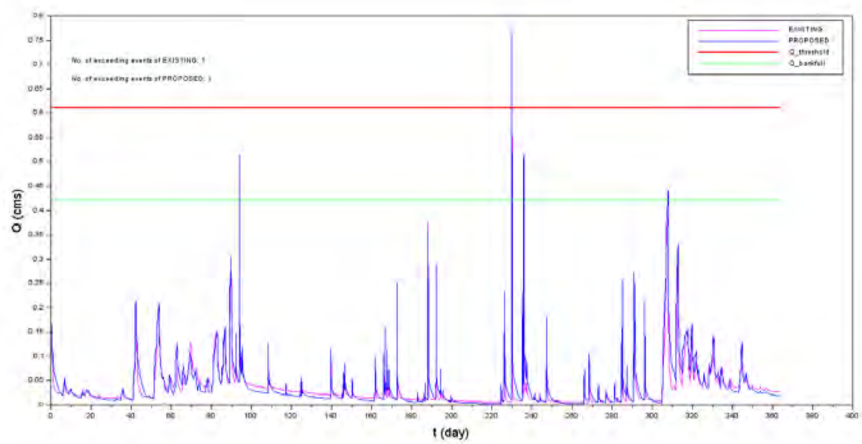
Reach 1 - 1974	
Reach 1 - 1975	

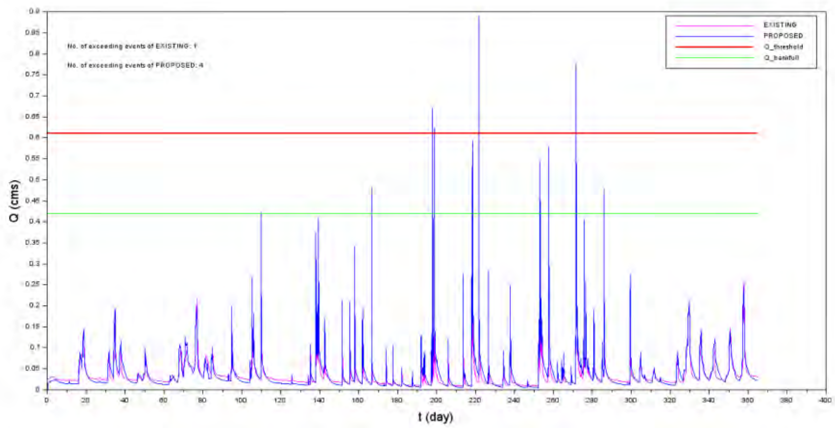
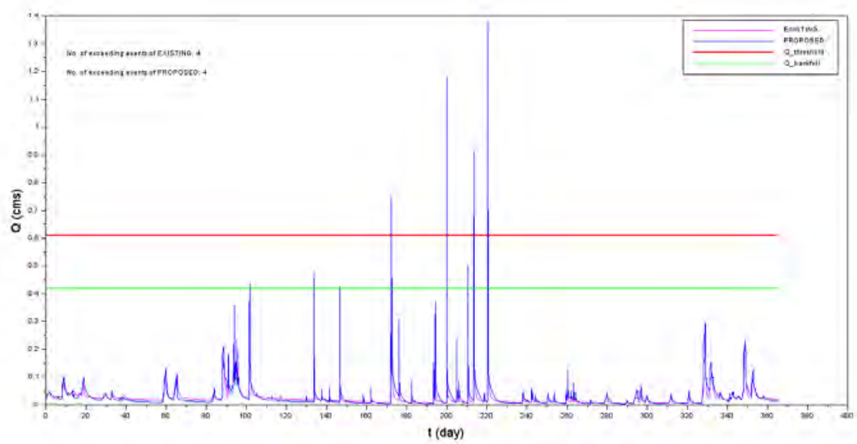
Reach 1 - 1976	
Reach 1 - 1977	

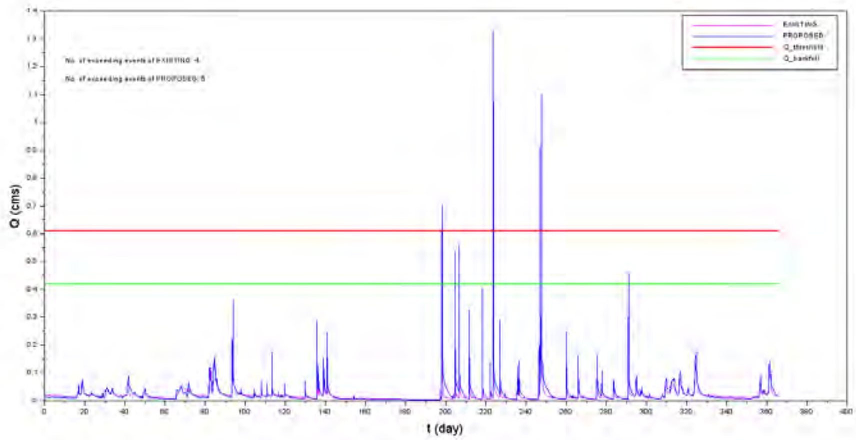
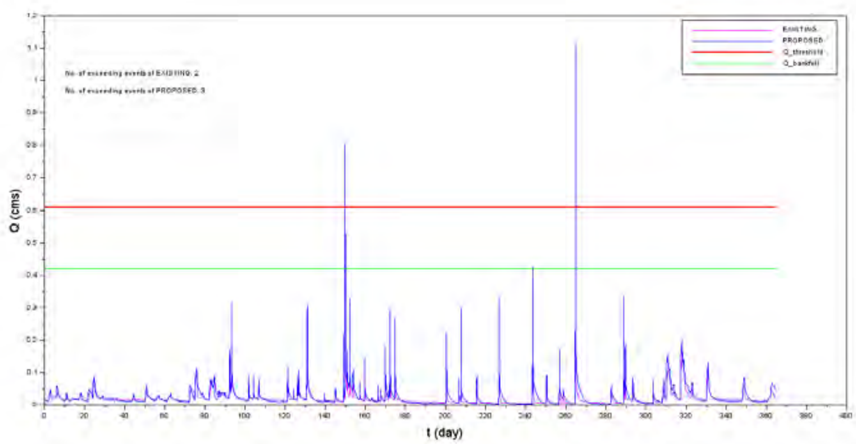
Reach 1 - 1978	
Reach 1 - 1979	

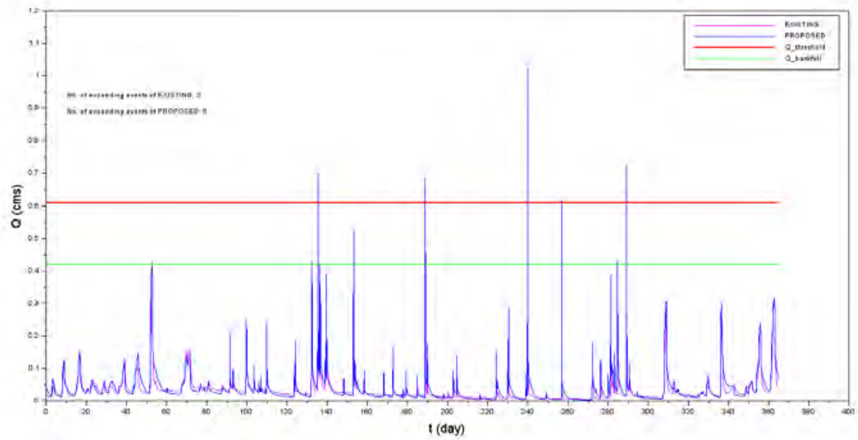
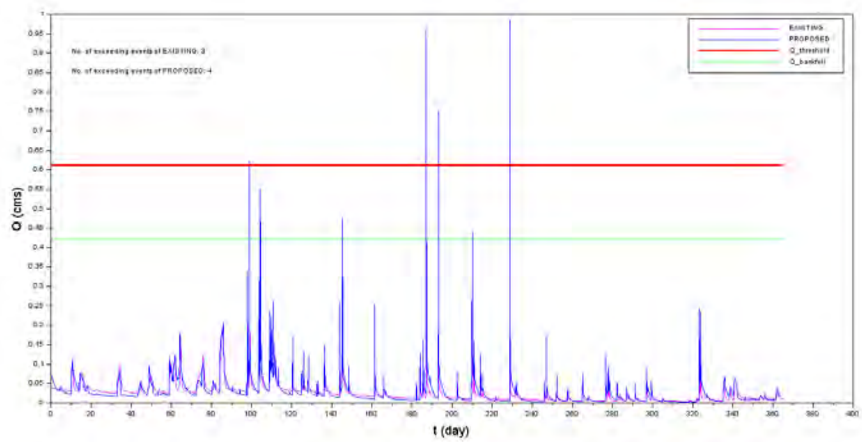
Reach 1 - 1980	
Reach 1 - 1981	

Reach 1 - 1982	
Reach 1 - 1983	

Reach 1 - 1984	
Reach 1 - 1985	

Reach 1 - 1986	
Reach 1 - 1987	

Reach 1 - 1988	
Reach 1 - 1989	

Reach 1 - 1990	
Reach 1 - 1991	

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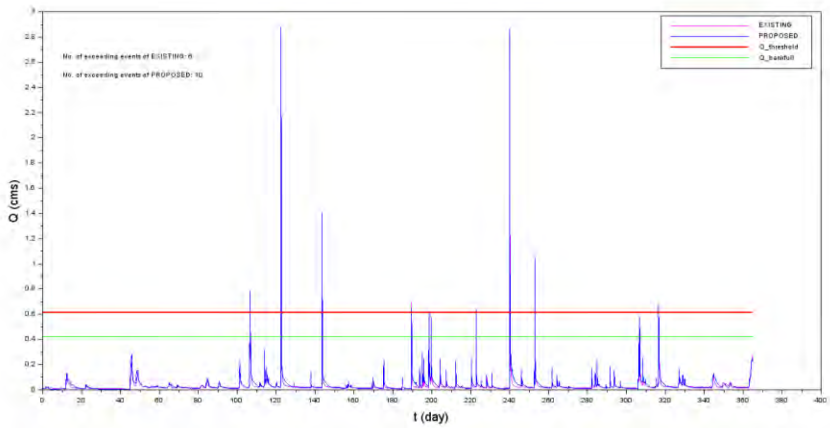
<td>
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urbantech west

APPENDIX F
HYDROLOGIC ANALYSIS

F-1 MIKE 11 Continuous Modelling Update – Watercourse 9 BSS#3 (January 2020)
F-2 Revisions to SCUBE East Model (June 2018)
F-3 VO5 Scenario Modelling Schematic and Output Files
F-4 Excerpts from SCUBE Study (2013) and FDRP Hydrology Report (1989)
F-5 SCUBE East Model Update – Sensitivity Analysis (February 2020)

urbantech west

APPENDIX F-1
MIKE 11 Continuous Modelling Update – DHI Memo (January 2020)

MEMO

To:	Janis Lobo, Urbantech West
Cc:	Andrew Fata, Rob Merwin
From:	Patrick Delaney
Date:	15/1/2020
Subject:	Scube East Model Update 4 – Flow Frequency Analysis for Continuous Simulations

1 Introduction

Based on comments from Hamilton Conservation Authority regarding the "Block Servicing Strategy, Fruitland-Winona Secondary Plan Area, Block 3, Second Submission, August 2019" (see Hamilton Conservation Authority memo dated September 30, 2019) DHI was asked to perform a flow frequency analysis for a continuous, 30-year simulation period from the beginning of 1962 to the end of 1992 for:

- Existing conditions
- Proposed development Scenario 2a with stormwater management ponds P2DA and P3DA
- Proposed development Scenario 2a without stormwater management ponds P2DA and P3DA

Scenario 2a included routing catchments 200, 300, 201A, 201B and P3DA through a storm sewer along Lewis Road and routing the outflow from catchment P2DA through a storm sewer along Barton Road.

2 Continuous Model Setup

For the purposes of this modelling update it was not necessary to run the continuous simulation for the Existing Conditions model since it had already been run in earlier phases of the study. This section provides an overview of the steps taken to run the continuous, 30-year simulation for Scenario 2a, with and without ponds.

2.1 Hydrology Model

The MIKE 11 continuous hydrology model setup used a combination of the NAM lumped conceptual model for simulating runoff contributions from undeveloped areas and the Kinematic Wave model for simulating runoff from developed areas of the study area. The climate inputs included a continuous time-series of hourly rainfall and reference evapotranspiration, and daily temperature data from the beginning of 1962 to the end of 1992. The climate data was provided with the original MIKE 11 model files provided by Hamilton Conservation Authority.

The Hydrology model was run for the entire 30-year simulation period and the result file containing runoff hydrographs from each catchment area was used as input to the MIKE 11 river hydraulic model.

It was not necessary to make any changes to the hydrology model for the condition where the ponds are omitted since the ponds will only affect the routing of the runoff hydrograph through the drainage channels and pipes.

2.2 Hydraulic Model

The Scenario 2a MIKE 11 hydraulic model setup was not changed from the version used in the August 2019 submission, with the exception of some minor adjustments to the stage-discharge curves used for stormwater management ponds P2DA and P3DA (see Table 1 below).

Table 1 Stage-Discharge Curves for Stormwater Management Ponds

P2DA			**P3DA**	
Stage (m)	**Discharge (m^3/s)**		**Stage (m)**	**Discharge (m^3/s)**
85.37	0		86.35	0
85.9	0.039		86.8	0.013
86.5	0.105		87.45	0.015
86.9	0.155		87.8	0.019
87.2	0.185		88	0.024
87.5	0.214		88.2	0.029
87.8	0.248		88.5	0.032
88.1	0.273		88.85	0.036

For the Scenario 2a model where the ponds are removed, the runoff hydrograph from each pond was directed to the branch immediately downstream of the pond (i.e. the runoff from catchment P2DA was connected to Branch 9_5 at chainage 27.3 m, and the runoff from catchment P3DA was connected to Branch 9_6 at chainage 508.6 m).

Due to the length of the simulation period and the time required to run the simulation it was run as 4 separate simulation periods; 1962-1969, 1970-1977, 1978-1985, and 1986-1992.

2.3 Model Results Analysis

The MIKE 11 hydraulic model results for the Existing Conditions model and the proposed Scenario 2a models, with and without ponds, were analyzed by extracting a time-series of flows for the 30-year simulation period at the node locations shown in Figure 1 below.

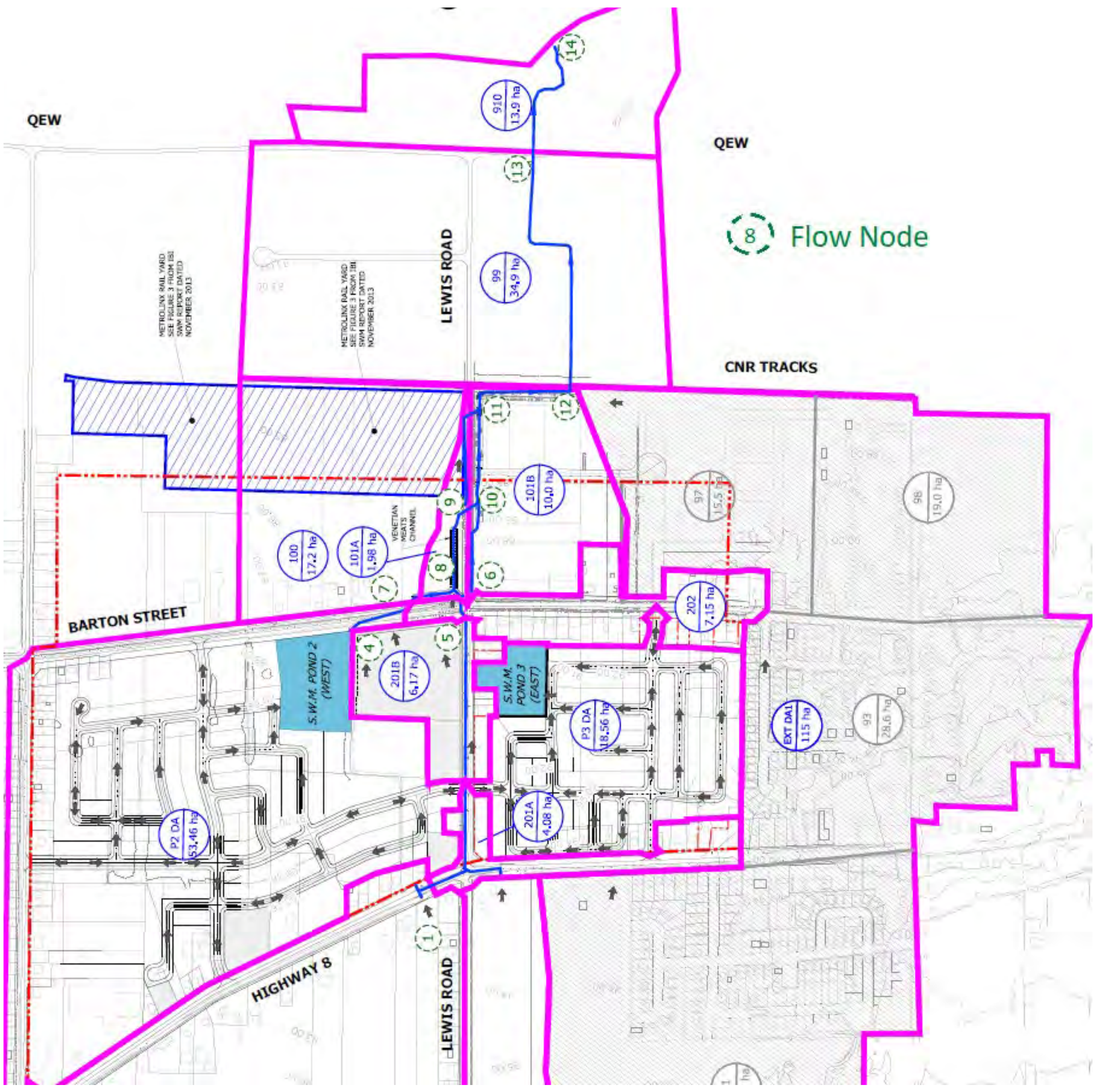


Figure 1 Map of Flow Node Locations

The annual maximum flow for each calendar year of the simulation was extracted for each flow node location and the linear moment for each time series were calculated and plotted on a Linear Moment Ratio Diagram to determine the most suitable distribution (see Figure 2). The plot indicates a Generalized Pareto (GPA) distribution provides the best fit for the data.

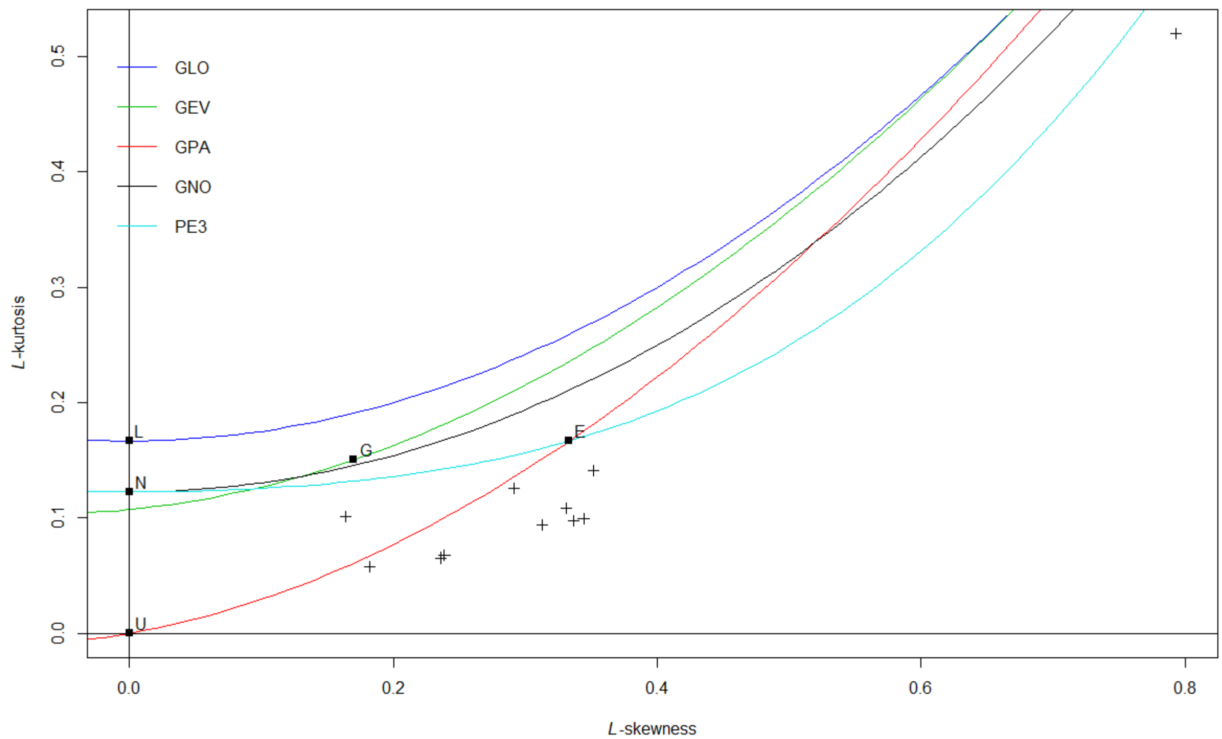


Figure 2 Linear Moment Ratio Diagram for Annual Maximum Flows (Scenario 2a - with Ponds)

The linear moments for each time-series were then used to estimate the GPA parameters and quantiles for the 2, 5, 10, 25, 50 and 100 year return periods. The flow frequency results for the Existing Condition, Scenario 2a with Ponds, and Scenario 2a without Ponds are presented in Table 2, Table 3 and Table 4, respectively. Table 5 presents a summary of the difference between Scenario 2a without Ponds vs. Scenario 2a with Ponds.

Table 2 Flow Frequency Analysis for Existing Conditions

	Node_1	Node_2	Node_3	Node_4	Node_5	Node_6	Node_7	Node_8	Node_9	Node_10	Node_11	Node_12	Node_13	Node_14
	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)
2-yr	0.49	0.19	0.38	0.37	0.44	0.15	0.04	0.68	0.15	0.68	1.06	1.79	3.67	3.54
5-yr	0.93	0.40	0.56	0.66	0.78	0.22	0.06	1.17	0.22	1.27	1.76	2.84	5.82	5.74
10-yr	1.29	0.61	0.64	0.92	1.02	0.26	0.06	1.50	0.25	1.77	2.20	3.45	7.04	7.04
25-yr	1.80	0.93	0.72	1.28	1.35	0.29	0.07	1.90	0.29	2.54	2.67	4.05	8.25	8.40
50-yr	2.21	1.23	0.76	1.59	1.59	0.31	0.07	2.17	0.31	3.21	2.97	4.39	8.94	9.21
100-yr	2.65	1.59	0.79	1.93	1.83	0.33	0.07	2.42	0.32	3.96	3.22	4.66	9.48	9.87

Table 3 Flow Frequency Analysis for Scenario 2a - with Ponds

	Node_1	**Node_4**	**Node_5**	**Node_6**	**Node_7**	**Node_8**	**Node_9**	**Node_10**	**Node_11**	**Node_12**	**Node_13**	**Node_14**
	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)
2-yr	0.517	0.1	0.738	0	0.1	0.962	0.148	0.941	1.239	1.829	3.948	4.062
5-yr	0.969	0.142	1.348	0	0.142	1.686	0.217	1.66	2.089	2.892	6.27	6.453
10-yr	1.321	0.172	1.793	0	0.172	2.236	0.254	2.214	2.729	3.481	7.729	7.947
25-yr	1.804	0.208	2.36	0	0.208	2.969	0.288	2.961	3.571	4.055	9.335	9.582
50-yr	2.181	0.233	2.773	0.001	0.233	3.527	0.306	3.538	4.205	4.373	10.344	10.604
100-yr	2.569	0.257	3.173	0.001	0.257	4.088	0.32	4.123	4.837	4.617	11.205	11.472

Table 4 Flow Frequency Analysis for Scenario 2a - without Ponds

	Node_1	Node_4	Node_5	Node_6	Node_7	Node_8	Node_9	Node_10	Node_11	Node_12	Node_13	Node_14
	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)
2-yr	0.517	1.305	1.160	0	1.305	2.603	0.148	2.600	2.912	1.829	5.611	5.668
5-yr	0.968	1.903	1.986	0	1.903	4.146	0.217	4.146	4.614	2.892	8.811	8.907
10-yr	1.321	2.226	2.586	0	2.226	5.159	0.254	5.156	5.711	3.481	10.727	10.869
25-yr	1.804	2.531	3.348	0	2.531	6.323	0.288	6.311	6.946	4.055	12.735	12.949
50-yr	2.181	2.696	3.902	0.001	2.696	7.087	0.306	7.066	7.742	4.373	13.937	14.210
100-yr	2.569	2.819	4.437	0.001	2.819	7.764	0.320	7.733	8.436	4.617	14.921	15.251

Table 5 Flow Frequency Difference Analysis for Scenario 2a ('without Ponds' minus 'with Ponds')

	Node_1	Node_4	Node_5	Node_6	Node_7	Node_8	Node_9	Node_10	Node_11	Node_12	Node_13	Node_14
	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)
2-yr	0.00	1.20	0.42	0.00	1.20	1.64	0.00	1.66	1.67	0.00	1.66	1.61
5-yr	0.00	1.76	0.64	0.00	1.76	2.46	0.00	2.49	2.53	0.00	2.54	2.45
10-yr	0.00	2.05	0.79	0.00	2.05	2.92	0.00	2.94	2.98	0.00	3.00	2.92
25-yr	0.00	2.32	0.99	0.00	2.32	3.35	0.00	3.35	3.38	0.00	3.40	3.37
50-yr	0.00	2.46	1.13	0.00	2.46	3.56	0.00	3.53	3.54	0.00	3.59	3.61
100-yr	0.00	2.56	1.26	0.00	2.56	3.68	0.00	3.61	3.60	0.00	3.72	3.78

Disclaimer

As with the previous SCUBE MIKE 11 model update assignments, DHI take no professional responsibility and makes no warranties regarding the accuracy or correctness of the model itself or the modelling results delivered in this assignment. DHI was not involved in the development or calibration of the original SCUBE MIKE 11 model and has only been asked to make changes to the model as instructed by Urbantech, to run the simulations, and to provide the model results for Urbantech to analyse, interpret and use as they see fit.

APPENDIX F-2
Revisions to SCUBE East Model – Revised Slopes DHI Memo
June 2018

MEMO

To:	Lisa Matruska, Andrew Fata, Rob Merwin, Cory Harris
Cc:	Henrik Loecke
From:	Patrick Delaney
Date:	6/12/2018
Subject:	Scube East Model Update – Corrected Slopes

1 Introduction

For the purposes of this memo, the following naming conventions will be used:

- Original Model: The MIKE 11 model originally developed by AquaforBeech
- Updated Model v1: The MIKE 11 model delivered by DHI to Urbantech West in January 2018
- Updated Model v2: The MIKE 11 model delivered by DHI to Urbantech West together with this memo.

This Memo documents changes made in the Updated Model v2 as a result of mistakes that were observed in the Updated Model v1 (mistakes that were embedded in the Original Model), and addresses comments received from HCA on the results from the Updated Model v1.

2 Model updates to correct urban catchment slopes

The work completed by DHI on the Updated Model v1 involved making adjustments to the Original Model to support changes requested by Urbantech West. DHI followed instructions from Urbantech West regarding the required changes to the drainage network and catchment hydrology parameters of the Original Model for 3 scenarios (Existing Conditions, Proposed Conditions without stormwater ponds, and Proposed Conditions with stormwater ponds).

A peer review of the Original Model was not performed and the validity of the Original Model parameters was not conducted prior to initiating the changes to the Original Model. However, during the process of addressing the comments received from HCA it was observed that the slopes of the urban catchments were unrealistically low.

The default units for slope of an urban catchment in MIKE 11's NAM hydrology model is 'per mille' rather than 'percent'. Therefore, a slope of '1%' should be expressed as a value of '10' in the NAM model. However, the model delivered by AquaforBeech used values that reflected a dimensionless ratio (e.g. a value of '1%' was expressed as a value of '0.01'). As a result, it was concluded that all of the urban catchment slope values were under-estimated by a factor of 1000. The impact of this mistake on the model results is to increase the time to peak and significantly decrease the peak value of rainfall runoff from the urban catchments.

The Original Model files were opened in the 2007 version of MIKE 11 to confirm that the slope unit issue was not something introduced by a difference in the version of MIKE 11 being used to run the model.

In order to address this mistake, DHI increased all of the urban catchment slope values in Updated Model v2 by a factor of 1000.

DHI also noted that the urban catchment drainage path length values were, in some cases, unusually long (e.g. Catchment 101B_URBAN has an area of 0.07 km^2 and a drainage length of 1900 m). However, there was no consistent relationship between the length values and the catchment area, and the methodology used to calculate the values was not documented, so it was not possible to determine whether this was an unintentional mistake or not.

The impact of longer drainage path lengths is to increase the time to peak and reduce the peak value of rainfall runoff. However, a sensitivity analysis performed using adjusted length values revealed it has a much smaller impact on the results than the corrected slope (see Addendum 1).

Since it was unclear whether the length values were incorrectly calculated and the impacts on the results were less significant, it was decided to leave the length values 'as is' for this version of the updated model.

2.1 Corrected NAM Area for catchment 300_NAM

A correction was made to the catchment 300 to reduce the undeveloped runoff catchment area (represented by catchment 300_NAM) from 0.587 km^2 under existing conditions to 0.553 km^2 under proposed conditions. This resulted in a total catchment area of 63.6 ha for catchment 300.

2.2 Addressing Comments

HRCA Comment:

The DHI memorandum ("Scube East Model Update" dated January 12, 2018) reports peak flow rates under future uncontrolled conditions in Watercourse 9 at the CNR, QEW and Lake Ontario outlet which are significantly lower (23 – 30 % lower for the 100 year event) compared to the findings from the SCUBE East Sub-Watershed Study (Aquafor Beech 2013).

The updated drainage area is 9.5 ha smaller, due to the fact that the updated modeling did not include the planned diversion of catchments 1011 and 1012 from Watercourse 10-2 storm sewer to the lined eastern tributary of Watercourse 9 (as was included in the SCUBE

East Sub-Watershed Study). Also, the imperviousness assumed under future uncontrolled conditions is slightly smaller in the updated modeling.

HCA staff are not confident that these changes alone justify the 23 – 30 % decrease in 100 year peak flow rates. It is also noted that the existing condition peak flow rates are quite similar between the updated modeling and SCUBE 2013 at the CNR, QEW and Lake Ontario outlet.

DHI Response:

An evaluation of the Updated Model v1 setup was inconclusive in addressing this comment so it was decided to do a comparison of the Original Model result files provided by AquaforBeech with the Original Model result files generated using MIKE 11 2017. The results of this comparison (see Addendum 2) show the results from the 2017 version of MIKE 11 produce peak flows that are significantly lower and this appears to be mainly attributed to differences in the urban runoff component. A detailed investigation of the reasons for this difference was not conducted.

HCRA Comment:

Peak Flows Comparison - At Upstream End of the Watercourse 9 Tributary That Drains Across the Site:

The DHI memorandum ("Scube East Model Update" dated January 12, 2018) reports peak flow rates in the Watercourse 9 tributary at a location just south of Highway 8 (Node 9_5 – 0) that are significantly lower under proposed conditions with SWM, compared to existing conditions.

Given that this is external drainage flowing onto the site, it was expected that the peak flow rates would be very similar to existing conditions. Please provide rationale for this decrease in peak flow rate.

DHI Response:

An error in the Combined Catchment details was observed in Scenario 2 for Catchment 300 and Catchment 201B in the Updated Model v1. This error was corrected in the Updated Model v2.

HCA Comment:

Catchment Area ExtDA1:

The DHI memorandum ("Scube East Model Update" dated January 12, 2018) reports an area of 51.75 ha for the EXTDA1 catchment (Tables 2 & 7), however the Urbantech West report Figures 2 and 3 states an area of 115 to 116 ha.

Please confirm that the DHI modeling included the full external area draining to node 9-1871.05. Based on review of the SCUBE East Sub-Watershed Study (Aquafor Beech 2013), this total external drainage area was expected to be approximately 116 ha.

DHI Response:

Catchment EXTDA1 is represented in figures differently that how it is represented in the model. In the figures, Catchment EXTDA1 is the sum of Catchments 93, 97, 98 and 121 model minus the area of Catchment 200. In the model Catchments 93, 97 and 98 are still present and Catchment EXTDA1 occupies the remaining area. The sum of the area of Catchments EXTDA1, 93, 97 and 98 is equal to 116 ha.

HCA Comment:

Calculated Urban Length Values Based on the Previous Length Divided by the Square Root of the Area Reduction Factor:

The DHI memorandum ("Scube East Model Update" dated January 12, 2018) reports that the calculated urban length for catchment 101B under existing and proposed conditions is 1944m.

Also, the calculated urban length for catchment P2DA and P3DA under proposed conditions is 2233m and 1457m.

These adopted model parameters seem potentially large to HCA staff, compared to the urban length adopted for the EXTDA1 catchment, which according to the Figures could be expected to have the longest urban length.

It is suggested that the sensitivity of the resultant peak flows to the urban lengths be reviewed. If peak flows are significantly sensitive to this parameter, it is requested that the urban lengths calculated by this approach be further justified.

DHI Response:

See discussion above regarding catchment drainage path lengths and Addendum 1.

HCA Comment:

Adopted Urban Slopes:

For a number of catchments, the adopted urban slope is 0, including for P2DA and P3DA. It is suggested that the sensitivity of the resultant peak flows to the urban slope be reviewed. If peak flows are significantly sensitive to this parameter, it is requested that the urban slopes of 0 value be further justified.

DHI Response:

See discussion of changes to Urban Catchment slopes above.

HCA Comment:

Catchment Area for Catchment 300, Under Proposed Conditions:

The DHI memorandum ("Scube East Model Update" dated January 12, 2018) reports a total area of 67.0 ha for catchment 300 for both existing and proposed conditions (Tables 2 & 7). However the Urbantech West report Figure 3 state an area of 63.6 ha for proposed conditions.

Please confirm the catchment area of catchment 300 under proposed conditions, and that the Figures, Tables and modeling are all consistent.

DHI Response:

See corrections to catchment 300 drainage area noted above.

Addendum 1:
Sensitivity Analysis for Urban Catchment Slopes and Drainage Path Lengths

Content of Emails sent by Henrik Loecke, DHI to Lisa Maruska, Urbantech West on May 2, 2018.

Hi Lisa

We have run the sensitivity analysis for all urban catchments (NAM part excluded from this analysis, except for the Network analysis where it is included).

The attached Sensitivity.pdf shows one page per catchment.

We analysed three options (based on Scenario 1):

1. Original
2. Updated slope
3. Updated length and slope

For the update, we multiplied all slopes by 1000.

For length we adjusted to more reasonable values. We multiplied lengths up to 500 m by 0.3, 500-1000 m by 0.2 and above 1000 m by 0.1. This is only suitable for this sensitivity analysis and not for future reruns where they should be examined further.

Catchment	Area	Length Old (m)	Slope Old (o/oo)	Length Factor	Slope Factor	Length New (m)	Slope New (o/oo)
100_URBAN	3.04	550	0.009	0.2	1000	110	9
101A_URBAN	0.98	716	0.009	0.2	1000	143	9
101B_URBAN	7.23	1944	0.009	0.1	1000	194	9
200_URBAN	1.58	493	0.057	0.3	1000	148	57
201A_URBAN	2.34	452	0.005	0.3	1000	136	5
201B_URBAN	1.92	409	0.005	0.3	1000	123	5
202_URBAN	5.51	848	0.005	0.2	1000	170	5
300_URBAN	8.3	1326	0.084	0.1	1000	133	84
301_URBAN	1.68	327	0.005	0.3	1000	98	5
302B_URBAN	12.01	936	0.005	0.2	1000	187	5
EXTDA1_URBAN	19.42	1880	0.057	0.1	1000	188	57

We analysed for three events:

- 17/09/76-19/09/76
- 24/08/82-26/08/82
- 27/08/92-29/08/92

Across the catchments we see peaks 2-5 times higher for the updated model. The accumulation is mostly around 10-50% higher. It is found that the difference in slope has a much higher impact than the update of length (as it is changes by a factor of 1000)

Below I show a screendump from one of the catchment to explain how they are to be interpreted.

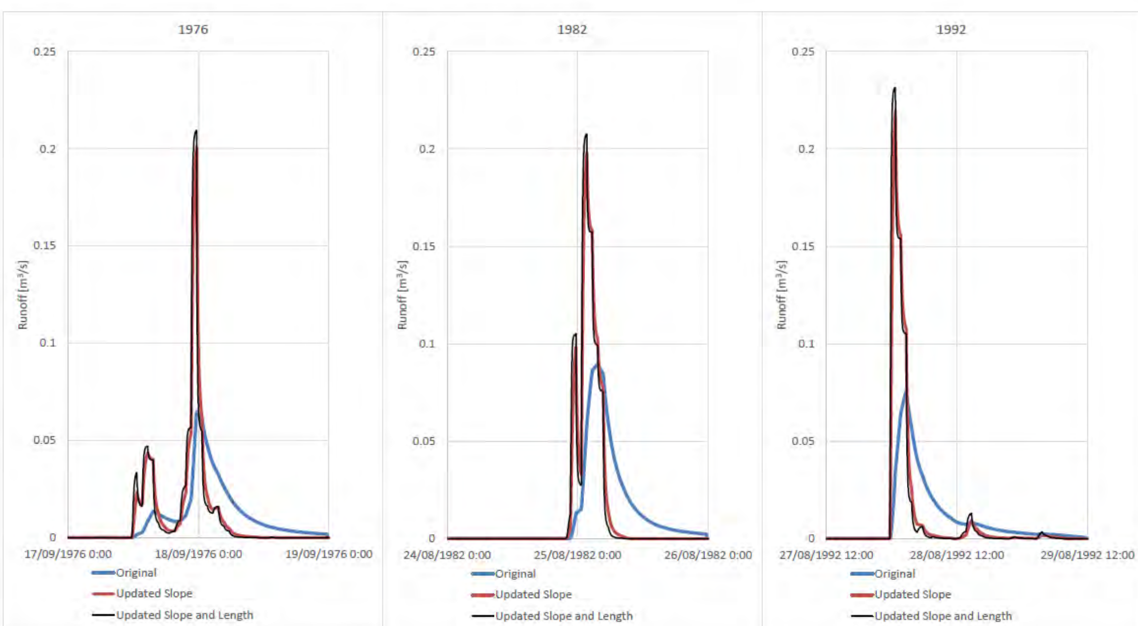
Each page contains:

- Three graphs, one for each event (the 1992 event appears incomplete but it is not, it starts sharply at midninght).
    - o The blue line is original
    - o The red is updated slope
    - o The black is updated length and slope

- One data table showing:
    - o Length. In the example original and slope option length is 550 m and updated slope and length is 110 m.
    - o Slope in per thousand (o/oo)
    - o Peak – for example the original 1976 peak is 0.065 m^3/s, the updated slope peak is 0.201 m^3/s and the updated slope and length is 0.209 m^3/s
    - o Accumulation over two days - for example the original 1976 accumulation is 1808 m^3, the updated slope accumulation is 1981 m^3 and the updated slope and length accumulation is 2000 m^3

100_URBAN

	Length (m)	Slope (o/oo)	Peak (m^3/s) 1976	Acc. (m^3) 1976	Peak (m^3/s) 1982	Acc. (m^3) 1982	Peak (m^3/s) 1992	Acc. (m^3) 1992
Original	550	0.009	0.065	1808	0.090	2172	0.076	1727
Updated Slope	550	9	0.201	1981	0.198	2438	0.219	1925
Updated Slope and Length	110	9	0.209	2000	0.208	2457	0.231	1950

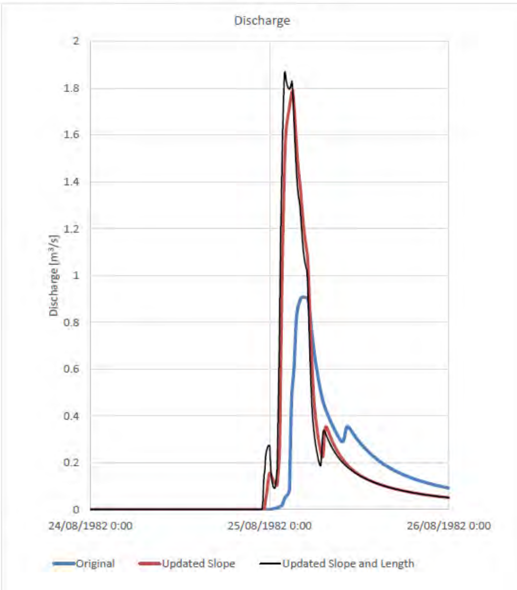


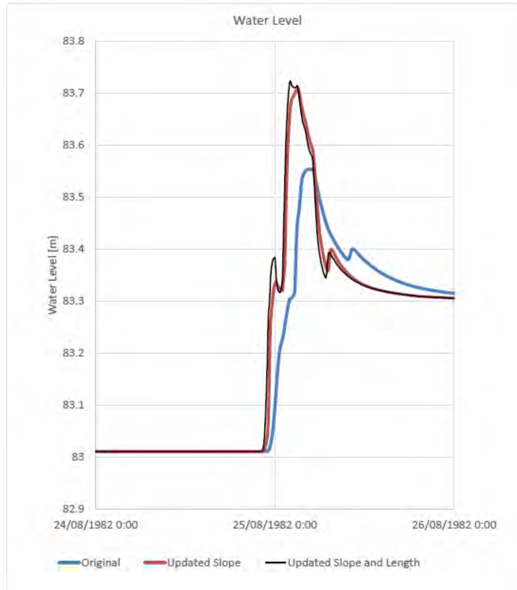
For Sensitivity_Network.pdf please refer to the flow node locations shown below for the three plotted locations.

The setup of this sheet is similar to the runoff sheet but has water level. It also has one comment line with additional information (row 3).

Flow Node 11
Branch 9_1 Chainage 955
Catchment 101B drains to this downstream location.

	Peak (m^3/s)	Acc. (m^3)	Peak (m)
	Discharge		Level
Original	0.908	24675	83.55
Updated Slope	1.789	31247	83.71
Updated Slope and Length	1.870	32093	83.72





Best regards
Henrik Løcke

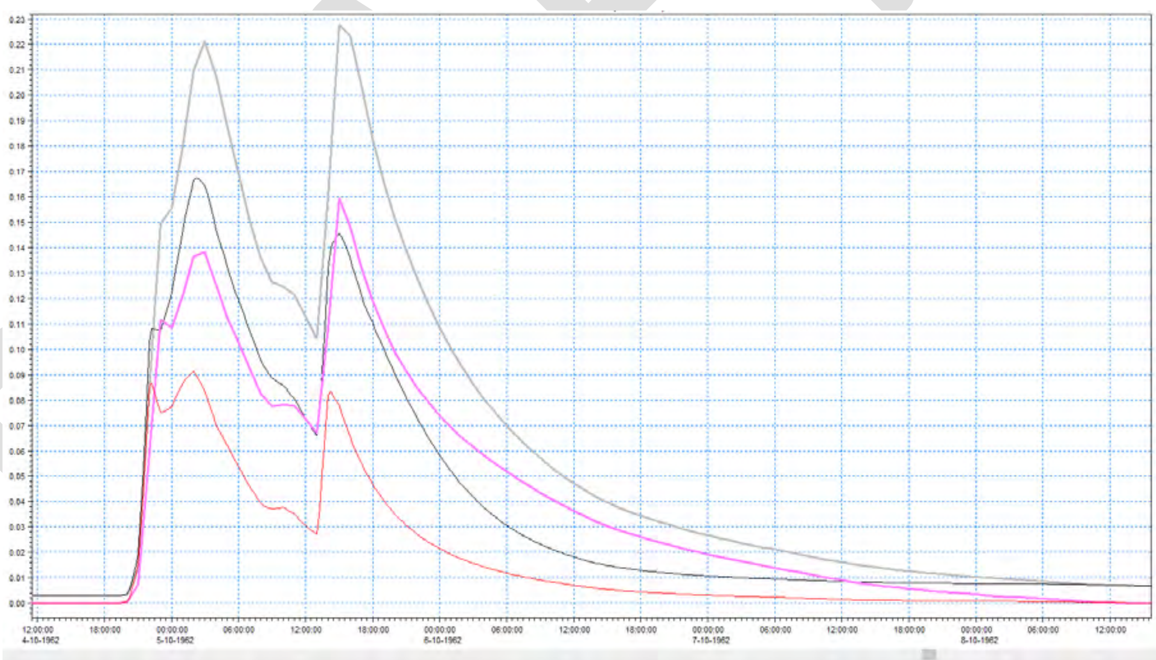
DHI Canada
Tel: +1 519 650 4545, Mobile: +1 519 651 7002

Addendum 2:
Comparison of Original Model Results

The comments from HCA noted a reduction in flows in the order of 20-30% when comparing the proposed condition from the AquaforBeech report to the proposed condition with the new model. While there are some differences in the model setup, those differences do not likely account for such a significant difference in peak flows.

As part of the investigation it was decided to run the model file provide by AquaforBeech with the 2017 version of MIKE 11 and compare the result files to those provided by AquaforBeech. In doing so it was observed that the results provided by AquaforBeech had significantly higher peak flows during significant events than the results obtained with the 2017 version of MIKE 11. The difference in the peak flows appears to be due to differences in the Urban runoff results.

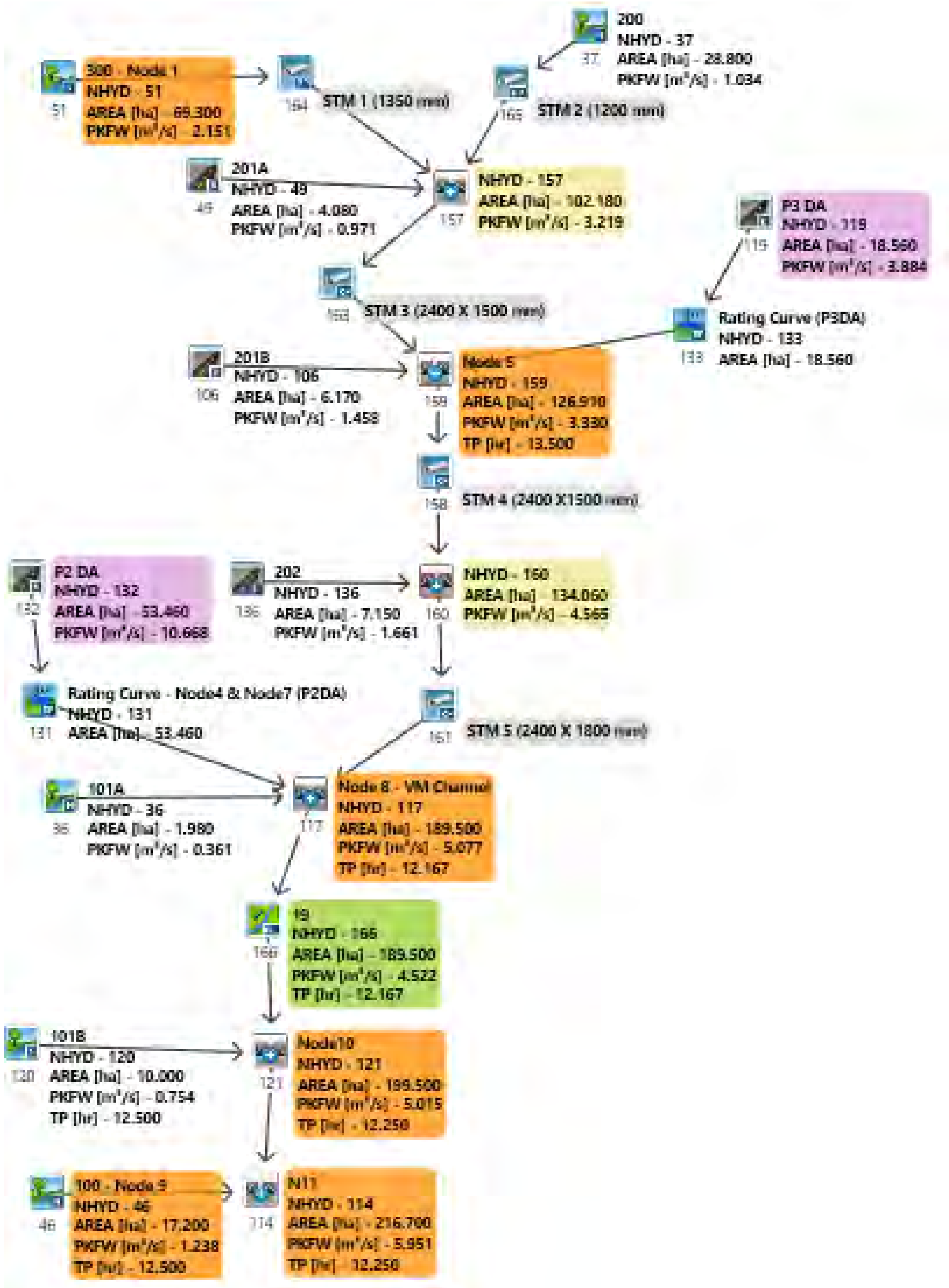
The figure below shows a comparison between the AquaforBeech results and the 2017 version results for Catchment 92 where; the Total runoff for the AquaforBeech result file is shown in gray and the Total runoff for the 2017 version is shown in black; and the Urban runoff for AquaforBeech result file is shown in pink and the Urban runoff for the 2017 version is shown in red.



For the event depicted in the above figure, the 2017 version results show a 23% reduction in peak flow, while a comparison of the accumulated runoff from catchment 92 for the entire year in 1962 shows the 2017 version produces approximately 8% less runoff volume.

APPENDIX F-3
VO5 Scenario Modelling Schematic and Output Files

Post Development Scenario – (100-Year Schematic shown)



```
********************************
** SIMULATION:Run 01         **
********************************

--------------------
|    READ STORM    |    Filename: C:\Users\Janis Lobo\AppD
|                  |           ata\Local\Temp\
|                  |           9d3c8ff4-eb6c-4319-bb26-ce62fa26e7e3\f3bd6d83
| Ptotal= 25.00 mm |    Comments: 25 mm, 4 hr. chicago dist'n. - water qua
--------------------
             TIME    RAIN |  TIME    RAIN |' TIME    RAIN |  TIME    RAIN
              hrs   mm/hr |   hrs   mm/hr |'  hrs   mm/hr |   hrs   mm/hr
             0.17    2.07 |  1.17    5.70 |  2.17    5.19 |  3.17    2.80
             0.33    2.27 |  1.33   10.78 |  2.33    4.47 |  3.33    2.62
             0.50    2.52 |  1.50   50.21 |  2.50    3.95 |  3.50    2.48
             0.67    2.88 |  1.67   13.37 |  2.67    3.56 |  3.67    2.35
             0.83    3.38 |  1.83    8.29 |  2.83    3.25 |  3.83    2.23
             1.00    4.18 |  2.00    6.30 |  3.00    3.01 |  4.00    2.14

-------------------------------------------------------------------------------


--------------------
| CALIB            |
| NASHYD  (  0036)|   Area    (ha)=   1.98   Curve Number   (CN)= 68.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  13.90   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.09

       NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                        ---- TRANSFORMED HYETOGRAPH ----
             TIME    RAIN |  TIME    RAIN |' TIME    RAIN |  TIME    RAIN
              hrs   mm/hr |   hrs   mm/hr |'  hrs   mm/hr |   hrs   mm/hr
            0.083    2.07 | 1.083    5.70 | 2.083    5.19 |  3.08    2.80
            0.167    2.07 | 1.167    5.70 | 2.167    5.19 |  3.17    2.80
            0.250    2.27 | 1.250   10.78 | 2.250    4.47 |  3.25    2.62
            0.333    2.27 | 1.333   10.78 | 2.333    4.47 |  3.33    2.62
            0.417    2.52 | 1.417   50.21 | 2.417    3.95 |  3.42    2.48
            0.500    2.52 | 1.500   50.21 | 2.500    3.95 |  3.50    2.48
            0.583    2.88 | 1.583   13.37 | 2.583    3.56 |  3.58    2.35
            0.667    2.88 | 1.667   13.37 | 2.667    3.56 |  3.67    2.35
            0.750    3.38 | 1.750    8.29 | 2.750    3.25 |  3.75    2.23
            0.833    3.38 | 1.833    8.29 | 2.833    3.25 |  3.83    2.23
            0.917    4.17 | 1.917    6.30 | 2.917    3.01 |  3.92    2.14
            1.000    4.18 | 2.000    6.29 | 3.000    3.01 |  4.00    2.14

    Unit Hyd Qpeak  (cms)=   0.840

    PEAK FLOW       (cms)=   0.002 (i)
    TIME TO PEAK    (hrs)=   2.167
    RUNOFF VOLUME    (mm)=   0.907
    TOTAL RAINFALL   (mm)=  24.996
    RUNOFF COEFFICIENT   =   0.036

    (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD  (  0037)|   Area    (ha)=  28.80   Curve Number   (CN)= 68.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  13.90   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.21

    Unit Hyd Qpeak  (cms)=   0.908

    PEAK FLOW       (cms)=   0.025 (i)
    TIME TO PEAK    (hrs)=   4.250
    RUNOFF VOLUME    (mm)=   0.942
    TOTAL RAINFALL   (mm)=  24.996
    RUNOFF COEFFICIENT   =   0.038

    (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
--------------------
| ROUTEPIPE(  0165)|     PIPE Number     =   1.00
| IN= 2---> OUT= 1 |     Diameter    (mm)=1200.00
| DT=  5.0 min     |     Length       (m)=  73.30
--------------------      Slope      (m/m)=  0.010
                         Manning n       =  0.013

    <----------------- TRAVEL TIME TABLE -------------------->
     DEPTH     VOLUME    FLOW RATE   VELOCITY    TRAV.TIME
      (m)     (cu.m.)     (cms)       (m/s)        min
     0.06    .167E+01      0.0         0.92        1.33
     0.13    .465E+01      0.1         1.43        0.85
     0.19    .840E+01      0.2         1.84        0.66
     0.25    .127E+02      0.4         2.19        0.56
```

0.32	.174E+02	0.6	2.49	0.49
0.38	.225E+02	0.8	2.75	0.44
0.44	.277E+02	1.1	2.99	0.41
0.51	.332E+02	1.4	3.19	0.38
0.57	.387E+02	1.8	3.37	0.36
0.63	.442E+02	2.1	3.52	0.35
0.69	.497E+02	2.5	3.65	0.33
0.76	.552E+02	2.8	3.76	0.32
0.82	.604E+02	3.2	3.84	0.32
0.88	.655E+02	3.5	3.90	0.31
0.95	.702E+02	3.8	3.93	0.31
1.01	.745E+02	4.0	3.93	0.31
1.07	.783E+02	4.1	3.89	0.31
1.14	.812E+02	4.2	3.78	0.32
1.20	.829E+02	3.9	3.45	0.35

```
                    <---- hydrograph ---->  <-pipe / channel->
                 AREA    QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                 (ha)    (cms)   (hrs)   (mm)     (m)      (m/s)
INFLOW : ID= 2 (  0037)  28.80    0.03    4.25   0.94     0.07     0.94
OUTFLOW: ID= 1 (  0165)  28.80    0.03    4.33   0.94     0.07     0.94
```

```
-------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD   (  0051)|   Area    (ha)=  69.30   Curve Number   (CN)= 68.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  13.90   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.45

    Unit Hyd Qpeak  (cms)=   1.825

    PEAK FLOW       (cms)=   0.055 (i)
    TIME TO PEAK    (hrs)=   4.500
    RUNOFF VOLUME    (mm)=   0.942
    TOTAL RAINFALL   (mm)=  24.996
    RUNOFF COEFFICIENT   =   0.038

    (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
--------------------
| ROUTEPIPE(  0164)|     PIPE Number     =   1.00
| IN= 2---> OUT= 1 |     Diameter    (mm)=1350.00
| DT=  5.0 min     |     Length      (m)= 104.50
--------------------     Slope     (m/m)=  0.010
                         Manning n      =  0.013
```

<----------------- TRAVEL TIME TABLE -------------------->

DEPTH (m)	VOLUME (cu.m.)	FLOW RATE (cms)	VELOCITY (m/s)	TRAV.TIME min
0.07	.302E+01	0.0	0.99	1.76
0.14	.839E+01	0.1	1.55	1.13
0.21	.152E+02	0.3	1.99	0.88
0.28	.229E+02	0.5	2.37	0.74
0.36	.314E+02	0.8	2.69	0.65
0.43	.405E+02	1.2	2.98	0.58
0.50	.500E+02	1.5	3.23	0.54
0.57	.598E+02	2.0	3.45	0.50
0.64	.698E+02	2.4	3.64	0.48
0.71	.798E+02	2.9	3.81	0.46
0.78	.898E+02	3.4	3.95	0.44
0.85	.996E+02	3.9	4.07	0.43
0.92	.109E+03	4.3	4.16	0.42
0.99	.118E+03	4.8	4.22	0.41
1.07	.127E+03	5.2	4.25	0.41
1.14	.134E+03	5.5	4.25	0.41
1.21	.141E+03	5.7	4.20	0.41
1.28	.147E+03	5.7	4.09	0.43
1.35	NaN	NaN	NaN	NaN

```
                    <---- hydrograph ---->  <-pipe / channel->
                 AREA    QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                 (ha)    (cms)   (hrs)   (mm)     (m)      (m/s)
INFLOW : ID= 2 (  0051)  69.30    0.05    4.50   0.94     0.09     1.10
OUTFLOW: ID= 1 (  0164)  69.30    0.05    4.50   0.94     0.09     1.10
```

```
-------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  0049)|   Area    (ha)=   4.08
|ID= 1 DT= 5.0 min |   Total Imp(%)=  67.00   Dir. Conn.(%)=  55.00
--------------------
                        IMPERVIOUS    PERVIOUS (i)
    Surface Area    (ha)=     2.73         1.35
    Dep. Storage    (mm)=     1.00         5.00
    Average Slope    (%)=     1.00         2.00
    Length           (m)=   164.92       215.00
    Mannings n          =    0.014        0.250
```

```
    Max.Eff.Inten.(mm/hr)=     50.21        3.55
             over (min)        5.00       80.00
    Storage Coeff.  (min)=      4.75 (ii)   78.38 (ii)
    Unit Hyd. Tpeak (min)=       5.00       80.00
    Unit Hyd. peak  (cms)=       0.22        0.01
                                   *TOTALS*
    PEAK FLOW       (cms)=      0.28        0.01        0.283 (iii)
    TIME TO PEAK    (hrs)=      1.50        3.17         1.50
    RUNOFF VOLUME    (mm)=      24.00        4.17        15.06
    TOTAL RAINFALL   (mm)=      25.00       25.00        25.00
    RUNOFF COEFFICIENT   =       0.96        0.17         0.60

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
         CN*  =  68.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
         THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------


--------------------
| ADD HYD  (  0157)|
|   1 +  2 =  3    |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 1 (  0164):    69.30   0.055     4.50     0.94
    + ID2= 2 (  0165):    28.80   0.025     4.33     0.94
      ========================================================
      ID = 3 (  0157):    98.10   0.080     4.42     0.94

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------


--------------------
| ADD HYD  (  0157)|
|   3 +  2 =  1    |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 3 (  0157):    98.10   0.080     4.42     0.94
    + ID2= 2 (  0049):     4.08   0.283     1.50    15.06
      ========================================================
      ID = 1 (  0157):   102.18   0.283     1.50     1.51
```

```
    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| ROUTEPIPE(  0163)|     PIPE Number     =   1.00
| IN= 2---> OUT= 1 |     Width       (mm)=2400.00     Height   (mm)=1500.00
| DT=  5.0 min     |     Length       (m)= 346.00
--------------------     Slope      (m/m)=  0.007
                         Manning n       =  0.013

    <----------------- TRAVEL TIME TABLE -------------------->
     DEPTH     VOLUME    FLOW RATE   VELOCITY   TRAV.TIME
      (m)      (cu.m.)     (cms)       (m/s)       min
     0.08    .656E+02      0.2        1.18       21.26
     0.16    .131E+03      0.7        1.79       13.94
     0.24    .197E+03      1.3        2.26       11.05
     0.32    .262E+03      2.0        2.65        9.45
     0.39    .328E+03      2.8        2.97        8.42
     0.47    .393E+03      3.7        3.25        7.70
     0.55    .459E+03      4.6        3.49        7.17
     0.63    .524E+03      5.6        3.70        6.75
     0.71    .590E+03      6.6        3.89        6.42
     0.79    .656E+03      7.7        4.07        6.15
     0.87    .721E+03      8.8        4.22        5.92
     0.95    .787E+03      9.9        4.36        5.73
     1.03    .852E+03     11.1        4.49        5.56
     1.11    .918E+03     12.2        4.61        5.42
     1.18    .983E+03     13.4        4.72        5.29
     1.26    .105E+04     14.6        4.82        5.18
     1.34    .111E+04     15.8        4.92        5.08
     1.42    .118E+04     17.1        5.01        4.99
     1.50    .125E+04     18.3        5.09        4.91
                         <---- hydrograph ---->  <-pipe / channel->
                       AREA    QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                       (ha)    (cms)   (hrs)   (mm)      (m)      (m/s)
  INFLOW : ID= 2 (  0157)  102.18     0.28    1.50   1.51      0.09      1.23
  OUTFLOW: ID= 1 (  0163)  102.18     0.12    1.58   1.51      0.04      1.18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--------------------
| CALIB            |
| STANDHYD (  0106)|   Area    (ha)=   6.17
```

```
|ID= 1 DT= 5.0 min |   Total Imp(%)=  67.00   Dir. Conn.(%)=  55.00
--------------------
                       IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=     4.13        2.04
    Dep. Storage     (mm)=      1.00        5.00
    Average Slope    (%)=      1.00        2.00
    Length           (m)=    202.81      215.00
    Mannings n          =     0.014       0.250

    Max.Eff.Inten.(mm/hr)=     50.21        3.55
             over (min)       5.00       80.00
    Storage Coeff.  (min)=      5.38 (ii)   79.00 (ii)
    Unit Hyd. Tpeak (min)=      5.00       80.00
    Unit Hyd. peak  (cms)=      0.21        0.01
                                              *TOTALS*
    PEAK FLOW       (cms)=      0.41        0.01         0.415 (iii)
    TIME TO PEAK    (hrs)=      1.50        3.17          1.50
    RUNOFF VOLUME    (mm)=     24.00        4.17         15.07
    TOTAL RAINFALL   (mm)=     25.00       25.00         25.00
    RUNOFF COEFFICIENT   =      0.96        0.17          0.60


     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
         CN*  =  68.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
         THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

----------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  0119)|   Area    (ha)=  18.56
|ID= 1 DT= 5.0 min |   Total Imp(%)=  69.00   Dir. Conn.(%)=  45.00
--------------------
                       IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=    12.81        5.75
    Dep. Storage     (mm)=      1.00        5.00
    Average Slope    (%)=      1.00        2.00
    Length           (m)=    351.76      215.00
    Mannings n          =     0.014       0.250

    Max.Eff.Inten.(mm/hr)=     50.21        6.17
             over (min)       5.00       70.00
    Storage Coeff.  (min)=      7.48 (ii)   66.48 (ii)
    Unit Hyd. Tpeak (min)=      5.00       70.00
    Unit Hyd. peak  (cms)=      0.17        0.02
                                              *TOTALS*
    PEAK FLOW       (cms)=      0.92        0.05         0.919 (iii)
    TIME TO PEAK    (hrs)=      1.50        2.83          1.50
    RUNOFF VOLUME    (mm)=     24.00        5.49         13.82
    TOTAL RAINFALL   (mm)=     25.00       25.00         25.00
    RUNOFF COEFFICIENT   =      0.96        0.22          0.55


     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
         CN*  =  68.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
         THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

----------------------------------------------------------------------------
--------------------
| RESERVOIR(  0133)|
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |    OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)    (ha.m.)   |   (cms)     (ha.m.)
                         0.0000     0.0000   |  0.0250     1.0741
                         0.0140     0.2394   |  0.0290     1.2348
                         0.0150     0.6048   |  0.0340     1.4904
                         0.0210     0.8843   |  0.0380     1.7173

                            AREA     QPEAK     TPEAK      R.V.
                            (ha)     (cms)     (hrs)      (mm)
  INFLOW : ID= 2 (  0119)    18.560     0.919      1.50     13.82
  OUTFLOW: ID= 1 (  0133)    18.560     0.014      5.67     13.38

              PEAK   FLOW   REDUCTION [Qout/Qin](%)=  1.49
              TIME SHIFT OF PEAK FLOW         (min)=250.00
              MAXIMUM  STORAGE   USED         (ha.m.)=  0.2334

----------------------------------------------------------------------------

--------------------
| ADD HYD  (  0159)|
|  1 +  2 =  3     |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
       ID1= 1 (  0106):      6.17   0.415     1.50    15.07
     + ID2= 2 (  0133):     18.56   0.014     5.67    13.38
```

```
   ====================================================
   ID = 3 (  0159):    24.73   0.418    1.50    13.80

 NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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--------------------
| ADD HYD  (  0159)|
|   3 +  2 =  1    |        AREA    QPEAK    TPEAK     R.V.
--------------------       (ha)    (cms)    (hrs)     (mm)
      ID1= 3 (  0159):    24.73   0.418     1.50    13.80
    + ID2= 2 (  0163):   102.18   0.125     1.58     1.51
      ====================================================
      ID = 1 (  0159):   126.91   0.518     1.50     3.90

 NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| ROUTEPIPE(  0158)|     PIPE Number     =   1.00
| IN= 2---> OUT= 1 |     Width       (mm)=2400.00     Height   (mm)=1500.00
| DT=  5.0 min     |     Length       (m)= 253.00
--------------------     Slope      (m/m)=  0.005
                         Manning n       =  0.013

  <----------------- TRAVEL TIME TABLE -------------------->
   DEPTH     VOLUME    FLOW RATE    VELOCITY    TRAV.TIME
    (m)     (cu.m.)     (cms)        (m/s)        min
   0.08     .479E+02      0.2         0.96        26.04
   0.16     .959E+02      0.6         1.46        17.07
   0.24     .144E+03      1.1         1.85        13.53
   0.32     .192E+03      1.6         2.16        11.57
   0.39     .240E+03      2.3         2.42        10.32
   0.47     .288E+03      3.0         2.65         9.44
   0.55     .336E+03      3.8         2.85         8.78
   0.63     .384E+03      4.6         3.02         8.27
   0.71     .431E+03      5.4         3.18         7.86
   0.79     .479E+03      6.3         3.32         7.53
   0.87     .527E+03      7.2         3.45         7.25
   0.95     .575E+03      8.1         3.56         7.02
   1.03     .623E+03      9.0         3.67         6.82
   1.11     .671E+03     10.0         3.77         6.64
   1.18     .719E+03     11.0         3.86         6.48
   1.26     .767E+03     11.9         3.94         6.35
   1.34     .815E+03     12.9         4.02         6.23
   1.42     .863E+03     13.9         4.09         6.12
   1.50     .911E+03     15.0         4.15         6.02
                         <---- hydrograph ---->   <-pipe / channel->
                     AREA    QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                     (ha)    (cms)   (hrs)   (mm)      (m)      (m/s)
  INFLOW : ID= 2 (  0159)  126.91     0.52    1.50   3.90     0.15     1.39
  OUTFLOW: ID= 1 (  0158)  126.91     0.24    1.67   3.90     0.09     1.02


--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  0136)|   Area    (ha)=   7.15
|ID= 1 DT= 5.0 min |   Total Imp(%)=  67.00   Dir. Conn.(%)=  55.00
--------------------
                      IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=      4.79         2.36
    Dep. Storage     (mm)=      1.00        13.90
    Average Slope     (%)=      1.00         2.00
    Length            (m)=    218.33       215.00
    Mannings n          =     0.014        0.250

    Max.Eff.Inten.(mm/hr)=     50.21         1.50
             over (min)        5.00       110.00
    Storage Coeff.  (min)=      5.62 (ii)  109.36 (ii)
    Unit Hyd. Tpeak (min)=      5.00       110.00
    Unit Hyd. peak  (cms)=      0.20         0.01
                                                *TOTALS*
    PEAK FLOW       (cms)=      0.47         0.00         0.474 (iii)
    TIME TO PEAK    (hrs)=      1.50         4.42          1.50
    RUNOFF VOLUME    (mm)=     24.00         2.14         14.15
    TOTAL RAINFALL   (mm)=     25.00        25.00         25.00
    RUNOFF COEFFICIENT   =      0.96         0.09          0.57


     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
         CN*  =  68.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
         THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| ADD HYD  (  0160)|
|   1 +  2 =  3    |        AREA    QPEAK    TPEAK    R.V.
--------------------        (ha)    (cms)    (hrs)    (mm)
      ID1= 1 (  0136):     7.15   0.474     1.50    14.15
    + ID2= 2 (  0158):   126.91   0.243     1.67     3.90
      =====================================================
      ID = 3 (  0160):   134.06   0.652     1.50     4.45

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| ROUTEPIPE(  0161)|     PIPE Number     =   1.00
| IN= 2---> OUT= 1 |     Width       (mm)=2400.00     Height   (mm)=1800.00
| DT=  5.0 min     |     Length       (m)=  43.50
--------------------     Slope      (m/m)=  0.003
                         Manning n       =  0.013

    <----------------- TRAVEL TIME TABLE -------------------->
     DEPTH      VOLUME    FLOW RATE    VELOCITY    TRAV.TIME
      (m)      (cu.m.)     (cms)        (m/s)        min
     0.09    .989E+01      0.2          0.83        36.02
     0.19    .198E+02      0.6          1.26        23.78
     0.28    .297E+02      1.1          1.58        18.97
     0.38    .396E+02      1.7          1.84        16.32
     0.47    .495E+02      2.3          2.05        14.62
     0.57    .593E+02      3.0          2.23        13.43
     0.66    .692E+02      3.8          2.39        12.55
     0.76    .791E+02      4.6          2.53        11.86
     0.85    .890E+02      5.4          2.65        11.32
     0.95    .989E+02      6.3          2.76        10.87
     1.04    .109E+03      7.1          2.86        10.50
     1.14    .119E+03      8.0          2.95        10.19
     1.23    .129E+03      8.9          3.03         9.92
     1.33    .138E+03      9.9          3.10         9.68
     1.42    .148E+03     10.8          3.17         9.48
     1.52    .158E+03     11.7          3.23         9.29
     1.61    .168E+03     12.7          3.28         9.13
     1.71    .178E+03     13.7          3.34         8.99
     1.80    .188E+03     14.6          3.39         8.86
                      <---- hydrograph ---->  <-pipe / channel->
                   AREA    QPEAK   TPEAK   R.V.   MAX DEPTH   MAX VEL
                   (ha)    (cms)   (hrs)   (mm)      (m)       (m/s)
  INFLOW : ID= 2 (  0160)  134.06     0.65    1.50   4.45      0.20      1.30
  OUTFLOW: ID= 1 (  0161)  134.06     0.30    1.83   4.45      0.12      0.92


--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  0132)|    Area     (ha)=  53.46
|ID= 1 DT= 5.0 min |    Total Imp(%)=  69.00    Dir. Conn.(%)=  45.00
--------------------
                          IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=     36.89       16.57
    Dep. Storage     (mm)=      1.00        5.00
    Average Slope     (%)=      1.00        2.00
    Length            (m)=    596.99      215.00
    Mannings n           =     0.014       0.250

    Max.Eff.Inten.(mm/hr)=     50.21        6.17
             over (min)       10.00       70.00
    Storage Coeff.  (min)=     10.28 (ii)  69.28 (ii)
    Unit Hyd. Tpeak (min)=     10.00       70.00
    Unit Hyd. peak  (cms)=      0.11        0.02
                                                  *TOTALS*
    PEAK FLOW       (cms)=      2.08        0.14       2.090 (iii)
    TIME TO PEAK    (hrs)=      1.58        2.83        1.58
    RUNOFF VOLUME    (mm)=     24.00        5.49       13.82
    TOTAL RAINFALL   (mm)=     25.00       25.00       25.00
    RUNOFF COEFFICIENT   =      0.96        0.22        0.55


     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
         CN*  =  68.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
         THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| RESERVOIR(  0131)|
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                         0.0000     0.0000    |  0.1700     2.5907
```

```
          0.0550   0.7098  |  0.2155    3.1239
          0.1004   1.5249  |  0.2600    3.5865
          0.1400   2.1680  |  0.3014    4.0085

               AREA    QPEAK    TPEAK     R.V.
               (ha)    (cms)    (hrs)     (mm)
 INFLOW : ID= 2 (  0132)   53.460    2.090     1.58     13.82
 OUTFLOW: ID= 1 (  0131)   53.460    0.051     5.42     13.68

         PEAK   FLOW   REDUCTION [Qout/Qin](%)=  2.44
         TIME SHIFT OF PEAK FLOW        (min)=230.00
         MAXIMUM  STORAGE   USED      (ha.m.)=  0.6574

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--------------------
| ADD HYD  (  0117)|
|   1 +  2 =  3    |       AREA    QPEAK    TPEAK     R.V.
--------------------       (ha)    (cms)    (hrs)     (mm)
    ID1= 1 (  0131):    53.46   0.051     5.42    13.68
  + ID2= 2 (  0161):   134.06   0.298     1.83     4.45
    ====================================================
    ID = 3 (  0117):   187.52   0.325     1.92     7.08

  NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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--------------------
| ADD HYD  (  0117)|
|   3 +  2 =  1    |       AREA    QPEAK    TPEAK     R.V.
--------------------       (ha)    (cms)    (hrs)     (mm)
    ID1= 3 (  0117):   187.52   0.325     1.92     7.08
  + ID2= 2 (  0036):     1.98   0.002     2.17     0.91
    ====================================================
    ID = 1 (  0117):   189.50   0.327     1.92     7.01

  NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| ROUTE CHN(  0166)|
| IN= 2---> OUT= 1 |     Routing time step (min)'=  5.00
--------------------
```

```
          <------ DATA FOR SECTION (   2.0) ------>
          Distance     Elevation      Manning
            0.00        100.20        0.0400
           46.50        101.25     0.0400 /0.0350  Main Channel
           52.50         99.25        0.0350     Main Channel
           61.50        101.25     0.0350 /0.0400  Main Channel
          105.00        102.00        0.0400

     <--------------------- TRAVEL TIME TABLE ---------------------->
      DEPTH    ELEV     VOLUME    FLOW RATE    VELOCITY   TRAV.TIME
       (m)      (m)    (cu.m.)     (cms)       (m/s)      (min)
      0.05    99.30   .328E+01      0.0         0.23      25.78
      0.10    99.35   .131E+02      0.0         0.36      16.24
      0.15    99.40   .295E+02      0.0         0.47      12.39
      0.20    99.45   .525E+02      0.1         0.57      10.23
      0.25    99.50   .820E+02      0.2         0.66       8.82
      0.30    99.55   .118E+03      0.3         0.75       7.81
      0.35    99.60   .161E+03      0.4         0.83       7.04
      0.40    99.65   .210E+03      0.5         0.91       6.44
      0.45    99.70   .266E+03      0.7         0.98       5.96
      0.50    99.75   .328E+03      1.0         1.05       5.55
      0.55    99.80   .397E+03      1.3         1.12       5.21
      0.60    99.85   .472E+03      1.6         1.19       4.92
      0.65    99.90   .554E+03      2.0         1.25       4.66
      0.70    99.95   .643E+03      2.4         1.31       4.44
      0.75   100.00   .738E+03      2.9         1.38       4.24
      0.80   100.05   .840E+03      3.4         1.44       4.06
      0.85   100.10   .948E+03      4.1         1.50       3.90
      0.90   100.15   .106E+04      4.7         1.55       3.75
      0.95   100.20   .118E+04      5.5         1.61       3.62

                         <---- hydrograph ---->  <-pipe / channel->
                       AREA    QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                       (ha)    (cms)   (hrs)   (mm)      (m)      (m/s)
 INFLOW : ID= 2 (  0117)  189.50    0.33    1.92   7.01      0.33      0.79
 OUTFLOW: ID= 1 (  0166)  189.50    0.32    2.00   7.01      0.33      0.79


--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD   (  0120)|   Area    (ha)=  10.00   Curve Number   (CN)= 68.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  13.90   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.44
```

```
    Unit Hyd Qpeak  (cms)=   0.868

    PEAK FLOW       (cms)=   0.011 (i)
    TIME TO PEAK    (hrs)=   3.083
    RUNOFF VOLUME    (mm)=   0.942
    TOTAL RAINFALL   (mm)=  24.996
    RUNOFF COEFFICIENT   =   0.038

    (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------

--------------------
| ADD HYD  (  0121)|
|  1 +  2 =  3    |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 1 (  0120):    10.00   0.011     3.08     0.94
    + ID2= 2 (  0166):   189.50   0.323     2.00     7.01
      ==================================================
      ID = 3 (  0121):   199.50   0.328     2.08     6.71

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD   (  0046)|   Area    (ha)=  17.20   Curve Number   (CN)= 68.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  13.90   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.47

    Unit Hyd Qpeak  (cms)=   1.398

    PEAK FLOW       (cms)=   0.019 (i)
    TIME TO PEAK    (hrs)=   3.167
    RUNOFF VOLUME    (mm)=   0.942
    TOTAL RAINFALL   (mm)=  24.996
    RUNOFF COEFFICIENT   =   0.038

    (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------

--------------------
| ADD HYD  (  0114)|
|  1 +  2 =  3    |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 1 (  0121):   199.50   0.328     2.08     6.71
    + ID2= 2 (  0046):    17.20   0.019     3.17     0.94
      ==================================================
      ID = 3 (  0114):   216.70   0.336     2.08     6.25

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

------------------------------------------------------------------------------
********************************
** SIMULATION:Run 02          **
********************************

--------------------
|   READ STORM     |    Filename: C:\Users\Janis Lobo\AppD
|                  |              ata\Local\Temp\
|                  |              9d3c8ff4-eb6c-4319-bb26-ce62fa26e7e3\998e761b
| Ptotal= 53.10 mm |    Comments: 2-year - 24-h SCS RBG
--------------------
```

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.17	0.00	6.33	1.06	12.50	7.65	18.67	0.96
0.33	0.58	6.50	1.06	12.67	7.65	18.83	0.96
0.50	0.58	6.67	1.06	12.83	3.93	19.00	0.96
0.67	0.58	6.83	1.06	13.00	3.93	19.17	0.96
0.83	0.58	7.00	1.06	13.17	3.93	19.33	0.96
1.00	0.58	7.17	1.06	13.33	0.74	19.50	0.96
1.17	0.58	7.33	1.06	13.50	0.74	19.67	0.96
1.33	0.58	7.50	1.06	13.67	0.74	19.83	0.96
1.50	0.58	7.67	1.06	13.83	4.35	20.00	0.96
1.67	0.58	7.83	1.06	14.00	4.35	20.17	0.96
1.83	0.58	8.00	1.06	14.17	4.35	20.33	0.64
2.00	0.58	8.17	1.06	14.33	1.59	20.50	0.64
2.17	0.58	8.33	1.43	14.50	1.59	20.67	0.64
2.33	0.69	8.50	1.43	14.67	1.59	20.83	0.64
2.50	0.69	8.67	1.43	14.83	1.59	21.00	0.64
2.67	0.69	8.83	1.43	15.00	1.59	21.17	0.64
2.83	0.69	9.00	1.43	15.17	1.59	21.33	0.64
3.00	0.69	9.17	1.43	15.33	1.59	21.50	0.64
3.17	0.69	9.33	1.70	15.50	1.59	21.67	0.64
3.33	0.69	9.50	1.70	15.67	1.59	21.83	0.64
3.50	0.69	9.67	1.70	15.83	1.59	22.00	0.64

3.67	0.69	9.83	1.91	16.00	1.59	22.17	0.64
3.83	0.69	10.00	1.91	16.17	1.59	22.33	0.64
4.00	0.69	10.17	1.91	16.33	0.96	22.50	0.64
4.17	0.69	10.33	2.44	16.50	0.96	22.67	0.64
4.33	0.85	10.50	2.44	16.67	0.96	22.83	0.64
4.50	0.85	10.67	2.44	16.83	0.96	23.00	0.64
4.67	0.85	10.83	3.29	17.00	0.96	23.17	0.64
4.83	0.85	11.00	3.29	17.17	0.96	23.33	0.64
5.00	0.85	11.17	3.29	17.33	0.96	23.50	0.64
5.17	0.85	11.33	5.10	17.50	0.96	23.67	0.64
5.33	0.85	11.50	5.10	17.67	0.96	23.83	0.64
5.50	0.85	11.67	5.10	17.83	0.96	24.00	0.64
5.67	0.85	11.83	22.09	18.00	0.96	24.17	0.64
5.83	0.85	12.00	40.36	18.17	0.96		
6.00	0.85	12.17	58.62	18.33	0.96		
6.17	0.85	12.33	7.65	18.50	0.96		

| CALIB |
| NASHYD (0036)| Area (ha)= 1.98 Curve Number (CN)= 68.0
|ID= 1 DT= 5.0 min | Ia (mm)= 13.90 # of Linear Res.(N)= 3.00
-------------------- U.H. Tp(hrs)= 0.09

NOTE: RAINFALL WAS TRANSFORMED TO 5.0 MIN. TIME STEP.

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	0.00	6.167	0.85	12.250	7.66	18.33	0.96
0.167	0.00	6.250	1.06	12.333	7.65	18.42	0.96
0.250	0.58	6.333	1.06	12.417	7.65	18.50	0.96
0.333	0.58	6.417	1.06	12.500	7.65	18.58	0.96
0.417	0.58	6.500	1.06	12.583	7.65	18.67	0.96
0.500	0.58	6.583	1.06	12.667	7.65	18.75	0.96
0.583	0.58	6.667	1.06	12.750	3.93	18.83	0.96
0.667	0.58	6.750	1.06	12.833	3.93	18.92	0.96
0.750	0.58	6.833	1.06	12.917	3.93	19.00	0.96
0.833	0.58	6.917	1.06	13.000	3.93	19.08	0.96
0.917	0.58	7.000	1.06	13.083	3.93	19.17	0.96
1.000	0.58	7.083	1.06	13.167	3.93	19.25	0.96
1.083	0.58	7.167	1.06	13.250	0.74	19.33	0.96
1.167	0.58	7.250	1.06	13.333	0.74	19.42	0.96
1.250	0.58	7.333	1.06	13.417	0.74	19.50	0.96
1.333	0.58	7.417	1.06	13.500	0.74	19.58	0.96
1.417	0.58	7.500	1.06	13.583	0.74	19.67	0.96
1.500	0.58	7.583	1.06	13.667	0.74	19.75	0.96
1.583	0.58	7.667	1.06	13.750	4.35	19.83	0.96
1.667	0.58	7.750	1.06	13.833	4.35	19.92	0.96
1.750	0.58	7.833	1.06	13.917	4.35	20.00	0.96
1.833	0.58	7.917	1.06	14.000	4.35	20.08	0.96
1.917	0.58	8.000	1.06	14.083	4.35	20.17	0.96
2.000	0.58	8.083	1.06	14.167	4.35	20.25	0.64
2.083	0.58	8.167	1.06	14.250	1.59	20.33	0.64
2.167	0.58	8.250	1.43	14.333	1.59	20.42	0.64
2.250	0.69	8.333	1.43	14.417	1.59	20.50	0.64
2.333	0.69	8.417	1.43	14.500	1.59	20.58	0.64
2.417	0.69	8.500	1.43	14.583	1.59	20.67	0.64
2.500	0.69	8.583	1.43	14.667	1.59	20.75	0.64
2.583	0.69	8.667	1.43	14.750	1.59	20.83	0.64
2.667	0.69	8.750	1.43	14.833	1.59	20.92	0.64
2.750	0.69	8.833	1.43	14.917	1.59	21.00	0.64
2.833	0.69	8.917	1.43	15.000	1.59	21.08	0.64
2.917	0.69	9.000	1.43	15.083	1.59	21.17	0.64
3.000	0.69	9.083	1.43	15.167	1.59	21.25	0.64
3.083	0.69	9.167	1.43	15.250	1.59	21.33	0.64
3.167	0.69	9.250	1.70	15.333	1.59	21.42	0.64
3.250	0.69	9.333	1.70	15.417	1.59	21.50	0.64
3.333	0.69	9.417	1.70	15.500	1.59	21.58	0.64
3.417	0.69	9.500	1.70	15.583	1.59	21.67	0.64
3.500	0.69	9.583	1.70	15.667	1.59	21.75	0.64
3.583	0.69	9.667	1.70	15.750	1.59	21.83	0.64
3.667	0.69	9.750	1.91	15.833	1.59	21.92	0.64
3.750	0.69	9.833	1.91	15.917	1.59	22.00	0.64
3.833	0.69	9.917	1.91	16.000	1.59	22.08	0.64
3.917	0.69	10.000	1.91	16.083	1.59	22.17	0.64
4.000	0.69	10.083	1.91	16.167	1.59	22.25	0.64
4.083	0.69	10.167	1.91	16.250	0.96	22.33	0.64
4.167	0.69	10.250	2.44	16.333	0.96	22.42	0.64
4.250	0.85	10.333	2.44	16.417	0.96	22.50	0.64
4.333	0.85	10.417	2.44	16.500	0.96	22.58	0.64
4.417	0.85	10.500	2.44	16.583	0.96	22.67	0.64
4.500	0.85	10.583	2.44	16.667	0.96	22.75	0.64
4.583	0.85	10.667	2.44	16.750	0.96	22.83	0.64
4.667	0.85	10.750	3.29	16.833	0.96	22.92	0.64
4.750	0.85	10.833	3.29	16.917	0.96	23.00	0.64

4.833	0.85	10.917	3.29	17.000	0.96	23.08	0.64
4.917	0.85	11.000	3.29	17.083	0.96	23.17	0.64
5.000	0.85	11.083	3.29	17.167	0.96	23.25	0.64
5.083	0.85	11.167	3.29	17.250	0.96	23.33	0.64
5.167	0.85	11.250	5.10	17.333	0.96	23.42	0.64
5.250	0.85	11.333	5.10	17.417	0.96	23.50	0.64
5.333	0.85	11.417	5.10	17.500	0.96	23.58	0.64
5.417	0.85	11.500	5.10	17.583	0.96	23.67	0.64
5.500	0.85	11.583	5.10	17.667	0.96	23.75	0.64
5.583	0.85	11.667	5.10	17.750	0.96	23.83	0.64
5.667	0.85	11.750	22.09	17.833	0.96	23.92	0.64
5.750	0.85	11.833	22.09	17.917	0.96	24.00	0.64
5.833	0.85	11.917	40.36	18.000	0.96	24.08	0.64
5.917	0.85	12.000	40.36	18.083	0.96	24.17	0.64
6.000	0.85	12.083	58.62	18.167	0.96		
6.083	0.85	12.167	58.62	18.250	0.96		

Unit Hyd Qpeak (cms)= 0.840

PEAK FLOW (cms)= 0.065 (i)
TIME TO PEAK (hrs)= 12.167
RUNOFF VOLUME (mm)= 9.317
TOTAL RAINFALL (mm)= 53.103
RUNOFF COEFFICIENT = 0.175

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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------------------------------------------------------------------------------
--------------------
| CALIB           |
| NASHYD  (  0037)|   Area    (ha)=  28.80   Curve Number   (CN)= 68.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  13.90   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.21
```

Unit Hyd Qpeak (cms)= 0.908

PEAK FLOW (cms)= 0.165 (i)
TIME TO PEAK (hrs)= 13.500
RUNOFF VOLUME (mm)= 9.682
TOTAL RAINFALL (mm)= 53.103
RUNOFF COEFFICIENT = 0.182

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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------------------------------------------------------------------------------
--------------------
| ROUTEPIPE(  0165)|     PIPE Number     =   1.00
| IN= 2---> OUT= 1 |     Diameter    (mm)=1200.00
| DT=  5.0 min     |     Length      (m)=  73.30
--------------------     Slope      (m/m)=  0.010
                         Manning n       =  0.013
```

<------------------ TRAVEL TIME TABLE -------------------->

DEPTH (m)	VOLUME (cu.m.)	FLOW RATE (cms)	VELOCITY (m/s)	TRAV.TIME min
0.06	.167E+01	0.0	0.92	1.33
0.13	.465E+01	0.1	1.43	0.85
0.19	.840E+01	0.2	1.84	0.66
0.25	.127E+02	0.4	2.19	0.56
0.32	.174E+02	0.6	2.49	0.49
0.38	.225E+02	0.8	2.75	0.44
0.44	.277E+02	1.1	2.99	0.41
0.51	.332E+02	1.4	3.19	0.38
0.57	.387E+02	1.8	3.37	0.36
0.63	.442E+02	2.1	3.52	0.35
0.69	.497E+02	2.5	3.65	0.33
0.76	.552E+02	2.8	3.76	0.32
0.82	.604E+02	3.2	3.84	0.32
0.88	.655E+02	3.5	3.90	0.31
0.95	.702E+02	3.8	3.93	0.31
1.01	.745E+02	4.0	3.93	0.31
1.07	.783E+02	4.1	3.89	0.31
1.14	.812E+02	4.2	3.78	0.32
1.20	.829E+02	3.9	3.45	0.35

	<---- hydrograph ---->				<-pipe / channel->	
	AREA (ha)	QPEAK (cms)	TPEAK (hrs)	R.V. (mm)	MAX DEPTH (m)	MAX VEL (m/s)
INFLOW : ID= 2 (0037)	28.80	0.16	13.50	9.68	0.17	1.66
OUTFLOW: ID= 1 (0165)	28.80	0.16	13.50	9.68	0.16	1.65

```
------------------------------------------------------------------------------
--------------------
| CALIB           |
| NASHYD  (  0051)|   Area    (ha)=  69.30   Curve Number   (CN)= 68.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  13.90   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.45
```

Unit Hyd Qpeak (cms)= 1.825

PEAK FLOW (cms)= 0.341 (i)
TIME TO PEAK (hrs)= 13.750
RUNOFF VOLUME (mm)= 9.682
TOTAL RAINFALL (mm)= 53.103
RUNOFF COEFFICIENT = 0.182

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

| ROUTEPIPE(0164)| PIPE Number = 1.00
| IN= 2---> OUT= 1 | Diameter (mm)=1350.00
| DT= 5.0 min | Length (m)= 104.50
-------------------- Slope (m/m)= 0.010
Manning n = 0.013

<----------------- TRAVEL TIME TABLE -------------------->

DEPTH (m)	VOLUME (cu.m.)	FLOW RATE (cms)	VELOCITY (m/s)	TRAV.TIME min
0.07	.302E+01	0.0	0.99	1.76
0.14	.839E+01	0.1	1.55	1.13
0.21	.152E+02	0.3	1.99	0.88
0.28	.229E+02	0.5	2.37	0.74
0.36	.314E+02	0.8	2.69	0.65
0.43	.405E+02	1.2	2.98	0.58
0.50	.500E+02	1.5	3.23	0.54
0.57	.598E+02	2.0	3.45	0.50
0.64	.698E+02	2.4	3.64	0.48
0.71	.798E+02	2.9	3.81	0.46
0.78	.898E+02	3.4	3.95	0.44
0.85	.996E+02	3.9	4.07	0.43
0.92	.109E+03	4.3	4.16	0.42
0.99	.118E+03	4.8	4.22	0.41
1.07	.127E+03	5.2	4.25	0.41
1.14	.134E+03	5.5	4.25	0.41
1.21	.141E+03	5.7	4.20	0.41
1.28	.147E+03	5.7	4.09	0.43
1.35	NaN	NaN	NaN	NaN

	<---- hydrograph ---->				<-pipe / channel->	
	AREA (ha)	QPEAK (cms)	TPEAK (hrs)	R.V. (mm)	MAX DEPTH (m)	MAX VEL (m/s)
INFLOW : ID= 2 (0051)	69.30	0.34	13.75	9.68	0.23	2.07
OUTFLOW: ID= 1 (0164)	69.30	0.34	13.75	9.68	0.23	2.07

| CALIB |
| STANDHYD (0049)| Area (ha)= 4.08
|ID= 1 DT= 5.0 min | Total Imp(%)= 67.00 Dir. Conn.(%)= 55.00

	IMPERVIOUS	PERVIOUS (i)	
Surface Area (ha)=	2.73	1.35	
Dep. Storage (mm)=	1.00	5.00	
Average Slope (%)=	1.00	2.00	
Length (m)=	164.92	215.00	
Mannings n =	0.014	0.250	
Max.Eff.Inten.(mm/hr)=	58.62	14.42	
over (min)	5.00	50.00	
Storage Coeff. (min)=	4.46 (ii)	46.47 (ii)	
Unit Hyd. Tpeak (min)=	5.00	50.00	
Unit Hyd. peak (cms)=	0.23	0.02	
			TOTALS
PEAK FLOW (cms)=	0.35	0.03	0.362 (iii)
TIME TO PEAK (hrs)=	12.17	12.83	12.17
RUNOFF VOLUME (mm)=	52.10	17.83	36.67
TOTAL RAINFALL (mm)=	53.10	53.10	53.10
RUNOFF COEFFICIENT =	0.98	0.34	0.69

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

(i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
CN* = 68.0 Ia = Dep. Storage (Above)
(ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
THAN THE STORAGE COEFFICIENT.
(iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

| ADD HYD (0157)|
| 1 + 2 = 3 |

	AREA (ha)	QPEAK (cms)	TPEAK (hrs)	R.V. (mm)
ID1= 1 (0164):	69.30	0.341	13.75	9.68
+ ID2= 2 (0165):	28.80	0.165	13.50	9.68

```
     ======================================================
     ID = 3 (  0157):    98.10   0.503    13.67     9.68

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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--------------------
| ADD HYD  (  0157)|
|   3 +  2 =  1    |         AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
     ID1= 3 (  0157):    98.10   0.503    13.67     9.68
   + ID2= 2 (  0049):     4.08   0.362    12.17    36.67
     ======================================================
     ID = 1 (  0157):   102.18   0.539    13.83    10.76

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| ROUTEPIPE(  0163)|     PIPE Number     =   1.00
| IN= 2---> OUT= 1 |     Width      (mm)=2400.00     Height   (mm)=1500.00
| DT=  5.0 min     |     Length       (m)= 346.00
--------------------    Slope      (m/m)=  0.007
                    Manning n       =  0.013

   <----------------- TRAVEL TIME TABLE -------------------->
    DEPTH      VOLUME     FLOW RATE    VELOCITY     TRAV.TIME
     (m)      (cu.m.)      (cms)        (m/s)         min
    0.08     .656E+02       0.2         1.18         4.90
    0.16     .131E+03       0.7         1.79         3.22
    0.24     .197E+03       1.3         2.26         2.55
    0.32     .262E+03       2.0         2.65         2.18
    0.39     .328E+03       2.8         2.97         1.94
    0.47     .393E+03       3.7         3.25         1.78
    0.55     .459E+03       4.6         3.49         1.65
    0.63     .524E+03       5.6         3.70         1.56
    0.71     .590E+03       6.6         3.89         1.48
    0.79     .656E+03       7.7         4.07         1.42
    0.87     .721E+03       8.8         4.22         1.37
    0.95     .787E+03       9.9         4.36         1.32
    1.03     .852E+03      11.1         4.49         5.56
    1.11     .918E+03      12.2         4.61         5.42
    1.18     .983E+03      13.4         4.72         5.29
```

```
    1.26     .105E+04      14.6         4.82         5.18
    1.34     .111E+04      15.8         4.92         5.08
    1.42     .118E+04      17.1         5.01         4.99
    1.50     .125E+04      18.3         5.09         4.91
                      <---- hydrograph ---->   <-pipe / channel->
                    AREA    QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                    (ha)    (cms)   (hrs)   (mm)      (m)      (m/s)
  INFLOW : ID= 2 (  0157)  102.18     0.54   13.83  10.76     0.13      1.54
  OUTFLOW: ID= 1 (  0163)  102.18     0.54   13.83  10.76     0.13      1.54



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--------------------
| CALIB            |
| STANDHYD (  0106)|   Area    (ha)=   6.17
|ID= 1 DT= 5.0 min |   Total Imp(%)=  67.00   Dir. Conn.(%)=  55.00
--------------------
                      IMPERVIOUS    PERVIOUS (i)
   Surface Area     (ha)=       4.13         2.04
   Dep. Storage     (mm)=       1.00         5.00
   Average Slope     (%)=       1.00         2.00
   Length            (m)=     202.81       215.00
   Mannings n          =      0.014        0.250

   Max.Eff.Inten.(mm/hr)=      58.62        14.42
             over (min)        5.00        50.00
   Storage Coeff.  (min)=       5.05 (ii)   47.06 (ii)
   Unit Hyd. Tpeak (min)=       5.00        50.00
   Unit Hyd. peak  (cms)=       0.21         0.02
                                                   *TOTALS*
   PEAK FLOW       (cms)=       0.53         0.05         0.541 (iii)
   TIME TO PEAK    (hrs)=      12.17        12.83         12.17
   RUNOFF VOLUME    (mm)=      52.10        17.83         36.67
   TOTAL RAINFALL   (mm)=      53.10        53.10         53.10
   RUNOFF COEFFICIENT   =       0.98         0.34          0.69


    (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
        CN*  =  68.0    Ia = Dep. Storage  (Above)
   (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
        THAN THE STORAGE COEFFICIENT.
  (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| CALIB            |
| STANDHYD (  0119)|   Area    (ha)=  18.56
|ID= 1 DT= 5.0 min |   Total Imp(%)=  69.00   Dir. Conn.(%)=  45.00
--------------------
                         IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=      12.81         5.75
    Dep. Storage     (mm)=       1.00         5.00
    Average Slope     (%)=       1.00         2.00
    Length            (m)=     351.76       215.00
    Mannings n          =      0.014        0.250

    Max.Eff.Inten.(mm/hr)=      58.62        27.33
             over (min)        5.00        40.00
    Storage Coeff.  (min)=       7.03 (ii)   39.56 (ii)
    Unit Hyd. Tpeak (min)=       5.00        40.00
    Unit Hyd. peak  (cms)=       0.17         0.03
                                                   *TOTALS*
    PEAK FLOW       (cms)=       1.23         0.25         1.330 (iii)
    TIME TO PEAK    (hrs)=      12.17        12.67         12.17
    RUNOFF VOLUME    (mm)=      52.10        21.49         35.27
    TOTAL RAINFALL   (mm)=      53.10        53.10         53.10
    RUNOFF COEFFICIENT   =       0.98         0.40          0.66


     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
         CN*  =  68.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
         THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| RESERVOIR(  0133)|
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                         0.0000     0.0000    |  0.0250     1.0741
                         0.0140     0.2394    |  0.0290     1.2348
                         0.0150     0.6048    |  0.0340     1.4904
                         0.0210     0.8843    |  0.0380     1.7173

                             AREA     QPEAK     TPEAK      R.V.
                             (ha)     (cms)     (hrs)      (mm)
```

```
  INFLOW : ID= 2 (  0119)     18.560      1.330     12.17      35.27
  OUTFLOW: ID= 1 (  0133)     18.560      0.015     24.33      32.70

            PEAK   FLOW   REDUCTION [Qout/Qin](%)=  1.12
            TIME SHIFT OF PEAK FLOW        (min)=730.00
            MAXIMUM  STORAGE   USED       (ha.m.)=  0.5770

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--------------------
| ADD HYD  (  0159)|
|   1 +  2 =  3    |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 1 (  0106):      6.17   0.541    12.17    36.67
    + ID2= 2 (  0133):     18.56   0.015    24.33    32.70
      ===================================================
      ID = 3 (  0159):     24.73   0.555    12.17    33.69

  NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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--------------------
| ADD HYD  (  0159)|
|   3 +  2 =  1    |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 3 (  0159):     24.73   0.555    12.17    33.69
    + ID2= 2 (  0163):    102.18   0.540    13.83    10.76
      ===================================================
      ID = 1 (  0159):    126.91   0.909    12.17    15.23

  NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| ROUTEPIPE(  0158)|     PIPE Number     =   1.00
| IN= 2---> OUT= 1 |     Width       (mm)=2400.00     Height   (mm)=1500.00
| DT=  5.0 min     |     Length       (m)= 253.00
--------------------     Slope      (m/m)=  0.005
                         Manning n       =  0.013

  <----------------- TRAVEL TIME TABLE -------------------->
    DEPTH     VOLUME    FLOW RATE    VELOCITY    TRAV.TIME
     (m)      (cu.m.)     (cms)        (m/s)        min
```

```
  0.08    .479E+02     0.2       0.96       4.39
  0.16    .959E+02     0.6       1.46       2.88
  0.24    .144E+03     1.1       1.85       2.28
  0.32    .192E+03     1.6       2.16       1.95
  0.39    .240E+03     2.3       2.42       1.74
  0.47    .288E+03     3.0       2.65       1.59
  0.55    .336E+03     3.8       2.85       1.48
  0.63    .384E+03     4.6       3.02       1.40
  0.71    .431E+03     5.4       3.18       1.33
  0.79    .479E+03     6.3       3.32       1.27
  0.87    .527E+03     7.2       3.45       1.22
  0.95    .575E+03     8.1       3.56       1.18
  1.03    .623E+03     9.0       3.67       6.82
  1.11    .671E+03    10.0       3.77       6.64
  1.18    .719E+03    11.0       3.86       6.48
  1.26    .767E+03    11.9       3.94       6.35
  1.34    .815E+03    12.9       4.02       6.23
  1.42    .863E+03    13.9       4.09       6.12
  1.50    .911E+03    15.0       4.15       6.02
                     <---- hydrograph ---->  <-pipe / channel->
                  AREA    QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                  (ha)    (cms)   (hrs)   (mm)      (m)      (m/s)
 INFLOW : ID= 2 (  0159)  126.91     0.91   12.17  15.23      0.21      1.72
 OUTFLOW: ID= 1 (  0158)  126.91     0.87   12.17  15.23      0.21      1.68


-----------------------------------------------------------------------------
--------------------
| CALIB              |
| STANDHYD (  0136)|   Area    (ha)=   7.15
|ID= 1 DT= 5.0 min |   Total Imp(%)=  67.00   Dir. Conn.(%)=  55.00
--------------------
                      IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=       4.79         2.36
    Dep. Storage     (mm)=       1.00         13.90
    Average Slope     (%)=       1.00          2.00
    Length           (m)=     218.33       215.00
    Mannings n          =      0.014        0.250

    Max.Eff.Inten.(mm/hr)=      58.62        10.45
            over (min)        5.00        55.00
    Storage Coeff.  (min)=       5.28 (ii)   53.06 (ii)
    Unit Hyd. Tpeak (min)=       5.00        55.00
    Unit Hyd. peak  (cms)=       0.21         0.02
```

```
                                        *TOTALS*
   PEAK FLOW       (cms)=       0.61         0.04          0.614 (iii)
   TIME TO PEAK    (hrs)=      12.17        13.00          12.17
   RUNOFF VOLUME    (mm)=      52.10        14.10          35.00
   TOTAL RAINFALL   (mm)=      53.10        53.10          53.10
   RUNOFF COEFFICIENT   =       0.98         0.27           0.66


    (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
        CN*  =  68.0    Ia = Dep. Storage  (Above)
   (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
        THAN THE STORAGE COEFFICIENT.
  (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-----------------------------------------------------------------------------


--------------------
| ADD HYD  (  0160)|
|  1 +  2 =  3    |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 1 (  0136):      7.15    0.614    12.17    35.00
    + ID2= 2 (  0158):    126.91    0.870    12.17    15.23
      =======================================================
      ID = 3 (  0160):    134.06    1.484    12.17    16.28

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-----------------------------------------------------------------------------
--------------------
| ROUTEPIPE(  0161)|     PIPE Number     =   1.00
| IN= 2---> OUT= 1 |      Width       (mm)=2400.00     Height   (mm)=1800.00
| DT=  5.0 min     |     Length       (m)=  43.50
--------------------     Slope      (m/m)=  0.003
                     Manning n       =  0.013

    <----------------- TRAVEL TIME TABLE -------------------->
     DEPTH      VOLUME    FLOW RATE    VELOCITY    TRAV.TIME
      (m)      (cu.m.)      (cms)        (m/s)         min
     0.09     .989E+01      0.2          0.83         0.87
     0.19     .198E+02      0.6          1.26         0.57
     0.28     .297E+02      1.1          1.58         0.46
     0.38     .396E+02      1.7          1.84         0.39
     0.47     .495E+02      2.3          2.05         0.35
     0.57     .593E+02      3.0          2.23         0.32
```

```
  0.66   .692E+02    3.8       2.39      0.30
  0.76   .791E+02    4.6       2.53      0.29
  0.85   .890E+02    5.4       2.65      0.27
  0.95   .989E+02    6.3       2.76      0.26
  1.04   .109E+03    7.1       2.86     10.50
  1.14   .119E+03    8.0       2.95     10.19
  1.23   .129E+03    8.9       3.03      9.92
  1.33   .138E+03    9.9       3.10      9.68
  1.42   .148E+03   10.8       3.17      9.48
  1.52   .158E+03   11.7       3.23      9.29
  1.61   .168E+03   12.7       3.28      9.13
  1.71   .178E+03   13.7       3.34      8.99
  1.80   .188E+03   14.6       3.39      8.86
                <---- hydrograph ---->  <-pipe / channel->
              AREA   QPEAK  TPEAK  R.V.  MAX DEPTH  MAX VEL
              (ha)   (cms)  (hrs)  (mm)     (m)      (m/s)
 INFLOW : ID= 2 (  0160)  134.06     1.48   12.17  16.28     0.35     1.75
 OUTFLOW: ID= 1 (  0161)  134.06     1.49   12.17  16.28     0.35     1.76


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--------------------
| CALIB            |
| STANDHYD (  0132)|   Area    (ha)=  53.46
|ID= 1 DT= 5.0 min |   Total Imp(%)=  69.00   Dir. Conn.(%)=  45.00
--------------------
                    IMPERVIOUS    PERVIOUS (i)
   Surface Area     (ha)=      36.89       16.57
   Dep. Storage     (mm)=       1.00        5.00
   Average Slope     (%)=       1.00        2.00
   Length            (m)=     596.99      215.00
   Mannings n          =       0.014       0.250

   Max.Eff.Inten.(mm/hr)=      58.62       27.33
            over (min)        10.00       45.00
   Storage Coeff.  (min)=       9.66 (ii)   42.19 (ii)
   Unit Hyd. Tpeak (min)=      10.00       45.00
   Unit Hyd. peak  (cms)=       0.11        0.03
                                              *TOTALS*
   PEAK FLOW       (cms)=       3.03        0.68         3.278 (iii)
   TIME TO PEAK    (hrs)=      12.17       12.75        12.17
   RUNOFF VOLUME    (mm)=      52.10       21.49        35.27
   TOTAL RAINFALL   (mm)=      53.10       53.10        53.10
   RUNOFF COEFFICIENT   =       0.98        0.40         0.66


    (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
        CN*  =  68.0    Ia = Dep. Storage  (Above)
   (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
        THAN THE STORAGE COEFFICIENT.
  (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| RESERVOIR(  0131)|
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                         0.0000     0.0000    |   0.1700     2.5907
                         0.0550     0.7098    |   0.2155     3.1239
                         0.1004     1.5249    |   0.2600     3.5865
                         0.1400     2.1680    |   0.3014     4.0085

                          AREA     QPEAK     TPEAK      R.V.
                          (ha)     (cms)     (hrs)      (mm)
  INFLOW : ID= 2 (  0132)     53.460      3.278      12.17      35.27
  OUTFLOW: ID= 1 (  0131)     53.460      0.097      20.50      34.72

              PEAK   FLOW   REDUCTION [Qout/Qin](%)=  2.95
              TIME SHIFT OF PEAK FLOW        (min)=500.00
              MAXIMUM  STORAGE   USED       (ha.m.)=  1.4592

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--------------------
| ADD HYD  (  0117)|
|   1 +  2 =  3    |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 1 (  0131):    53.46   0.097    20.50    34.72
    + ID2= 2 (  0161):   134.06   1.493    12.17    16.28
      ====================================================
      ID = 3 (  0117):   187.52   1.539    12.17    21.54

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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| ADD HYD  (  0117)|
|   3 +  2 =  1    |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 3 (  0117):   187.52   1.539    12.17    21.54
    + ID2= 2 (  0036):     1.98   0.065    12.17     9.32
      ===================================================
      ID = 1 (  0117):   189.50   1.604    12.17    21.41

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| ROUTE CHN(  0166)|
| IN= 2---> OUT= 1 |     Routing time step (min)'=  5.00
--------------------
            <------ DATA FOR SECTION (    2.0) ------>
            Distance      Elevation       Manning
               0.00        100.20         0.0400
              46.50        101.25     0.0400 /0.0350  Main Channel
              52.50         99.25         0.0350      Main Channel
              61.50        101.25     0.0350 /0.0400  Main Channel
             105.00        102.00         0.0400

     <--------------------- TRAVEL TIME TABLE ---------------------->
      DEPTH    ELEV      VOLUME    FLOW RATE    VELOCITY   TRAV.TIME
       (m)      (m)     (cu.m.)      (cms)       (m/s)       (min)
      0.05    99.30   .328E+01       0.0         0.23       25.78
      0.10    99.35   .131E+02       0.0         0.36       16.24
      0.15    99.40   .295E+02       0.0         0.47       12.39
      0.20    99.45   .525E+02       0.1         0.57       10.23
      0.25    99.50   .820E+02       0.2         0.66        8.82
      0.30    99.55   .118E+03       0.3         0.75        7.81
      0.35    99.60   .161E+03       0.4         0.83        7.04
      0.40    99.65   .210E+03       0.5         0.91        6.44
      0.45    99.70   .266E+03       0.7         0.98        5.96
      0.50    99.75   .328E+03       1.0         1.05        5.55
      0.55    99.80   .397E+03       1.3         1.12        5.21
      0.60    99.85   .472E+03       1.6         1.19        4.92
      0.65    99.90   .554E+03       2.0         1.25        4.66
      0.70    99.95   .643E+03       2.4         1.31        4.44
      0.75   100.00   .738E+03       2.9         1.38        4.24
      0.80   100.05   .840E+03       3.4         1.44        4.06
      0.85   100.10   .948E+03       4.1         1.50        3.90
      0.90   100.15   .106E+04       4.7         1.55        3.75
      0.95   100.20   .118E+04       5.5         1.61        3.62

                         <---- hydrograph ---->   <-pipe / channel->
                        AREA    QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                        (ha)    (cms)   (hrs)   (mm)      (m)      (m/s)
   INFLOW : ID= 2 (  0117)  189.50     1.60   12.17  21.41      0.60      1.19
   OUTFLOW: ID= 1 (  0166)  189.50     1.39   12.25  21.41      0.57      1.14


--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD   (  0120)|   Area    (ha)=  10.00   Curve Number   (CN)= 68.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  13.90   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.44

    Unit Hyd Qpeak  (cms)=   0.868

    PEAK FLOW       (cms)=   0.119 (i)
    TIME TO PEAK    (hrs)=  12.583
    RUNOFF VOLUME    (mm)=   9.681
    TOTAL RAINFALL   (mm)=  53.103
    RUNOFF COEFFICIENT   =   0.182

    (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| ADD HYD  (  0121)|
|   1 +  2 =  3    |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 1 (  0120):    10.00   0.119    12.58     9.68
    + ID2= 2 (  0166):   189.50   1.389    12.25    21.41
      ===================================================
      ID = 3 (  0121):   199.50   1.469    12.25    20.82

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD   (  0046)|   Area    (ha)=  17.20   Curve Number   (CN)= 68.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  13.90   # of Linear Res.(N)= 3.00
```

-------------------- U.H. Tp(hrs)= 0.47

Unit Hyd Qpeak (cms)= 1.398

PEAK FLOW (cms)= 0.196 (i)
TIME TO PEAK (hrs)= 12.583
RUNOFF VOLUME (mm)= 9.682
TOTAL RAINFALL (mm)= 53.103
RUNOFF COEFFICIENT = 0.182

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

| ADD HYD (0114)|
| 1 + 2 = 3 | AREA QPEAK TPEAK R.V.
-------------------- (ha) (cms) (hrs) (mm)
ID1= 1 (0121): 199.50 1.469 12.25 20.82
+ ID2= 2 (0046): 17.20 0.196 12.58 9.68
==
ID = 3 (0114): 216.70 1.593 12.25 19.94

NOTE: PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

****
** SIMULATION:Run 03 **
****

| READ STORM | Filename: C:\Users\Janis Lobo\AppD
| | ata\Local\Temp\
| | 9d3c8ff4-eb6c-4319-bb26-ce62fa26e7e3\93c7028f
| Ptotal= 71.78 mm | Comments: 5-year - 24-h SCS RBG

TIME	RAIN	TIME	RAIN	TIME	RAIN	TIME	RAIN
hrs	mm/hr	hrs	mm/hr	hrs	mm/hr	hrs	mm/hr
0.17	0.00	6.33	1.44	12.50	10.34	18.67	1.29
0.33	0.79	6.50	1.44	12.67	10.34	18.83	1.29
0.50	0.79	6.67	1.44	12.83	5.31	19.00	1.29
0.67	0.79	6.83	1.44	13.00	5.31	19.17	1.29
0.83	0.79	7.00	1.44	13.17	5.31	19.33	1.29
1.00	0.79	7.17	1.44	13.33	1.01	19.50	1.29
1.17	0.79	7.33	1.44	13.50	1.01	19.67	1.29
1.33	0.79	7.50	1.44	13.67	1.01	19.83	1.29
1.50	0.79	7.67	1.44	13.83	5.89	20.00	1.29
1.67	0.79	7.83	1.44	14.00	5.89	20.17	1.29
1.83	0.79	8.00	1.44	14.17	5.89	20.33	0.86
2.00	0.79	8.17	1.44	14.33	2.15	20.50	0.86
2.17	0.79	8.33	1.94	14.50	2.15	20.67	0.86
2.33	0.93	8.50	1.94	14.67	2.15	20.83	0.86
2.50	0.93	8.67	1.94	14.83	2.15	21.00	0.86
2.67	0.93	8.83	1.94	15.00	2.15	21.17	0.86
2.83	0.93	9.00	1.94	15.17	2.15	21.33	0.86
3.00	0.93	9.17	1.94	15.33	2.15	21.50	0.86
3.17	0.93	9.33	2.30	15.50	2.15	21.67	0.86
3.33	0.93	9.50	2.30	15.67	2.15	21.83	0.86
3.50	0.93	9.67	2.30	15.83	2.15	22.00	0.86
3.67	0.93	9.83	2.58	16.00	2.15	22.17	0.86
3.83	0.93	10.00	2.58	16.17	2.15	22.33	0.86
4.00	0.93	10.17	2.58	16.33	1.29	22.50	0.86
4.17	0.93	10.33	3.30	16.50	1.29	22.67	0.86
4.33	1.15	10.50	3.30	16.67	1.29	22.83	0.86
4.50	1.15	10.67	3.30	16.83	1.29	23.00	0.86
4.67	1.15	10.83	4.45	17.00	1.29	23.17	0.86
4.83	1.15	11.00	4.45	17.17	1.29	23.33	0.86
5.00	1.15	11.17	4.45	17.33	1.29	23.50	0.86
5.17	1.15	11.33	6.89	17.50	1.29	23.67	0.86
5.33	1.15	11.50	6.89	17.67	1.29	23.83	0.86
5.50	1.15	11.67	6.89	17.83	1.29	24.00	0.86
5.67	1.15	11.83	29.87	18.00	1.29	24.17	0.86
5.83	1.15	12.00	54.57	18.17	1.29		
6.00	1.15	12.17	79.27	18.33	1.29		
6.17	1.15	12.33	10.34	18.50	1.29		

| CALIB |
| NASHYD (0036)| Area (ha)= 1.98 Curve Number (CN)= 68.0
|ID= 1 DT= 5.0 min | Ia (mm)= 13.90 # of Linear Res.(N)= 3.00
-------------------- U.H. Tp(hrs)= 0.09

NOTE: RAINFALL WAS TRANSFORMED TO 5.0 MIN. TIME STEP.

---- TRANSFORMED HYETOGRAPH ----

TIME	RAIN	TIME	RAIN	TIME	RAIN	TIME	RAIN
hrs	mm/hr	hrs	mm/hr	hrs	mm/hr	hrs	mm/hr
0.083	0.00	6.167	1.15	12.250	10.35	18.33	1.29
0.167	0.00	6.250	1.44	12.333	10.34	18.42	1.29
0.250	0.79	6.333	1.44	12.417	10.34	18.50	1.29
0.333	0.79	6.417	1.44	12.500	10.34	18.58	1.29
0.417	0.79	6.500	1.44	12.583	10.34	18.67	1.29
0.500	0.79	6.583	1.44	12.667	10.34	18.75	1.29
0.583	0.79	6.667	1.44	12.750	5.31	18.83	1.29
0.667	0.79	6.750	1.44	12.833	5.31	18.92	1.29
0.750	0.79	6.833	1.44	12.917	5.31	19.00	1.29
0.833	0.79	6.917	1.44	13.000	5.31	19.08	1.29
0.917	0.79	7.000	1.44	13.083	5.31	19.17	1.29
1.000	0.79	7.083	1.44	13.167	5.31	19.25	1.29
1.083	0.79	7.167	1.44	13.250	1.01	19.33	1.29
1.167	0.79	7.250	1.44	13.333	1.01	19.42	1.29
1.250	0.79	7.333	1.44	13.417	1.01	19.50	1.29
1.333	0.79	7.417	1.44	13.500	1.01	19.58	1.29
1.417	0.79	7.500	1.44	13.583	1.01	19.67	1.29
1.500	0.79	7.583	1.44	13.667	1.01	19.75	1.29
1.583	0.79	7.667	1.44	13.750	5.89	19.83	1.29
1.667	0.79	7.750	1.44	13.833	5.89	19.92	1.29
1.750	0.79	7.833	1.44	13.917	5.89	20.00	1.29
1.833	0.79	7.917	1.44	14.000	5.89	20.08	1.29
1.917	0.79	8.000	1.44	14.083	5.89	20.17	1.29
2.000	0.79	8.083	1.44	14.167	5.89	20.25	0.86
2.083	0.79	8.167	1.44	14.250	2.15	20.33	0.86
2.167	0.79	8.250	1.94	14.333	2.15	20.42	0.86
2.250	0.93	8.333	1.94	14.417	2.15	20.50	0.86
2.333	0.93	8.417	1.94	14.500	2.15	20.58	0.86
2.417	0.93	8.500	1.94	14.583	2.15	20.67	0.86
2.500	0.93	8.583	1.94	14.667	2.15	20.75	0.86
2.583	0.93	8.667	1.94	14.750	2.15	20.83	0.86
2.667	0.93	8.750	1.94	14.833	2.15	20.92	0.86
2.750	0.93	8.833	1.94	14.917	2.15	21.00	0.86
2.833	0.93	8.917	1.94	15.000	2.15	21.08	0.86
2.917	0.93	9.000	1.94	15.083	2.15	21.17	0.86
3.000	0.93	9.083	1.94	15.167	2.15	21.25	0.86
3.083	0.93	9.167	1.94	15.250	2.15	21.33	0.86
3.167	0.93	9.250	2.30	15.333	2.15	21.42	0.86
3.250	0.93	9.333	2.30	15.417	2.15	21.50	0.86
3.333	0.93	9.417	2.30	15.500	2.15	21.58	0.86
3.417	0.93	9.500	2.30	15.583	2.15	21.67	0.86
3.500	0.93	9.583	2.30	15.667	2.15	21.75	0.86
3.583	0.93	9.667	2.30	15.750	2.15	21.83	0.86
3.667	0.93	9.750	2.58	15.833	2.15	21.92	0.86
3.750	0.93	9.833	2.58	15.917	2.15	22.00	0.86
3.833	0.93	9.917	2.58	16.000	2.15	22.08	0.86
3.917	0.93	10.000	2.58	16.083	2.15	22.17	0.86
4.000	0.93	10.083	2.58	16.167	2.15	22.25	0.86
4.083	0.93	10.167	2.58	16.250	1.29	22.33	0.86
4.167	0.93	10.250	3.30	16.333	1.29	22.42	0.86
4.250	1.15	10.333	3.30	16.417	1.29	22.50	0.86
4.333	1.15	10.417	3.30	16.500	1.29	22.58	0.86
4.417	1.15	10.500	3.30	16.583	1.29	22.67	0.86
4.500	1.15	10.583	3.30	16.667	1.29	22.75	0.86
4.583	1.15	10.667	3.30	16.750	1.29	22.83	0.86
4.667	1.15	10.750	4.45	16.833	1.29	22.92	0.86
4.750	1.15	10.833	4.45	16.917	1.29	23.00	0.86
4.833	1.15	10.917	4.45	17.000	1.29	23.08	0.86
4.917	1.15	11.000	4.45	17.083	1.29	23.17	0.86
5.000	1.15	11.083	4.45	17.167	1.29	23.25	0.86
5.083	1.15	11.167	4.45	17.250	1.29	23.33	0.86
5.167	1.15	11.250	6.89	17.333	1.29	23.42	0.86
5.250	1.15	11.333	6.89	17.417	1.29	23.50	0.86
5.333	1.15	11.417	6.89	17.500	1.29	23.58	0.86
5.417	1.15	11.500	6.89	17.583	1.29	23.67	0.86
5.500	1.15	11.583	6.89	17.667	1.29	23.75	0.86
5.583	1.15	11.667	6.89	17.750	1.29	23.83	0.86
5.667	1.15	11.750	29.87	17.833	1.29	23.92	0.86
5.750	1.15	11.833	29.87	17.917	1.29	24.00	0.86
5.833	1.15	11.917	54.57	18.000	1.29	24.08	0.86
5.917	1.15	12.000	54.57	18.083	1.29	24.17	0.86
6.000	1.15	12.083	79.27	18.167	1.29		
6.083	1.15	12.167	79.27	18.250	1.29		

Unit Hyd Qpeak (cms)= 0.840

PEAK FLOW (cms)= 0.131 (i)
TIME TO PEAK (hrs)= 12.167
RUNOFF VOLUME (mm)= 18.170
TOTAL RAINFALL (mm)= 71.780
RUNOFF COEFFICIENT = 0.253

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

| CALIB |
| NASHYD (0037)| Area (ha)= 28.80 Curve Number (CN)= 68.0
|ID= 1 DT= 5.0 min | Ia (mm)= 13.90 # of Linear Res.(N)= 3.00
-------------------- U.H. Tp(hrs)= 1.21

Unit Hyd Qpeak (cms)= 0.908

PEAK FLOW (cms)= 0.350 (i)
TIME TO PEAK (hrs)= 13.417
RUNOFF VOLUME (mm)= 18.883
TOTAL RAINFALL (mm)= 71.780
RUNOFF COEFFICIENT = 0.263

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

| ROUTEPIPE(0165)| PIPE Number = 1.00
| IN= 2---> OUT= 1 | Diameter (mm)=1200.00
| DT= 5.0 min | Length (m)= 73.30
-------------------- Slope (m/m)= 0.010
Manning n = 0.013

<----------------- TRAVEL TIME TABLE -------------------->

DEPTH	VOLUME	FLOW RATE	VELOCITY	TRAV.TIME
(m)	(cu.m.)	(cms)	(m/s)	min
0.06	.167E+01	0.0	0.92	1.33
0.13	.465E+01	0.1	1.43	0.85
0.19	.840E+01	0.2	1.84	0.66
0.25	.127E+02	0.4	2.19	0.56
0.32	.174E+02	0.6	2.49	0.49
0.38	.225E+02	0.8	2.75	0.44
0.44	.277E+02	1.1	2.99	0.41
0.51	.332E+02	1.4	3.19	0.38
0.57	.387E+02	1.8	3.37	0.36
0.63	.442E+02	2.1	3.52	0.35
0.69	.497E+02	2.5	3.65	0.33
0.76	.552E+02	2.8	3.76	0.32
0.82	.604E+02	3.2	3.84	0.32
0.88	.655E+02	3.5	3.90	0.31
0.95	.702E+02	3.8	3.93	0.31
1.01	.745E+02	4.0	3.93	0.31
1.07	.783E+02	4.1	3.89	0.31
1.14	.812E+02	4.2	3.78	0.32
1.20	.829E+02	3.9	3.45	0.35

	<---- hydrograph ---->				<-pipe / channel->	
	AREA	QPEAK	TPEAK	R.V.	MAX DEPTH	MAX VEL
	(ha)	(cms)	(hrs)	(mm)	(m)	(m/s)
INFLOW : ID= 2 (0037)	28.80	0.35	13.42	18.88	0.24	2.12
OUTFLOW: ID= 1 (0165)	28.80	0.35	13.42	18.88	0.24	2.11

| CALIB |
| NASHYD (0051)| Area (ha)= 69.30 Curve Number (CN)= 68.0
|ID= 1 DT= 5.0 min | Ia (mm)= 13.90 # of Linear Res.(N)= 3.00
-------------------- U.H. Tp(hrs)= 1.45

Unit Hyd Qpeak (cms)= 1.825

PEAK FLOW (cms)= 0.725 (i)
TIME TO PEAK (hrs)= 13.667
RUNOFF VOLUME (mm)= 18.883
TOTAL RAINFALL (mm)= 71.780
RUNOFF COEFFICIENT = 0.263

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

| ROUTEPIPE(0164)| PIPE Number = 1.00
| IN= 2---> OUT= 1 | Diameter (mm)=1350.00
| DT= 5.0 min | Length (m)= 104.50
-------------------- Slope (m/m)= 0.010
Manning n = 0.013

<----------------- TRAVEL TIME TABLE -------------------->

DEPTH	VOLUME	FLOW RATE	VELOCITY	TRAV.TIME
(m)	(cu.m.)	(cms)	(m/s)	min
0.07	.302E+01	0.0	0.99	1.76
0.14	.839E+01	0.1	1.55	1.13
0.21	.152E+02	0.3	1.99	0.88
0.28	.229E+02	0.5	2.37	0.74
0.36	.314E+02	0.8	2.69	0.65
0.43	.405E+02	1.2	2.98	0.58
0.50	.500E+02	1.5	3.23	0.54
0.57	.598E+02	2.0	3.45	0.50

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     0.64    .698E+02     2.4        3.64        0.48
     0.71    .798E+02     2.9        3.81        0.46
     0.78    .898E+02     3.4        3.95        0.44
     0.85    .996E+02     3.9        4.07        0.43
     0.92    .109E+03     4.3        4.16        0.42
     0.99    .118E+03     4.8        4.22        0.41
     1.07    .127E+03     5.2        4.25        0.41
     1.14    .134E+03     5.5        4.25        0.41
     1.21    .141E+03     5.7        4.20        0.41
     1.28    .147E+03     5.7        4.09        0.43
     1.35        NaN       NaN        NaN         NaN
                   <---- hydrograph ---->   <-pipe / channel->
                  AREA    QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                  (ha)    (cms)   (hrs)   (mm)      (m)      (m/s)
 INFLOW : ID= 2 (  0051)  69.30     0.72  13.67  18.88      0.33      2.59
 OUTFLOW: ID= 1 (  0164)  69.30     0.72  13.67  18.88      0.33      2.58


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--------------------
| CALIB            |
| STANDHYD (  0049)|   Area    (ha)=   4.08
|ID= 1 DT= 5.0 min |   Total Imp(%)=  67.00   Dir. Conn.(%)=  55.00
--------------------
                     IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=       2.73        1.35
    Dep. Storage     (mm)=       1.00        5.00
    Average Slope    (%)=       1.00        2.00
    Length           (m)=     164.92      215.00
    Mannings n         =      0.014       0.250

    Max.Eff.Inten.(mm/hr)=      79.27       29.21
             over (min)        5.00       40.00
    Storage Coeff.  (min)=       3.96 (ii)   35.63 (ii)
    Unit Hyd. Tpeak (min)=       5.00       40.00
    Unit Hyd. peak  (cms)=       0.24        0.03
                                        *TOTALS*
    PEAK FLOW       (cms)=       0.48        0.07         0.508 (iii)
    TIME TO PEAK    (hrs)=      12.17       12.67         12.17
    RUNOFF VOLUME    (mm)=      70.78       29.78         52.33
    TOTAL RAINFALL   (mm)=      71.78       71.78         71.78
    RUNOFF COEFFICIENT   =       0.99        0.41          0.73

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

    (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
        CN*  =  68.0    Ia = Dep. Storage  (Above)
   (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
        THAN THE STORAGE COEFFICIENT.
  (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| ADD HYD  (  0157)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
       ID1= 1 (  0164):    69.30   0.725    13.67    18.88
     + ID2= 2 (  0165):    28.80   0.350    13.42    18.88
       ===================================================
       ID = 3 (  0157):    98.10   1.068    13.58    18.88

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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--------------------
| ADD HYD  (  0157)|
|   3 +  2 =  1    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
       ID1= 3 (  0157):    98.10   1.068    13.58    18.88
     + ID2= 2 (  0049):     4.08   0.508    12.17    52.33
       ===================================================
       ID = 1 (  0157):   102.18   1.110    13.75    20.22

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-----------------------------------------------------------------------------
--------------------
| ROUTEPIPE(  0163)|     PIPE Number     =   1.00
| IN= 2---> OUT= 1 |     Width       (mm)=2400.00     Height   (mm)=1500.00
| DT=  5.0 min     |     Length       (m)= 346.00
--------------------     Slope      (m/m)=  0.007
                         Manning n       =  0.013

    <----------------- TRAVEL TIME TABLE -------------------->
      DEPTH      VOLUME    FLOW RATE    VELOCITY    TRAV.TIME
       (m)      (cu.m.)      (cms)        (m/s)        min
```

```
   0.08   .656E+02    0.2      1.18     4.90
   0.16   .131E+03    0.7      1.79     3.22
   0.24   .197E+03    1.3      2.26     2.55
   0.32   .262E+03    2.0      2.65     2.18
   0.39   .328E+03    2.8      2.97     1.94
   0.47   .393E+03    3.7      3.25     1.78
   0.55   .459E+03    4.6      3.49     1.65
   0.63   .524E+03    5.6      3.70     1.56
   0.71   .590E+03    6.6      3.89     1.48
   0.79   .656E+03    7.7      4.07     1.42
   0.87   .721E+03    8.8      4.22     1.37
   0.95   .787E+03    9.9      4.36     1.32
   1.03   .852E+03   11.1      4.49     5.56
   1.11   .918E+03   12.2      4.61     5.42
   1.18   .983E+03   13.4      4.72     5.29
   1.26   .105E+04   14.6      4.82     5.18
   1.34   .111E+04   15.8      4.92     5.08
   1.42   .118E+04   17.1      5.01     4.99
   1.50   .125E+04   18.3      5.09     4.91
                    <---- hydrograph ---->  <-pipe / channel->
                 AREA   QPEAK  TPEAK  R.V.  MAX DEPTH  MAX VEL
                 (ha)   (cms)  (hrs)  (mm)     (m)      (m/s)
  INFLOW : ID= 2 (  0157)  102.18    1.11  13.75  20.22    0.21    2.10
  OUTFLOW: ID= 1 (  0163)  102.18    1.11  13.83  20.22    0.21    2.09


-------------------------------------------------------------------------------
--------------------
| CALIB          |
| STANDHYD (  0106)|   Area    (ha)=   6.17
|ID= 1 DT= 5.0 min |   Total Imp(%)=  67.00   Dir. Conn.(%)=  55.00
--------------------
                      IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=      4.13        2.04
    Dep. Storage     (mm)=      1.00        5.00
    Average Slope     (%)=      1.00        2.00
    Length            (m)=    202.81      215.00
    Mannings n          =      0.014       0.250

    Max.Eff.Inten.(mm/hr)=     79.27       29.21
             over (min)        5.00       40.00
    Storage Coeff.  (min)=      4.48 (ii)  36.15 (ii)
    Unit Hyd. Tpeak (min)=      5.00       40.00
    Unit Hyd. peak  (cms)=      0.23        0.03
                                                      *TOTALS*
    PEAK FLOW       (cms)=      0.72        0.10        0.760 (iii)
    TIME TO PEAK    (hrs)=     12.17       12.67       12.17
    RUNOFF VOLUME    (mm)=     70.78       29.78       52.33
    TOTAL RAINFALL   (mm)=     71.78       71.78       71.78
    RUNOFF COEFFICIENT   =      0.99        0.41        0.73

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
         CN*  =  68.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
         THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
--------------------
| CALIB          |
| STANDHYD (  0119)|   Area    (ha)=  18.56
|ID= 1 DT= 5.0 min |   Total Imp(%)=  69.00   Dir. Conn.(%)=  45.00
--------------------
                      IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=     12.81        5.75
    Dep. Storage     (mm)=      1.00        5.00
    Average Slope     (%)=      1.00        2.00
    Length            (m)=    351.76      215.00
    Mannings n          =      0.014       0.250

    Max.Eff.Inten.(mm/hr)=     79.27       56.67
             over (min)        5.00       35.00
    Storage Coeff.  (min)=      6.23 (ii)  30.53 (ii)
    Unit Hyd. Tpeak (min)=      5.00       35.00
    Unit Hyd. peak  (cms)=      0.19        0.04
                                                      *TOTALS*
    PEAK FLOW       (cms)=      1.70        0.48        1.926 (iii)
    TIME TO PEAK    (hrs)=     12.17       12.58       12.17
    RUNOFF VOLUME    (mm)=     70.78       34.88       51.04
    TOTAL RAINFALL   (mm)=     71.78       71.78       71.78
    RUNOFF COEFFICIENT   =      0.99        0.49        0.71


     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
         CN*  =  68.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
```

```
    THAN THE STORAGE COEFFICIENT.
  (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------
--------------------
| RESERVOIR( 0133)|
| IN= 2---> OUT= 1 |
| DT= 5.0 min    |    OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------     (cms)    (ha.m.)  |  (cms)     (ha.m.)
                    0.0000    0.0000  |  0.0250     1.0741
                    0.0140    0.2394  |  0.0290     1.2348
                    0.0150    0.6048  |  0.0340     1.4904
                    0.0210    0.8843  |  0.0380     1.7173

                        AREA     QPEAK     TPEAK      R.V.
                        (ha)    (cms)     (hrs)      (mm)
 INFLOW : ID= 2 ( 0119)    18.560     1.926     12.17     51.04
 OUTFLOW: ID= 1 ( 0133)    18.560     0.020     24.33     44.59

             PEAK   FLOW   REDUCTION [Qout/Qin](%)=  1.05
             TIME SHIFT OF PEAK FLOW        (min)=730.00
             MAXIMUM  STORAGE   USED       (ha.m.)=  0.8486

------------------------------------------------------------------------------


--------------------
| ADD HYD  ( 0159)|
|  1 +  2 =  3   |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 1 ( 0106):    6.17  0.760   12.17    52.33
    + ID2= 2 ( 0133):   18.56  0.020   24.33    44.59
      ==================================================
      ID = 3 ( 0159):   24.73  0.774   12.17    46.52

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

------------------------------------------------------------------------------

--------------------
| ADD HYD  ( 0159)|
|  3 +  2 =  1   |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 3 ( 0159):   24.73  0.774    12.17    46.52
    + ID2= 2 ( 0163):  102.18  1.106    13.83    20.22
```

```
      ==================================================
      ID = 1 ( 0159):   126.91   1.363    12.17    25.34

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

------------------------------------------------------------------------------
--------------------
| ROUTEPIPE( 0158)|    PIPE Number     =   1.00
| IN= 2---> OUT= 1 |     Width      (mm)=2400.00    Height   (mm)=1500.00
| DT=  5.0 min    |     Length      (m)= 253.00
--------------------     Slope     (m/m)=  0.005
                      Manning n       =  0.013

   <----------------- TRAVEL TIME TABLE -------------------->
    DEPTH     VOLUME    FLOW RATE    VELOCITY    TRAV.TIME
     (m)      (cu.m.)     (cms)        (m/s)        min
    0.08    .479E+02      0.2         0.96        4.39
    0.16    .959E+02      0.6         1.46        2.88
    0.24    .144E+03      1.1         1.85        2.28
    0.32    .192E+03      1.6         2.16        1.95
    0.39    .240E+03      2.3         2.42        1.74
    0.47    .288E+03      3.0         2.65        1.59
    0.55    .336E+03      3.8         2.85        1.48
    0.63    .384E+03      4.6         3.02        1.40
    0.71    .431E+03      5.4         3.18        1.33
    0.79    .479E+03      6.3         3.32        1.27
    0.87    .527E+03      7.2         3.45        1.22
    0.95    .575E+03      8.1         3.56        1.18
    1.03    .623E+03      9.0         3.67        6.82
    1.11    .671E+03     10.0         3.77        6.64
    1.18    .719E+03     11.0         3.86        6.48
    1.26    .767E+03     11.9         3.94        6.35
    1.34    .815E+03     12.9         4.02        6.23
    1.42    .863E+03     13.9         4.09        6.12
    1.50    .911E+03     15.0         4.15        6.02
                     <---- hydrograph ---->  <-pipe / channel->
                  AREA    QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                  (ha)    (cms)   (hrs)   (mm)      (m)      (m/s)
 INFLOW : ID= 2 ( 0159)  126.91     1.36   12.17  25.34     0.28     2.00
 OUTFLOW: ID= 1 ( 0158)  126.91     1.32   12.17  25.34     0.27     1.98


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```
| CALIB            |
| STANDHYD ( 0136)|   Area    (ha)=   7.15
|ID= 1 DT= 5.0 min |   Total Imp(%)=  67.00   Dir. Conn.(%)=  55.00
--------------------
                    IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=       4.79         2.36
    Dep. Storage     (mm)=       1.00        13.90
    Average Slope     (%)=       1.00         2.00
    Length            (m)=     218.33       215.00
    Mannings n           =      0.014        0.250

    Max.Eff.Inten.(mm/hr)=      79.27        24.74
             over (min)         5.00        40.00
    Storage Coeff.  (min)=       4.68 (ii)   38.53 (ii)
    Unit Hyd. Tpeak (min)=       5.00        40.00
    Unit Hyd. peak  (cms)=       0.22         0.03
                                                  *TOTALS*
    PEAK FLOW       (cms)=       0.83         0.09         0.865 (iii)
    TIME TO PEAK    (hrs)=      12.17        12.75         12.17
    RUNOFF VOLUME    (mm)=      70.78        25.41         50.36
    TOTAL RAINFALL   (mm)=      71.78        71.78         71.78
    RUNOFF COEFFICIENT   =       0.99         0.35          0.70

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
         CN*  =  68.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
         THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------

--------------------
| ADD HYD  ( 0160)|
|  1 +  2 =  3    |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 1 ( 0136):      7.15    0.865    12.17     50.36
    + ID2= 2 ( 0158):    126.91    1.320    12.17     25.34
      =======================================================
      ID = 3 ( 0160):    134.06    2.184    12.17     26.68

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| ROUTEPIPE( 0161)|     PIPE Number     =   1.00
| IN= 2---> OUT= 1 |     Width      (mm)=2400.00     Height   (mm)=1800.00
| DT=  5.0 min     |     Length      (m)=  43.50
--------------------     Slope     (m/m)=  0.003
                         Manning n      =  0.013

   <----------------- TRAVEL TIME TABLE -------------------->
    DEPTH      VOLUME    FLOW RATE    VELOCITY    TRAV.TIME
     (m)      (cu.m.)      (cms)        (m/s)        min
    0.09     .989E+01      0.2          0.83         0.87
    0.19     .198E+02      0.6          1.26         0.57
    0.28     .297E+02      1.1          1.58         0.46
    0.38     .396E+02      1.7          1.84         0.39
    0.47     .495E+02      2.3          2.05         0.35
    0.57     .593E+02      3.0          2.23         0.32
    0.66     .692E+02      3.8          2.39         0.30
    0.76     .791E+02      4.6          2.53         0.29
    0.85     .890E+02      5.4          2.65         0.27
    0.95     .989E+02      6.3          2.76         0.26
    1.04     .109E+03      7.1          2.86        10.50
    1.14     .119E+03      8.0          2.95        10.19
    1.23     .129E+03      8.9          3.03         9.92
    1.33     .138E+03      9.9          3.10         9.68
    1.42     .148E+03     10.8          3.17         9.48
    1.52     .158E+03     11.7          3.23         9.29
    1.61     .168E+03     12.7          3.28         9.13
    1.71     .178E+03     13.7          3.34         8.99
    1.80     .188E+03     14.6          3.39         8.86
                          <---- hydrograph ---->  <-pipe / channel->
                         AREA    QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                         (ha)    (cms)   (hrs)   (mm)      (m)      (m/s)
 INFLOW : ID= 2 ( 0160)  134.06   2.18   12.17  26.68     0.45      2.00
 OUTFLOW: ID= 1 ( 0161)  134.06   2.20   12.17  26.68     0.46      2.01


--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD ( 0132)|   Area    (ha)=  53.46
|ID= 1 DT= 5.0 min |   Total Imp(%)=  69.00   Dir. Conn.(%)=  45.00
--------------------
                    IMPERVIOUS    PERVIOUS (i)
```

```
 Surface Area     (ha)=     36.89       16.57
 Dep. Storage     (mm)=      1.00        5.00
 Average Slope     (%)=      1.00        2.00
 Length             (m)=    596.99      215.00
 Mannings n           =     0.014       0.250

 Max.Eff.Inten.(mm/hr)=     79.27       56.67
          over (min)      10.00       35.00
 Storage Coeff.  (min)=      8.56 (ii)   32.86 (ii)
 Unit Hyd. Tpeak (min)=     10.00       35.00
 Unit Hyd. peak  (cms)=      0.12        0.03
                                    *TOTALS*
 PEAK FLOW       (cms)=      4.24        1.33        4.876 (iii)
 TIME TO PEAK    (hrs)=     12.17       12.58        12.17
 RUNOFF VOLUME    (mm)=     70.78       34.88        51.04
 TOTAL RAINFALL   (mm)=     71.78       71.78        71.78
 RUNOFF COEFFICIENT   =      0.99        0.49         0.71


  (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
      CN*  =  68.0    Ia = Dep. Storage  (Above)
  (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
      THAN THE STORAGE COEFFICIENT.
 (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| RESERVOIR(  0131)|
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------       (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   0.1700     2.5907
                          0.0550     0.7098   |   0.2155     3.1239
                          0.1004     1.5249   |   0.2600     3.5865
                          0.1400     2.1680   |   0.3014     4.0085

                              AREA     QPEAK     TPEAK       R.V.
                              (ha)     (cms)     (hrs)       (mm)
  INFLOW : ID= 2 (  0132)     53.460     4.876     12.17      51.04
  OUTFLOW: ID= 1 (  0131)     53.460     0.138     20.50      50.18

             PEAK   FLOW   REDUCTION [Qout/Qin](%)=  2.82
             TIME SHIFT OF PEAK FLOW         (min)=500.00
             MAXIMUM  STORAGE   USED       (ha.m.)=  2.1276

--------------------------------------------------------------------------------

--------------------
| ADD HYD  (  0117)|
|   1 +  2 =  3    |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 1 (  0131):    53.46   0.138    20.50    50.18
    + ID2= 2 (  0161):   134.06   2.196    12.17    26.68
      ===================================================
      ID = 3 (  0117):   187.52   2.260    12.17    33.38

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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--------------------
| ADD HYD  (  0117)|
|   3 +  2 =  1    |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 3 (  0117):   187.52   2.260    12.17    33.38
    + ID2= 2 (  0036):     1.98   0.131    12.17    18.17
      ===================================================
      ID = 1 (  0117):   189.50   2.391    12.17    33.22

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| ROUTE CHN(  0166)|
| IN= 2---> OUT= 1 |     Routing time step (min)'=  5.00
--------------------
            <------ DATA FOR SECTION (   2.0) ------>
            Distance      Elevation       Manning
               0.00       100.20        0.0400
              46.50       101.25     0.0400 /0.0350  Main Channel
              52.50        99.25        0.0350      Main Channel
              61.50       101.25     0.0350 /0.0400  Main Channel
             105.00       102.00        0.0400

     <--------------------- TRAVEL TIME TABLE ---------------------->
      DEPTH    ELEV      VOLUME    FLOW RATE    VELOCITY   TRAV.TIME
       (m)      (m)    (cu.m.)      (cms)        (m/s)      (min)
      0.05    99.30    .328E+01      0.0         0.23       25.78
```

```
 0.10   99.35   .131E+02    0.0      0.36    16.24
 0.15   99.40   .295E+02    0.0      0.47    12.39
 0.20   99.45   .525E+02    0.1      0.57    10.23
 0.25   99.50   .820E+02    0.2      0.66     8.82
 0.30   99.55   .118E+03    0.3      0.75     7.81
 0.35   99.60   .161E+03    0.4      0.83     7.04
 0.40   99.65   .210E+03    0.5      0.91     6.44
 0.45   99.70   .266E+03    0.7      0.98     5.96
 0.50   99.75   .328E+03    1.0      1.05     5.55
 0.55   99.80   .397E+03    1.3      1.12     5.21
 0.60   99.85   .472E+03    1.6      1.19     4.92
 0.65   99.90   .554E+03    2.0      1.25     4.66
 0.70   99.95   .643E+03    2.4      1.31     4.44
 0.75  100.00   .738E+03    2.9      1.38     4.24
 0.80  100.05   .840E+03    3.4      1.44     4.06
 0.85  100.10   .948E+03    4.1      1.50     3.90
 0.90  100.15   .106E+04    4.7      1.55     3.75
 0.95  100.20   .118E+04    5.5      1.61     3.62

                   <---- hydrograph ---->  <-pipe / channel->
                 AREA    QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                 (ha)    (cms)   (hrs)   (mm)      (m)      (m/s)
 INFLOW : ID= 2 (  0117)  189.50     2.39   12.17  33.22      0.70      1.31
 OUTFLOW: ID= 1 (  0166)  189.50     2.06   12.17  33.21      0.66      1.26


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--------------------
| CALIB            |
| NASHYD   (  0120)|   Area    (ha)=  10.00   Curve Number   (CN)= 68.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  13.90   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.44

    Unit Hyd Qpeak  (cms)=   0.868

    PEAK FLOW      (cms)=   0.256 (i)
    TIME TO PEAK    (hrs)=  12.500
    RUNOFF VOLUME    (mm)=  18.882
    TOTAL RAINFALL   (mm)=  71.780
    RUNOFF COEFFICIENT   =   0.263

    (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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```

```
--------------------
| ADD HYD  (  0121)|
|  1 +  2 =  3     |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 1 (  0120):    10.00   0.256    12.50    18.88
    + ID2= 2 (  0166):   189.50   2.065    12.17    33.21
      ====================================================
      ID = 3 (  0121):   199.50   2.247    12.25    32.49

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD   (  0046)|   Area    (ha)=  17.20   Curve Number   (CN)= 68.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  13.90   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.47

    Unit Hyd Qpeak  (cms)=   1.398

    PEAK FLOW      (cms)=   0.418 (i)
    TIME TO PEAK    (hrs)=  12.583
    RUNOFF VOLUME    (mm)=  18.882
    TOTAL RAINFALL   (mm)=  71.780
    RUNOFF COEFFICIENT   =   0.263

    (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| ADD HYD  (  0114)|
|  1 +  2 =  3     |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 1 (  0121):   199.50   2.247    12.25    32.49
    + ID2= 2 (  0046):    17.20   0.418    12.58    18.88
      ====================================================
      ID = 3 (  0114):   216.70   2.540    12.25    31.41

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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** SIMULATION:Run 04 **
****

| READ STORM | Filename: C:\Users\Janis Lobo\AppD
| | ata\Local\Temp\
| | 9d3c8ff4-eb6c-4319-bb26-ce62fa26e7e3\29860050
| Ptotal= 84.21 mm | Comments: 10-year - 24-h SCS RBG

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.17	0.00	6.33	1.68	12.50	12.12	18.67	1.52
0.33	0.93	6.50	1.68	12.67	12.12	18.83	1.52
0.50	0.93	6.67	1.68	12.83	6.23	19.00	1.52
0.67	0.93	6.83	1.68	13.00	6.23	19.17	1.52
0.83	0.93	7.00	1.68	13.17	6.23	19.33	1.52
1.00	0.93	7.17	1.68	13.33	1.18	19.50	1.52
1.17	0.93	7.33	1.68	13.50	1.18	19.67	1.52
1.33	0.93	7.50	1.68	13.67	1.18	19.83	1.52
1.50	0.93	7.67	1.68	13.83	6.90	20.00	1.52
1.67	0.93	7.83	1.68	14.00	6.90	20.17	1.52
1.83	0.93	8.00	1.68	14.17	6.90	20.33	1.01
2.00	0.93	8.17	1.68	14.33	2.53	20.50	1.01
2.17	0.93	8.33	2.27	14.50	2.53	20.67	1.01
2.33	1.09	8.50	2.27	14.67	2.53	20.83	1.01
2.50	1.09	8.67	2.27	14.83	2.53	21.00	1.01
2.67	1.09	8.83	2.27	15.00	2.53	21.17	1.01
2.83	1.09	9.00	2.27	15.17	2.53	21.33	1.01
3.00	1.09	9.17	2.27	15.33	2.53	21.50	1.01
3.17	1.09	9.33	2.69	15.50	2.53	21.67	1.01
3.33	1.09	9.50	2.69	15.67	2.53	21.83	1.01
3.50	1.09	9.67	2.69	15.83	2.53	22.00	1.01
3.67	1.09	9.83	3.03	16.00	2.53	22.17	1.01
3.83	1.09	10.00	3.03	16.17	2.53	22.33	1.01
4.00	1.09	10.17	3.03	16.33	1.52	22.50	1.01
4.17	1.09	10.33	3.87	16.50	1.52	22.67	1.01
4.33	1.35	10.50	3.87	16.67	1.52	22.83	1.01
4.50	1.35	10.67	3.87	16.83	1.52	23.00	1.01
4.67	1.35	10.83	5.22	17.00	1.52	23.17	1.01
4.83	1.35	11.00	5.22	17.17	1.52	23.33	1.01
5.00	1.35	11.17	5.22	17.33	1.52	23.50	1.01
5.17	1.35	11.33	8.08	17.50	1.52	23.67	1.01
5.33	1.35	11.50	8.08	17.67	1.52	23.83	1.01
5.50	1.35	11.67	8.08	17.83	1.52	24.00	1.01
5.67	1.35	11.83	35.03	18.00	1.52	24.17	1.01
5.83	1.35	12.00	63.99	18.17	1.52		
6.00	1.35	12.17	92.96	18.33	1.52		
6.17	1.35	12.33	12.12	18.50	1.52		

| CALIB |
| NASHYD (0036)| Area (ha)= 1.98 Curve Number (CN)= 68.0
|ID= 1 DT= 5.0 min | Ia (mm)= 13.90 # of Linear Res.(N)= 3.00
-------------------- U.H. Tp(hrs)= 0.09

NOTE: RAINFALL WAS TRANSFORMED TO 5.0 MIN. TIME STEP.

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	0.00	6.167	1.35	12.250	12.13	18.33	1.52
0.167	0.00	6.250	1.68	12.333	12.12	18.42	1.52
0.250	0.93	6.333	1.68	12.417	12.12	18.50	1.52
0.333	0.93	6.417	1.68	12.500	12.12	18.58	1.52
0.417	0.93	6.500	1.68	12.583	12.12	18.67	1.52
0.500	0.93	6.583	1.68	12.667	12.12	18.75	1.52
0.583	0.93	6.667	1.68	12.750	6.23	18.83	1.52
0.667	0.93	6.750	1.68	12.833	6.23	18.92	1.52
0.750	0.93	6.833	1.68	12.917	6.23	19.00	1.52
0.833	0.93	6.917	1.68	13.000	6.23	19.08	1.52
0.917	0.93	7.000	1.68	13.083	6.23	19.17	1.52
1.000	0.93	7.083	1.68	13.167	6.23	19.25	1.52
1.083	0.93	7.167	1.68	13.250	1.18	19.33	1.52
1.167	0.93	7.250	1.68	13.333	1.18	19.42	1.52
1.250	0.93	7.333	1.68	13.417	1.18	19.50	1.52
1.333	0.93	7.417	1.68	13.500	1.18	19.58	1.52
1.417	0.93	7.500	1.68	13.583	1.18	19.67	1.52
1.500	0.93	7.583	1.68	13.667	1.18	19.75	1.52
1.583	0.93	7.667	1.68	13.750	6.90	19.83	1.52
1.667	0.93	7.750	1.68	13.833	6.90	19.92	1.52
1.750	0.93	7.833	1.68	13.917	6.90	20.00	1.52
1.833	0.93	7.917	1.68	14.000	6.90	20.08	1.52
1.917	0.93	8.000	1.68	14.083	6.90	20.17	1.52
2.000	0.93	8.083	1.68	14.167	6.90	20.25	1.01
2.083	0.93	8.167	1.68	14.250	2.53	20.33	1.01

2.167	0.93	8.250	2.27	14.333	2.53	20.42	1.01
2.250	1.09	8.333	2.27	14.417	2.53	20.50	1.01
2.333	1.09	8.417	2.27	14.500	2.53	20.58	1.01
2.417	1.09	8.500	2.27	14.583	2.53	20.67	1.01
2.500	1.09	8.583	2.27	14.667	2.53	20.75	1.01
2.583	1.09	8.667	2.27	14.750	2.53	20.83	1.01
2.667	1.09	8.750	2.27	14.833	2.53	20.92	1.01
2.750	1.09	8.833	2.27	14.917	2.53	21.00	1.01
2.833	1.09	8.917	2.27	15.000	2.53	21.08	1.01
2.917	1.09	9.000	2.27	15.083	2.53	21.17	1.01
3.000	1.09	9.083	2.27	15.167	2.53	21.25	1.01
3.083	1.09	9.167	2.27	15.250	2.53	21.33	1.01
3.167	1.09	9.250	2.69	15.333	2.53	21.42	1.01
3.250	1.09	9.333	2.69	15.417	2.53	21.50	1.01
3.333	1.09	9.417	2.69	15.500	2.53	21.58	1.01
3.417	1.09	9.500	2.69	15.583	2.53	21.67	1.01
3.500	1.09	9.583	2.69	15.667	2.53	21.75	1.01
3.583	1.09	9.667	2.69	15.750	2.53	21.83	1.01
3.667	1.09	9.750	3.03	15.833	2.53	21.92	1.01
3.750	1.09	9.833	3.03	15.917	2.53	22.00	1.01
3.833	1.09	9.917	3.03	16.000	2.53	22.08	1.01
3.917	1.09	10.000	3.03	16.083	2.53	22.17	1.01
4.000	1.09	10.083	3.03	16.167	2.53	22.25	1.01
4.083	1.09	10.167	3.03	16.250	1.52	22.33	1.01
4.167	1.09	10.250	3.87	16.333	1.52	22.42	1.01
4.250	1.35	10.333	3.87	16.417	1.52	22.50	1.01
4.333	1.35	10.417	3.87	16.500	1.52	22.58	1.01
4.417	1.35	10.500	3.87	16.583	1.52	22.67	1.01
4.500	1.35	10.583	3.87	16.667	1.52	22.75	1.01
4.583	1.35	10.667	3.87	16.750	1.52	22.83	1.01
4.667	1.35	10.750	5.22	16.833	1.52	22.92	1.01
4.750	1.35	10.833	5.22	16.917	1.52	23.00	1.01
4.833	1.35	10.917	5.22	17.000	1.52	23.08	1.01
4.917	1.35	11.000	5.22	17.083	1.52	23.17	1.01
5.000	1.35	11.083	5.22	17.167	1.52	23.25	1.01
5.083	1.35	11.167	5.22	17.250	1.52	23.33	1.01
5.167	1.35	11.250	8.08	17.333	1.52	23.42	1.01
5.250	1.35	11.333	8.08	17.417	1.52	23.50	1.01
5.333	1.35	11.417	8.08	17.500	1.52	23.58	1.01
5.417	1.35	11.500	8.08	17.583	1.52	23.67	1.01
5.500	1.35	11.583	8.08	17.667	1.52	23.75	1.01
5.583	1.35	11.667	8.08	17.750	1.52	23.83	1.01
5.667	1.35	11.750	35.03	17.833	1.52	23.92	1.01
5.750	1.35	11.833	35.03	17.917	1.52	24.00	1.01
5.833	1.35	11.917	63.99	18.000	1.52	24.08	1.01
5.917	1.35	12.000	63.99	18.083	1.52	24.17	1.01
6.000	1.35	12.083	92.96	18.167	1.52		
6.083	1.35	12.167	92.96	18.250	1.52		

Unit Hyd Qpeak (cms)= 0.840

PEAK FLOW (cms)= 0.181 (i)
TIME TO PEAK (hrs)= 12.167
RUNOFF VOLUME (mm)= 25.055
TOTAL RAINFALL (mm)= 84.207
RUNOFF COEFFICIENT = 0.298

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

| CALIB |
| NASHYD (0037)| Area (ha)= 28.80 Curve Number (CN)= 68.0
|ID= 1 DT= 5.0 min | Ia (mm)= 13.90 # of Linear Res.(N)= 3.00
-------------------- U.H. Tp(hrs)= 1.21

Unit Hyd Qpeak (cms)= 0.908

PEAK FLOW (cms)= 0.496 (i)
TIME TO PEAK (hrs)= 13.417
RUNOFF VOLUME (mm)= 26.038
TOTAL RAINFALL (mm)= 84.207
RUNOFF COEFFICIENT = 0.309

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

| ROUTEPIPE(0165)| PIPE Number = 1.00
| IN= 2---> OUT= 1 | Diameter (mm)=1200.00
| DT= 5.0 min | Length (m)= 73.30
-------------------- Slope (m/m)= 0.010
Manning n = 0.013

<----------------- TRAVEL TIME TABLE -------------------->

DEPTH	VOLUME	FLOW RATE	VELOCITY	TRAV.TIME
(m)	(cu.m.)	(cms)	(m/s)	min
0.06	.167E+01	0.0	0.92	1.33

0.13	.465E+01	0.1	1.43	0.85
0.19	.840E+01	0.2	1.84	0.66
0.25	.127E+02	0.4	2.19	0.56
0.32	.174E+02	0.6	2.49	0.49
0.38	.225E+02	0.8	2.75	0.44
0.44	.277E+02	1.1	2.99	0.41
0.51	.332E+02	1.4	3.19	0.38
0.57	.387E+02	1.8	3.37	0.36
0.63	.442E+02	2.1	3.52	0.35
0.69	.497E+02	2.5	3.65	0.33
0.76	.552E+02	2.8	3.76	0.32
0.82	.604E+02	3.2	3.84	0.32
0.88	.655E+02	3.5	3.90	0.31
0.95	.702E+02	3.8	3.93	0.31
1.01	.745E+02	4.0	3.93	0.31
1.07	.783E+02	4.1	3.89	0.31
1.14	.812E+02	4.2	3.78	0.32
1.20	.829E+02	3.9	3.45	0.35

	<---- hydrograph ---->			<-pipe / channel->	
	AREA (ha)	QPEAK (cms)	TPEAK (hrs)	R.V. (mm)	MAX DEPTH (m)	MAX VEL (m/s)
INFLOW : ID= 2 (0037)	28.80	0.50	13.42	26.04	0.29	2.34
OUTFLOW: ID= 1 (0165)	28.80	0.50	13.42	26.04	0.29	2.34

| CALIB |
| NASHYD (0051)| Area (ha)= 69.30 Curve Number (CN)= 68.0
|ID= 1 DT= 5.0 min | Ia (mm)= 13.90 # of Linear Res.(N)= 3.00
-------------------- U.H. Tp(hrs)= 1.45

Unit Hyd Qpeak (cms)= 1.825

PEAK FLOW (cms)= 1.028 (i)
TIME TO PEAK (hrs)= 13.667
RUNOFF VOLUME (mm)= 26.038
TOTAL RAINFALL (mm)= 84.207
RUNOFF COEFFICIENT = 0.309

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

| ROUTEPIPE(0164)| PIPE Number = 1.00
| IN= 2---> OUT= 1 | Diameter (mm)=1350.00
| DT= 5.0 min | Length (m)= 104.50
-------------------- Slope (m/m)= 0.010
Manning n = 0.013

<----------------- TRAVEL TIME TABLE -------------------->

DEPTH (m)	VOLUME (cu.m.)	FLOW RATE (cms)	VELOCITY (m/s)	TRAV.TIME min
0.07	.302E+01	0.0	0.99	1.76
0.14	.839E+01	0.1	1.55	1.13
0.21	.152E+02	0.3	1.99	0.88
0.28	.229E+02	0.5	2.37	0.74
0.36	.314E+02	0.8	2.69	0.65
0.43	.405E+02	1.2	2.98	0.58
0.50	.500E+02	1.5	3.23	0.54
0.57	.598E+02	2.0	3.45	0.50
0.64	.698E+02	2.4	3.64	0.48
0.71	.798E+02	2.9	3.81	0.46
0.78	.898E+02	3.4	3.95	0.44
0.85	.996E+02	3.9	4.07	0.43
0.92	.109E+03	4.3	4.16	0.42
0.99	.118E+03	4.8	4.22	0.41
1.07	.127E+03	5.2	4.25	0.41
1.14	.134E+03	5.5	4.25	0.41
1.21	.141E+03	5.7	4.20	0.41
1.28	.147E+03	5.7	4.09	0.43
1.35	NaN	NaN	NaN	NaN

	<---- hydrograph ---->			<-pipe / channel->	
	AREA (ha)	QPEAK (cms)	TPEAK (hrs)	R.V. (mm)	MAX DEPTH (m)	MAX VEL (m/s)
INFLOW : ID= 2 (0051)	69.30	1.03	13.67	26.04	0.40	2.87
OUTFLOW: ID= 1 (0164)	69.30	1.03	13.67	26.04	0.40	2.87

| CALIB |
| STANDHYD (0049)| Area (ha)= 4.08
|ID= 1 DT= 5.0 min | Total Imp(%)= 67.00 Dir. Conn.(%)= 55.00

		IMPERVIOUS	PERVIOUS (i)
Surface Area	(ha)=	2.73	1.35
Dep. Storage	(mm)=	1.00	5.00

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    Average Slope     (%)=       1.00        2.00
    Length           (m)=     164.92      215.00
    Mannings n         =      0.014       0.250

    Max.Eff.Inten.(mm/hr)=      92.96       42.77
             over (min)        5.00       35.00
    Storage Coeff.  (min)=       3.71 (ii)   30.90 (ii)
    Unit Hyd. Tpeak (min)=       5.00       35.00
    Unit Hyd. peak  (cms)=       0.25        0.04
                                          *TOTALS*
    PEAK FLOW       (cms)=       0.57        0.09         0.611 (iii)
    TIME TO PEAK    (hrs)=      12.17       12.58         12.17
    RUNOFF VOLUME    (mm)=      83.21       38.57         63.11
    TOTAL RAINFALL   (mm)=      84.21       84.21         84.21
    RUNOFF COEFFICIENT   =       0.99        0.46          0.75

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
         CN*  =  68.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
         THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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| ADD HYD  (  0157)|
|  1 +  2 =  3    |          AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
       ID1= 1 (  0164):     69.30   1.028    13.67    26.04
     + ID2= 2 (  0165):     28.80   0.496    13.42    26.04
       ====================================================
       ID = 3 (  0157):     98.10   1.515    13.58    26.04

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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| ADD HYD  (  0157)|
|  3 +  2 =  1    |          AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
       ID1= 3 (  0157):     98.10   1.515    13.58    26.04
     + ID2= 2 (  0049):      4.08   0.611    12.17    63.11
       ====================================================
       ID = 1 (  0157):    102.18   1.555    13.75    27.52

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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| ROUTEPIPE(  0163)|     PIPE Number     =   1.00
| IN= 2---> OUT= 1 |     Width       (mm)=2400.00     Height   (mm)=1500.00
| DT=  5.0 min     |     Length       (m)= 346.00
--------------------     Slope      (m/m)=  0.007
                         Manning n       =  0.013

    <----------------- TRAVEL TIME TABLE -------------------->
     DEPTH      VOLUME    FLOW RATE    VELOCITY     TRAV.TIME
      (m)      (cu.m.)      (cms)        (m/s)         min
     0.08    .656E+02      0.2         1.18         4.90
     0.16    .131E+03      0.7         1.79         3.22
     0.24    .197E+03      1.3         2.26         2.55
     0.32    .262E+03      2.0         2.65         2.18
     0.39    .328E+03      2.8         2.97         1.94
     0.47    .393E+03      3.7         3.25         1.78
     0.55    .459E+03      4.6         3.49         1.65
     0.63    .524E+03      5.6         3.70         1.56
     0.71    .590E+03      6.6         3.89         1.48
     0.79    .656E+03      7.7         4.07         1.42
     0.87    .721E+03      8.8         4.22         1.37
     0.95    .787E+03      9.9         4.36         1.32
     1.03    .852E+03     11.1         4.49         5.56
     1.11    .918E+03     12.2         4.61         5.42
     1.18    .983E+03     13.4         4.72         5.29
     1.26    .105E+04     14.6         4.82         5.18
     1.34    .111E+04     15.8         4.92         5.08
     1.42    .118E+04     17.1         5.01         4.99
     1.50    .125E+04     18.3         5.09         4.91
                          <---- hydrograph ---->   <-pipe / channel->
                        AREA    QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                        (ha)    (cms)   (hrs)   (mm)      (m)      (m/s)
  INFLOW : ID= 2 (  0157)  102.18     1.56   13.75  27.52      0.27      2.39
  OUTFLOW: ID= 1 (  0163)  102.18     1.55   13.58  27.52      0.27      2.39


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| CALIB           |
| STANDHYD ( 0106)|   Area    (ha)=   6.17
|ID= 1 DT= 5.0 min |   Total Imp(%)=  67.00   Dir. Conn.(%)=  55.00
--------------------
                         IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=       4.13        2.04
    Dep. Storage     (mm)=       1.00        5.00
    Average Slope     (%)=       1.00        2.00
    Length           (m)=     202.81      215.00
    Mannings n          =      0.014       0.250

    Max.Eff.Inten.(mm/hr)=      92.96       42.77
             over (min)        5.00       35.00
    Storage Coeff.  (min)=       4.20 (ii)   31.39 (ii)
    Unit Hyd. Tpeak (min)=       5.00       35.00
    Unit Hyd. peak  (cms)=       0.24        0.03
                                                   *TOTALS*
    PEAK FLOW       (cms)=       0.85        0.14         0.915 (iii)
    TIME TO PEAK    (hrs)=      12.17       12.58         12.17
    RUNOFF VOLUME    (mm)=      83.21       38.57         63.12
    TOTAL RAINFALL   (mm)=      84.21       84.21         84.21
    RUNOFF COEFFICIENT   =       0.99        0.46          0.75

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
         CN*  =  68.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
         THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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| CALIB           |
| STANDHYD ( 0119)|   Area    (ha)=  18.56
|ID= 1 DT= 5.0 min |   Total Imp(%)=  69.00   Dir. Conn.(%)=  45.00
--------------------
                         IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=      12.81        5.75
    Dep. Storage     (mm)=       1.00        5.00
    Average Slope     (%)=       1.00        2.00
    Length           (m)=     351.76      215.00
    Mannings n          =      0.014       0.250

    Max.Eff.Inten.(mm/hr)=      92.96       72.67
             over (min)        5.00       30.00
    Storage Coeff.  (min)=       5.85 (ii)   27.85 (ii)
    Unit Hyd. Tpeak (min)=       5.00       30.00
    Unit Hyd. peak  (cms)=       0.20        0.04
                                                   *TOTALS*
    PEAK FLOW       (cms)=       2.01        0.66         2.379 (iii)
    TIME TO PEAK    (hrs)=      12.17       12.50         12.17
    RUNOFF VOLUME    (mm)=      83.21       44.53         61.93
    TOTAL RAINFALL   (mm)=      84.21       84.21         84.21
    RUNOFF COEFFICIENT   =       0.99        0.53          0.74


     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
         CN*  =  68.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
         THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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| RESERVOIR( 0133)|
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                         0.0000     0.0000   |   0.0250     1.0741
                         0.0140     0.2394   |   0.0290     1.2348
                         0.0150     0.6048   |   0.0340     1.4904
                         0.0210     0.8843   |   0.0380     1.7173

                              AREA     QPEAK     TPEAK      R.V.
                              (ha)     (cms)     (hrs)      (mm)
  INFLOW : ID= 2 ( 0119)     18.560     2.379     12.17     61.93
  OUTFLOW: ID= 1 ( 0133)     18.560     0.024     24.33     51.46

              PEAK   FLOW   REDUCTION [Qout/Qin](%)=  1.01
              TIME SHIFT OF PEAK FLOW        (min)=730.00
              MAXIMUM  STORAGE   USED      (ha.m.)=  1.0327

--------------------------------------------------------------------------------

--------------------
| ADD HYD  ( 0159)|
```

```
|  1 +  2 =  3   |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 1 (  0106):     6.17   0.915    12.17    63.12
    + ID2= 2 (  0133):    18.56   0.024    24.33    51.46
      ====================================================
      ID = 3 (  0159):    24.73   0.930    12.17    54.37

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------


--------------------
| ADD HYD  (  0159)|
|  3 +  2 =  1   |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 3 (  0159):    24.73   0.930    12.17    54.37
    + ID2= 2 (  0163):   102.18   1.555    13.58    27.52
      ====================================================
      ID = 1 (  0159):   126.91   1.717    12.17    32.75

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| ROUTEPIPE(  0158)|     PIPE Number     =   1.00
| IN= 2---> OUT= 1 |     Width       (mm)=2400.00     Height   (mm)=1500.00
| DT=  5.0 min     |     Length       (m)= 253.00
--------------------     Slope      (m/m)=  0.005
                     Manning n       =  0.013

    <----------------- TRAVEL TIME TABLE -------------------->
      DEPTH      VOLUME    FLOW RATE    VELOCITY    TRAV.TIME
       (m)      (cu.m.)     (cms)        (m/s)        min
      0.08    .479E+02      0.2          0.96         4.39
      0.16    .959E+02      0.6          1.46         2.88
      0.24    .144E+03      1.1          1.85         2.28
      0.32    .192E+03      1.6          2.16         1.95
      0.39    .240E+03      2.3          2.42         1.74
      0.47    .288E+03      3.0          2.65         1.59
      0.55    .336E+03      3.8          2.85         1.48
      0.63    .384E+03      4.6          3.02         1.40
      0.71    .431E+03      5.4          3.18         1.33
      0.79    .479E+03      6.3          3.32         1.27
      0.87    .527E+03      7.2          3.45         1.22
      0.95    .575E+03      8.1          3.56         1.18
      1.03    .623E+03      9.0          3.67         6.82
      1.11    .671E+03     10.0          3.77         6.64
      1.18    .719E+03     11.0          3.86         6.48
      1.26    .767E+03     11.9          3.94         6.35
      1.34    .815E+03     12.9          4.02         6.23
      1.42    .863E+03     13.9          4.09         6.12
      1.50    .911E+03     15.0          4.15         6.02
                          <---- hydrograph ---->   <-pipe / channel->
                      AREA    QPEAK   TPEAK   R.V.   MAX DEPTH   MAX VEL
                      (ha)    (cms)   (hrs)   (mm)      (m)       (m/s)
    INFLOW : ID= 2 (  0159)  126.91     1.72   12.17  32.75      0.33       2.19
    OUTFLOW: ID= 1 (  0158)  126.91     1.66   12.17  32.75      0.32       2.17


--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  0136)|    Area     (ha)=   7.15
|ID= 1 DT= 5.0 min |    Total Imp(%)=  67.00    Dir. Conn.(%)=  55.00
--------------------
                       IMPERVIOUS     PERVIOUS (i)
    Surface Area      (ha)=       4.79         2.36
    Dep. Storage      (mm)=       1.00        13.90
    Average Slope      (%)=       1.00         2.00
    Length             (m)=     218.33       215.00
    Mannings n           =      0.014        0.250

    Max.Eff.Inten.(mm/hr)=      92.96        37.59
             over (min)         5.00        35.00
    Storage Coeff.  (min)=       4.39 (ii)   33.03 (ii)
    Unit Hyd. Tpeak (min)=       5.00        35.00
    Unit Hyd. peak  (cms)=       0.23         0.03
                                                     *TOTALS*
    PEAK FLOW       (cms)=       0.98         0.14         1.041 (iii)
    TIME TO PEAK    (hrs)=      12.17        12.58        12.17
    RUNOFF VOLUME    (mm)=      83.21        33.88        61.01
    TOTAL RAINFALL   (mm)=      84.21        84.21        84.21
    RUNOFF COEFFICIENT   =       0.99         0.40         0.72

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

      (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
          CN*  =  68.0    Ia = Dep. Storage  (Above)
```

```
   (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
        THAN THE STORAGE COEFFICIENT.
  (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| ADD HYD  (  0160)|
|  1 +  2 =  3    |        AREA    QPEAK    TPEAK     R.V.
--------------------       (ha)    (cms)    (hrs)     (mm)
      ID1= 1 (  0136):     7.15   1.041    12.17    61.01
    + ID2= 2 (  0158):   126.91   1.665    12.17    32.75
      =======================================================
      ID = 3 (  0160):   134.06   2.706    12.17    34.26

  NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| ROUTEPIPE(  0161)|     PIPE Number     =   1.00
| IN= 2---> OUT= 1 |     Width       (mm)=2400.00     Height   (mm)=1800.00
| DT=  5.0 min     |     Length      (m)=  43.50
--------------------     Slope      (m/m)=  0.003
                         Manning n       =  0.013

    <----------------- TRAVEL TIME TABLE -------------------->
     DEPTH      VOLUME    FLOW RATE    VELOCITY    TRAV.TIME
      (m)      (cu.m.)      (cms)        (m/s)        min
     0.09    .989E+01       0.2          0.83        0.87
     0.19    .198E+02       0.6          1.26        0.57
     0.28    .297E+02       1.1          1.58        0.46
     0.38    .396E+02       1.7          1.84        0.39
     0.47    .495E+02       2.3          2.05        0.35
     0.57    .593E+02       3.0          2.23        0.32
     0.66    .692E+02       3.8          2.39        0.30
     0.76    .791E+02       4.6          2.53        0.29
     0.85    .890E+02       5.4          2.65        0.27
     0.95    .989E+02       6.3          2.76        0.26
     1.04    .109E+03       7.1          2.86       10.50
     1.14    .119E+03       8.0          2.95       10.19
     1.23    .129E+03       8.9          3.03        9.92
     1.33    .138E+03       9.9          3.10        9.68
     1.42    .148E+03      10.8          3.17        9.48
     1.52    .158E+03      11.7          3.23        9.29
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     1.61    .168E+03      12.7          3.28        9.13
     1.71    .178E+03      13.7          3.34        8.99
     1.80    .188E+03      14.6          3.39        8.86
                      <---- hydrograph ---->  <-pipe / channel->
                   AREA    QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                   (ha)    (cms)   (hrs)   (mm)      (m)      (m/s)
 INFLOW : ID= 2 (  0160)  134.06     2.71   12.17  34.26      0.52      2.14
 OUTFLOW: ID= 1 (  0161)  134.06     2.73   12.17  34.26      0.53      2.15


--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  0132)|   Area    (ha)=  53.46
|ID= 1 DT= 5.0 min |   Total Imp(%)=  69.00   Dir. Conn.(%)=  45.00
--------------------
                         IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=     36.89       16.57
    Dep. Storage     (mm)=      1.00        5.00
    Average Slope     (%)=      1.00        2.00
    Length            (m)=    596.99      215.00
    Mannings n          =     0.014       0.250

    Max.Eff.Inten.(mm/hr)=     92.96       72.67
             over (min)       10.00       35.00
    Storage Coeff.  (min)=      8.03 (ii)   30.03 (ii)
    Unit Hyd. Tpeak (min)=     10.00       35.00
    Unit Hyd. peak  (cms)=      0.13        0.04
                                                *TOTALS*
    PEAK FLOW       (cms)=      5.06        1.78         5.929 (iii)
    TIME TO PEAK    (hrs)=     12.17       12.58         12.17
    RUNOFF VOLUME    (mm)=     83.21       44.53         61.93
    TOTAL RAINFALL   (mm)=     84.21       84.21         84.21
    RUNOFF COEFFICIENT   =      0.99        0.53          0.74


     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
         CN*  =  68.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
         THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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| RESERVOIR(  0131)|
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                     0.0000    0.0000   |  0.1700      2.5907
                     0.0550    0.7098   |  0.2155      3.1239
                     0.1004    1.5249   |  0.2600      3.5865
                     0.1400    2.1680   |  0.3014      4.0085

                          AREA     QPEAK     TPEAK       R.V.
                          (ha)     (cms)     (hrs)       (mm)
  INFLOW : ID= 2 (  0132)     53.460      5.929     12.17      61.93
  OUTFLOW: ID= 1 (  0131)     53.460      0.169     20.42      60.86

               PEAK   FLOW   REDUCTION [Qout/Qin](%)=  2.85
               TIME SHIFT OF PEAK FLOW        (min)=495.00
               MAXIMUM  STORAGE   USED       (ha.m.)=  2.5803

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--------------------
| ADD HYD  (  0117)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
      ID1= 1 (  0131):    53.46   0.169    20.42    60.86
    + ID2= 2 (  0161):   134.06   2.727    12.17    34.26
      ===================================================
      ID = 3 (  0117):   187.52   2.801    12.17    41.84

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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--------------------
| ADD HYD  (  0117)|
|   3 +  2 =  1    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
      ID1= 3 (  0117):   187.52   2.801    12.17    41.84
    + ID2= 2 (  0036):     1.98   0.181    12.17    25.06
      ===================================================
      ID = 1 (  0117):   189.50   2.982    12.17    41.67

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
```

```
--------------------------------------------------------------------------------
--------------------
| ROUTE CHN(  0166)|
| IN= 2---> OUT= 1 |     Routing time step (min)'=  5.00
--------------------
            <------ DATA FOR SECTION (   2.0) ------>
            Distance      Elevation      Manning
               0.00        100.20       0.0400
              46.50         101.25    0.0400 /0.0350  Main Channel
              52.50          99.25       0.0350     Main Channel
              61.50         101.25    0.0350 /0.0400  Main Channel
             105.00         102.00       0.0400

     <--------------------- TRAVEL TIME TABLE ---------------------->
      DEPTH    ELEV      VOLUME     FLOW RATE     VELOCITY    TRAV.TIME
       (m)      (m)     (cu.m.)      (cms)        (m/s)       (min)
      0.05    99.30    .328E+01       0.0          0.23       25.78
      0.10    99.35    .131E+02       0.0          0.36       16.24
      0.15    99.40    .295E+02       0.0          0.47       12.39
      0.20    99.45    .525E+02       0.1          0.57       10.23
      0.25    99.50    .820E+02       0.2          0.66        8.82
      0.30    99.55    .118E+03       0.3          0.75        7.81
      0.35    99.60    .161E+03       0.4          0.83        7.04
      0.40    99.65    .210E+03       0.5          0.91        6.44
      0.45    99.70    .266E+03       0.7          0.98        5.96
      0.50    99.75    .328E+03       1.0          1.05        5.55
      0.55    99.80    .397E+03       1.3          1.12        5.21
      0.60    99.85    .472E+03       1.6          1.19        4.92
      0.65    99.90    .554E+03       2.0          1.25        4.66
      0.70    99.95    .643E+03       2.4          1.31        4.44
      0.75   100.00    .738E+03       2.9          1.38        4.24
      0.80   100.05    .840E+03       3.4          1.44        4.06
      0.85   100.10    .948E+03       4.1          1.50        3.90
      0.90   100.15    .106E+04       4.7          1.55        3.75
      0.95   100.20    .118E+04       5.5          1.61        3.62

                          <---- hydrograph ---->  <-pipe / channel->
                      AREA    QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                      (ha)    (cms)   (hrs)   (mm)      (m)      (m/s)
  INFLOW : ID= 2 (  0117)  189.50     2.98   12.17  41.67      0.76      1.38
  OUTFLOW: ID= 1 (  0166)  189.50     2.60   12.17  41.66      0.72      1.33


--------------------------------------------------------------------------------
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--------------------
| CALIB            |
| NASHYD  ( 0120)|   Area    (ha)=  10.00   Curve Number   (CN)= 68.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  13.90   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.44

    Unit Hyd Qpeak  (cms)=   0.868

    PEAK FLOW       (cms)=   0.362 (i)
    TIME TO PEAK    (hrs)=  12.500
    RUNOFF VOLUME    (mm)=  26.036
    TOTAL RAINFALL   (mm)=  84.207
    RUNOFF COEFFICIENT   =   0.309

    (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------


--------------------
| ADD HYD  ( 0121)|
|  1 +  2 =  3    |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 1 (  0120):    10.00   0.362    12.50    26.04
    + ID2= 2 (  0166):   189.50   2.597    12.17    41.66
      ===================================================
      ID = 3 (  0121):   199.50   2.842    12.25    40.87

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD  ( 0046)|   Area    (ha)=  17.20   Curve Number   (CN)= 68.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  13.90   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.47

    Unit Hyd Qpeak  (cms)=   1.398

    PEAK FLOW       (cms)=   0.593 (i)
    TIME TO PEAK    (hrs)=  12.500
    RUNOFF VOLUME    (mm)=  26.037
    TOTAL RAINFALL   (mm)=  84.207
    RUNOFF COEFFICIENT   =   0.309

    (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------


--------------------
| ADD HYD  ( 0114)|
|  1 +  2 =  3    |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 1 (  0121):   199.50   2.842    12.25    40.87
    + ID2= 2 (  0046):    17.20   0.593    12.50    26.04
      ===================================================
      ID = 3 (  0114):   216.70   3.270    12.25    39.70

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

------------------------------------------------------------------------------
********************************
** SIMULATION:Run 05          **
********************************


--------------------
|   READ STORM     |    Filename: C:\Users\Janis Lobo\AppD
|                  |              ata\Local\Temp\
|                  |              9d3c8ff4-eb6c-4319-bb26-ce62fa26e7e3\89f4cd38
| Ptotal= 97.47 mm |    Comments: 25-year - 24-h SCS RBG
--------------------
```

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.17	0.00	6.33	2.00	12.50	14.37	18.67	1.80
0.33	1.10	6.50	2.00	12.67	7.39	18.83	1.80
0.50	1.10	6.67	2.00	12.83	7.39	19.00	1.80
0.67	1.10	6.83	2.00	13.00	1.40	19.17	1.80
0.83	1.10	7.00	2.00	13.17	1.40	19.33	1.80
1.00	1.10	7.17	2.00	13.33	8.18	19.50	1.80
1.17	1.10	7.33	2.00	13.50	8.18	19.67	1.80
1.33	1.10	7.50	2.00	13.67	8.18	19.83	1.80
1.50	1.10	7.67	2.00	13.83	2.99	20.00	1.80
1.67	1.10	7.83	2.00	14.00	2.99	20.17	1.80
1.83	1.10	8.00	2.00	14.17	2.99	20.33	1.20
2.00	1.10	8.17	2.00	14.33	2.99	20.50	1.20
2.17	1.10	8.33	2.69	14.50	2.99	20.67	1.20
2.33	1.30	8.50	2.69	14.67	2.99	20.83	1.20
2.50	1.30	8.67	2.69	14.83	2.99	21.00	1.20
2.67	1.30	8.83	2.69	15.00	2.99	21.17	1.20

2.83	1.30	9.00	2.69	15.17	2.99	21.33	1.20
3.00	1.30	9.17	2.69	15.33	2.99	21.50	1.20
3.17	1.30	9.33	3.19	15.50	2.99	21.67	1.20
3.33	1.30	9.50	3.19	15.67	2.99	21.83	1.20
3.50	1.30	9.67	3.19	15.83	2.99	22.00	1.20
3.67	1.30	9.83	3.59	16.00	2.99	22.17	1.20
3.83	1.30	10.00	3.59	16.17	2.99	22.33	1.20
4.00	1.30	10.17	3.59	16.33	1.80	22.50	1.20
4.17	1.30	10.33	4.59	16.50	1.80	22.67	1.20
4.33	1.60	10.50	4.59	16.67	1.80	22.83	1.20
4.50	1.60	10.67	4.59	16.83	1.80	23.00	1.20
4.67	1.60	10.83	6.19	17.00	1.80	23.17	1.20
4.83	1.60	11.00	6.19	17.17	1.80	23.33	1.20
5.00	1.60	11.17	6.19	17.33	1.80	23.50	1.20
5.17	1.60	11.33	9.58	17.50	1.80	23.67	1.20
5.33	1.60	11.50	9.58	17.67	1.80	23.83	1.20
5.50	1.60	11.67	9.58	17.83	1.80	24.00	1.20
5.67	1.60	11.83	41.52	18.00	1.80	24.17	1.20
5.83	1.60	12.00	75.85	18.17	1.80		
6.00	1.60	12.17	110.18	18.33	1.80		
6.17	1.60	12.33	14.37	18.50	1.80		

| CALIB |
| NASHYD (0036)| Area (ha)= 1.98 Curve Number (CN)= 68.0
|ID= 1 DT= 5.0 min | Ia (mm)= 13.90 # of Linear Res.(N)= 3.00
-------------------- U.H. Tp(hrs)= 0.09

NOTE: RAINFALL WAS TRANSFORMED TO 5.0 MIN. TIME STEP.

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	0.00	6.167	1.60	12.250	14.38	18.33	1.80
0.167	0.00	6.250	2.00	12.333	14.37	18.42	1.80
0.250	1.10	6.333	2.00	12.417	14.37	18.50	1.80
0.333	1.10	6.417	2.00	12.500	14.37	18.58	1.80
0.417	1.10	6.500	2.00	12.583	7.39	18.67	1.80
0.500	1.10	6.583	2.00	12.667	7.39	18.75	1.80
0.583	1.10	6.667	2.00	12.750	7.39	18.83	1.80
0.667	1.10	6.750	2.00	12.833	7.39	18.92	1.80
0.750	1.10	6.833	2.00	12.917	1.40	19.00	1.80
0.833	1.10	6.917	2.00	13.000	1.40	19.08	1.80
0.917	1.10	7.000	2.00	13.083	1.40	19.17	1.80
1.000	1.10	7.083	2.00	13.167	1.40	19.25	1.80
1.083	1.10	7.167	2.00	13.250	8.18	19.33	1.80
1.167	1.10	7.250	2.00	13.333	8.18	19.42	1.80
1.250	1.10	7.333	2.00	13.417	8.18	19.50	1.80
1.333	1.10	7.417	2.00	13.500	8.18	19.58	1.80
1.417	1.10	7.500	2.00	13.583	8.18	19.67	1.80
1.500	1.10	7.583	2.00	13.667	8.18	19.75	1.80
1.583	1.10	7.667	2.00	13.750	2.99	19.83	1.80
1.667	1.10	7.750	2.00	13.833	2.99	19.92	1.80
1.750	1.10	7.833	2.00	13.917	2.99	20.00	1.80
1.833	1.10	7.917	2.00	14.000	2.99	20.08	1.80
1.917	1.10	8.000	2.00	14.083	2.99	20.17	1.80
2.000	1.10	8.083	2.00	14.167	2.99	20.25	1.20
2.083	1.10	8.167	2.00	14.250	2.99	20.33	1.20
2.167	1.10	8.250	2.69	14.333	2.99	20.42	1.20
2.250	1.30	8.333	2.69	14.417	2.99	20.50	1.20
2.333	1.30	8.417	2.69	14.500	2.99	20.58	1.20
2.417	1.30	8.500	2.69	14.583	2.99	20.67	1.20
2.500	1.30	8.583	2.69	14.667	2.99	20.75	1.20
2.583	1.30	8.667	2.69	14.750	2.99	20.83	1.20
2.667	1.30	8.750	2.69	14.833	2.99	20.92	1.20
2.750	1.30	8.833	2.69	14.917	2.99	21.00	1.20
2.833	1.30	8.917	2.69	15.000	2.99	21.08	1.20
2.917	1.30	9.000	2.69	15.083	2.99	21.17	1.20
3.000	1.30	9.083	2.69	15.167	2.99	21.25	1.20
3.083	1.30	9.167	2.69	15.250	2.99	21.33	1.20
3.167	1.30	9.250	3.19	15.333	2.99	21.42	1.20
3.250	1.30	9.333	3.19	15.417	2.99	21.50	1.20
3.333	1.30	9.417	3.19	15.500	2.99	21.58	1.20
3.417	1.30	9.500	3.19	15.583	2.99	21.67	1.20
3.500	1.30	9.583	3.19	15.667	2.99	21.75	1.20
3.583	1.30	9.667	3.19	15.750	2.99	21.83	1.20
3.667	1.30	9.750	3.59	15.833	2.99	21.92	1.20
3.750	1.30	9.833	3.59	15.917	2.99	22.00	1.20
3.833	1.30	9.917	3.59	16.000	2.99	22.08	1.20
3.917	1.30	10.000	3.59	16.083	2.99	22.17	1.20
4.000	1.30	10.083	3.59	16.167	2.99	22.25	1.20
4.083	1.30	10.167	3.59	16.250	1.80	22.33	1.20
4.167	1.30	10.250	4.59	16.333	1.80	22.42	1.20
4.250	1.60	10.333	4.59	16.417	1.80	22.50	1.20
4.333	1.60	10.417	4.59	16.500	1.80	22.58	1.20

4.417	1.60	10.500	4.59	16.583	1.80	22.67	1.20
4.500	1.60	10.583	4.59	16.667	1.80	22.75	1.20
4.583	1.60	10.667	4.59	16.750	1.80	22.83	1.20
4.667	1.60	10.750	6.19	16.833	1.80	22.92	1.20
4.750	1.60	10.833	6.19	16.917	1.80	23.00	1.20
4.833	1.60	10.917	6.19	17.000	1.80	23.08	1.20
4.917	1.60	11.000	6.19	17.083	1.80	23.17	1.20
5.000	1.60	11.083	6.19	17.167	1.80	23.25	1.20
5.083	1.60	11.167	6.19	17.250	1.80	23.33	1.20
5.167	1.60	11.250	9.58	17.333	1.80	23.42	1.20
5.250	1.60	11.333	9.58	17.417	1.80	23.50	1.20
5.333	1.60	11.417	9.58	17.500	1.80	23.58	1.20
5.417	1.60	11.500	9.58	17.583	1.80	23.67	1.20
5.500	1.60	11.583	9.58	17.667	1.80	23.75	1.20
5.583	1.60	11.667	9.58	17.750	1.80	23.83	1.20
5.667	1.60	11.750	41.52	17.833	1.80	23.92	1.20
5.750	1.60	11.833	41.52	17.917	1.80	24.00	1.20
5.833	1.60	11.917	75.85	18.000	1.80	24.08	1.20
5.917	1.60	12.000	75.85	18.083	1.80	24.17	1.20
6.000	1.60	12.083	110.18	18.167	1.80		
6.083	1.60	12.167	110.18	18.250	1.80		

Unit Hyd Qpeak (cms)= 0.840

PEAK FLOW (cms)= 0.250 (i)
TIME TO PEAK (hrs)= 12.167
RUNOFF VOLUME (mm)= 33.089
TOTAL RAINFALL (mm)= 97.470
RUNOFF COEFFICIENT = 0.339

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

| CALIB |
| NASHYD (0037)| Area (ha)= 28.80 Curve Number (CN)= 68.0
|ID= 1 DT= 5.0 min | Ia (mm)= 13.90 # of Linear Res.(N)= 3.00
-------------------- U.H. Tp(hrs)= 1.21

Unit Hyd Qpeak (cms)= 0.908

PEAK FLOW (cms)= 0.666 (i)
TIME TO PEAK (hrs)= 13.333
RUNOFF VOLUME (mm)= 34.387
TOTAL RAINFALL (mm)= 97.470
RUNOFF COEFFICIENT = 0.353

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

| ROUTEPIPE(0165)| PIPE Number = 1.00
| IN= 2---> OUT= 1 | Diameter (mm)=1200.00
| DT= 5.0 min | Length (m)= 73.30
-------------------- Slope (m/m)= 0.010
Manning n = 0.013

<----------------- TRAVEL TIME TABLE -------------------->

DEPTH (m)	VOLUME (cu.m.)	FLOW RATE (cms)	VELOCITY (m/s)	TRAV.TIME min
0.06	.167E+01	0.0	0.92	1.33
0.13	.465E+01	0.1	1.43	0.85
0.19	.840E+01	0.2	1.84	0.66
0.25	.127E+02	0.4	2.19	0.56
0.32	.174E+02	0.6	2.49	0.49
0.38	.225E+02	0.8	2.75	0.44
0.44	.277E+02	1.1	2.99	0.41
0.51	.332E+02	1.4	3.19	0.38
0.57	.387E+02	1.8	3.37	0.36
0.63	.442E+02	2.1	3.52	0.35
0.69	.497E+02	2.5	3.65	0.33
0.76	.552E+02	2.8	3.76	0.32
0.82	.604E+02	3.2	3.84	0.32
0.88	.655E+02	3.5	3.90	0.31
0.95	.702E+02	3.8	3.93	0.31
1.01	.745E+02	4.0	3.93	0.31
1.07	.783E+02	4.1	3.89	0.31
1.14	.812E+02	4.2	3.78	0.32
1.20	.829E+02	3.9	3.45	0.35

	<---- hydrograph ---->				<-pipe / channel->	
	AREA (ha)	QPEAK (cms)	TPEAK (hrs)	R.V. (mm)	MAX DEPTH (m)	MAX VEL (m/s)
INFLOW : ID= 2 (0037)	28.80	0.67	13.33	34.39	0.33	2.56
OUTFLOW: ID= 1 (0165)	28.80	0.67	13.33	34.39	0.33	2.56


```
| CALIB            |
| NASHYD  (  0051)|   Area    (ha)=  69.30   Curve Number   (CN)= 68.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  13.90   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.45

    Unit Hyd Qpeak  (cms)=   1.825

    PEAK FLOW       (cms)=   1.386 (i)
    TIME TO PEAK    (hrs)=  13.667
    RUNOFF VOLUME    (mm)=  34.387
    TOTAL RAINFALL   (mm)=  97.470
    RUNOFF COEFFICIENT   =   0.353

    (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| ROUTEPIPE(  0164)|     PIPE Number     =   1.00
| IN= 2---> OUT= 1 |     Diameter    (mm)=1350.00
| DT=  5.0 min     |     Length       (m)= 104.50
--------------------     Slope      (m/m)=  0.010
                         Manning n       =  0.013

    <----------------- TRAVEL TIME TABLE -------------------->
```

DEPTH (m)	VOLUME (cu.m.)	FLOW RATE (cms)	VELOCITY (m/s)	TRAV.TIME min
0.07	.302E+01	0.0	0.99	1.76
0.14	.839E+01	0.1	1.55	1.13
0.21	.152E+02	0.3	1.99	0.88
0.28	.229E+02	0.5	2.37	0.74
0.36	.314E+02	0.8	2.69	0.65
0.43	.405E+02	1.2	2.98	0.58
0.50	.500E+02	1.5	3.23	0.54
0.57	.598E+02	2.0	3.45	0.50
0.64	.698E+02	2.4	3.64	0.48
0.71	.798E+02	2.9	3.81	0.46
0.78	.898E+02	3.4	3.95	0.44
0.85	.996E+02	3.9	4.07	0.43
0.92	.109E+03	4.3	4.16	0.42
0.99	.118E+03	4.8	4.22	0.41
1.07	.127E+03	5.2	4.25	0.41
1.14	.134E+03	5.5	4.25	0.41
1.21	.141E+03	5.7	4.20	0.41
1.28	.147E+03	5.7	4.09	0.43
1.35	NaN	NaN	NaN	NaN

```
                   <---- hydrograph ---->  <-pipe / channel->
                   AREA    QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                   (ha)    (cms)   (hrs)   (mm)      (m)      (m/s)
  INFLOW : ID= 2 (  0051)   69.30     1.39   13.67  34.39      0.47      3.12
  OUTFLOW: ID= 1 (  0164)   69.30     1.39   13.67  34.39      0.47      3.12


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--------------------
| CALIB            |
| STANDHYD (  0049)|   Area    (ha)=   4.08
|ID= 1 DT= 5.0 min |   Total Imp(%)=  67.00   Dir. Conn.(%)=  55.00
--------------------
                         IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=       2.73         1.35
    Dep. Storage     (mm)=       1.00         5.00
    Average Slope     (%)=       1.00         2.00
    Length            (m)=     164.92       215.00
    Mannings n          =      0.014        0.250

    Max.Eff.Inten.(mm/hr)=     110.18        62.92
              over (min)        5.00        30.00
    Storage Coeff.  (min)=       3.47 (ii)   26.77 (ii)
    Unit Hyd. Tpeak (min)=       5.00        30.00
    Unit Hyd. peak  (cms)=       0.26         0.04
                                                     *TOTALS*
    PEAK FLOW       (cms)=       0.67         0.14          0.750 (iii)
    TIME TO PEAK    (hrs)=      12.17        12.50          12.17
    RUNOFF VOLUME    (mm)=      96.47        48.49          74.88
    TOTAL RAINFALL   (mm)=      97.47        97.47          97.47
    RUNOFF COEFFICIENT   =       0.99         0.50           0.77

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

      (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
          CN*  =  68.0    Ia = Dep. Storage  (Above)
     (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
          THAN THE STORAGE COEFFICIENT.
    (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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| ADD HYD  (  0157)|
|   1 +  2 =  3    |        AREA    QPEAK    TPEAK     R.V.
--------------------       (ha)    (cms)     (hrs)     (mm)
      ID1= 1 (  0164):    69.30   1.386    13.67    34.39
    + ID2= 2 (  0165):    28.80   0.666    13.33    34.39
      ====================================================
      ID = 3 (  0157):    98.10   2.033    13.50    34.39

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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--------------------
| ADD HYD  (  0157)|
|   3 +  2 =  1    |        AREA    QPEAK    TPEAK     R.V.
--------------------       (ha)    (cms)     (hrs)     (mm)
      ID1= 3 (  0157):    98.10   2.033    13.50    34.39
    + ID2= 2 (  0049):     4.08   0.750    12.17    74.88
      ====================================================
      ID = 1 (  0157):   102.18   2.117    13.50    36.00

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| ROUTEPIPE(  0163)|     PIPE Number     =   1.00
| IN= 2---> OUT= 1 |     Width       (mm)=2400.00     Height   (mm)=1500.00
| DT=  5.0 min     |     Length       (m)= 346.00
--------------------     Slope       (m/m)=  0.007
                         Manning n       =  0.013

    <----------------- TRAVEL TIME TABLE -------------------->
      DEPTH      VOLUME    FLOW RATE    VELOCITY    TRAV.TIME
       (m)      (cu.m.)     (cms)        (m/s)        min
      0.08    .656E+02      0.2          1.18         4.90
      0.16    .131E+03      0.7          1.79         3.22
      0.24    .197E+03      1.3          2.26         2.55
      0.32    .262E+03      2.0          2.65         2.18
      0.39    .328E+03      2.8          2.97         1.94
      0.47    .393E+03      3.7          3.25         1.78
      0.55    .459E+03      4.6          3.49         1.65
      0.63    .524E+03      5.6          3.70         1.56
      0.71    .590E+03      6.6          3.89         1.48
      0.79    .656E+03      7.7          4.07         1.42
      0.87    .721E+03      8.8          4.22         1.37
      0.95    .787E+03      9.9          4.36         1.32
      1.03    .852E+03     11.1          4.49         5.56
      1.11    .918E+03     12.2          4.61         5.42
      1.18    .983E+03     13.4          4.72         5.29
      1.26    .105E+04     14.6          4.82         5.18
      1.34    .111E+04     15.8          4.92         5.08
      1.42    .118E+04     17.1          5.01         4.99
      1.50    .125E+04     18.3          5.09         4.91
                        <---- hydrograph ---->  <-pipe / channel->
                    AREA    QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                    (ha)    (cms)   (hrs)   (mm)      (m)      (m/s)
  INFLOW : ID= 2 (  0157)  102.18     2.12   13.50  36.00      0.33      2.69
  OUTFLOW: ID= 1 (  0163)  102.18     2.12   13.58  36.00      0.33      2.69


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--------------------
| CALIB            |
| STANDHYD (  0106)|   Area    (ha)=   6.17
|ID= 1 DT= 5.0 min |   Total Imp(%)=  67.00   Dir. Conn.(%)=  55.00
--------------------
                         IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=      4.13         2.04
    Dep. Storage     (mm)=      1.00         5.00
    Average Slope     (%)=      1.00         2.00
    Length            (m)=    202.81       215.00
    Mannings n          =     0.014        0.250

    Max.Eff.Inten.(mm/hr)=    110.18        62.92
             over (min)         5.00        30.00
    Storage Coeff.  (min)=      3.93 (ii)   27.23 (ii)
    Unit Hyd. Tpeak (min)=      5.00        30.00
    Unit Hyd. peak  (cms)=      0.24         0.04
                                                    *TOTALS*
    PEAK FLOW       (cms)=      1.01         0.20         1.125 (iii)
    TIME TO PEAK    (hrs)=     12.17        12.50         12.17
    RUNOFF VOLUME    (mm)=     96.47        48.49         74.88
    TOTAL RAINFALL   (mm)=     97.47        97.47         97.47
    RUNOFF COEFFICIENT   =      0.99         0.50          0.77

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
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       CN*  =  68.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
        THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| CALIB            |
| STANDHYD ( 0119)|   Area    (ha)=  18.56
|ID= 1 DT= 5.0 min |   Total Imp(%)=  69.00   Dir. Conn.(%)=  45.00
--------------------
                        IMPERVIOUS    PERVIOUS (i)
   Surface Area     (ha)=      12.81         5.75
   Dep. Storage     (mm)=       1.00         5.00
   Average Slope     (%)=       1.00         2.00
   Length            (m)=     351.76       215.00
   Mannings n          =      0.014        0.250

   Max.Eff.Inten.(mm/hr)=     110.18       107.58
            over (min)        5.00        25.00
   Storage Coeff.  (min)=       5.46 (ii)   24.27 (ii)
   Unit Hyd. Tpeak (min)=       5.00        25.00
   Unit Hyd. peak  (cms)=       0.20         0.05
                                                    *TOTALS*
   PEAK FLOW       (cms)=       2.40         0.94          3.019 (iii)
   TIME TO PEAK    (hrs)=      12.17        12.42         12.17
   RUNOFF VOLUME    (mm)=      96.47        55.29         73.82
   TOTAL RAINFALL   (mm)=      97.47        97.47         97.47
   RUNOFF COEFFICIENT   =       0.99         0.57          0.76


    (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
       CN*  =  68.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
        THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| RESERVOIR( 0133)|
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   0.0250     1.0741
                          0.0140     0.2394   |   0.0290     1.2348
                          0.0150     0.6048   |   0.0340     1.4904
                          0.0210     0.8843   |   0.0380     1.7173

                               AREA    QPEAK     TPEAK      R.V.
                               (ha)    (cms)     (hrs)      (mm)
   INFLOW : ID= 2 ( 0119)     18.560     3.019     12.17     73.82
   OUTFLOW: ID= 1 ( 0133)     18.560     0.029     24.33     57.92

           PEAK   FLOW   REDUCTION [Qout/Qin](%)=  0.96
           TIME SHIFT OF PEAK FLOW        (min)=730.00
           MAXIMUM  STORAGE   USED       (ha.m.)=  1.2320

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--------------------
| ADD HYD  ( 0159)|
|  1 +  2 =  3    |        AREA    QPEAK    TPEAK     R.V.
--------------------       (ha)    (cms)    (hrs)     (mm)
     ID1= 1 ( 0106):     6.17   1.125    12.17    74.88
   + ID2= 2 ( 0133):    18.56   0.029    24.33    57.92
     ======================================================
     ID = 3 ( 0159):    24.73   1.140    12.17    62.15

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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--------------------
| ADD HYD  ( 0159)|
|  3 +  2 =  1    |        AREA    QPEAK    TPEAK     R.V.
--------------------       (ha)    (cms)    (hrs)     (mm)
     ID1= 3 ( 0159):    24.73   1.140    12.17    62.15
   + ID2= 2 ( 0163):   102.18   2.117    13.58    36.00
     ======================================================
     ID = 1 ( 0159):   126.91   2.266    13.50    41.10

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
--------------------
| ROUTEPIPE( 0158)|     PIPE Number     =   1.00
| IN= 2---> OUT= 1 |     Width       (mm)=2400.00     Height   (mm)=1500.00
| DT=  5.0 min     |     Length       (m)= 253.00
```

-------------------- Slope (m/m)= 0.005
Manning n = 0.013

<----------------- TRAVEL TIME TABLE -------------------->

DEPTH (m)	VOLUME (cu.m.)	FLOW RATE (cms)	VELOCITY (m/s)	TRAV.TIME min
0.08	.479E+02	0.2	0.96	4.39
0.16	.959E+02	0.6	1.46	2.88
0.24	.144E+03	1.1	1.85	2.28
0.32	.192E+03	1.6	2.16	1.95
0.39	.240E+03	2.3	2.42	1.74
0.47	.288E+03	3.0	2.65	1.59
0.55	.336E+03	3.8	2.85	1.48
0.63	.384E+03	4.6	3.02	1.40
0.71	.431E+03	5.4	3.18	1.33
0.79	.479E+03	6.3	3.32	1.27
0.87	.527E+03	7.2	3.45	1.22
0.95	.575E+03	8.1	3.56	1.18
1.03	.623E+03	9.0	3.67	6.82
1.11	.671E+03	10.0	3.77	6.64
1.18	.719E+03	11.0	3.86	6.48
1.26	.767E+03	11.9	3.94	6.35
1.34	.815E+03	12.9	4.02	6.23
1.42	.863E+03	13.9	4.09	6.12
1.50	.911E+03	15.0	4.15	6.02

	<---- hydrograph ---->				<-pipe / channel->	
	AREA (ha)	QPEAK (cms)	TPEAK (hrs)	R.V. (mm)	MAX DEPTH (m)	MAX VEL (m/s)
INFLOW : ID= 2 (0159)	126.91	2.27	13.50	41.10	0.39	2.41
OUTFLOW: ID= 1 (0158)	126.91	2.27	13.58	41.10	0.39	2.41

| CALIB |
| STANDHYD (0136)| Area (ha)= 7.15
|ID= 1 DT= 5.0 min | Total Imp(%)= 67.00 Dir. Conn.(%)= 55.00

	IMPERVIOUS	PERVIOUS (i)
Surface Area (ha)=	4.79	2.36
Dep. Storage (mm)=	1.00	13.90
Average Slope (%)=	1.00	2.00
Length (m)=	218.33	215.00
Mannings n =	0.014	0.250
Max.Eff.Inten.(mm/hr)=	110.18	57.53
over (min)	5.00	30.00
Storage Coeff. (min)=	4.10 (ii)	28.25 (ii)
Unit Hyd. Tpeak (min)=	5.00	30.00
Unit Hyd. peak (cms)=	0.24	0.04

			TOTALS
PEAK FLOW (cms)=	1.17	0.21	1.280 (iii)
TIME TO PEAK (hrs)=	12.17	12.50	12.17
RUNOFF VOLUME (mm)=	96.47	43.54	72.65
TOTAL RAINFALL (mm)=	97.47	97.47	97.47
RUNOFF COEFFICIENT =	0.99	0.45	0.75

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

(i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
CN* = 68.0 Ia = Dep. Storage (Above)
(ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
THAN THE STORAGE COEFFICIENT.
(iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

| ADD HYD (0160)|
| 1 + 2 = 3 | AREA QPEAK TPEAK R.V.
-------------------- (ha) (cms) (hrs) (mm)

	AREA (ha)	QPEAK (cms)	TPEAK (hrs)	R.V. (mm)
ID1= 1 (0136):	7.15	1.280	12.17	72.65
+ ID2= 2 (0158):	126.91	2.267	13.58	41.10
ID = 3 (0160):	134.06	3.410	12.17	42.78

NOTE: PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

| ROUTEPIPE(0161)| PIPE Number = 1.00
| IN= 2---> OUT= 1 | Width (mm)=2400.00 Height (mm)=1800.00
| DT= 5.0 min | Length (m)= 43.50
-------------------- Slope (m/m)= 0.003
Manning n = 0.013

<----------------- TRAVEL TIME TABLE -------------------->
DEPTH VOLUME FLOW RATE VELOCITY TRAV.TIME

```
     (m)     (cu.m.)     (cms)       (m/s)       min
    0.09     .989E+01      0.2        0.83        0.87
    0.19     .198E+02      0.6        1.26        0.57
    0.28     .297E+02      1.1        1.58        0.46
    0.38     .396E+02      1.7        1.84        0.39
    0.47     .495E+02      2.3        2.05        0.35
    0.57     .593E+02      3.0        2.23        0.32
    0.66     .692E+02      3.8        2.39        0.30
    0.76     .791E+02      4.6        2.53        0.29
    0.85     .890E+02      5.4        2.65        0.27
    0.95     .989E+02      6.3        2.76        0.26
    1.04     .109E+03      7.1        2.86       10.50
    1.14     .119E+03      8.0        2.95       10.19
    1.23     .129E+03      8.9        3.03        9.92
    1.33     .138E+03      9.9        3.10        9.68
    1.42     .148E+03     10.8        3.17        9.48
    1.52     .158E+03     11.7        3.23        9.29
    1.61     .168E+03     12.7        3.28        9.13
    1.71     .178E+03     13.7        3.34        8.99
    1.80     .188E+03     14.6        3.39        8.86
                      <---- hydrograph ---->  <-pipe / channel->
                   AREA    QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                   (ha)    (cms)   (hrs)   (mm)      (m)      (m/s)
  INFLOW : ID= 2 (  0160)  134.06     3.41   12.17  42.78      0.61      2.31
  OUTFLOW: ID= 1 (  0161)  134.06     3.43   12.17  42.78      0.62      2.31

   **** WARNING:  COMPUTATIONS FAILED TO CONVERGE.

------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  0132)|   Area    (ha)=  53.46
|ID= 1 DT= 5.0 min |   Total Imp(%)=  69.00   Dir. Conn.(%)=  45.00
--------------------
                   IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=      36.89        16.57
    Dep. Storage     (mm)=       1.00         5.00
    Average Slope     (%)=       1.00         2.00
    Length           (m)=     596.99       215.00
    Mannings n          =      0.014        0.250

    Max.Eff.Inten.(mm/hr)=     110.18       107.58
            over (min)       10.00        30.00
    Storage Coeff.  (min)=       7.51 (ii)   26.31 (ii)
    Unit Hyd. Tpeak (min)=      10.00        30.00
    Unit Hyd. peak  (cms)=       0.13         0.04
                                                   *TOTALS*
    PEAK FLOW       (cms)=       6.10         2.52          7.543 (iii)
    TIME TO PEAK    (hrs)=      12.17        12.50         12.17
    RUNOFF VOLUME    (mm)=      96.47        55.29         73.82
    TOTAL RAINFALL   (mm)=      97.47        97.47         97.47
    RUNOFF COEFFICIENT   =       0.99         0.57          0.76


     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
         CN*  =  68.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
         THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------
--------------------
| RESERVOIR(  0131)|
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------       (cms)      (ha.m.)   |   (cms)      (ha.m.)
                         0.0000     0.0000   |   0.1700     2.5907
                         0.0550     0.7098   |   0.2155     3.1239
                         0.1004     1.5249   |   0.2600     3.5865
                         0.1400     2.1680   |   0.3014     4.0085

                            AREA     QPEAK     TPEAK      R.V.
                            (ha)     (cms)     (hrs)      (mm)
  INFLOW : ID= 2 (  0132)     53.460      7.543     12.17      73.82
  OUTFLOW: ID= 1 (  0131)     53.460      0.209     20.33      72.53

            PEAK   FLOW   REDUCTION [Qout/Qin](%)=  2.77
            TIME SHIFT OF PEAK FLOW         (min)=490.00
            MAXIMUM  STORAGE   USED       (ha.m.)=  3.0517

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--------------------
| ADD HYD  (  0117)|
|  1 +  2 =  3     |        AREA    QPEAK    TPEAK     R.V.
--------------------          (ha)    (cms)    (hrs)     (mm)
       ID1= 1 (  0131):     53.46   0.209    20.33    72.53
     + ID2= 2 (  0161):    134.06   3.434    12.17    42.78
```

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     ======================================================
     ID = 3 (  0117):   187.52   3.523    12.17    51.26

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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--------------------
| ADD HYD  (  0117)|
|   3 +  2 =  1    |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
     ID1= 3 (  0117):   187.52   3.523    12.17    51.26
   + ID2= 2 (  0036):     1.98   0.250    12.17    33.09
     ======================================================
     ID = 1 (  0117):   189.50   3.773    12.17    51.07

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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--------------------
| ROUTE CHN(  0166)|
| IN= 2---> OUT= 1 |      Routing time step (min)'=  5.00
--------------------
          <------ DATA FOR SECTION (    2.0) ------>
          Distance      Elevation       Manning
             0.00        100.20        0.0400
            46.50        101.25    0.0400 /0.0350  Main Channel
            52.50         99.25        0.0350      Main Channel
            61.50        101.25    0.0350 /0.0400  Main Channel
           105.00        102.00        0.0400

    <--------------------- TRAVEL TIME TABLE ---------------------->
    DEPTH    ELEV      VOLUME    FLOW RATE    VELOCITY   TRAV.TIME
     (m)      (m)    (cu.m.)      (cms)        (m/s)      (min)
    0.05    99.30   .328E+01      0.0          0.23      25.78
    0.10    99.35   .131E+02      0.0          0.36      16.24
    0.15    99.40   .295E+02      0.0          0.47      12.39
    0.20    99.45   .525E+02      0.1          0.57      10.23
    0.25    99.50   .820E+02      0.2          0.66       8.82
    0.30    99.55   .118E+03      0.3          0.75       7.81
    0.35    99.60   .161E+03      0.4          0.83       7.04
    0.40    99.65   .210E+03      0.5          0.91       6.44
    0.45    99.70   .266E+03      0.7          0.98       5.96
    0.50    99.75   .328E+03      1.0          1.05       5.55
    0.55    99.80   .397E+03      1.3          1.12       5.21
    0.60    99.85   .472E+03      1.6          1.19       4.92
    0.65    99.90   .554E+03      2.0          1.25       4.66
    0.70    99.95   .643E+03      2.4          1.31       4.44
    0.75   100.00   .738E+03      2.9          1.38       4.24
    0.80   100.05   .840E+03      3.4          1.44       4.06
    0.85   100.10   .948E+03      4.1          1.50       3.90
    0.90   100.15   .106E+04      4.7          1.55       3.75
    0.95   100.20   .118E+04      5.5          1.61       3.62

                            <---- hydrograph ---->  <-pipe / channel->
                          AREA    QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                          (ha)    (cms)   (hrs)   (mm)      (m)      (m/s)
 INFLOW : ID= 2 (  0117)  189.50     3.77   12.17  51.07      0.83      1.47
 OUTFLOW: ID= 1 (  0166)  189.50     3.33   12.17  51.06      0.79      1.42


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--------------------
| CALIB            |
| NASHYD   (  0120)|   Area    (ha)=  10.00   Curve Number   (CN)= 68.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  13.90   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.44

   Unit Hyd Qpeak  (cms)=   0.868

   PEAK FLOW       (cms)=   0.511 (i)
   TIME TO PEAK    (hrs)=  12.500
   RUNOFF VOLUME    (mm)=  34.384
   TOTAL RAINFALL   (mm)=  97.470
   RUNOFF COEFFICIENT    =   0.353

   (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| ADD HYD  (  0121)|
|   1 +  2 =  3    |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
     ID1= 1 (  0120):    10.00   0.511    12.50    34.38
   + ID2= 2 (  0166):   189.50   3.328    12.17    51.06
     ======================================================
     ID = 3 (  0121):   199.50   3.661    12.25    50.23
```

NOTE: PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

| CALIB |
| NASHYD (0046)| Area (ha)= 17.20 Curve Number (CN)= 68.0
|ID= 1 DT= 5.0 min | Ia (mm)= 13.90 # of Linear Res.(N)= 3.00
-------------------- U.H. Tp(hrs)= 0.47

Unit Hyd Qpeak (cms)= 1.398

PEAK FLOW (cms)= 0.838 (i)
TIME TO PEAK (hrs)= 12.500
RUNOFF VOLUME (mm)= 34.385
TOTAL RAINFALL (mm)= 97.470
RUNOFF COEFFICIENT = 0.353

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

| ADD HYD (0114)|
| 1 + 2 = 3 | AREA QPEAK TPEAK R.V.
-------------------- (ha) (cms) (hrs) (mm)
ID1= 1 (0121): 199.50 3.661 12.25 50.23
+ ID2= 2 (0046): 17.20 0.838 12.50 34.38
===
ID = 3 (0114): 216.70 4.280 12.25 48.97

NOTE: PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

****
** SIMULATION:Run 06 **
****

| READ STORM | Filename: C:\Users\Janis Lobo\AppD
| | ata\Local\Temp\
| | 9d3c8ff4-eb6c-4319-bb26-ce62fa26e7e3\90aa799a
| Ptotal=110.43 mm | Comments: 50-year - 24-h SCS RBG

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.17	0.00	6.33	2.23	12.50	16.04	18.67	2.01
0.33	1.23	6.50	2.23	12.67	16.04	18.83	1.34
0.50	1.23	6.67	2.23	12.83	8.24	19.00	1.34
0.67	1.23	6.83	2.23	13.00	8.24	19.17	1.34
0.83	1.23	7.00	2.23	13.17	8.24	19.33	1.34
1.00	1.23	7.17	2.23	13.33	1.56	19.50	1.34
1.17	1.23	7.33	2.23	13.50	1.56	19.67	1.34
1.33	1.23	7.50	2.23	13.67	1.56	19.83	1.34
1.50	1.23	7.67	2.23	13.83	9.13	20.00	1.34
1.67	1.23	7.83	2.23	14.00	9.13	20.17	1.34
1.83	1.23	8.00	2.23	14.17	9.13	20.33	1.34
2.00	1.23	8.17	2.23	14.33	3.34	20.50	1.34
2.17	1.23	8.33	3.01	14.50	3.34	20.67	1.34
2.33	1.45	8.50	3.01	14.67	3.34	20.83	1.34
2.50	1.45	8.67	3.01	14.83	3.34	21.00	1.34
2.67	1.45	8.83	3.01	15.00	3.34	21.17	1.34
2.83	1.45	9.00	3.01	15.17	3.34	21.33	1.34
3.00	1.45	9.17	3.01	15.33	3.34	21.50	1.34
3.17	1.45	9.33	3.56	15.50	3.34	21.67	1.34
3.33	1.45	9.50	3.56	15.67	3.34	21.83	1.34
3.50	1.45	9.67	3.56	15.83	3.34	22.00	1.34
3.67	1.45	9.83	4.01	16.00	3.34	22.17	1.34
3.83	1.45	10.00	4.01	16.17	3.34	22.33	1.34
4.00	1.45	10.17	4.01	16.33	2.01	22.50	1.34
4.17	1.45	10.33	5.12	16.50	2.01	22.67	1.34
4.33	1.78	10.50	5.12	16.67	2.01	22.83	1.34
4.50	1.78	10.67	5.12	16.83	2.01	23.00	1.34
4.67	1.78	10.83	6.91	17.00	2.01	23.17	1.34
4.83	1.78	11.00	6.91	17.17	2.01	23.33	1.34
5.00	1.78	11.17	6.91	17.33	2.01	23.50	1.34
5.17	1.78	11.33	10.69	17.50	2.01	23.67	1.34
5.33	1.78	11.50	10.69	17.67	2.01	23.83	1.34
5.50	1.78	11.67	10.69	17.83	2.01	24.00	1.34
5.67	1.78	11.83	46.34	18.00	2.01	24.17	1.34
5.83	1.78	12.00	84.66	18.17	2.01		
6.00	1.78	12.17	122.99	18.33	2.01		
6.17	1.78	12.33	16.04	18.50	2.01		

| CALIB |

| NASHYD (0036)| Area (ha)= 1.98 Curve Number (CN)= 68.0
|ID= 1 DT= 5.0 min | Ia (mm)= 13.90 # of Linear Res.(N)= 3.00
-------------------- U.H. Tp(hrs)= 0.09

NOTE: RAINFALL WAS TRANSFORMED TO 5.0 MIN. TIME STEP.

---- TRANSFORMED HYETOGRAPH ----

TIME	RAIN	TIME	RAIN	TIME	RAIN	TIME	RAIN
hrs	mm/hr	hrs	mm/hr	hrs	mm/hr	hrs	mm/hr
0.083	0.00	6.167	1.78	12.250	16.05	18.33	2.01
0.167	0.00	6.250	2.23	12.333	16.04	18.42	2.01
0.250	1.23	6.333	2.23	12.417	16.04	18.50	2.01
0.333	1.23	6.417	2.23	12.500	16.04	18.58	2.01
0.417	1.23	6.500	2.23	12.583	16.04	18.67	2.01
0.500	1.23	6.583	2.23	12.667	16.04	18.75	1.34
0.583	1.23	6.667	2.23	12.750	8.24	18.83	1.34
0.667	1.23	6.750	2.23	12.833	8.24	18.92	1.34
0.750	1.23	6.833	2.23	12.917	8.24	19.00	1.34
0.833	1.23	6.917	2.23	13.000	8.24	19.08	1.34
0.917	1.23	7.000	2.23	13.083	8.24	19.17	1.34
1.000	1.23	7.083	2.23	13.167	8.24	19.25	1.34
1.083	1.23	7.167	2.23	13.250	1.56	19.33	1.34
1.167	1.23	7.250	2.23	13.333	1.56	19.42	1.34
1.250	1.23	7.333	2.23	13.417	1.56	19.50	1.34
1.333	1.23	7.417	2.23	13.500	1.56	19.58	1.34
1.417	1.23	7.500	2.23	13.583	1.56	19.67	1.34
1.500	1.23	7.583	2.23	13.667	1.56	19.75	1.34
1.583	1.23	7.667	2.23	13.750	9.13	19.83	1.34
1.667	1.23	7.750	2.23	13.833	9.13	19.92	1.34
1.750	1.23	7.833	2.23	13.917	9.13	20.00	1.34
1.833	1.23	7.917	2.23	14.000	9.13	20.08	1.34
1.917	1.23	8.000	2.23	14.083	9.13	20.17	1.34
2.000	1.23	8.083	2.23	14.167	9.13	20.25	1.34
2.083	1.23	8.167	2.23	14.250	3.34	20.33	1.34
2.167	1.23	8.250	3.01	14.333	3.34	20.42	1.34
2.250	1.45	8.333	3.01	14.417	3.34	20.50	1.34
2.333	1.45	8.417	3.01	14.500	3.34	20.58	1.34
2.417	1.45	8.500	3.01	14.583	3.34	20.67	1.34
2.500	1.45	8.583	3.01	14.667	3.34	20.75	1.34
2.583	1.45	8.667	3.01	14.750	3.34	20.83	1.34
2.667	1.45	8.750	3.01	14.833	3.34	20.92	1.34
2.750	1.45	8.833	3.01	14.917	3.34	21.00	1.34
2.833	1.45	8.917	3.01	15.000	3.34	21.08	1.34
2.917	1.45	9.000	3.01	15.083	3.34	21.17	1.34
3.000	1.45	9.083	3.01	15.167	3.34	21.25	1.34
3.083	1.45	9.167	3.01	15.250	3.34	21.33	1.34
3.167	1.45	9.250	3.56	15.333	3.34	21.42	1.34
3.250	1.45	9.333	3.56	15.417	3.34	21.50	1.34
3.333	1.45	9.417	3.56	15.500	3.34	21.58	1.34
3.417	1.45	9.500	3.56	15.583	3.34	21.67	1.34
3.500	1.45	9.583	3.56	15.667	3.34	21.75	1.34
3.583	1.45	9.667	3.56	15.750	3.34	21.83	1.34
3.667	1.45	9.750	4.01	15.833	3.34	21.92	1.34
3.750	1.45	9.833	4.01	15.917	3.34	22.00	1.34
3.833	1.45	9.917	4.01	16.000	3.34	22.08	1.34
3.917	1.45	10.000	4.01	16.083	3.34	22.17	1.34
4.000	1.45	10.083	4.01	16.167	3.34	22.25	1.34
4.083	1.45	10.167	4.01	16.250	2.01	22.33	1.34
4.167	1.45	10.250	5.12	16.333	2.01	22.42	1.34
4.250	1.78	10.333	5.12	16.417	2.01	22.50	1.34
4.333	1.78	10.417	5.12	16.500	2.01	22.58	1.34
4.417	1.78	10.500	5.12	16.583	2.01	22.67	1.34
4.500	1.78	10.583	5.12	16.667	2.01	22.75	1.34
4.583	1.78	10.667	5.12	16.750	2.01	22.83	1.34
4.667	1.78	10.750	6.91	16.833	2.01	22.92	1.34
4.750	1.78	10.833	6.91	16.917	2.01	23.00	1.34
4.833	1.78	10.917	6.91	17.000	2.01	23.08	1.34
4.917	1.78	11.000	6.91	17.083	2.01	23.17	1.34
5.000	1.78	11.083	6.91	17.167	2.01	23.25	1.34
5.083	1.78	11.167	6.91	17.250	2.01	23.33	1.34
5.167	1.78	11.250	10.69	17.333	2.01	23.42	1.34
5.250	1.78	11.333	10.69	17.417	2.01	23.50	1.34
5.333	1.78	11.417	10.69	17.500	2.01	23.58	1.34
5.417	1.78	11.500	10.69	17.583	2.01	23.67	1.34
5.500	1.78	11.583	10.69	17.667	2.01	23.75	1.34
5.583	1.78	11.667	10.69	17.750	2.01	23.83	1.34
5.667	1.78	11.750	46.34	17.833	2.01	23.92	1.34
5.750	1.78	11.833	46.34	17.917	2.01	24.00	1.34
5.833	1.78	11.917	84.66	18.000	2.01	24.08	1.34
5.917	1.78	12.000	84.66	18.083	2.01	24.17	1.34
6.000	1.78	12.083	122.99	18.167	2.01		
6.083	1.78	12.167	122.99	18.250	2.01		

Unit Hyd Qpeak (cms)= 0.840

PEAK FLOW (cms)= 0.305 (i)
TIME TO PEAK (hrs)= 12.167

RUNOFF VOLUME (mm)= 41.497
TOTAL RAINFALL (mm)= 110.427
RUNOFF COEFFICIENT = 0.376

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| CALIB            |
| NASHYD  ( 0037)|   Area    (ha)=  28.80   Curve Number   (CN)= 68.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  13.90   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.21
```

Unit Hyd Qpeak (cms)= 0.908

PEAK FLOW (cms)= 0.863 (i)
TIME TO PEAK (hrs)= 13.417
RUNOFF VOLUME (mm)= 43.125
TOTAL RAINFALL (mm)= 110.427
RUNOFF COEFFICIENT = 0.391

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| ROUTEPIPE( 0165)|     PIPE Number     =   1.00
| IN= 2---> OUT= 1 |     Diameter    (mm)=1200.00
| DT=  5.0 min     |     Length       (m)=  73.30
--------------------     Slope       (m/m)=  0.010
                    Manning n       =  0.013
```

<----------------- TRAVEL TIME TABLE -------------------->

DEPTH (m)	VOLUME (cu.m.)	FLOW RATE (cms)	VELOCITY (m/s)	TRAV.TIME min
0.06	.167E+01	0.0	0.92	1.33
0.13	.465E+01	0.1	1.43	0.85
0.19	.840E+01	0.2	1.84	0.66
0.25	.127E+02	0.4	2.19	0.56
0.32	.174E+02	0.6	2.49	0.49
0.38	.225E+02	0.8	2.75	0.44
0.44	.277E+02	1.1	2.99	0.41
0.51	.332E+02	1.4	3.19	0.38
0.57	.387E+02	1.8	3.37	0.36
0.63	.442E+02	2.1	3.52	0.35
0.69	.497E+02	2.5	3.65	0.33
0.76	.552E+02	2.8	3.76	0.32
0.82	.604E+02	3.2	3.84	0.32
0.88	.655E+02	3.5	3.90	0.31
0.95	.702E+02	3.8	3.93	0.31
1.01	.745E+02	4.0	3.93	0.31
1.07	.783E+02	4.1	3.89	0.31
1.14	.812E+02	4.2	3.78	0.32
1.20	.829E+02	3.9	3.45	0.35

```
                 <---- hydrograph ---->  <-pipe / channel->
                 AREA   QPEAK  TPEAK  R.V.   MAX DEPTH  MAX VEL
                 (ha)   (cms)  (hrs)  (mm)     (m)      (m/s)
INFLOW : ID= 2 ( 0037)  28.80   0.86  13.42  43.12    0.38     2.77
OUTFLOW: ID= 1 ( 0165)  28.80   0.86  13.42  43.12    0.38     2.76
```

```
--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD  ( 0051)|   Area    (ha)=  69.30   Curve Number   (CN)= 68.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  13.90   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.45
```

Unit Hyd Qpeak (cms)= 1.825

PEAK FLOW (cms)= 1.795 (i)
TIME TO PEAK (hrs)= 13.583
RUNOFF VOLUME (mm)= 43.125
TOTAL RAINFALL (mm)= 110.427
RUNOFF COEFFICIENT = 0.391

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

```
--------------------------------------------------------------------------------
--------------------
| ROUTEPIPE( 0164)|     PIPE Number     =   1.00
| IN= 2---> OUT= 1 |     Diameter    (mm)=1350.00
| DT=  5.0 min     |     Length       (m)= 104.50
--------------------     Slope       (m/m)=  0.010
                    Manning n       =  0.013
```

<----------------- TRAVEL TIME TABLE -------------------->

DEPTH (m)	VOLUME (cu.m.)	FLOW RATE (cms)	VELOCITY (m/s)	TRAV.TIME min

```
     0.07    .302E+01     0.0       0.99      1.76
     0.14    .839E+01     0.1       1.55      1.13
     0.21    .152E+02     0.3       1.99      0.88
     0.28    .229E+02     0.5       2.37      0.74
     0.36    .314E+02     0.8       2.69      0.65
     0.43    .405E+02     1.2       2.98      0.58
     0.50    .500E+02     1.5       3.23      0.54
     0.57    .598E+02     2.0       3.45      0.50
     0.64    .698E+02     2.4       3.64      0.48
     0.71    .798E+02     2.9       3.81      0.46
     0.78    .898E+02     3.4       3.95      0.44
     0.85    .996E+02     3.9       4.07      0.43
     0.92    .109E+03     4.3       4.16      0.42
     0.99    .118E+03     4.8       4.22      0.41
     1.07    .127E+03     5.2       4.25      0.41
     1.14    .134E+03     5.5       4.25      0.41
     1.21    .141E+03     5.7       4.20      0.41
     1.28    .147E+03     5.7       4.09      0.43
     1.35       NaN      NaN        NaN       NaN
                    <---- hydrograph ---->  <-pipe / channel->
                  AREA   QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                  (ha)   (cms)   (hrs)   (mm)      (m)      (m/s)
  INFLOW : ID= 2 (  0051)  69.30    1.79   13.58  43.13     0.54     3.35
  OUTFLOW: ID= 1 (  0164)  69.30    1.79   13.67  43.12     0.54     3.35


-------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  0049)|   Area    (ha)=   4.08
|ID= 1 DT= 5.0 min |   Total Imp(%)=  67.00   Dir. Conn.(%)=  55.00
--------------------
                       IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=       2.73         1.35
    Dep. Storage     (mm)=       1.00         5.00
    Average Slope     (%)=       1.00         2.00
    Length            (m)=     164.92       215.00
    Mannings n          =      0.014        0.250

    Max.Eff.Inten.(mm/hr)=     122.99        74.57
             over (min)        5.00        30.00
    Storage Coeff.  (min)=      3.32 (ii)   25.09 (ii)
    Unit Hyd. Tpeak (min)=      5.00        30.00
    Unit Hyd. peak  (cms)=      0.26         0.04
```

```
                                                *TOTALS*
    PEAK FLOW       (cms)=      0.75         0.17         0.848 (iii)
    TIME TO PEAK    (hrs)=     12.17        12.50        12.17
    RUNOFF VOLUME    (mm)=    109.43        58.62        86.56
    TOTAL RAINFALL   (mm)=    110.43       110.43       110.43
    RUNOFF COEFFICIENT   =      0.99         0.53         0.78

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
         CN*  =  68.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
         THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------


--------------------
| ADD HYD  (  0157)|
|   1 +  2 =  3    |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 1 (  0164):     69.30    1.794    13.67    43.12
    + ID2= 2 (  0165):     28.80    0.863    13.42    43.12
      =====================================================
      ID = 3 (  0157):     98.10    2.642    13.50    43.12

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------


--------------------
| ADD HYD  (  0157)|
|   3 +  2 =  1    |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 3 (  0157):     98.10    2.642    13.50    43.12
    + ID2= 2 (  0049):      4.08    0.848    12.17    86.56
      =====================================================
      ID = 1 (  0157):    102.18    2.696    13.50    44.86

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
--------------------
| ROUTEPIPE(  0163)|     PIPE Number     =   1.00
```

```
| IN= 2---> OUT= 1 |     Width      (mm)=2400.00    Height   (mm)=1500.00
| DT=  5.0 min     |     Length      (m)= 346.00
--------------------    Slope      (m/m)=  0.007
                    Manning n       =  0.013

    <----------------- TRAVEL TIME TABLE -------------------->
     DEPTH     VOLUME    FLOW RATE    VELOCITY    TRAV.TIME
      (m)      (cu.m.)     (cms)        (m/s)        min
     0.08     .656E+02      0.2          1.18        4.90
     0.16     .131E+03      0.7          1.79        3.22
     0.24     .197E+03      1.3          2.26        2.55
     0.32     .262E+03      2.0          2.65        2.18
     0.39     .328E+03      2.8          2.97        1.94
     0.47     .393E+03      3.7          3.25        1.78
     0.55     .459E+03      4.6          3.49        1.65
     0.63     .524E+03      5.6          3.70        1.56
     0.71     .590E+03      6.6          3.89        1.48
     0.79     .656E+03      7.7          4.07        1.42
     0.87     .721E+03      8.8          4.22        1.37
     0.95     .787E+03      9.9          4.36        1.32
     1.03     .852E+03     11.1          4.49        5.56
     1.11     .918E+03     12.2          4.61        5.42
     1.18     .983E+03     13.4          4.72        5.29
     1.26     .105E+04     14.6          4.82        5.18
     1.34     .111E+04     15.8          4.92        5.08
     1.42     .118E+04     17.1          5.01        4.99
     1.50     .125E+04     18.3          5.09        4.91
                          <---- hydrograph ---->   <-pipe / channel->
                        AREA    QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                        (ha)    (cms)   (hrs)   (mm)      (m)      (m/s)
  INFLOW : ID= 2 (  0157)  102.18     2.70   13.50  44.86      0.38      2.92
  OUTFLOW: ID= 1 (  0163)  102.18     2.69   13.50  44.86      0.38      2.91


--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  0106)|   Area    (ha)=   6.17
|ID= 1 DT= 5.0 min |   Total Imp(%)=  67.00   Dir. Conn.(%)=  55.00
--------------------
                        IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=      4.13        2.04
    Dep. Storage     (mm)=      1.00        5.00
    Average Slope     (%)=      1.00        2.00
    Length            (m)=    202.81      215.00
    Mannings n          =     0.014       0.250

    Max.Eff.Inten.(mm/hr)=    122.99       74.57
             over (min)       5.00       30.00
    Storage Coeff.  (min)=      3.76 (ii)   25.53 (ii)
    Unit Hyd. Tpeak (min)=      5.00       30.00
    Unit Hyd. peak  (cms)=      0.25        0.04
                                              *TOTALS*
    PEAK FLOW       (cms)=      1.13        0.25         1.273 (iii)
    TIME TO PEAK    (hrs)=     12.17       12.50        12.17
    RUNOFF VOLUME    (mm)=    109.43       58.62        86.56
    TOTAL RAINFALL   (mm)=    110.43      110.43       110.43
    RUNOFF COEFFICIENT   =      0.99        0.53         0.78

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
         CN*  =  68.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
         THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  0119)|   Area    (ha)=  18.56
|ID= 1 DT= 5.0 min |   Total Imp(%)=  69.00   Dir. Conn.(%)=  45.00
--------------------
                        IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=     12.81        5.75
    Dep. Storage     (mm)=      1.00        5.00
    Average Slope     (%)=      1.00        2.00
    Length            (m)=    351.76      215.00
    Mannings n          =     0.014       0.250

    Max.Eff.Inten.(mm/hr)=    122.99      126.02
             over (min)       5.00       25.00
    Storage Coeff.  (min)=      5.23 (ii)   22.88 (ii)
    Unit Hyd. Tpeak (min)=      5.00       25.00
    Unit Hyd. peak  (cms)=      0.21        0.05
                                              *TOTALS*
    PEAK FLOW       (cms)=      2.70        1.13         3.449 (iii)
    TIME TO PEAK    (hrs)=     12.17       12.42        12.17
```

```
    RUNOFF VOLUME    (mm)=     109.43       66.18         85.64
    TOTAL RAINFALL   (mm)=     110.43      110.43        110.43
    RUNOFF COEFFICIENT   =       0.99        0.60          0.78


     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
         CN*  =  68.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
         THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------
--------------------
| RESERVOIR(  0133)|
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                         0.0000     0.0000    |  0.0250     1.0741
                         0.0140     0.2394    |  0.0290     1.2348
                         0.0150     0.6048    |  0.0340     1.4904
                         0.0210     0.8843    |  0.0380     1.7173

                              AREA     QPEAK     TPEAK      R.V.
                              (ha)     (cms)     (hrs)      (mm)
  INFLOW : ID= 2 (  0119)     18.560     3.449     12.17      85.64
  OUTFLOW: ID= 1 (  0133)     18.560     0.033     24.33      64.79

             PEAK   FLOW   REDUCTION [Qout/Qin](%)=  0.95
             TIME SHIFT OF PEAK FLOW        (min)=730.00
             MAXIMUM  STORAGE   USED      (ha.m.)=  1.4307

------------------------------------------------------------------------------


--------------------
| ADD HYD  (  0159)|
|  1 +  2 =  3   |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 1 (  0106):     6.17   1.273    12.17    86.56
    + ID2= 2 (  0133):    18.56   0.033    24.33    64.79
      ====================================================
      ID = 3 (  0159):    24.73   1.288    12.17    70.22

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

------------------------------------------------------------------------------


--------------------
| ADD HYD  (  0159)|
|  3 +  2 =  1   |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 3 (  0159):    24.73   1.288    12.17    70.22
    + ID2= 2 (  0163):   102.18   2.695    13.50    44.86
      ====================================================
      ID = 1 (  0159):   126.91   2.805    13.75    49.80

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

------------------------------------------------------------------------------
--------------------
| ROUTEPIPE(  0158)|     PIPE Number     =   1.00
| IN= 2---> OUT= 1 |     Width       (mm)=2400.00     Height   (mm)=1500.00
| DT=  5.0 min     |     Length       (m)= 253.00
--------------------     Slope     (m/m)=  0.005
                         Manning n       =  0.013

    <----------------- TRAVEL TIME TABLE -------------------->
     DEPTH     VOLUME    FLOW RATE    VELOCITY    TRAV.TIME
      (m)      (cu.m.)     (cms)        (m/s)        min
      0.08    .479E+02      0.2          0.96         4.39
      0.16    .959E+02      0.6          1.46         2.88
      0.24    .144E+03      1.1          1.85         2.28
      0.32    .192E+03      1.6          2.16         1.95
      0.39    .240E+03      2.3          2.42         1.74
      0.47    .288E+03      3.0          2.65         1.59
      0.55    .336E+03      3.8          2.85         1.48
      0.63    .384E+03      4.6          3.02         1.40
      0.71    .431E+03      5.4          3.18         1.33
      0.79    .479E+03      6.3          3.32         1.27
      0.87    .527E+03      7.2          3.45         1.22
      0.95    .575E+03      8.1          3.56         1.18
      1.03    .623E+03      9.0          3.67         6.82
      1.11    .671E+03     10.0          3.77         6.64
      1.18    .719E+03     11.0          3.86         6.48
      1.26    .767E+03     11.9          3.94         6.35
      1.34    .815E+03     12.9          4.02         6.23
      1.42    .863E+03     13.9          4.09         6.12
      1.50    .911E+03     15.0          4.15         6.02
                     <---- hydrograph ---->   <-pipe / channel->
```

```
                    AREA    QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                    (ha)    (cms)   (hrs)   (mm)     (m)      (m/s)
 INFLOW : ID= 2 (  0159)  126.91     2.81   13.75  49.80      0.45       2.58
 OUTFLOW: ID= 1 (  0158)  126.91     2.81   13.83  49.80      0.45       2.58


--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  0136)|   Area    (ha)=   7.15
|ID= 1 DT= 5.0 min |   Total Imp(%)=  67.00   Dir. Conn.(%)=  55.00
--------------------
                      IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=      4.79        2.36
    Dep. Storage     (mm)=      1.00       13.90
    Average Slope    (%)=       1.00        2.00
    Length           (m)=     218.33      215.00
    Mannings n        =       0.014       0.250

    Max.Eff.Inten.(mm/hr)=    122.99       69.26
            over (min)       5.00       30.00
    Storage Coeff.  (min)=      3.93 (ii)   26.35 (ii)
    Unit Hyd. Tpeak (min)=      5.00       30.00
    Unit Hyd. peak  (cms)=      0.24        0.04
                                             *TOTALS*
    PEAK FLOW       (cms)=      1.31        0.26         1.451 (iii)
    TIME TO PEAK    (hrs)=     12.17       12.50        12.17
    RUNOFF VOLUME    (mm)=    109.43       53.47        84.24
    TOTAL RAINFALL   (mm)=    110.43      110.43       110.43
    RUNOFF COEFFICIENT   =      0.99        0.48         0.76

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
         CN*  =  68.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
         THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| ADD HYD  (  0160)|
|   1 +  2 =  3    |        AREA    QPEAK    TPEAK     R.V.
--------------------            (ha)    (cms)    (hrs)     (mm)
      ID1= 1 (  0136):     7.15    1.451     12.17    84.24
    + ID2= 2 (  0158):   126.91    2.807     13.83    49.80
      ==================================================
      ID = 3 (  0160):   134.06    3.926     12.17    51.64

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| ROUTEPIPE(  0161)|     PIPE Number     =   1.00
| IN= 2---> OUT= 1 |     Width       (mm)=2400.00     Height   (mm)=1800.00
| DT=  5.0 min     |     Length       (m)=  43.50
--------------------     Slope      (m/m)=  0.003
                         Manning n       =  0.013

   <----------------- TRAVEL TIME TABLE -------------------->
     DEPTH     VOLUME    FLOW RATE    VELOCITY    TRAV.TIME
      (m)     (cu.m.)     (cms)        (m/s)        min
     0.09    .989E+01      0.2          0.83        0.87
     0.19    .198E+02      0.6          1.26        0.57
     0.28    .297E+02      1.1          1.58        0.46
     0.38    .396E+02      1.7          1.84        0.39
     0.47    .495E+02      2.3          2.05        0.35
     0.57    .593E+02      3.0          2.23        0.32
     0.66    .692E+02      3.8          2.39        0.30
     0.76    .791E+02      4.6          2.53        0.29
     0.85    .890E+02      5.4          2.65        0.27
     0.95    .989E+02      6.3          2.76        0.26
     1.04    .109E+03      7.1          2.86       10.50
     1.14    .119E+03      8.0          2.95       10.19
     1.23    .129E+03      8.9          3.03        9.92
     1.33    .138E+03      9.9          3.10        9.68
     1.42    .148E+03     10.8          3.17        9.48
     1.52    .158E+03     11.7          3.23        9.29
     1.61    .168E+03     12.7          3.28        9.13
     1.71    .178E+03     13.7          3.34        8.99
     1.80    .188E+03     14.6          3.39        8.86
                        <---- hydrograph ---->   <-pipe / channel->
                    AREA    QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                    (ha)    (cms)   (hrs)   (mm)     (m)      (m/s)
 INFLOW : ID= 2 (  0160)  134.06     3.93   12.17  51.64      0.68       2.41
 OUTFLOW: ID= 1 (  0161)  134.06     3.95   12.17  51.64      0.68       2.41
```

```
 **** WARNING:  COMPUTATIONS FAILED TO CONVERGE.

-----------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  0132)|   Area    (ha)=  53.46
|ID= 1 DT= 5.0 min |   Total Imp(%)=  69.00   Dir. Conn.(%)=  45.00
--------------------
                        IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=      36.89        16.57
    Dep. Storage     (mm)=       1.00         5.00
    Average Slope     (%)=       1.00         2.00
    Length            (m)=     596.99       215.00
    Mannings n           =      0.014        0.250

    Max.Eff.Inten.(mm/hr)=     122.99       126.02
             over (min)        5.00        25.00
    Storage Coeff.  (min)=       7.18 (ii)   24.83 (ii)
    Unit Hyd. Tpeak (min)=       5.00        25.00
    Unit Hyd. peak  (cms)=       0.17         0.05
                                                *TOTALS*
    PEAK FLOW       (cms)=       7.39         3.14         9.452 (iii)
    TIME TO PEAK    (hrs)=      12.17        12.42         12.17
    RUNOFF VOLUME    (mm)=     109.43        66.18         85.64
    TOTAL RAINFALL   (mm)=     110.43       110.43        110.43
    RUNOFF COEFFICIENT   =       0.99         0.60          0.78


     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
         CN*  =  68.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
         THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-----------------------------------------------------------------------------
--------------------
| RESERVOIR(  0131)|
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                        0.0000     0.0000    |  0.1700     2.5907
                        0.0550     0.7098    |  0.2155     3.1239
                        0.1004     1.5249    |  0.2600     3.5865
                        0.1400     2.1680    |  0.3014     4.0085

                                   AREA     QPEAK     TPEAK      R.V.
                                   (ha)     (cms)     (hrs)      (mm)
  INFLOW : ID= 2 (  0132)       53.460     9.452     12.17     85.64
  OUTFLOW: ID= 1 (  0131)       53.460     0.257     18.75     84.14

               PEAK   FLOW   REDUCTION [Qout/Qin](%)=  2.71
               TIME SHIFT OF PEAK FLOW        (min)=395.00
               MAXIMUM  STORAGE   USED       (ha.m.)=  3.5507

-----------------------------------------------------------------------------


--------------------
| ADD HYD  (  0117)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
       ID1= 1 (  0131):     53.46   0.257    18.75    84.14
     + ID2= 2 (  0161):    134.06   3.952    12.17    51.64
       ==================================================
       ID = 3 (  0117):    187.52   4.061    12.17    60.90

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-----------------------------------------------------------------------------


--------------------
| ADD HYD  (  0117)|
|   3 +  2 =  1    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
       ID1= 3 (  0117):    187.52   4.061    12.17    60.90
     + ID2= 2 (  0036):      1.98   0.305    12.17    41.50
       ==================================================
       ID = 1 (  0117):    189.50   4.366    12.17    60.70

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-----------------------------------------------------------------------------
--------------------
| ROUTE CHN(  0166)|
| IN= 2---> OUT= 1 |     Routing time step (min)'=  5.00
--------------------
             <------ DATA FOR SECTION (   2.0) ------>
             Distance      Elevation       Manning
                0.00        100.20        0.0400
```

```
           46.50       101.25    0.0400 /0.0350  Main Channel
           52.50        99.25      0.0350      Main Channel
           61.50       101.25    0.0350 /0.0400  Main Channel
          105.00       102.00      0.0400

    <--------------------- TRAVEL TIME TABLE ---------------------->
     DEPTH    ELEV     VOLUME    FLOW RATE    VELOCITY   TRAV.TIME
      (m)      (m)    (cu.m.)      (cms)        (m/s)       (min)
     0.05    99.30    .328E+01      0.0          0.23       25.78
     0.10    99.35    .131E+02      0.0          0.36       16.24
     0.15    99.40    .295E+02      0.0          0.47       12.39
     0.20    99.45    .525E+02      0.1          0.57       10.23
     0.25    99.50    .820E+02      0.2          0.66        8.82
     0.30    99.55    .118E+03      0.3          0.75        7.81
     0.35    99.60    .161E+03      0.4          0.83        7.04
     0.40    99.65    .210E+03      0.5          0.91        6.44
     0.45    99.70    .266E+03      0.7          0.98        5.96
     0.50    99.75    .328E+03      1.0          1.05        5.55
     0.55    99.80    .397E+03      1.3          1.12        5.21
     0.60    99.85    .472E+03      1.6          1.19        4.92
     0.65    99.90    .554E+03      2.0          1.25        4.66
     0.70    99.95    .643E+03      2.4          1.31        4.44
     0.75   100.00    .738E+03      2.9          1.38        4.24
     0.80   100.05    .840E+03      3.4          1.44        4.06
     0.85   100.10    .948E+03      4.1          1.50        3.90
     0.90   100.15    .106E+04      4.7          1.55        3.75
     0.95   100.20    .118E+04      5.5          1.61        3.62

                        <---- hydrograph ---->   <-pipe / channel->
                     AREA    QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                     (ha)    (cms)   (hrs)   (mm)      (m)      (m/s)
  INFLOW : ID= 2 (  0117)  189.50     4.37   12.17  60.70     0.87      1.52
  OUTFLOW: ID= 1 (  0166)  189.50     3.88   12.17  60.69     0.83      1.48


--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD   (  0120)|   Area    (ha)=  10.00   Curve Number   (CN)= 68.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  13.90   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.44

    Unit Hyd Qpeak  (cms)=   0.868

    PEAK FLOW       (cms)=   0.630 (i)
    TIME TO PEAK    (hrs)=  12.500
    RUNOFF VOLUME    (mm)=  43.121
    TOTAL RAINFALL   (mm)= 110.427
    RUNOFF COEFFICIENT   =   0.390

    (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------


--------------------
| ADD HYD  (  0121)|
|   1 +  2 =  3    |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 1 (  0120):    10.00   0.630    12.50    43.12
    + ID2= 2 (  0166):   189.50   3.879    12.17    60.69
      ====================================================
      ID = 3 (  0121):   199.50   4.280    12.25    59.81

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD   (  0046)|   Area    (ha)=  17.20   Curve Number   (CN)= 68.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  13.90   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.47

    Unit Hyd Qpeak  (cms)=   1.398

    PEAK FLOW       (cms)=   1.034 (i)
    TIME TO PEAK    (hrs)=  12.500
    RUNOFF VOLUME    (mm)=  43.122
    TOTAL RAINFALL   (mm)= 110.427
    RUNOFF COEFFICIENT   =   0.391

    (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------


--------------------
| ADD HYD  (  0114)|
|   1 +  2 =  3    |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
```

```
 ID1= 1 (  0121):   199.50   4.280    12.25    59.81
+ ID2= 2 (  0046):    17.20   1.034    12.50    43.12
 ===================================================
 ID = 3 (  0114):   216.70   5.054    12.25    58.48

NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

------------------------------------------------------------------------------
********************************
** SIMULATION:Run 07         **
********************************


--------------------
|    READ STORM    |    Filename: C:\Users\Janis Lobo\AppD
|                  |           ata\Local\Temp\
|                  |           9d3c8ff4-eb6c-4319-bb26-ce62fa26e7e3\438691d7
| Ptotal=122.89 mm |    Comments: 100-year - 24-h SCS RBG
--------------------
```

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.17	0.00	6.33	2.46	12.50	17.70	18.67	2.21
0.33	1.35	6.50	2.46	12.67	17.70	18.83	2.21
0.50	1.35	6.67	2.46	12.83	9.09	19.00	2.21
0.67	1.35	6.83	2.46	13.00	9.09	19.17	2.21
0.83	1.35	7.00	2.46	13.17	9.09	19.33	2.21
1.00	1.35	7.17	2.46	13.33	1.72	19.50	2.21
1.17	1.35	7.33	2.46	13.50	1.72	19.67	2.21
1.33	1.35	7.50	2.46	13.67	1.72	19.83	2.21
1.50	1.35	7.67	2.46	13.83	10.08	20.00	2.21
1.67	1.35	7.83	2.46	14.00	10.08	20.17	2.21
1.83	1.35	8.00	2.46	14.17	10.08	20.33	1.47
2.00	1.35	8.17	2.46	14.33	3.69	20.50	1.47
2.17	1.35	8.33	3.32	14.50	3.69	20.67	1.47
2.33	1.60	8.50	3.32	14.67	3.69	20.83	1.47
2.50	1.60	8.67	3.32	14.83	3.69	21.00	1.47
2.67	1.60	8.83	3.32	15.00	3.69	21.17	1.47
2.83	1.60	9.00	3.32	15.17	3.69	21.33	1.47
3.00	1.60	9.17	3.32	15.33	3.69	21.50	1.47
3.17	1.60	9.33	3.93	15.50	3.69	21.67	1.47
3.33	1.60	9.50	3.93	15.67	3.69	21.83	1.47
3.50	1.60	9.67	3.93	15.83	3.69	22.00	1.47
3.67	1.60	9.83	4.42	16.00	3.69	22.17	1.47
3.83	1.60	10.00	4.42	16.17	3.69	22.33	1.47
4.00	1.60	10.17	4.42	16.33	2.21	22.50	1.47
4.17	1.60	10.33	5.65	16.50	2.21	22.67	1.47
4.33	1.97	10.50	5.65	16.67	2.21	22.83	1.47
4.50	1.97	10.67	5.65	16.83	2.21	23.00	1.47
4.67	1.97	10.83	7.62	17.00	2.21	23.17	1.47
4.83	1.97	11.00	7.62	17.17	2.21	23.33	1.47
5.00	1.97	11.17	7.62	17.33	2.21	23.50	1.47
5.17	1.97	11.33	11.80	17.50	2.21	23.67	1.47
5.33	1.97	11.50	11.80	17.67	2.21	23.83	1.47
5.50	1.97	11.67	11.80	17.83	2.21	24.00	1.47
5.67	1.97	11.83	51.13	18.00	2.21	24.17	1.47
5.83	1.97	12.00	93.40	18.17	2.21		
6.00	1.97	12.17	135.68	18.33	2.21		
6.17	1.97	12.33	17.70	18.50	2.21		

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------------------------------------------------------------------------------


--------------------
| CALIB            |
| NASHYD  (  0036)|   Area    (ha)=   1.98   Curve Number   (CN)= 68.0
|ID= 1 DT= 5.0 min |    Ia      (mm)=  13.90   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.09

    NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.
```

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	0.00	6.167	1.97	12.250	17.71	18.33	2.21
0.167	0.00	6.250	2.46	12.333	17.70	18.42	2.21
0.250	1.35	6.333	2.46	12.417	17.70	18.50	2.21
0.333	1.35	6.417	2.46	12.500	17.70	18.58	2.21
0.417	1.35	6.500	2.46	12.583	17.70	18.67	2.21
0.500	1.35	6.583	2.46	12.667	17.70	18.75	2.21
0.583	1.35	6.667	2.46	12.750	9.09	18.83	2.21
0.667	1.35	6.750	2.46	12.833	9.09	18.92	2.21
0.750	1.35	6.833	2.46	12.917	9.09	19.00	2.21
0.833	1.35	6.917	2.46	13.000	9.09	19.08	2.21
0.917	1.35	7.000	2.46	13.083	9.09	19.17	2.21
1.000	1.35	7.083	2.46	13.167	9.09	19.25	2.21
1.083	1.35	7.167	2.46	13.250	1.72	19.33	2.21
1.167	1.35	7.250	2.46	13.333	1.72	19.42	2.21
1.250	1.35	7.333	2.46	13.417	1.72	19.50	2.21
1.333	1.35	7.417	2.46	13.500	1.72	19.58	2.21

```
1.417   1.35 | 7.500   2.46 |13.583   1.72 | 19.67   2.21
1.500   1.35 | 7.583   2.46 |13.667   1.72 | 19.75   2.21
1.583   1.35 | 7.667   2.46 |13.750  10.08 | 19.83   2.21
1.667   1.35 | 7.750   2.46 |13.833  10.08 | 19.92   2.21
1.750   1.35 | 7.833   2.46 |13.917  10.08 | 20.00   2.21
1.833   1.35 | 7.917   2.46 |14.000  10.08 | 20.08   2.21
1.917   1.35 | 8.000   2.46 |14.083  10.08 | 20.17   2.21
2.000   1.35 | 8.083   2.46 |14.167  10.08 | 20.25   1.47
2.083   1.35 | 8.167   2.46 |14.250   3.69 | 20.33   1.47
2.167   1.35 | 8.250   3.32 |14.333   3.69 | 20.42   1.47
2.250   1.60 | 8.333   3.32 |14.417   3.69 | 20.50   1.47
2.333   1.60 | 8.417   3.32 |14.500   3.69 | 20.58   1.47
2.417   1.60 | 8.500   3.32 |14.583   3.69 | 20.67   1.47
2.500   1.60 | 8.583   3.32 |14.667   3.69 | 20.75   1.47
2.583   1.60 | 8.667   3.32 |14.750   3.69 | 20.83   1.47
2.667   1.60 | 8.750   3.32 |14.833   3.69 | 20.92   1.47
2.750   1.60 | 8.833   3.32 |14.917   3.69 | 21.00   1.47
2.833   1.60 | 8.917   3.32 |15.000   3.69 | 21.08   1.47
2.917   1.60 | 9.000   3.32 |15.083   3.69 | 21.17   1.47
3.000   1.60 | 9.083   3.32 |15.167   3.69 | 21.25   1.47
3.083   1.60 | 9.167   3.32 |15.250   3.69 | 21.33   1.47
3.167   1.60 | 9.250   3.93 |15.333   3.69 | 21.42   1.47
3.250   1.60 | 9.333   3.93 |15.417   3.69 | 21.50   1.47
3.333   1.60 | 9.417   3.93 |15.500   3.69 | 21.58   1.47
3.417   1.60 | 9.500   3.93 |15.583   3.69 | 21.67   1.47
3.500   1.60 | 9.583   3.93 |15.667   3.69 | 21.75   1.47
3.583   1.60 | 9.667   3.93 |15.750   3.69 | 21.83   1.47
3.667   1.60 | 9.750   4.42 |15.833   3.69 | 21.92   1.47
3.750   1.60 | 9.833   4.42 |15.917   3.69 | 22.00   1.47
3.833   1.60 | 9.917   4.42 |16.000   3.69 | 22.08   1.47
3.917   1.60 |10.000   4.42 |16.083   3.69 | 22.17   1.47
4.000   1.60 |10.083   4.42 |16.167   3.69 | 22.25   1.47
4.083   1.60 |10.167   4.42 |16.250   2.21 | 22.33   1.47
4.167   1.60 |10.250   5.65 |16.333   2.21 | 22.42   1.47
4.250   1.97 |10.333   5.65 |16.417   2.21 | 22.50   1.47
4.333   1.97 |10.417   5.65 |16.500   2.21 | 22.58   1.47
4.417   1.97 |10.500   5.65 |16.583   2.21 | 22.67   1.47
4.500   1.97 |10.583   5.65 |16.667   2.21 | 22.75   1.47
4.583   1.97 |10.667   5.65 |16.750   2.21 | 22.83   1.47
4.667   1.97 |10.750   7.62 |16.833   2.21 | 22.92   1.47
4.750   1.97 |10.833   7.62 |16.917   2.21 | 23.00   1.47
4.833   1.97 |10.917   7.62 |17.000   2.21 | 23.08   1.47
4.917   1.97 |11.000   7.62 |17.083   2.21 | 23.17   1.47
5.000   1.97 |11.083   7.62 |17.167   2.21 | 23.25   1.47
5.083   1.97 |11.167   7.62 |17.250   2.21 | 23.33   1.47
5.167   1.97 |11.250  11.80 |17.333   2.21 | 23.42   1.47
5.250   1.97 |11.333  11.80 |17.417   2.21 | 23.50   1.47
5.333   1.97 |11.417  11.80 |17.500   2.21 | 23.58   1.47
5.417   1.97 |11.500  11.80 |17.583   2.21 | 23.67   1.47
5.500   1.97 |11.583  11.80 |17.667   2.21 | 23.75   1.47
5.583   1.97 |11.667  11.80 |17.750   2.21 | 23.83   1.47
5.667   1.97 |11.750  51.13 |17.833   2.21 | 23.92   1.47
5.750   1.97 |11.833  51.13 |17.917   2.21 | 24.00   1.47
5.833   1.97 |11.917  93.39 |18.000   2.21 | 24.08   1.47
5.917   1.97 |12.000  93.40 |18.083   2.21 | 24.17   1.47
6.000   1.97 |12.083 135.67 |18.167   2.21 |
6.083   1.97 |12.167 135.68 |18.250   2.21 |

    Unit Hyd Qpeak  (cms)=   0.840

    PEAK FLOW       (cms)=   0.361 (i)
    TIME TO PEAK    (hrs)=  12.167
    RUNOFF VOLUME    (mm)=  50.017
    TOTAL RAINFALL   (mm)= 122.887
    RUNOFF COEFFICIENT   =   0.407

    (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD   (  0037)|   Area    (ha)=  28.80   Curve Number   (CN)= 68.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  13.90   # of Linear Res.(N)= 3.00
--------------------  U.H. Tp(hrs)=   1.21

    Unit Hyd Qpeak  (cms)=   0.908

    PEAK FLOW       (cms)=   1.034 (i)
    TIME TO PEAK    (hrs)=  13.333
    RUNOFF VOLUME    (mm)=  51.979
    TOTAL RAINFALL   (mm)= 122.887
    RUNOFF COEFFICIENT   =   0.423

    (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------
--------------------
| ROUTEPIPE(  0165)|     PIPE Number     =   1.00
```

| IN= 2---> OUT= 1 | Diameter   (mm)=1200.00
| DT= 5.0 min | Length   (m)= 73.30
--------------------   Slope   (m/m)= 0.010
                    Manning n   = 0.013

<----------------- TRAVEL TIME TABLE -------------------->

DEPTH (m)	VOLUME (cu.m.)	FLOW RATE (cms)	VELOCITY (m/s)	TRAV.TIME min
0.06	.167E+01	0.0	0.92	1.33
0.13	.465E+01	0.1	1.43	0.85
0.19	.840E+01	0.2	1.84	0.66
0.25	.127E+02	0.4	2.19	0.56
0.32	.174E+02	0.6	2.49	0.49
0.38	.225E+02	0.8	2.75	0.44
0.44	.277E+02	1.1	2.99	0.41
0.51	.332E+02	1.4	3.19	0.38
0.57	.387E+02	1.8	3.37	0.36
0.63	.442E+02	2.1	3.52	0.35
0.69	.497E+02	2.5	3.65	0.33
0.76	.552E+02	2.8	3.76	0.32
0.82	.604E+02	3.2	3.84	0.32
0.88	.655E+02	3.5	3.90	0.31
0.95	.702E+02	3.8	3.93	0.31
1.01	.745E+02	4.0	3.93	0.31
1.07	.783E+02	4.1	3.89	0.31
1.14	.812E+02	4.2	3.78	0.32
1.20	.829E+02	3.9	3.45	0.35

<---- hydrograph ----> <-pipe / channel->

	AREA (ha)	QPEAK (cms)	TPEAK (hrs)	R.V. (mm)	MAX DEPTH (m)	MAX VEL (m/s)
INFLOW : ID= 2 (0037)	28.80	1.03	13.33	51.98	0.42	2.90
OUTFLOW: ID= 1 (0165)	28.80	1.03	13.33	51.98	0.42	2.90

| CALIB |
| NASHYD   (0051)| Area   (ha)= 69.30   Curve Number   (CN)= 68.0
|ID= 1 DT= 5.0 min | Ia   (mm)= 13.90   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.45

Unit Hyd Qpeak (cms)=   1.825

PEAK FLOW   (cms)=   2.151 (i)
TIME TO PEAK   (hrs)= 13.583
RUNOFF VOLUME   (mm)= 51.979
TOTAL RAINFALL   (mm)= 122.887
RUNOFF COEFFICIENT   =   0.423

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

| ROUTEPIPE(0164)| PIPE Number   =   1.00
| IN= 2---> OUT= 1 | Diameter   (mm)=1350.00
| DT= 5.0 min | Length   (m)= 104.50
--------------------   Slope   (m/m)= 0.010
                    Manning n   = 0.013

<----------------- TRAVEL TIME TABLE -------------------->

DEPTH (m)	VOLUME (cu.m.)	FLOW RATE (cms)	VELOCITY (m/s)	TRAV.TIME min
0.07	.302E+01	0.0	0.99	1.76
0.14	.839E+01	0.1	1.55	1.13
0.21	.152E+02	0.3	1.99	0.88
0.28	.229E+02	0.5	2.37	0.74
0.36	.314E+02	0.8	2.69	0.65
0.43	.405E+02	1.2	2.98	0.58
0.50	.500E+02	1.5	3.23	0.54
0.57	.598E+02	2.0	3.45	0.50
0.64	.698E+02	2.4	3.64	0.48
0.71	.798E+02	2.9	3.81	0.46
0.78	.898E+02	3.4	3.95	0.44
0.85	.996E+02	3.9	4.07	0.43
0.92	.109E+03	4.3	4.16	0.42
0.99	.118E+03	4.8	4.22	0.41
1.07	.127E+03	5.2	4.25	0.41
1.14	.134E+03	5.5	4.25	0.41
1.21	.141E+03	5.7	4.20	0.41
1.28	.147E+03	5.7	4.09	0.43
1.35	NaN	NaN	NaN	NaN

<---- hydrograph ----> <-pipe / channel->

	AREA (ha)	QPEAK (cms)	TPEAK (hrs)	R.V. (mm)	MAX DEPTH (m)	MAX VEL (m/s)
INFLOW : ID= 2 (0051)	69.30	2.15	13.58	51.98	0.60	3.52
OUTFLOW: ID= 1 (0164)	69.30	2.15	13.58	51.98	0.59	3.52

```
-----------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD ( 0049)|   Area    (ha)=   4.08
|ID= 1 DT= 5.0 min |   Total Imp(%)=  67.00   Dir. Conn.(%)=  55.00
--------------------
                        IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=       2.73         1.35
    Dep. Storage     (mm)=       1.00         5.00
    Average Slope     (%)=       1.00         2.00
    Length            (m)=     164.92       215.00
    Mannings n          =      0.014        0.250

    Max.Eff.Inten.(mm/hr)=     135.68        99.22
             over (min)        5.00        25.00
    Storage Coeff.  (min)=       3.19 (ii)   22.61 (ii)
    Unit Hyd. Tpeak (min)=       5.00        25.00
    Unit Hyd. peak  (cms)=       0.27         0.05
                                                   *TOTALS*
    PEAK FLOW       (cms)=       0.83         0.21          0.971 (iii)
    TIME TO PEAK    (hrs)=      12.17        12.42          12.17
    RUNOFF VOLUME    (mm)=     121.89        68.70          97.95
    TOTAL RAINFALL   (mm)=     122.89       122.89         122.89
    RUNOFF COEFFICIENT   =       0.99         0.56           0.80

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
          CN*  =  68.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
         THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-----------------------------------------------------------------------------

--------------------
| ADD HYD  (  0157)|
|   1 +  2 =  3    |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
       ID1= 1 (  0164):    69.30   2.150    13.58    51.98
     + ID2= 2 (  0165):    28.80   1.034    13.33    51.98
       ==================================================
       ID = 3 (  0157):    98.10   3.166    13.50    51.98

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-----------------------------------------------------------------------------

--------------------
| ADD HYD  (  0157)|
|   3 +  2 =  1    |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
       ID1= 3 (  0157):    98.10   3.166    13.50    51.98
     + ID2= 2 (  0049):     4.08   0.971    12.17    97.95
       ==================================================
       ID = 1 (  0157):   102.18   3.219    13.50    53.81

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-----------------------------------------------------------------------------
--------------------
| ROUTEPIPE(  0163)|     PIPE Number     =   1.00
| IN= 2---> OUT= 1 |     Width       (mm)=2400.00     Height   (mm)=1500.00
| DT=  5.0 min     |     Length       (m)= 346.00
--------------------     Slope      (m/m)=  0.007
                         Manning n       =  0.013

    <----------------- TRAVEL TIME TABLE -------------------->
      DEPTH     VOLUME    FLOW RATE    VELOCITY    TRAV.TIME
       (m)     (cu.m.)     (cms)        (m/s)        min
      0.08    .656E+02      0.2         1.18         4.90
      0.16    .131E+03      0.7         1.79         3.22
      0.24    .197E+03      1.3         2.26         2.55
      0.32    .262E+03      2.0         2.65         2.18
      0.39    .328E+03      2.8         2.97         1.94
      0.47    .393E+03      3.7         3.25         1.78
      0.55    .459E+03      4.6         3.49         1.65
      0.63    .524E+03      5.6         3.70         1.56
      0.71    .590E+03      6.6         3.89         1.48
      0.79    .656E+03      7.7         4.07         1.42
      0.87    .721E+03      8.8         4.22         1.37
      0.95    .787E+03      9.9         4.36         1.32
      1.03    .852E+03     11.1         4.49         5.56
      1.11    .918E+03     12.2         4.61         5.42
      1.18    .983E+03     13.4         4.72         5.29
      1.26    .105E+04     14.6         4.82         5.18
      1.34    .111E+04     15.8         4.92         5.08
      1.42    .118E+04     17.1         5.01         4.99
```

```
   1.50    .125E+04     18.3        5.09        4.91
                        <---- hydrograph ---->  <-pipe / channel->
                     AREA    QPEAK   TPEAK   R.V.    MAX DEPTH  MAX VEL
                     (ha)    (cms)   (hrs)   (mm)      (m)      (m/s)
  INFLOW : ID= 2 (  0157)  102.18     3.22   13.50  53.81      0.43      3.09
  OUTFLOW: ID= 1 (  0163)  102.18     3.22   13.50  53.81      0.43      3.09


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--------------------
| CALIB            |
| STANDHYD (  0106)|   Area    (ha)=   6.17
|ID= 1 DT= 5.0 min |   Total Imp(%)=  67.00   Dir. Conn.(%)=  55.00
--------------------
                     IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=      4.13         2.04
    Dep. Storage     (mm)=      1.00         5.00
    Average Slope     (%)=      1.00         2.00
    Length            (m)=    202.81       215.00
    Mannings n           =     0.014        0.250

    Max.Eff.Inten.(mm/hr)=    135.68        99.22
             over (min)        5.00        25.00
    Storage Coeff.  (min)=      3.61 (ii)   23.03 (ii)
    Unit Hyd. Tpeak (min)=      5.00        25.00
    Unit Hyd. peak  (cms)=      0.25         0.05
                                        *TOTALS*
    PEAK FLOW       (cms)=      1.25         0.31         1.458 (iii)
    TIME TO PEAK    (hrs)=     12.17        12.42        12.17
    RUNOFF VOLUME    (mm)=    121.89        68.70        97.95
    TOTAL RAINFALL   (mm)=    122.89       122.89       122.89
    RUNOFF COEFFICIENT   =      0.99         0.56         0.80

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
         CN*  =  68.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
         THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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| CALIB            |
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| STANDHYD (  0119)|   Area    (ha)=  18.56
|ID= 1 DT= 5.0 min |   Total Imp(%)=  69.00   Dir. Conn.(%)=  45.00
--------------------
                     IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=     12.81         5.75
    Dep. Storage     (mm)=      1.00         5.00
    Average Slope     (%)=      1.00         2.00
    Length            (m)=    351.76       215.00
    Mannings n           =     0.014        0.250

    Max.Eff.Inten.(mm/hr)=    135.68       144.66
             over (min)        5.00        25.00
    Storage Coeff.  (min)=      5.03 (ii)   21.73 (ii)
    Unit Hyd. Tpeak (min)=      5.00        25.00
    Unit Hyd. peak  (cms)=      0.21         0.05
                                        *TOTALS*
    PEAK FLOW       (cms)=      2.99         1.33         3.884 (iii)
    TIME TO PEAK    (hrs)=     12.17        12.42        12.17
    RUNOFF VOLUME    (mm)=    121.89        76.91        97.15
    TOTAL RAINFALL   (mm)=    122.89       122.89       122.89
    RUNOFF COEFFICIENT   =      0.99         0.63         0.79


     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
         CN*  =  68.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
         THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| RESERVOIR(  0133)|
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |    OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------     (cms)     (ha.m.)   |   (cms)     (ha.m.)
                        0.0000     0.0000    |  0.0250     1.0741
                        0.0140     0.2394    |  0.0290     1.2348
                        0.0150     0.6048    |  0.0340     1.4904
                        0.0210     0.8843    |  0.0380     1.7173

                          AREA     QPEAK     TPEAK       R.V.
                          (ha)     (cms)     (hrs)       (mm)
  INFLOW : ID= 2 (  0119)     18.560     3.884    12.17     97.15
  OUTFLOW: ID= 1 (  0133)     18.560     0.036    24.33     71.87
```

```
            PEAK   FLOW   REDUCTION [Qout/Qin](%)=  0.94
            TIME SHIFT OF PEAK FLOW        (min)=730.00
            MAXIMUM  STORAGE   USED       (ha.m.)=  1.6273

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--------------------
| ADD HYD  (  0159)|
|  1 +  2 =  3   |        AREA    QPEAK    TPEAK     R.V.
--------------------       (ha)    (cms)    (hrs)     (mm)
      ID1= 1 (  0106):     6.17   1.458    12.17    97.95
    + ID2= 2 (  0133):    18.56   0.036    24.33    71.87
      =====================================================
      ID = 3 (  0159):    24.73   1.474    12.17    78.37

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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--------------------
| ADD HYD  (  0159)|
|  3 +  2 =  1   |        AREA    QPEAK    TPEAK     R.V.
--------------------       (ha)    (cms)    (hrs)     (mm)
      ID1= 3 (  0159):    24.73   1.474    12.17    78.37
    + ID2= 2 (  0163):   102.18   3.219    13.50    53.81
      =====================================================
      ID = 1 (  0159):   126.91   3.330    13.50    58.60

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| ROUTEPIPE(  0158)|    PIPE Number     =   1.00
| IN= 2---> OUT= 1 |     Width       (mm)=2400.00     Height   (mm)=1500.00
| DT=  5.0 min     |     Length       (m)= 253.00
--------------------     Slope      (m/m)=  0.005
                   Manning n       =  0.013

   <----------------- TRAVEL TIME TABLE -------------------->
     DEPTH      VOLUME    FLOW RATE    VELOCITY    TRAV.TIME
      (m)      (cu.m.)      (cms)        (m/s)         min
     0.08     .479E+02       0.2         0.96         4.39
     0.16     .959E+02       0.6         1.46         2.88
     0.24     .144E+03       1.1         1.85         2.28
     0.32     .192E+03       1.6         2.16         1.95
     0.39     .240E+03       2.3         2.42         1.74
     0.47     .288E+03       3.0         2.65         1.59
     0.55     .336E+03       3.8         2.85         1.48
     0.63     .384E+03       4.6         3.02         1.40
     0.71     .431E+03       5.4         3.18         1.33
     0.79     .479E+03       6.3         3.32         1.27
     0.87     .527E+03       7.2         3.45         1.22
     0.95     .575E+03       8.1         3.56         1.18
     1.03     .623E+03       9.0         3.67         6.82
     1.11     .671E+03      10.0         3.77         6.64
     1.18     .719E+03      11.0         3.86         6.48
     1.26     .767E+03      11.9         3.94         6.35
     1.34     .815E+03      12.9         4.02         6.23
     1.42     .863E+03      13.9         4.09         6.12
     1.50     .911E+03      15.0         4.15         6.02
                          <---- hydrograph ---->   <-pipe / channel->
                        AREA    QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                        (ha)    (cms)   (hrs)   (mm)      (m)      (m/s)
   INFLOW : ID= 2 (  0159)  126.91     3.33   13.50  58.60      0.51      2.73
   OUTFLOW: ID= 1 (  0158)  126.91     3.33   13.50  58.60      0.51      2.73
```

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--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  0136)|   Area     (ha)=   7.15
|ID= 1 DT= 5.0 min |   Total Imp(%)=  67.00   Dir. Conn.(%)=  55.00
--------------------
                        IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=      4.79          2.36
    Dep. Storage     (mm)=      1.00         13.90
    Average Slope     (%)=      1.00          2.00
    Length            (m)=    218.33        215.00
    Mannings n          =      0.014         0.250

    Max.Eff.Inten.(mm/hr)=    135.68         93.68
             over (min)        5.00         25.00
    Storage Coeff.  (min)=      3.78 (ii)   23.65 (ii)
    Unit Hyd. Tpeak (min)=      5.00         25.00
    Unit Hyd. peak  (cms)=      0.25          0.05
                                                   *TOTALS*
    PEAK FLOW       (cms)=      1.45          0.34          1.661 (iii)
```

```
    TIME TO PEAK    (hrs)=      12.17        12.42         12.17
    RUNOFF VOLUME    (mm)=     121.89        63.39         95.56
    TOTAL RAINFALL   (mm)=     122.89       122.89        122.89
    RUNOFF COEFFICIENT   =       0.99         0.52          0.78

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
         CN*  =  68.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
         THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-----------------------------------------------------------------------------


--------------------
| ADD HYD  (  0160)|
|   1 +  2 =  3    |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 1 (  0136):     7.15   1.661    12.17    95.56
    + ID2= 2 (  0158):   126.91   3.332    13.50    58.60
      ===================================================
      ID = 3 (  0160):   134.06   4.565    12.17    60.57

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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--------------------
| ROUTEPIPE(  0161)|     PIPE Number     =   1.00
| IN= 2---> OUT= 1 |     Width       (mm)=2400.00     Height   (mm)=1800.00
| DT=  5.0 min     |     Length      (m)=  43.50
--------------------     Slope      (m/m)=  0.003
                         Manning n       =  0.013

    <----------------- TRAVEL TIME TABLE -------------------->
      DEPTH     VOLUME    FLOW RATE    VELOCITY    TRAV.TIME
       (m)     (cu.m.)     (cms)        (m/s)        min
      0.09     .989E+01      0.2         0.83         0.87
      0.19     .198E+02      0.6         1.26         0.57
      0.28     .297E+02      1.1         1.58         0.46
      0.38     .396E+02      1.7         1.84         0.39
      0.47     .495E+02      2.3         2.05         0.35
      0.57     .593E+02      3.0         2.23         0.32
      0.66     .692E+02      3.8         2.39         0.30
      0.76     .791E+02      4.6         2.53         0.29
      0.85     .890E+02      5.4         2.65         0.27
      0.95     .989E+02      6.3         2.76         0.26
      1.04     .109E+03      7.1         2.86        10.50
      1.14     .119E+03      8.0         2.95        10.19
      1.23     .129E+03      8.9         3.03         9.92
      1.33     .138E+03      9.9         3.10         9.68
      1.42     .148E+03     10.8         3.17         9.48
      1.52     .158E+03     11.7         3.23         9.29
      1.61     .168E+03     12.7         3.28         9.13
      1.71     .178E+03     13.7         3.34         8.99
      1.80     .188E+03     14.6         3.39         8.86
                         <---- hydrograph ---->  <-pipe / channel->
                      AREA    QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                      (ha)    (cms)   (hrs)   (mm)      (m)      (m/s)
  INFLOW : ID= 2 (  0160)  134.06     4.56   12.17  60.57      0.75       2.52
  OUTFLOW: ID= 1 (  0161)  134.06     4.59   12.17  60.57      0.76       2.53

   **** WARNING:  COMPUTATIONS FAILED TO CONVERGE.

-----------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  0132)|   Area     (ha)=  53.46
|ID= 1 DT= 5.0 min |   Total Imp(%)=  69.00   Dir. Conn.(%)=  45.00
--------------------
                         IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=      36.89        16.57
    Dep. Storage     (mm)=       1.00         5.00
    Average Slope     (%)=       1.00         2.00
    Length            (m)=     596.99       215.00
    Mannings n           =      0.014        0.250

    Max.Eff.Inten.(mm/hr)=     135.68       144.66
              over (min)        5.00        25.00
    Storage Coeff.  (min)=       6.91 (ii)   23.61 (ii)
    Unit Hyd. Tpeak (min)=       5.00        25.00
    Unit Hyd. peak  (cms)=       0.18         0.05
                                                  *TOTALS*
    PEAK FLOW       (cms)=       8.21         3.69        10.668 (iii)
    TIME TO PEAK    (hrs)=      12.17        12.42         12.17
    RUNOFF VOLUME    (mm)=     121.89        76.91         97.15
    TOTAL RAINFALL   (mm)=     122.89       122.89        122.89
    RUNOFF COEFFICIENT   =       0.99         0.63          0.79
```

```
 (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
     CN*  =  68.0    Ia = Dep. Storage  (Above)
 (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
      THAN THE STORAGE COEFFICIENT.
 (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| RESERVOIR(  0131)|
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                         0.0000    0.0000   |  0.1700     2.5907
                         0.0550    0.7098   |  0.2155     3.1239
                         0.1004    1.5249   |  0.2600     3.5865
                         0.1400    2.1680   |  0.3014     4.0085

                           AREA     QPEAK     TPEAK      R.V.
                           (ha)     (cms)     (hrs)      (mm)
  INFLOW : ID= 2 (  0132)     53.460     10.668      12.17      97.15
  OUTFLOW: ID= 1 (  0131)     53.460      0.298      20.17      95.45

             PEAK   FLOW   REDUCTION [Qout/Qin](%)=  2.79
             TIME SHIFT OF PEAK FLOW        (min)=480.00
             MAXIMUM  STORAGE   USED       (ha.m.)=  3.9706

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--------------------
| ADD HYD  (  0117)|
|   1 +  2 =  3    |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 1 (  0131):    53.46   0.298    20.17    95.45
    + ID2= 2 (  0161):   134.06   4.593    12.17    60.57
      ===================================================
      ID = 3 (  0117):   187.52   4.716    12.17    70.51

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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--------------------
| ADD HYD  (  0117)|
|   3 +  2 =  1    |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
      ID1= 3 (  0117):   187.52   4.716    12.17    70.51
    + ID2= 2 (  0036):     1.98   0.361    12.17    50.02
      ===================================================
      ID = 1 (  0117):   189.50   5.077    12.17    70.30

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| ROUTE CHN(  0166)|
| IN= 2---> OUT= 1 |     Routing time step (min)'=  5.00
--------------------
            <------ DATA FOR SECTION (   2.0) ------>
            Distance      Elevation      Manning
               0.00        100.20        0.0400
              46.50        101.25    0.0400 /0.0350  Main Channel
              52.50         99.25        0.0350      Main Channel
              61.50        101.25    0.0350 /0.0400  Main Channel
             105.00        102.00        0.0400

      <--------------------- TRAVEL TIME TABLE ---------------------->
      DEPTH    ELEV     VOLUME    FLOW RATE    VELOCITY   TRAV.TIME
       (m)      (m)    (cu.m.)     (cms)       (m/s)      (min)
      0.05    99.30   .328E+01      0.0         0.23       25.78
      0.10    99.35   .131E+02      0.0         0.36       16.24
      0.15    99.40   .295E+02      0.0         0.47       12.39
      0.20    99.45   .525E+02      0.1         0.57       10.23
      0.25    99.50   .820E+02      0.2         0.66        8.82
      0.30    99.55   .118E+03      0.3         0.75        7.81
      0.35    99.60   .161E+03      0.4         0.83        7.04
      0.40    99.65   .210E+03      0.5         0.91        6.44
      0.45    99.70   .266E+03      0.7         0.98        5.96
      0.50    99.75   .328E+03      1.0         1.05        5.55
      0.55    99.80   .397E+03      1.3         1.12        5.21
      0.60    99.85   .472E+03      1.6         1.19        4.92
      0.65    99.90   .554E+03      2.0         1.25        4.66
      0.70    99.95   .643E+03      2.4         1.31        4.44
      0.75   100.00   .738E+03      2.9         1.38        4.24
      0.80   100.05   .840E+03      3.4         1.44        4.06
      0.85   100.10   .948E+03      4.1         1.50        3.90
      0.90   100.15   .106E+04      4.7         1.55        3.75
```

```
     0.95   100.20    .118E+04      5.5         1.61       3.62

                          <---- hydrograph ---->  <-pipe / channel->
                      AREA    QPEAK   TPEAK   R.V.   MAX DEPTH  MAX VEL
                      (ha)    (cms)   (hrs)   (mm)      (m)      (m/s)
  INFLOW : ID= 2 (  0117)  189.50     5.08   12.17  70.30      0.92      1.58
  OUTFLOW: ID= 1 (  0166)  189.50     4.52   12.17  70.29      0.88      1.53


--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD   (  0120)|   Area    (ha)=  10.00   Curve Number   (CN)= 68.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  13.90   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.44

    Unit Hyd Qpeak  (cms)=   0.868

    PEAK FLOW       (cms)=   0.754 (i)
    TIME TO PEAK    (hrs)=  12.500
    RUNOFF VOLUME    (mm)=  51.975
    TOTAL RAINFALL   (mm)= 122.887
    RUNOFF COEFFICIENT   =   0.423

    (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| ADD HYD  (  0121)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
      ID1= 1 (  0120):    10.00   0.754    12.50    51.97
    + ID2= 2 (  0166):   189.50   4.522    12.17    70.29
      =======================================================
      ID = 3 (  0121):   199.50   5.015    12.25    69.37

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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--------------------
| CALIB            |
| NASHYD   (  0046)|   Area    (ha)=  17.20   Curve Number   (CN)= 68.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  13.90   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.47

    Unit Hyd Qpeak  (cms)=   1.398

    PEAK FLOW       (cms)=   1.238 (i)
    TIME TO PEAK    (hrs)=  12.500
    RUNOFF VOLUME    (mm)=  51.976
    TOTAL RAINFALL   (mm)= 122.887
    RUNOFF COEFFICIENT   =   0.423

    (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------


--------------------
| ADD HYD  (  0114)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
      ID1= 1 (  0121):   199.50   5.015    12.25    69.37
    + ID2= 2 (  0046):    17.20   1.238    12.50    51.98
      =======================================================
      ID = 3 (  0114):   216.70   5.951    12.25    67.99

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
```

APPENDIX F-4
Excerpts from SCUBE Study (2013) and DFRP Hdyrology Report (1989)

Rob Merwin

From:	Bastien, Jonathan <Jonathan.Bastien@conservationhamilton.ca>
Sent:	January 14, 2020 11:41 AM
To:	Andrew Fata; Rob Merwin
Cc:	Stone, Mike; Janis Lobo; Rob Merwin; Patrick Delaney
Subject:	RE: BSS 3 - Next Steps Suggestions for Urban Tech

Good morning Andrew,

Preliminary results from our ongoing FPM study compared satisfactorily to the Watercourse 9 peak flow rates determined by your latest Block 3 modeling (Oct 2019 version). But given that our study has not yet been finalized, I would suggest not including our study's preliminary results in your report.

Feel free to call to discuss further.

Jonathan Bastien
Water Resources Engineering
Hamilton Conservation Authority
838 Mineral Springs Road, P.O. Box 81067
Ancaster, ON L9G 4X1
Phone: 905-525-2181 Ext. 138
Mobile: 905-515-3087
Email: jbastien@conservationhamilton.ca

A Healthy Watershed for Everyone

From: Andrew Fata <afata@urbantech.com>
Sent: January 13, 2020 10:15 AM
To: Bastien, Jonathan <Jonathan.Bastien@conservationhamilton.ca>; Rob Merwin <rmerwin@urbantech.com>
Cc: Stone, Mike <Mike.Stone@conservationhamilton.ca>; Janis Lobo <jlobo@urbantech.com>; Rob Merwin <rmerwin@urbantech.com>; Patrick Delaney <pad@dhigroup.com>
Subject: RE: BSS 3 - Next Steps Suggestions for Urban Tech

Hi Jonathan,

Hope you've had a great start to the new year.

We are wrapping up our final BSS 3 submission and would like to include the results of the FPM study you referenced below. I'm not sure where HCA and DHI (Patrick) left off with respect to the sensitivity analysis and comparison of the unit rates from the MIKE 11 BSS model to the FPM study.

Let me know if you are able to share these results or any conclusions you have reached with DHI regarding the model validity.

Thank you!

Andrew Fata, M.Sc., P.Eng.
Associate, Water Resources

Urbantech® Consulting, A Division of Leighton-Zec Ltd.
3760 14th Avenue , Suite 301 • Markham • ON • L3R 3T7
EMAIL: afata@urbantech.com WEBSITE: www.urbantech.com
TEL: 905-946-9461 Ext.415, MOB: 416-278-0118, DIR: 905.946.4176

From: Bastien, Jonathan <Jonathan.Bastien@conservationhamilton.ca>
Sent: November 4, 2019 5:11 PM
To: Rob Merwin <rmerwin@urbantech.com>; Andrew Fata <afata@urbantech.com>
Cc: Stone, Mike <Mike.Stone@conservationhamilton.ca>
Subject: BSS 3 - Next Steps Suggestions for Urban Tech

Good afternoon Rob and Andrew,

As discussed at the recent meeting, HCA suggests moving forward with the BSS designs and assessments based on the continuous modeling (as per the first submission).

As part of a revised first submission report, it is suggested that the following be included:

1. An assessment confirming that the proposed with SWM peak flow rates under the scenario with Catchment 300 flows bypassing the site will not result in any adverse flooding or erosion impacts on downstream channel sections or culverts (Nodes 5 – 14).

2. Updates to the modeling, designs and assessments, and reporting to account for Catchment 300 flows bypassing the site.

3. An explanation as to the reasons for the reduction in peak flow rates between Node 1 and Node 5, as explained in the second submission report.

4. Include tables and discussion comparing revised peak flow rates at Nodes 1 – 14 for the existing conditions, proposed development with SWM conditions, and future uncontrolled development conditions, in a similar manner to what was provided in the second submission for the design event model results.

5. Include tables and discussion comparing revised peak flow rates at Nodes 5 – 14 for the proposed development with SWM conditions and future uncontrolled development conditions TO the existing channel and culvert capacities, in a similar manner to what was provided in the second submission for the design event model results..

6. Summarize and identify tasks to be completed at the detailed design stages, as per the second submission report.

In addition, please note that HCA is in the process of developing future uncontrolled development peak flow rates for its FPM study. As part of this review, HCA staff will confirm that the Block 3 BSS proposed percent imperviousness will not have adverse impacts on the downstream updated official flood plain.

I am available to discuss in further detail. Thank you in advance for your consideration of these comments.

Have a nice day,

Jonathan Bastien
Water Resources Engineering
Hamilton Conservation Authority
838 Mineral Springs Road, P.O. Box 81067
Ancaster, ON L9G 4X1
Phone: 905-525-2181 Ext. 138
Mobile: 905-515-3087
Email: jbastien@conservationhamilton.ca

Hamilton Conservation Authority

A Healthy Watershed for Everyone

From: Rob Merwin <rmerwin@urbantech.com>
Sent: October 30, 2019 5:32 PM
To: Bastien, Jonathan <Jonathan.Bastien@conservationhamilton.ca>

Cc: Andrew Fata <afata@urbantech.com>
Subject: BSS

Hi Jonathan,
As discussed could you please send the updated requirements for the continuous model?
Thanks,
Rob

Rob Merwin, P.Eng.
Sr.Associate, Land Development.

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APPENDIX F-5
SCUBE East Model Update 4 – Sensitivity Analysis

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2030 Bristol Circle Suite 105 Oakville, Ontario L6H 0H2
TEL: 905.829.8818
www.urbantech.com

MEMO

To:	Janis Lobo, Urbantech West
Cc:	Andrew Fata, Rob Merwin
From:	Patrick Delaney
Date:	26/2/2020
Subject:	Scube East Model Update 4 – Sensitivity Analysis

1 Introduction

Based on comments from Hamilton Conservation Authority regarding the "Block Servicing Strategy, Fruitland-Winona Secondary Plan Area, Block 3, Second Submission, August 2019" (see Hamilton Conservation Authority memo dated September 30, 2019) DHI was asked to perform a sensitivity analysis on the MIKE 11 model to evaluate the potential range of flows based on the reasonable ranges of uncertainty in the hydrologic model parameters.

The sensitivity analysis was performed on the most recent version (December 2019) of the Scenario 2a model that includes stormwater management ponds for P2DA and P3DA.

2 Sensitivity Analysis Parameters

For the purposes of the sensitivity analysis it was necessary to identify the hydrology model parameters that may have the most significant influence on the model results and run the simulation using an upper and lower value that is with a reasonable range of potential values. The MIKE 11 model for the BSS uses a combination of hydrology models for each catchment depending on the development within each catchment. The developed areas of each catchment use the Kinematic Wave model to simulate Urban runoff while the undeveloped areas of each catchment use the NAM model to simulate Rural runoff. The following parameters from each model were selected for the sensitivity analysis:

Rural Drainage Area Parameters

- CQOF fraction of precipitation that runs off as overland flow
- CK12 time constant for routing overland flow to the outlet
- Umax maximum surface detention storage (must be filled before overland runoff can commence)
- Lmax maximum root zone storage (can be used together with TOF, TIF and TG to trigger overland flow, interflow and groundwater percolation)
- TOF fraction threshold ratio of L/Lmax required to trigger overland flow
- TIF fraction threshold ratio of L/Lmax required to trigger interflow

Urban Drainage Area Parameters

- L drainage path length
- Imp % of area that is impervious

A total of 13 sensitivity analysis runs were completed as follows:

- SA1: CQOF = CQOF x 0.5
- SA2: CQOF = CQOF x 2
- SA3: CK12 = CK12 x 0.5
- SA4: CK12 = CK12 x 2
- SA5: Umax = Umax x 0.5
- SA6: Lmax = Lmax x 0.5
- SA7: Lmax = Lmax x 2
- SA8: TOF = TOF x 0.5
- SA9: TOF = TOF x 2
- SA10: TIF = TIF x 0.5
- SA11: TIF = TIF x 2
- SA12: L = L x0.5
- SA13: %Imp = %Imp – 10

The Umax and L values in the Base model were already in the range of high values so the sensitivity analysis only looked at reducing these values by a factor of 2. The %Imp values can be estimated relatively accurately so the adjustment to this value was limited to reducing it by a value of 10%.

2.1 Sensitivity Analysis Results

The MIKE 11 hydrology model setup for each sensitivity analysis was run for the 100-Year Design Storm event and the runoff hydrographs generated from each catchment were used as inflow to the hydraulic network model. The results of the sensitivity analysis are summarized in the following table. The Base model is the latest Scenario 2a model with ponds.

The results show the changes in flow at the downstream end of the study area are generally within +/- 10% of the Base model for most of the sensitivity analysis runs except for the CQOF and the Length parameters.

Table 1 Summary Model Senstivity Analysis for Scenario 2a Model with Ponds

	Peak Flow (m3/s) during 100-Year Design Storm Event for each Sensitivity Analysis															
Node	**Base**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**Min**	**Max**
		CQOF/2	**CQOF*2**	**CK12/2**	**CK12*2**	**Umax/2**	**Lmax/2**	**Lmax*2**	**TOF/2**	**TOF*2**	**TIF/2**	**TIF*2**	**L/2**	**Imp-10**		
1	1.5	0.8	3.3	2.8	0.8	1.6	1.9	1.0	1.6	1.3	1.5	1.5	1.5	1.5	0.8	3.3
4	0.2	0.2	0.2	0.2	0.3	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.3
5	4.9	3.0	8.8	6.0	2.6	5.0	6.5	3.3	5.1	4.0	4.9	4.9	5.2	4.8	2.6	8.8
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.2	0.2	0.2	0.2	0.3	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.3
8	6.4	4.3	9.7	7.9	4.1	6.6	8.0	4.6	6.7	5.5	6.4	6.4	6.6	6.1	4.1	9.7
9	1.0	0.9	1.0	1.1	0.9	1.0	1.0	0.9	1.0	0.9	1.0	1.0	1.1	0.9	0.9	1.1
10	6.4	4.4	9.3	8.1	4.2	6.6	8.2	4.7	6.7	5.4	6.4	6.4	7.0	6.0	4.2	9.3
11	7.8	5.9	10.7	10.0	5.8	8.0	9.6	6.2	8.1	6.8	7.8	7.8	8.7	7.3	5.8	10.7
12	8.0	7.9	8.3	8.2	7.8	8.0	8.1	7.9	8.0	7.9	8.0	8.0	10.3	7.2	7.2	10.3
13	20.3	18.8	22.1	22.5	18.6	20.5	22.0	19.0	20.6	19.4	20.3	20.3	23.7	18.5	18.5	23.7
14	20.1	19.1	23.1	22.5	19.0	20.3	22.0	19.2	20.4	19.4	20.1	20.1	24.6	18.6	18.6	24.6

Disclaimer

As with the previous SCUBE MIKE 11 model update assignments, DHI take no professional responsibility and makes no warranties regarding the accuracy or correctness of the model itself or the modelling results delivered in this assignment. DHI was not involved in the development or calibration of the original SCUBE MIKE 11 model and has only been asked to make changes to the model as instructed by Urbantech, to run the simulations, and to provide the model results for Urbantech to analyse, interpret and use as they see fit.

APPENDIX G
Storm Sewer and Overland Flow Calculations

urbantech

STORM SEWER DESIGN SHEET

5Yr STORM WEST POND (Scenario 2a)

BSS

HAMILTON

PROJECT DETAILS

Project No: 12-062W
Date: 18-Jul-19
Designed by: R.MOIR
Checked by: R.MERWIN

DESIGN CRITERIA

Min. Diameter = 300 mm
Mannings 'n'= 0.013
Starting Tc = 10 min
Factor of Safety = 15 %

Rainfall Intensity = $\frac{A}{(Tc+B)^c}$

A = 1049.5
B = 8
c = 0.803

NOMINAL PIPE SIZE USED

STREET	FROM MH	TO MH	AREA (ha)	RUNOFF COEFFICIENT "R"	'AR'	ACCUM. 'AR'	RAINFALL INTENSITY (mm/hr)	FLOW (m3/s)	CONSTANT FLOW (m3/s)	ACCUM. CONSTANT FLOW (m3/s)	TOTAL FLOW (m3/s)	LENGTH (m)	SLOPE (%)	PIPE DIAMETER (mm)	FULL FLOW CAPACITY (m3/s)	FULL FLOW VELOCITY (m/s)	INITIAL Tc (min)	TIME OF CONCENTRATION (min)	ACC. TIME OF CONCENTRATION (min)	PERCENT FULL (%)
COLLECTOR ROAD 'E'	MH6-W	MH5-W	0.81	0.65	0.53	0.53	103.0	0.151			0.151	130.8	0.50	450	0.202	1.27	10.00	1.72	11.72	75%
STREET 'P'	STM.WEST CONDO	MH29-W					103.0		0.776	0.776	0.776	16.8	0.50	825	1.015	1.90	10.00	0.15	10.15	76%
STREET 'P'	STM.COMM 1	MH29-W					103.0		0.057	0.057	0.057	21.7	0.50	300	0.068	0.97	10.00	0.37	10.37	84%
STREET 'P'	STM.PARK 1	MH29-W					103.0		0.190	0.190	0.190	11.2	0.50	525	0.304	1.40	10.00	0.13	10.13	63%
STREET 'P'	MH29-W	MH5-W	1.62	0.65	1.05	1.05	101.4	0.296		1.024	1.320	248.2	0.50	975	1.585	2.12	10.37	1.95	12.32	83%
STREET 'O'	STM.COMM 2	MH22-W					103.0		0.227	0.227	0.227	11.8	0.50	525	0.304	1.40	10.00	0.14	10.14	75%
STREET 'O'	MH22-W	MH5-W	0.42	0.65	0.27	0.27	102.4	0.078		0.227	0.304	97.4	0.50	600	0.434	1.54	10.14	1.06	11.20	70%
COLLECTOR ROAD 'E'	MH5-W	MH4-W	0.18	0.65	0.12	1.97	93.5	0.511		1.250	1.762	82.5	0.50	1200	2.757	2.44	12.32	0.56	12.89	64%
COLLECTOR ROAD 'D'	MH7-W	MH4-W	2.66	0.65	1.73	1.73	103.0	0.495	0.083	0.083	0.578	350.3	0.30	825	0.786	1.47	10.00	3.97	13.97	74%
COLLECTOR ROAD 'D'	MH23W(1)	MH4-W	0.75	0.65	0.49	0.49	103.0	0.140			0.140	103.4	0.50	450	0.202	1.27	10.00	1.36	11.36	69%
STREET 'N'	MH23-W(2)	MH4-W	1.42	0.65	0.92	0.92	103.0	0.264			0.264	212.6	0.50	525	0.304	1.40	10.00	2.52	12.52	87%
COLLECTOR ROAD 'E'	MH4-W	MH2-W	1.49	0.65	0.97	6.08	87.8	1.482		1.334	2.816	288.8	0.50	1350	3.774	2.64	13.97	1.83	15.80	75%
STREET 'Q'	MH13-W	MH12-W	0.13	0.65	0.08	0.08	103.0	0.024			0.024	66.0	0.50	300	0.068	0.97	10.00	1.14	11.14	35%
STREET 'Q'	MH12-W	MH10-W	1.01	0.65	0.66	0.74	98.1	0.202			0.202	184.7	0.50	525	0.304	1.40	11.14	2.19	13.33	66%
STREET 'R'	MH12-W(1)	MH10-W	2.32	0.65	1.51	1.51	103.0	0.432			0.432	245.7	0.50	675	0.594	1.66	10.00	2.47	12.47	73%
STREET 'S'	MH12-W(2)	MH10-W	2.12	0.65	1.38	1.38	103.0	0.394			0.394	288.4	0.50	675	0.594	1.66	10.00	2.89	12.89	66%
STREET 'L'	MH10-W	MH2-W	1.50	0.65	0.98	4.60	89.9	1.149			1.149	243.3	0.50	975	1.585	2.12	13.33	1.91	15.24	73%
COLLECTOR ROAD 'E'	MH33-W	MH2-W	0.15	0.65	0.10	0.10	103.0	0.028			0.028	47.6	0.50	300	0.068	0.97	10.00	0.82	10.82	41%
STREET 'L'	MH2-W	MH1-W	0.86	0.65	0.56	11.34	82.3	2.593		1.334	3.927	140.9	0.50	1200x1800 (BOX)	5.946	2.75	15.80	0.85	16.65	66%
STREET 'O'	STM.COMM 3	MH19-W					103.0		0.110	0.110	0.110	11.3	0.50	450	0.202	1.27	10.00	0.15	10.15	54%
STREET 'O'	MH19-W	MH18-W	0.28	0.65	0.18	0.18	102.4	0.052	0.033	0.143	0.195	82.5	0.50	525	0.304	1.40	10.15	0.98	11.13	64%

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www.urbantech.com

F:\Projects\12-062W (Branthaven-Fruitland Winona)\Design\Storm\12-062W STM (5 yr) (WEST) (19-07-18).xls:STM

urbantech

STREET	FROM MH	TO MH	AREA (ha)	RUNOFF COEFFICIENT "R"	'AR'	ACCUM. 'AR'	RAINFALL INTENSITY (mm/hr)	FLOW (m3/s)	CONSTANT FLOW (m3/s)	ACCUM. CONSTANT FLOW (m3/s)	TOTAL FLOW (m3/s)	LENGTH (m)	SLOPE (%)	PIPE DIAMETER (mm)	FULL FLOW CAPACITY (m3/s)	FULL FLOW VELOCITY (m/s)	INITIAL Tc (min)	TIME OF CONCENTRATION (min)	ACC. TIME OF CONCENTRATION (min)	PERCENT FULL (%)
COLLECTOR ROAD 'D'	STM.PARK 2	MH18-W					103.0		0.193	0.193	0.193	13.4	0.50	525	0.304	1.40	10.00	0.16	10.16	64%
COLLECTOR ROAD 'D'	MH18-W	MH16-W	1.55	0.65	1.01	1.19	98.1	0.324	0.101	0.437	0.761	293.9	0.50	825	1.015	1.90	11.13	2.58	13.71	75%
STREET 'O'	MH21-W	MH20-W	1.46	0.65	0.95	0.95	103.0	0.272			0.272	184.5	0.50	600	0.434	1.54	10.00	2.00	12.00	63%
STREET 'O'	STM.CONDO EAST	MH22-W					103.0		0.138	0.138	0.138	11.1	0.50	450	0.202	1.27	10.00	0.15	10.15	68%
STREET 'O'	STM.CONDO EAST	MH22-W					103.0		0.125	0.125	0.125	11.0	0.50	450	0.202	1.27	10.00	0.14	10.14	62%
STREET 'O'	MH22-W	MH20-W	0.59	0.65	0.38	0.38	102.4	0.109		0.490	0.599	129.8	0.50	750	0.787	1.78	10.15	1.21	11.36	76%
STREET 'M'	MH20-W	MH16-W	0.15	0.65	0.10	1.43	94.7	0.376		0.490	0.866	85.1	0.50	825	1.015	1.90	12.00	0.75	12.75	85%
STREET 'D'	MH23-W(3)	MH16-W	0.60	0.65	0.39	0.39	197.6	0.214			0.214	85.4		0						
STREET 'M'	MH16-W	MH14-W	1.53	0.65	0.99	4.00	88.7	0.986		0.927	1.913	213.5	0.50	1200	2.757	2.44	13.71	1.46	15.17	69%
STREET 'M'	MH15-W	MH14-W	0.86	0.65	0.56	0.56	103.0	0.160			0.160	123.6	0.50	450	0.202	1.27	10.00	1.63	11.63	79%
STREET 'L'	MH14-W	MH1-W	0.34	0.65	0.22	4.78	84.1	1.118		0.927	2.045	84.1	0.50	1200	2.757	2.44	15.17	0.58	15.74	74%
POND	MH1-W	HW1-W	0.00	0.00	0.00	16.12	80.1	3.585	0.000	2.261	5.845	21.6	0.50	1200x2400 (BOX)	8.504	2.95	16.65	0.12	16.77	69%
MC NEILLY	DI 27-W	MH26-W	8.08	0.90	7.27	7.27	72.7	1.469	0.948	0.948	2.417	319.9	0.30	900x1800 (BOX)	3.059	1.89	19.78	2.82	22.60	79%
COLLECTOR ROAD 'E'	STM.CONDO 3	MH28-W					103.0		0.378	0.378	0.378	11.8	0.50	675	0.594	1.66	10.00	0.12	10.12	64%
COLLECTOR ROAD 'E'	STM.CONDO 4	MH28-W					103.0		0.231	0.231	0.231	18.0	0.50	525	0.304	1.40	10.00	0.21	10.21	76%
COLLECTOR ROAD 'E'	MH28-W	MH26-W	0.21	0.65	0.14	0.14	102.1	0.039	0.035	0.644	0.683	66.1	0.30	825	0.786	1.47	10.21	0.75	10.96	87%
BARTON STREET	MH26-W	MH24-W	0.67	0.90	0.60	8.01	67.3	1.497	0.128	1.721	3.218	171.7	0.30	1200x1800 (BOX)	4.605	2.13	22.60	1.34	23.95	70%
BARTON STREET	MH25-W	MH24-W	0.50	0.90	0.45	0.45	103.0	0.129	0.092	0.092	0.221	120.0	0.30	600	0.336	1.19	10.00	1.68	11.68	66%
BARTON STREET	MH24-W	HW2-W				8.46	65.0	1.528		1.812	3.340	34.3	0.25	1200x1800 (BOX)	4.204	1.95	23.95	0.29	24.24	79%
WEST POND	STM.OUTLET MH	MH32-W					103.0		0.279	0.279	0.279	18.0	0.30	825	0.786	1.47	10.00	0.20	10.20	35%
	MH32-W	MH31-W					102.1			0.279	0.279	20.2	0.30	825	0.786	1.47	10.20	0.23	10.43	35%
	MH31-W	MH30-W					101.1			0.279	0.279	102.8	0.30	825	0.786	1.47	10.43	1.16	11.60	35%
	MH30-W	HW3-W					96.2			0.279	0.279	36.9	0.30	825	0.786	1.47	11.60	0.42	12.02	35%

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PROJECT DETAILS	
Title1:	**STORM SEWER DESIGN SHEET**
Title2:	**CONSTANT FLOWS (Scenario 2a - west)**
Project Name:	**BSS**
Municipality:	**HAMILTON**
Project No:	**12-062W**
Date:	**18-Jul-19**
Designed by:	**R.MOIR**
Checked by:	**R.MERWIN**

IDF Parameters for HAMILTON			
		5-yr	100-yr
I=A/(T+b)^c	A	1049.5	2317.4
	B	8	11
	C	0.803	0.836

CAPTURE LOCATION	AREA ID	CAPTURE POINT	Area ha	R	AR	Flow Length m	Velocity m/s	Tc* min	I5 mm/hr	I100 mm/hr	Q5 m3/s	Q100 m3/s	Q100-Q5 m3/s	Const. flow m3/s
WEST CONDO	WEST COND	WEST CONDO	4.09	0.75	3.07	360.00	2.00	13.00	91.0	162.6	0.776	1.386	0.610	0.610
STREET 'P'	COMM 1	COMM 1	0.23	0.90	0.21	84.00	2.00	10.70	99.9	176.9	0.057	0.102	0.044	0.044
STREET 'P'	PARK 1	PARK 1	2.94	0.25	0.74	215.00	1.50	12.39	93.2	166.2	0.190	0.339	0.149	0.149
COLLECTOR ROAD 'D'	PARK 2	PARK 2	3.00	0.25	0.75	225.00	1.50	12.50	92.8	165.5	0.193	0.345	0.151	0.151
STREET 'O'	COMM 2	COMM 2	0.93	0.90	0.84	155.00	2.00	11.29	97.5	173.0	0.227	0.402	0.176	0.176
STREET 'O'	CONDO 1	CONDO 1	0.67	0.75	0.50	118.00	2.00	10.98	98.7	175.0	0.138	0.244	0.106	0.106
STREET 'O'	CONDO 2	CONDO 2	0.61	0.75	0.46	118.00	2.00	10.98	98.7	175.0	0.125	0.222	0.097	0.097
STREET 'O'	COMM 3	COMM 3	0.44	0.90	0.40	90.00	2.00	10.75	99.7	176.6	0.110	0.194	0.085	0.085
COLLECTOR ROAD 'E'	CONDO 3	CONDO 3	1.94	0.75	1.46	275.00	2.00	12.29	93.6	166.7	0.378	0.674	0.296	0.296
COLLECTOR ROAD 'E'	CONDO 4	CONDO 4	1.15	0.75	0.86	188.00	2.00	11.57	96.4	171.2	0.231	0.410	0.179	0.179
COLLECTOR ROAD 'D'	13	MH7-W	0.61	0.65	0.40	108.00	1.50	11.20	97.8	173.6	0.108	0.191	0.083	0.083
COLLECTOR ROAD 'D'	37	MH18-W	0.17	0.65	0.11	70.00	1.50	10.78	99.6	176.4	0.031	0.054	0.024	0.024
COLLECTOR ROAD 'D'	38	MH18-W	0.27	0.65	0.18	75.00	1.50	10.83	99.4	176.0	0.048	0.086	0.037	0.037
COLLECTOR ROAD 'D'	39	MH19-W	0.07	0.65	0.05	45.50	1.50	10.51	100.8	178.2	0.013	0.023	0.010	0.010
COLLECTOR ROAD 'D'	40	MH18-W	0.29	0.65	0.19	100.00	1.50	11.11	98.2	174.1	0.051	0.091	0.040	0.040
COLLECTOR ROAD 'D'	41	MH19-W	0.17	0.65	0.11	62.00	1.50	10.69	100.0	177.0	0.031	0.054	0.024	0.024
COLLECTOR ROAD 'E'	73	MH28-W	0.17	0.65	0.11	67.00	1.50	10.74	99.7	176.6	0.031	0.054	0.024	0.024
BARTON STREET	EXT 1	MH25-W	0.49	0.90	0.44	140.00	1.50	11.56	96.4	171.3	0.118	0.210	0.092	0.092
BARTON STREET	EXT 2	MH26-W	0.49	0.90	0.44	140.00	1.50	11.56	96.4	171.3	0.118	0.210	0.092	0.092
BARTON STREET	EXT 3	MH26-W	0.19	0.90	0.17	52.00	1.50	10.58	100.5	177.7	0.048	0.084	0.037	0.037
COLLECTOR ROAD 'E'	EXT 4	MH28-W	0.08	0.65	0.05	28.00	1.50	10.31	101.6	179.6	0.015	0.026	0.011	0.011
BARTON STREET	EXT 5	DI27-W	0.25	0.90	0.23	69.00	1.50	10.77	99.6	176.4	0.062	0.110	0.048	0.048
BARTON STREET	EXT 6	DI27-W	0.49	0.90	0.44	140.00	1.50	11.56	96.4	171.3	0.118	0.210	0.092	0.092
BARTON STREET	EXT 7	DI27-W	0.84	0.65	0.55	180.00	1.50	12.00	94.7	168.5	0.144	0.256	0.112	0.112
MC NEILLY	EXT 8	DI27-W	6.50	0.65	4.23	880.00	1.50	19.78	72.7	132.1	0.854	1.550	0.697	0.697

*Where available, Tc is calculated from design sheet or overland flow calculation

Tc calcs *where Tc = starting Tc + flow length/velocity*
(starting Tc = 10min)

Assumed Velocities for Calculation of time of Concentration
Pipe Flow Velocity= 2.0 m/s
OLF Velocity= 1.5 m/s
External Flow Velocity= 0.25 m/s

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STORM SEWER DESIGN SHEET

5Yr STORM EAST POND

BSS

HAMILTON

PROJECT DETAILS

Project No: 12-062W
Date: 18-Jul-19
Designed by: R.MOIR
Checked by: R.MERWIN

DESIGN CRITERIA

Min. Diameter =	300	mm	Rainfall Intensity =	$\frac{A}{(Tc+B)^c}$
Mannings 'n'=	0.013			
Starting Tc =	10	min	A =	1049.5
			B =	8
Factor of Safety =	15	%	c =	0.803

NOMINAL PIPE SIZE USED

STREET	FROM MH	TO MH	AREA (ha)	RUNOFF COEFFICIENT "R"	'AR'	ACCUM. 'AR'	RAINFALL INTENSITY (mm/hr)	FLOW (m3/s)	CONSTANT FLOW (m3/s)	ACCUM. CONSTANT FLOW (m3/s)	TOTAL FLOW (m3/s)	LENGTH (m)	SLOPE (%)	PIPE DIAMETER (mm)	FULL FLOW CAPACITY (m3/s)	FULL FLOW VELOCITY (m/s)	INITIAL Tc (min)	TIME OF CONCENTRATION (min)	ACC. TIME OF CONCENTRATION (min)	PERCENT FULL (%)
STREET 'H'	MH18-E	MH17-E	0.39	0.65	0.25	0.25	103.0	0.073	0.025	0.025	0.098	117.7	0.50	375	0.124	1.12	10.00	1.75	11.75	79%
STREET 'L'	MH24-E	MH17-E	0.25	0.65	0.16	0.16	103.0	0.047			0.047	65.8	0.50	300	0.068	0.97	10.00	1.13	11.13	68%
COLLECTOR ROAD 'D'	MH17-E	MH16-E	0.43	0.65	0.28	0.70	95.6	0.185		0.025	0.210	165.0	0.50	525	0.304	1.40	11.75	1.96	13.71	69%
STREET 'C'	MH19-E	MH16-E	1.26	0.65	0.82	0.82	103.0	0.234			0.234	168.2	0.50	525	0.304	1.40	10.00	2.00	12.00	77%
STREET 'B'	MH16-E	MH2-E	1.13	0.65	0.73	2.25	88.7	0.554		0.025	0.579	193.0	0.50	750	0.787	1.78	13.71	1.81	15.51	74%
STREET 'F'	MH14-E	MH7-E	0.52	0.65	0.34	0.34	103.0	0.097			0.097	102.4	0.50	375	0.124	1.12	10.00	1.52	11.52	78%
STREET 'K'	MH13-E	MH7-E	0.62	0.65	0.40	0.40	103.0	0.115			0.115	93.7	0.50	450	0.202	1.27	10.00	1.23	11.23	57%
														0						
COLLECTOR ROAD 'D'	MH7-E	MH4-E	0.93	0.65	0.60	1.35	96.5	0.361			0.361	171.3	0.50	600	0.434	1.54	11.52	1.86	13.38	83%
														0						
STREET 'F'	MH12-E	MH11-E	0.48	0.65	0.31	0.31	103.0	0.089			0.089	120.8	0.50	375	0.124	1.12	10.00	1.79	11.79	72%
														0						
STREET 'F'	MH10-E	MH11-E	0.32	0.65	0.21	0.21	103.0	0.060			0.060	70.2	0.50	375	0.124	1.12	10.00	1.04	11.04	48%
STREET 'G'	MH11-E	MH4-E	0.55	0.65	0.36	0.88	95.5	0.233			0.233	111.4	0.50	525	0.304	1.40	11.79	1.32	13.12	77%
														0						
STREET 'F'	MH10(1)	MH9-E	0.80	0.65	0.52	0.52	103.0	0.149			0.149	122.0	0.50	450	0.202	1.27	10.00	1.60	11.60	74%
COLLECTOR ROAD 'D'	MH9-E	MH4-E	0.39	0.65	0.25	0.77	96.2	0.207			0.207	146.7	0.50	525	0.304	1.40	11.60	1.74	13.34	68%
STREET 'E'	MH25-E	MH4-E	1.27	0.65	0.83	0.83	103.0	0.236			0.236	162.9	0.50	525	0.304	1.40	10.00	1.93	11.93	78%
STREET 'A'	MH4-E	MH2-E	0.80	0.65	0.52	4.34	89.7	1.082			1.082	165.1	0.50	900	1.280	2.01	13.38	1.37	14.75	85%
STREET 'A'	MH2-E	MH1-E	0.05	0.65	0.03	6.62	83.1	1.530		0.025	1.555	25.3	0.50	1050	1.931	2.23	15.51	0.19	15.70	81%
WINONA HILLS	MH23-E	MH22-E	2.94	0.65	1.91	1.91	103.0	0.547			0.547	350.0	0.30	825	0.786	1.47	10.00	3.97	13.97	70%
STREET 'I'	MH21-E	MH22-E	1.72	0.65	1.12	1.12	103.0	0.320			0.320	229.2	0.50	600	0.434	1.54	10.00	2.49	12.49	74%
STREET 'J'	MH22-E	MH26-E	0.37	0.65	0.24	3.27	87.8	0.798			0.798	78.4	0.30	900	0.992	1.56	13.97	0.84	14.80	80%
														0						
COLLECTOR ROAD 'D'	MH27-E	MH26-E	0.28	0.65	0.18	0.18	103.0	0.052			0.052	110.3	0.50	300	0.068	0.97	10.00	1.90	11.90	76%
														0						

COLLECTOR ROAD 'D'	MH16(1)	MH26-E	0.15	0.65	0.10	0.10	103.0	0.028			0.028	78.0	1.00	300	0.097	1.37	10.00	0.95	10.95	29%
STREET 'A'	MH26-E	MH1-E	1.56	0.65	1.01	4.56	85.2	1.080			1.080	241.5	0.30	1050	1.496	1.73	14.80	2.33	17.13	72%
														0						
POND	MH1-E	HW1				11.19	78.8	2.449		0.025	2.474	6.1	0.50	1350	3.774	2.64	17.13	0.04	17.17	66%
														0						
POND	EAST POND	MH51-E					103.0		0.038	0.038	0.038	30.6	3.00	300	0.167	2.37	10.00	0.22	10.22	23%
POND	MH51-E	MH52-E					102.1			0.038	0.038	56.0	0.30	300	0.053	0.75	10.22	1.25	11.46	72%
POND	MH52-E	MH3-C					96.8			0.038	0.038	15.5	0.30	300	0.053	0.75	11.46	0.34	11.81	72%

PROJECT DETAILS	
Title1:	**STORM SEWER DESIGN SHEET**
Title2:	**CONSTANT FLOWS (east)**
Project Name:	
Municipality:	
Project No:	
Date:	
Designed by:	
Checked by:	

IDF Parameters for HAMILTON			
		5-yr	100-yr
I=A/(T+b)^c	A	1049.5	2317.4
	B	8	11
	C	0.803	0.836

			Area	R	AR	Flow Length	Velocity	Tc*	I5	I100	Q5	Q100	Q100-Q5	Const. flow
CAPTURE LOCATION	AREA ID	CAPTURE POINT	ha			m	m/s	min	mm/hr	mm/hr	m3/s	m3/s	m3/s	m3/s
STREET 'H'	8	MH10	0.18	0.65	0.12	44.00	1.50	10.49	100.8	178.3	0.033	0.058	0.025	0.025

*Where available, Tc is calculated from design sheet or overland flow calculation

Tc calcs *where Tc = starting Tc + flow length/velocity*
(starting Tc = 10min)

Assumed Velocities for Calculation of time of Concentration
Pipe Flow Velocity= 2.0 m/s
OLF Velocity= 1.5 m/s
External Flow Velocity= 0.25 m/s

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STORM SEWER DESIGN SHEET

100+5Yr STORM CHANNEL

BLOCK 3 SERVICING STUDY (BSS)

HAMILTON

PROJECT DETAILS

Project No: 12-062W
Date: 13-Jan-20
Designed by: R.MOIR
Checked by: R.MERWIN

DESIGN CRITERIA

Min. Diameter = 300 mm
Mannings 'n'= 0.013
Starting Tc = 10 min
Factor of Safety = 15 %

Rainfall Intensity = $\frac{A}{(Tc+B)^c}$

A = 1049.5
B = 8
c = 0.803

NOMINAL PIPE SIZE USED

AREA ID	STREET	FROM MH	TO MH	AREA (ha)	RUNOFF COEFFICIENT "R"	'AR'	ACCUM. 'AR'	RAINFALL INTENSITY (mm/hr)	FLOW (m3/s)	CONSTANT FLOW (m3/s)	ACCUM. CONSTANT FLOW (m3/s)	TOTAL FLOW (m3/s)	LENGTH (m)	SLOPE (%)	PIPE DIAMETER (mm)	FULL FLOW CAPACITY (m3/s)	FULL FLOW VELOCITY (m/s)	INITIAL Tc (min)	TIME OF CONCENTRATION (min)	ACC. TIME OF CONCENTRATION (min)	PERCENT FULL (%)
300	CHANNEL	HW2-C	MH8-C					103.0		2.648	2.648	2.648	15.7	0.94	1350	5.175	3.62	10.00	0.07	10.07	51%
	HWY8	MH8-C	MH7-C					102.7			2.648	2.648	88.7	1.00	1350	5.337	3.73	10.07	0.40	10.47	50%
	HWY8	MH7-C	MH6-C					100.9			2.648	2.648	11.4	0.50	1500	4.998	2.83	10.47	0.07	10.54	53%
200	EXTERNAL	HW3-C	MH10-C					103.0		1.474	1.474	1.474	15.9	1.00	900	1.810	2.85	10.00	0.09	10.09	81%
201A	HWY8	MH10-C	MH9-C	4.08	0.90	3.67	3.67	102.6	1.047		1.474	2.521	57.4	1.00	1200	3.899	3.45	10.09	0.28	10.37	65%
	LEWIS ROAD	MH9-C	MH6-C				3.67	101.4	1.034		1.474	2.508	12.0	0.50	1350	3.774	2.64	10.37	0.08	10.45	66%
		MH6-C	MH5-C				3.67	100.6	1.027		4.122	5.149	168.2	0.50	1500x2400 (BOX)	11.695	3.25	10.54	0.86	11.40	44%
201B		MH5-C	MH4-C	0.90	0.65	0.59	4.26	97.0	1.147		4.122	5.269	75.6	0.50	1500x2400 (BOX)	11.695	3.25	11.40	0.39	11.79	45%
201C		MH4-C	MH3-C	1.03	0.65	0.67	4.93	95.5	1.307		4.122	5.429	150.0	0.50	1500x2400 (BOX)	11.695	3.25	11.79	0.77	12.56	46%
EAST POND	POND	MH51-E	MH52-E					103.0		0.018	0.018	0.018	56.0	0.30	300	0.053	0.75	10.00	1.25	11.25	34%
	POND	MH52-E	MH3-C					97.6			0.018	0.018	13.1	0.30	300	0.053	0.75	11.25	0.29	11.54	34%
201E	LEWIS ROAD	MH3-C	MH2-C	0.50	0.65	0.33	5.25	92.6	1.351		4.140	5.491	87.6	0.30	1500x2400 (BOX)	9.059	2.52	12.56	0.58	13.14	61%
201F	LEWIS ROAD	MH2-C	MH1-C	0.49	0.90	0.44	5.69	90.6	1.432		4.140	5.572	15.1	0.30	1500x2400 (BOX)	9.059	2.52	13.14	0.10	13.24	62%
201D	LEWIS ROAD	Ex. School	MH1-C					197.6		1.144	1.144	1.144									
202	BARTON STREET	MH53-E	MH1-C					103.0		1.025	1.025	1.025	567.8	0.30	975	1.227	1.64	10.00	5.76	15.76	84%
	LEWIS ROAD	MH1-C	HW1-C	0.49			5.69	82.5	1.304		6.309	7.613	28.4	0.30	1800x2400 (BOX)	11.683	2.70	15.76	0.18	15.93	65%

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PROJECT DETAILS	
Title1:	STORM SEWER DESIGN SHEET
Title2:	CONSTANT FLOWS (Scenario 2a)
Project Name:	BLOCK 3 SERVICING STUDY (BSS)
Municipality:	100+5Yr STORM CHANNEL
Project No:	12-062W
Date:	13-Jan-20
Designed by:	R.MOIR
Checked by:	13/01/2020

IDF Parameters for HAMILTON			
		5-yr	100-yr
$I=A/(T+b)^c$	A	1049.5	2317.4
	B	8	11
	C	0.803	0.836

CAPTURE LOCATION	AREA ID	CAPTURE POINT	Area ha	R	AR	Flow Length m	Velocity m/s	Tc* min	I5 mm/hr	I100 mm/hr	Q5 m3/s	Q100 m3/s	Q100-Q5 m3/s	Const. flow m3/s
Lewis Road	201A	MH3-C	4.08	0.90	3.67	610.00	2.00	15.08	84.4	1500.0	0.861	15.300	14.439	14.439
								1.47						
Lewis Road	201D	MH3-C	3.75	0.65	2.44	230.00	2.00	11.92	95.0	169.0	0.643	1.144	0.501	0.501
Barton Street**	202	MH1-C	6.66	0.65	4.33	575.00	2.00	14.79	85.2	153.1	1.025			

*Where available, Tc is calculated from design sheet or overland flow calculation
**Barton Street Used for Tc calc, not 100YR

Tc calcs *where Tc = starting Tc + flow length/velocity*
(starting Tc = 10min)

Assumed Velocities for Calculation of time of Concentration
Pipe Flow Velocity= 2.0 m/s
OLF Velocity= 1.5 m/s
External Flow Velocity= 0.25 m/s

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OVERLAND FLOW ROUTE - ROW CAPACITY CALCULATIONS

Project Name: Fruitland Winona - BSS
Municipality: City of Hamilton
Project No.: 12-062W
Date: 20-Dec-18

Prepared by: J.L
Checked by: L.M

ROW Capacity (Calculated using AutoCAD Civil 3D Tool - HYDRAFLOW Express)

Roads Checked	Location	Accumulated 'AR'	Tc*	Q_{sewer}*	I_{100}	Q_{100}	Overland Flow (Q_{100}-Q_{sewer})	ROW Width - Narrowest Road - just upstream of Pond	Road Slope	ROW Capacity (at d_{max} = 0.30 m; see results)	Min. Capacity Provided?
			(min)	(m^3/s)	(mm/hr)	(m^3/s)	(m^3/s)	(m)	(%)	(m^3/s)	
Street 'L'	Just Upstream of West Pond	13.19	16.3	4.889	146.0	5.349	0.460	20	0.72	3.480	Yes
Street 'A'	Just Upstream of East Pond	11.05	17.94	2.358	139.0	4.268	1.910	20	0.75	3.552	Yes

* Refer to Storm Sewer Design Sheets for flows conveyed through sewer and Tc

Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Thursday, Dec 20 2018

STREET 'L' - OVERLAND CAPACITY ANALYSIS

User-defined

Invert Elev (m)	=	99.7400
Slope (%)	=	0.7200
N-Value	=	0.016

Calculations

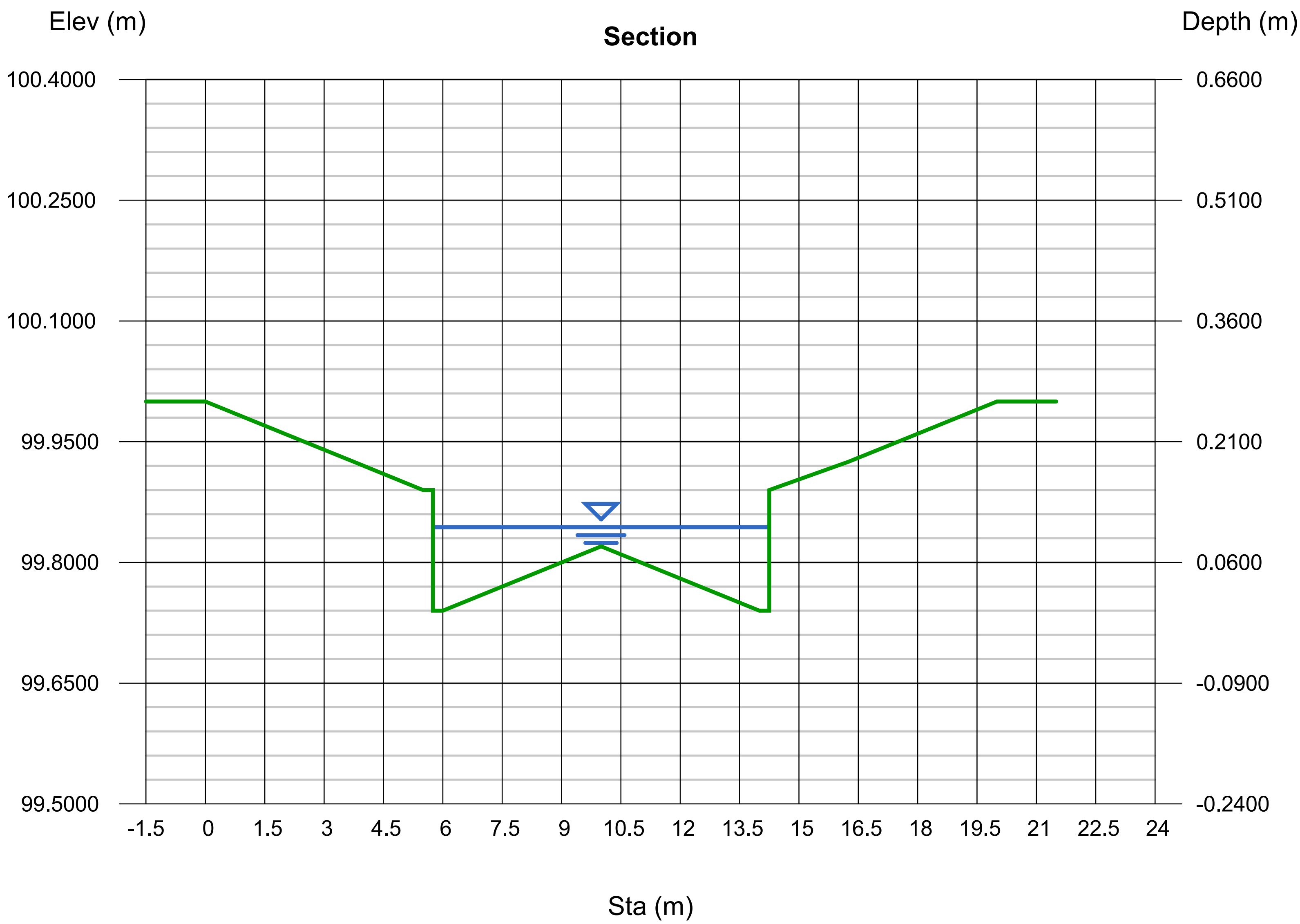
Compute by:		Known Q
Known Q (cms)	=	0.4600

Highlighted

Depth (m)	=	0.1036
Q (cms)	=	0.4600
Area (sqm)	=	0.5608
Velocity (m/s)	=	0.8202
Wetted Perim (m)	=	8.7089
Crit Depth, Yc (m)	=	0.1067
Top Width (m)	=	8.5000
EGL (m)	=	0.1379

(Sta, El, n)-(Sta, El, n)...

(0.0000, 100.0000)-(2.2500, 99.9550, 0.013)-(3.7500, 99.9250, 0.013)-(5.5000, 99.8900, 0.020)-(5.7500, 99.8900, 0.013)-(5.7500, 99.7400, 0.013)-(6.0000, 99.7400
-(10.0000, 99.8200, 0.016)-(14.0000, 99.7400, 0.016)-(14.2500, 99.7400, 0.013)-(14.2500, 99.8900, 0.013)-(16.2500, 99.9250, 0.020)-(17.7500, 99.9550, 0.013)-(20

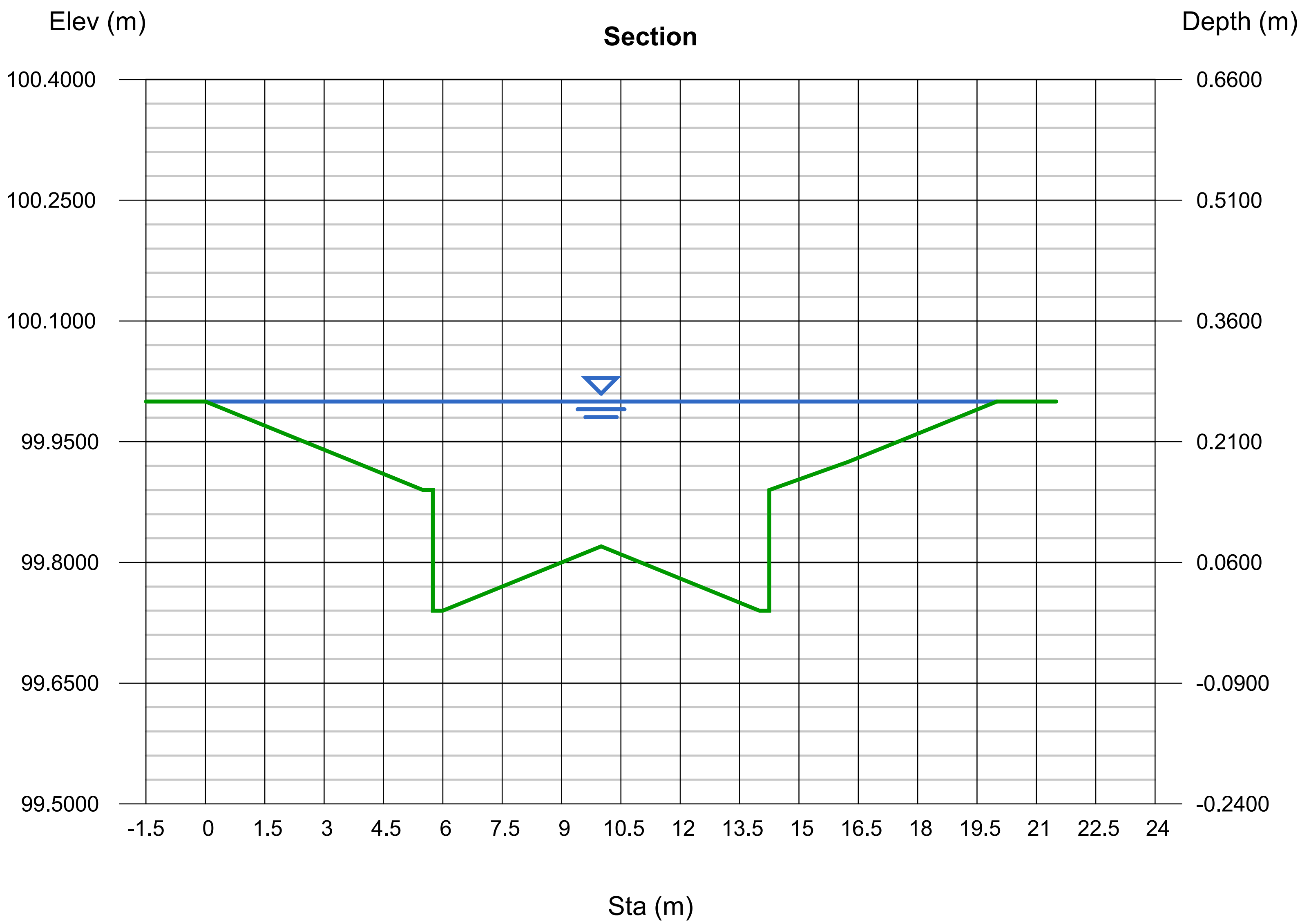


Channel Report

STREET 'L' - OVERLAND CAPACITY ANALYSIS

User-defined		**Highlighted**	
Invert Elev (m)	= 99.7400	Depth (m)	= 0.2600
Slope (%)	= 0.7200	Q (cms)	= 3.4799
N-Value	= Composite	Area (sqm)	= 2.5457
		Velocity (m/s)	= 1.3670
Calculations		Wetted Perim (m)	= 20.3038
Compute by:	Q vs Depth	Crit Depth, Yc (m)	= 0.2600
No. Increments	= 10	Top Width (m)	= 20.0000
		EGL (m)	= 0.3553

(Sta, El, n)-(Sta, El, n)...
(0.0000, 100.0000)-(2.2500, 99.9550, 0.013)-(3.7500, 99.9250, 0.013)-(5.5000, 99.8900, 0.020)-(5.7500, 99.8900, 0.013)-(5.7500, 99.7400, 0.013)-(6.0000, 99.7400
-(10.0000, 99.8200, 0.016)-(14.0000, 99.7400, 0.016)-(14.2500, 99.7400, 0.013)-(14.2500, 99.8900, 0.013)-(16.2500, 99.9250, 0.020)-(17.7500, 99.9550, 0.013)-(20



Depth	Q	Area	Veloc
(m)	(cms)	(sqm)	(m/s)
0.0260	0.015	0.047	0.3311
0.0520	0.080	0.161	0.4962
0.0780	0.218	0.343	0.6360
0.1040	0.490	0.564	0.8692
0.1300	0.848	0.785	1.0805
0.1560	1.189	1.009	1.1779
0.1820	1.428	1.290	1.1069
0.2080	1.934	1.641	1.1789
0.2340	2.618	2.059	1.2709
0.2600	3.480	2.546	1.3670

Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Thursday, Dec 20 2018

STREET 'A' - OVERLAND CAPACITY ANALYSIS

User-defined

Invert Elev (m)	=	99.7400
Slope (%)	=	0.7500
N-Value	=	0.016

Calculations

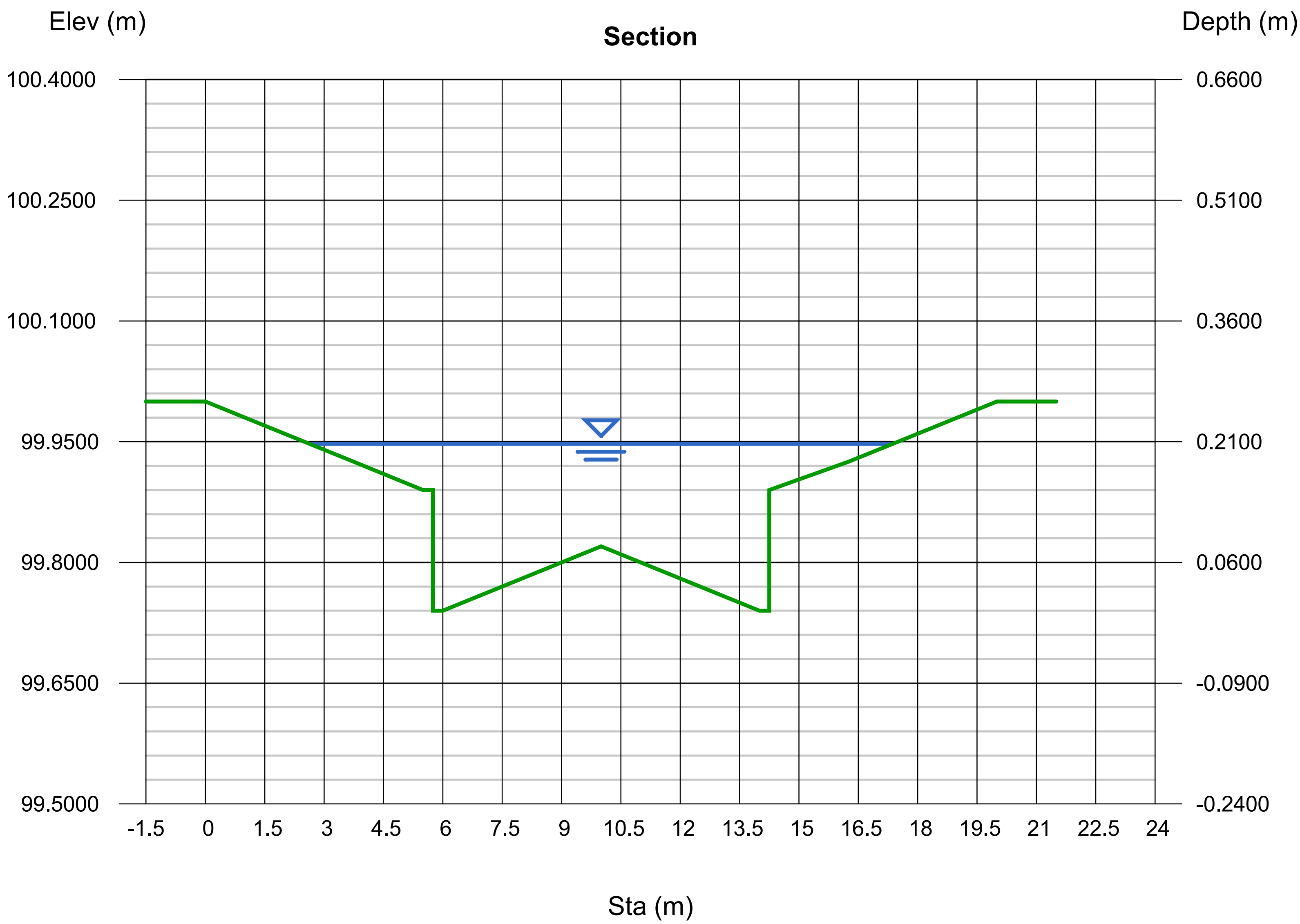
Compute by:		Known Q
Known Q (cms)	=	1.9100

Highlighted

Depth (m)	=	0.2073
Q (cms)	=	1.9100
Area (sqm)	=	1.6299
Velocity (m/s)	=	1.1718
Wetted Perim (m)	=	15.0294
Crit Depth, Yc (m)	=	0.2195
Top Width (m)	=	14.7267
EGL (m)	=	0.2773

(Sta, El, n)-(Sta, El, n)...

(0.0000, 100.0000)-(2.2500, 99.9550, 0.013)-(3.7500, 99.9250, 0.013)-(5.5000, 99.8900, 0.020)-(5.7500, 99.8900, 0.013)-(5.7500, 99.7400, 0.013)-(6.0000, 99.7400
-(10.0000, 99.8200, 0.016)-(14.0000, 99.7400, 0.016)-(14.2500, 99.7400, 0.013)-(14.2500, 99.8900, 0.013)-(16.2500, 99.9250, 0.020)-(17.7500, 99.9550, 0.013)-(20



Channel Report

STREET 'A' - OVERLAND CAPACITY ANALYSIS

User-defined

Invert Elev (m)	= 99.7400
Slope (%)	= 0.7500
N-Value	= Composite

Calculations

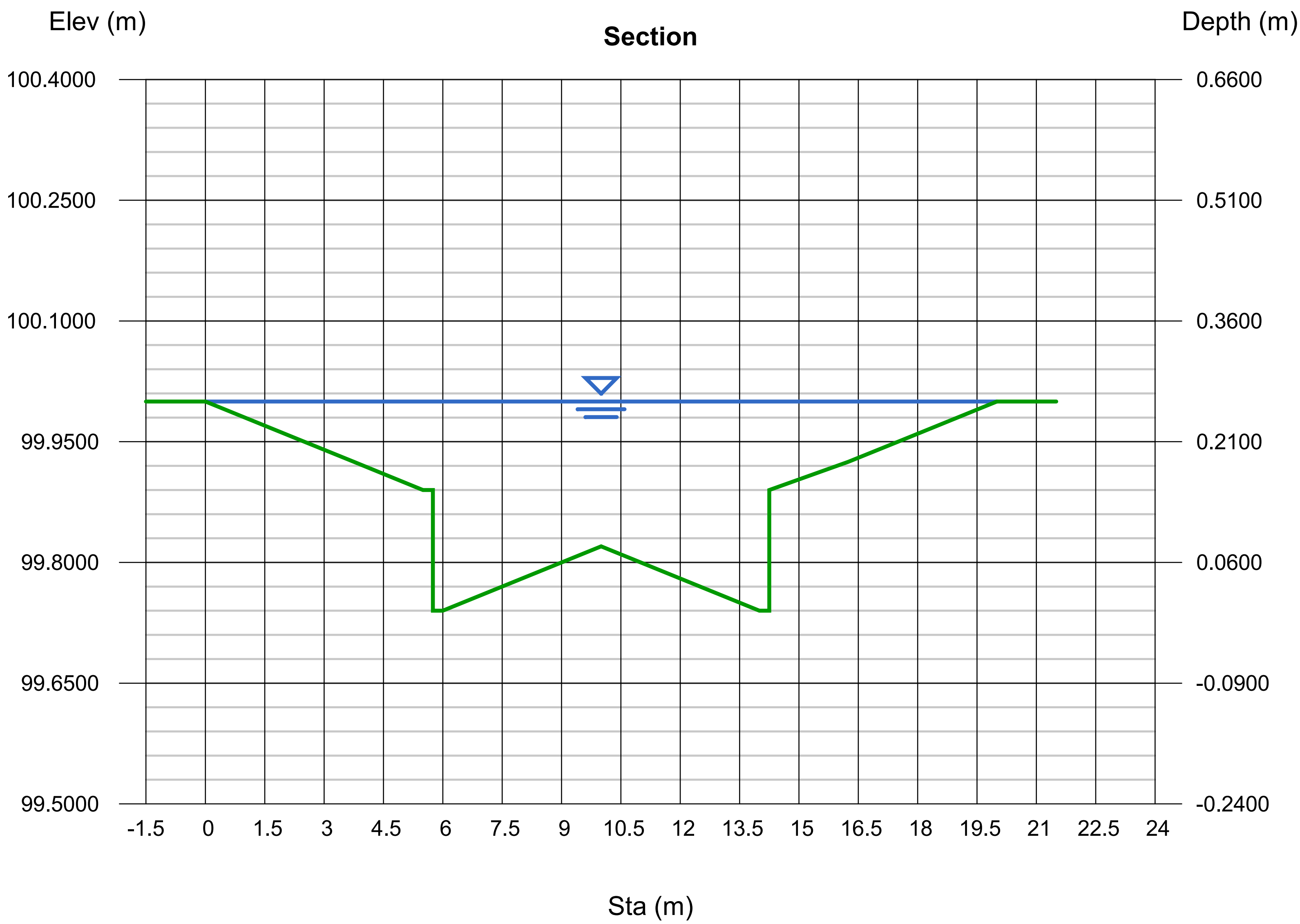
Compute by:	Q vs Depth
No. Increments	= 10

Highlighted

Depth (m)	= 0.2600
Q (cms)	= 3.5517
Area (sqm)	= 2.5457
Velocity (m/s)	= 1.3952
Wetted Perim (m)	= 20.3038
Crit Depth, Yc (m)	= 0.2600
Top Width (m)	= 20.0000
EGL (m)	= 0.3593

(Sta, El, n)-(Sta, El, n)...

(0.0000, 100.0000)-(2.2500, 99.9550, 0.013)-(3.7500, 99.9250, 0.013)-(5.5000, 99.8900, 0.020)-(5.7500, 99.8900, 0.013)-(5.7500, 99.7400, 0.013)-(6.0000, 99.7400
-(10.0000, 99.8200, 0.016)-(14.0000, 99.7400, 0.016)-(14.2500, 99.7400, 0.013)-(14.2500, 99.8900, 0.013)-(16.2500, 99.9250, 0.020)-(17.7500, 99.9550, 0.013)-(20



Depth	Q	Area	Veloc
(m)	(cms)	(sqm)	(m/s)
0.0260	0.016	0.047	0.3379
0.0520	0.082	0.161	0.5064
0.0780	0.223	0.343	0.6491
0.1040	0.500	0.564	0.8872
0.1300	0.866	0.785	1.1028
0.1560	1.213	1.009	1.2022
0.1820	1.457	1.290	1.1297
0.2080	1.974	1.641	1.2032
0.2340	2.671	2.059	1.2971
0.2600	3.552	2.546	1.3952

APPENDIX H
STORMWATER MANAGEMENT CALCULATIONS

H-1 SWM Pond Scenario 2a Calculations
H-2 Figure 7.1 Stormwater Management Strategy

APPENDIX H-1
SWM Pond Scenario 2a Calculations

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SCENARIO 2a: SWM DESIGN CALCULATIONS - POND 2 (WEST)
HYRDO-0: Contributing Drainage Area and Land Use

Project Name: Fruitland Winona BSS Area #3
Municipality: City of Hamilton
Project No.: 12-062W
Date: 14-Jan-20

Prepared by: J.L
Checked by: AF
Submission #: 3rd Submission

POND 2 (West of Lewis)

POND 2 (West of Lewis)	From	To	Area [ha]	Runoff Coefficient	Imperviousness %IMP=100 X (C-0.2)/0.7	Imperviousness %IMP=(C-0.05)/0.009	Design Requirement		
							Conveyance	Quantity	Quality
Total Drainage Area to HW-1			38.16	0.64	62.9	65.6	•	•	•
Total Drainage Area to HW-2			12.76	0.73	75.7	75.6	•	•	•
Pond Block			2.54	0.90	100.0	94.4	•	•	•
Total Drainage Area (Quality Control Only)			**53.46**	**0.67**	**67.7**	69.3			
Total Drainage Area (Quantity Control Only)			**53.46**	**0.67**	**67.7**	69.3			
Total Drainage Area to Pond			**53.46**	**0.67**	**67.7**	69.3	**53.46**	**53.46**	**53.46**

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SWM POND DESIGN CALCULATION - POND 2 (WEST)
SWMF-1 TARGET SUMMARY

Project Name: Fruitland Winona BSS Area #3
Municipality: City of Hamilton
Project No.: 12-062W
Date: 14-Jan-20

Prepared by: J.L
Checked by: AF
Submission #: 3rd Submission

POND 2 (West of Lewis)
Based on VO5 Model

Pond Layout

Head Wall
Number of Headwalls: 2
Drainage Area to Headwall [ha]: 53.46

Elevation (m)	Storm Event	Surface Area (m^2)	Total Volume (m^3)	Active Storage Volume (m^3)
84.00	BOTTOM WET CELL	5,385	0	0
84.00	BOTTOM FOREBAY	2,419	0	0
85.15		10,751	10,669	0
85.50		11,585	13,126	0
85.57	**PERM POOL**	**12,465**	**17,142**	0
85.60		12,588	17,518	376
85.65		12,778	18,152	1,010
85.70		13,103	18,799	1,657
85.75		13,227	19,457	2,315
85.80		13,352	20,122	2,980
85.85		13,477	20,793	3,650
85.90		13,602	21,470	4,327
85.95		13,729	22,153	5,011
86.00		13,855	22,842	5,700
86.05		13,982	23,538	6,396
86.10	**EXT DET**	14,109	24,241	7,098
86.15		14,237	24,949	7,807
86.20		14,365	25,664	8,522
86.25		14,493	26,386	9,244
86.30		14,623	27,114	9,972
86.35		14,752	27,848	10,706
86.40		14,883	28,589	11,447
86.45		15,013	29,336	12,194
86.50		15,144	30,090	12,948
86.55		15,277	30,851	13,709
86.60		15,408	31,618	14,476
86.65	**2-YR**	15,541	32,392	15,249
86.70		15,673	33,172	16,030
86.75		15,807	33,959	16,817
86.80		15,941	34,753	17,611
86.85		16,076	35,553	18,411
86.90		16,210	36,360	19,218
86.95		16,346	37,174	20,032
87.00		16,482	37,995	20,853
87.05	**5-YR**	16,619	38,823	21,680
87.10		16,756	39,657	22,515
87.15		16,892	40,498	23,356
87.20		17,030	41,346	24,204
87.25		17,168	42,201	25,059
87.30	**10-YR**	17,306	43,063	25,921
87.35		17,447	43,932	26,790
87.40		17,586	44,808	27,665
87.45		17,726	45,690	28,548
87.50		17,866	46,580	29,438
87.55		18,008	47,477	30,335
87.60	**25-YR**	18,149	48,381	31,239
87.65		18,291	49,292	32,150
87.70		18,433	50,210	33,068
87.75		18,577	51,135	33,993
87.80		18,720	52,068	34,926

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87.85	**50-YR**	18,863	53,007	35,865
87.90		19,008	53,954	36,812
87.95		19,153	54,908	37,766
88.00		19,298	55,869	38,727
88.05		19,444	56,838	39,696
88.07	100-YR	19,503	57,228	40,085
88.20		19,885	59,788	42,645
88.40		20,478	63,824	46,682
88.60	EMERGENCY	20,795	67,951	50,809
89.00	--	21,492	76,409	59,266

Design Target

Event	Volume	Discharge	Description
PERM POOL	183 m^3/ha	-	(Modified for 69% imperv.)
EXT DET	25 mm storm event - VO5	0.155 m^3/s	Revised Target - Erosion Threshold Un Rate (shown in Extended Detention Po Calculation Sheet)
ORIGINAL SCUBESS TARGETS - SUPERSEDED			(
EXT DET	*294 m^3 /ha [SCUBE]*	*0.0006 m^3/s/ha [SCUBE]*	*[SCUBE - 15% of 2-y]*
2 YR	*420 m^3 /ha [SCUBE]*	*0.0043 m^3/s/ha [SCUBE]*	*[SCUBE]*
5 YR	*m^3*	*m^3/s/ha*	
25 YR	*m^3*	*m^3/s/ha*	
100 YR	*1132 m^3 /ha [SCUBE]*	*0.0174 m^3/s/ha [SCUBE]*	*[SCUBE]*

**** Quantity storage tagets include extended detention storage.** ** Quant

Wet Pond *(Per MOE Stormwater Management Planning and Design Manual 2003, Table 3.2)*

Impervious Level	Water Quality Storage Vol	Extended Detention	Permanent Pool
(%)	m^3/ha	m^3/ha	m^3/ha
35%	140	40	100
55%	190	40	150
70%	225	40	185
85%	250	40	210
Interpolated Storage Requirement			
69%	223	40	**183**

	Area [ha]	IMP%
Total Contributing Area	53.46	69%
Quantity Control Only	53.46	69%
Quality Control Only	53.46	69%

Return Period	Stage [m]	Original SCUBE Required Volume [m^3]	Original SCUBE Target Discharge [m^3/s]	Revised Required Volume [Based on Scenario 2a] [m^3]	Revised Target Discharge [Based on Scenario 2] [m^3/s]	Provided [m^3]
PERM POOL	85.57	*9805*	*-*	9,805	-	17,142
EXT DET	86.10	*10894*	*0.032*	6,576	0.051	7,098
2-YR	86.65	*15563*	*0.230*	14,498	0.100	15,249
5-YR	87.05	*N/A*	*N/A*	21,333	0.138	21,680
10-YR	87.30	*N/A*	*N/A*	25,841	0.169	25,921
25-YR	87.60	*N/A*	*N/A*	30,209	0.215	31,239
50-YR	87.85	*N/A*	*N/A*	35,303	0.256	35,865
100-YR	88.07	*41947*	*0.930*	39,612	0.301	40,085
EMERGENCY *	88.60	-			9.93	46,682

*Emergency flow target is the larger of the 100-Year uncontrolled and Regional Storm event

	100-Yr Uncontrolled Flow (m^3/s)	Regional Flow (m^3/s)
West Pond	9.928	6.957

EXTENDED DETENTION POND TARGET - EROSION THRESHOLD
SWMF-1 TARGET SUMMARY -Part II

Project Name:	Fruitland Winona BSS Area #3	**Prepared by:**	J.L
Municipality:	City of Hamilton	**Checked by:**	AF
Project No.:	12-062W	**Submission #:**	3rd Submission
Date:	14-Jan-20		

POND 2 (West of Lewis)

Extended Detention Pond Target:

To be based on the Erosion Threshold determined by the GEO Morphix studies for Node 10 (where flows merge downstream of Venetian Meats' Channel) under existing conditions, which is **0.609 m^3/s.**

NODE 10:

0.609	m^3/s - Erosion Threshold Target to Define Unit Flow Rates from SWM Facilities for Extended Detention Flows
193.05	ha - Existing Drainage area to Node 10
0.00315	**m^3/s/ha Unit Flow Rate**

P2 (West):

53.12 ha (total) - 3.97 ha (additional area to pond under post-development not included under existing conditions from McNeilly and Barton ROWs) =

49.15	ha
0.155	**m^3/s**

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SWM POND TARGET SCENARIOS

SWMF-1 TARGET SUMMARY - Part III

Project Name: Fruitland Winona BSS Area #3
Municipality: City of Hamilton
Project No.: 12-062W
Date: 14-Jan-20

Prepared by: J.L
Checked by: AF
Submission #: 3rd Submission

Scenario 2a

	Existing Catchment 302B (Node 3)	Proposed Condition - MIKE 11 Frequency Flow Analysis (Node 4)	Pond Discharge (VO5 - revised outlet structure)	VO5 Required Storage
Pond Level	Flow (m^3/s)	Flow (m^3/s)	Flow (m^3/s)	(m^3)
ED	0.155	-	0.051	6,576
2	0.730	0.100	0.100	14,498
5	1.113	0.138	0.138	21,333
10	1.396	0.169	0.169	25,841
25	1.774	0.215	0.215	30,209
50	2.059	0.256	0.256	35,303
100	2.364	0.301	0.301	39,612

Storm Event	Pond-2 (West) Area = 53.46 ha; IMP%=69%			
	Unit Volume m^3/ha	Volume m^3	Unit Release Rates L/s/ha	Flow m^3/s
Permanent Pool	183	9,805	-	-
Erosion Control	177	6,576	2.900	0.155
2-Year	391	14,498	1.878	0.100
100-Year	1069	39,612	5.638	0.301

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SWM POND DESIGN CALCULATIONS
SWMF-2: Drawdown Time

Project Name: Fruitland Winona BSS Area #3
Municipality: City of Hamilton
Project No.: 12-062W
Date: 14-Jan-20

Prepared by: J.L
Checked by: AF
Submission Number: 3rd Submission

POND 2 (West of Lewis)

Detention Time Calculations

$t = (0.66C_2h^{1.5}+2C_3h^{0.5})/2.75Ao$ *(MOECC Eq'n 4.11)*

t=	**195905**	*drawdown time in seconds*
t=	**54.4**	*drawdown time in hours*
d =	0.2	*diameter of orifice (m)*
A_0=	0.0314	*cross-sectional area of the orifice (m^2)*
h=	0.430	*maximum water elevation above orifice (m)*
$Q_{ext\ det}$ =	0.0548	*proposed extended detention release rate (m3/s)*
Q_{target}=	0.155	*based on Erosion threshold UFR*
C_2=	3102.83	*slope coefficient from the area-depth linear regression*
C_3=	12465	*intercept from the area-depth linear regression*

Pond area-depth relationship:

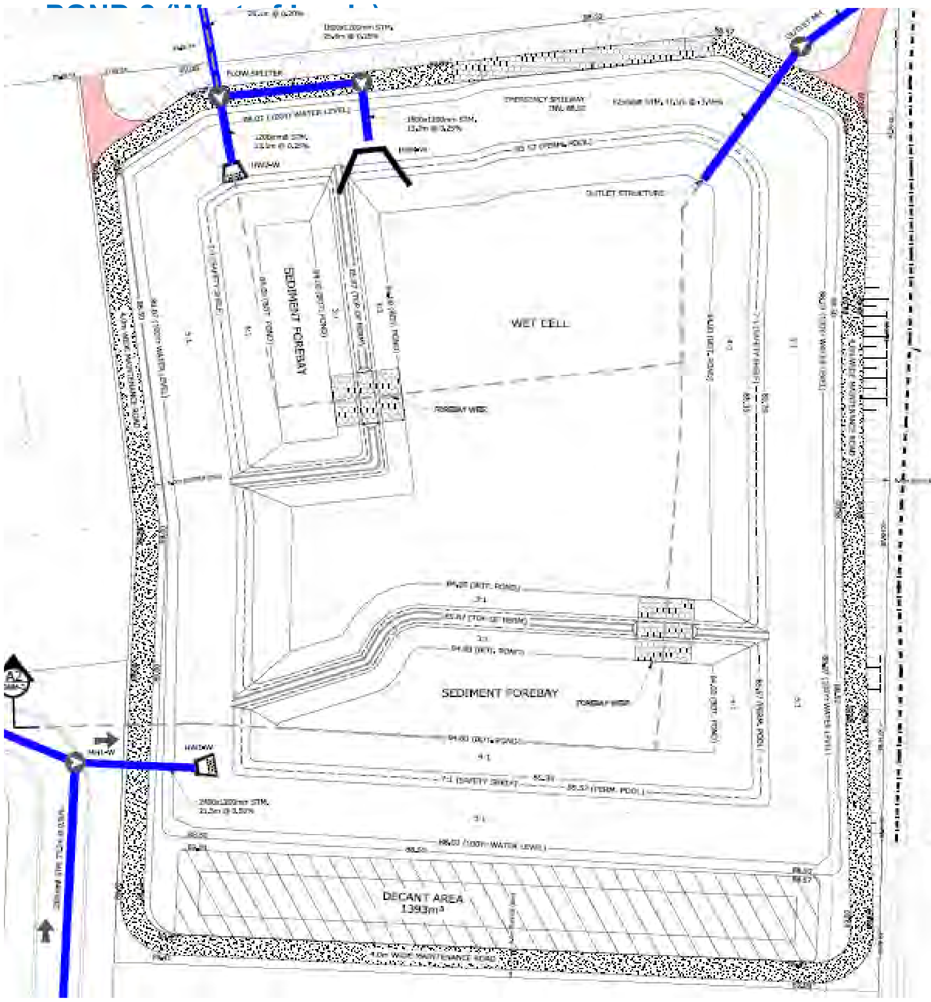
	Elevation (m)	Area (m^2)	Depth (m)
PERM POOL	85.57	12465	0.00
EXT DET	86.10	14109	0.53

The drawdown time for POND 2 (West of Lewis) is 54.4 hours (2.3 days)
The drawdowntime is greater than the target of 48 hours.

DESIGN CALCULATIONS
SWMF-3a: Forebay Length to Width Ratio Calculation

Project Name: Fruitland Winona BSS Area #3
Municipality: City of Hamilton
Project No.: 12-062W
Date: 2020-01-14

Prepared by: J.L
Checked by:
Submission #: 3rd Submission



Total Provided Permanent Pool Volume= **17142** m^3
Required Permanent Pool Volume= **9805** m^3

	Length	Width	Ratio		Length	Width	Ratio
Forebay HW-1	**87.0m**	**19.0m**	**4.58 : 1**	Forebay HW2-2	**88.0m**	**29.0m**	**3.03 : 1**
Wet Cell	**108.0m**	**71.0m**	**1.52 : 1**	Wet Cell	**102.0m**	**72.0m**	**1.42 : 1**
Weighted Average			**2.17 : 1**				**1.88 : 1**

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SWM POND DESIGN CALCULATIONS
SWMF-3: Sediment Forebay Sizing

Project Name: Fruitland Winona BSS Area #3
Municipality: City of Hamilton
Project No.: 12-062W
Date: 14-Jan-20

Prepared by: J.L
Checked by: AF
Submission #: 3rd Submission

POND 2 (West of Lewis)

	Drainage Area (ha)	Runoff Coefficient
HW-1	40.70	0.66
HW-2	12.76	0.73

Settling Calcs (MOECC 2003, Wet Pond)

$Dist_R = (rQ_p/V_s)^{0.5}$ *(MOECC Eq'n 4.5)*

Parameter	HW-1	HW-2	Description
r =	3.6	4.58	*Proposed length-to-width ratio of forebay*
Q_p =	0.055	0.055	*Proposed Extended Detention Release Rate (m3/s)*
V_s =	0.0003	0.0003	*Settling velocity (0.0003 m/s most cases)*
$Dist_R$ =	26	29	*Forebay Length Required (m)*
$Dist_P$ =	105	87	*Forebay Length Provided (m)*

SUFFICIENT FOREBAY LENGTH PROVIDED.

Note: Forebay should not exceed one-third of pond surface area

Minor and Major system flow approximation (from Design Sheet)			
	Area (ha)	Q (m^3/s)	Q100 (m^3/s)
HW-1	40.7	4.89	9.52
HW-2	12.76	3.48	3.56

Dispersion Length (MOECC 2003, Wet Pond)

$Dist_R = 8*Q/d/V_r$ *(MOECC Eq'n 4.6)*

Parameter	HW-1	HW-2	Description
Q	9.52	3.56	*Minor inlet flowrate (m^3/s)*
d	1.50	1.50	*Depth of permanent pool in forebay (m)*
V_r	0.5	0.5	*Desired velocity of forebay (m/s)*
$Dist_R$	102	38	*Dispersion Length Required (m)*
$Dist_P$	105	87	*Dispersion Length Provided (m)*

SUFFICIENT FOREBAY LENGTH PROVIDED

SWM DESIGN CALCULATIONS
SWMF-5 EMERGENCY SPILLWAY WEIR

SCENARIO 2a: SWM DESIGN CALCULATIONS - POND 2 (WEST)

Project Name: Fruitland Winona BSS Area #3
Municipality: City of Hamilton
Project No.: 12-062W
Date: 2020-01-14

Prepared by: J.L
Checked by: AF
Last Revised: 3rd Submission

POND 2 (West of Lewis)

Input Parameters:

Side Slope, S_1	10	:1 (2%)
Side Slope, S_2	10	:1 (2%)
Spillway Invert	88.60	m
Water Level	89.00	m
Flow Depth, H	0.40	m
Bottom Width, B:	37.0	m

Weir equation: $Q = BxC_dxH^{3/2} + SxC_dxH^{5/2}$

$C_d = 1.5$

where:
Q=flow rate (m3/s)
H= head on the weir (m)
B=width of the weir (m)
S = side slopes of weir (H:V)

Computed Values:

Capacity, Q at 89m	**15.56**	m^3/s
Emergency Flow Required via Spillway	**9.93**	m^3/s

The proposed emergency spillway provides sufficient capacity.

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SWM DESIGN CALCULATIONS
SWMF-6 DECANTING AREA

SCENARIO 2a: SWM DESIGN CALCULATIONS - POND 2 (WEST)

Project Name: Fruitland Winona BSS Area #3
Municipality: City of Hamilton
Project No.: 12-062W
Date: 14-Jan-20

Prepared by: J.L
Checked by: AF
Submission #: 3rd Submission

POND 2 (West of Lewis)

Drainage Area to POND 2 (West of Lewis)	53.46	ha	
Imperviousness=	69%		
Required Protection level=	70	% TSS Removal (Enhanced)	
Required storage volume for Enhanced level of protection (70% TSS Removal)=	90	m3//ha	*(MOECC-Table 3.2)*
Required permanent storage volume for Normal level of protection (70% TSS Removal)=	4797	m3	*(SWMF-1)*
Provided permanent pool storage volume	13126	m3	*(SWMF-1)*
Required storage volume for Basic level of protection (60% TSS Removal)=	44	m3//ha	*(MOECC-Table 3.2)*
Required storage volume for Basic level of protection (60% TSS Removal)=	2373	m3	
Required Storage Volume for 65% TSS Removal=	67	m3//ha	
Required Storage Volume for 65% TSS Removal=	3585	m3	
Storage volume equivalent to 5% TSS reduction=	**9542**	m3	
Annual Sediment Loading (from MOE-Table 6.3)=	2.79	m3/ha/yr based on %IMP	
	149.07	m3/yr	

Theoretical Cleanout Frequency=	**64**	**yrs**

Volume provided in the decanting area=	1393	m3
Maximum Depth of Decanting Area=	1	m
Slope in Decanting Area=	4	:1

Proposed Cleanout Frequency=	**9.3**	**yrs**

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SWM POND DESIGN CALCULATION - POND 3 (EAST)
HYRDO-0: Contributing Drainage Area and Land Use

Project Name: Fruitland Winona BSS Area #3
Municipality: City of Hamilton
Project No.: 12-062W
Date: 14-Jan-20

Prepared by: J.L
Checked by: AF
Submission #: 3rd Submission

POND 3 (East of Lewis)

POND 3 (East of Lewis)	From	To	Area [ha]	Runoff Coefficient	Imperviousness %IMP=100 X (C-0.2)/0.7	Imperviousness %IMP= (C-0.05)/0.009	Design Requirement		
							Conveyance	Quantity	Quality
Total Drainage Area to HW-1			17.05	0.65	64.3	66.7	•	•	•
Pond Block			1.51	0.90	100.0	94.4	•	•	•
Total Drainage Area (Quality Control Only)			**18.56**	**0.670**	**67.2**	68.9			
Total Drainage Area (Quantity Control Only)			**18.56**	**0.67**	**67.2**	68.9			
Total Drainage Area to Pond			**18.56**	**0.67**	**67.2**	68.9	**18.56**	**18.56**	**18.56**

SWM POND DESIGN CALCULATION - POND 3 (EAST)
SWMF-1 TARGET SUMMARY

Project Name: Fruitland Winona BSS Area #3
Municipality: City of Hamilton
Project No.: 12-062W
Date: 14-Jan-20

Prepared by: J.L
Checked by: AF
Submission #: 3rd Submission

POND 3 (East of Lewis)
Based on VO5 Model - Scenario 2 (Defined in SWM Pond Target Scenarios Sheet)

Pond Layout

Head Wall HW1-E
Number of Headwalls: 1
Drainage Area to Headwall [ha]: 18.56

Elevation (m)	Storm Event	Surface Area (m^2)	Total Volume (m^3)	Active Storage Volume (m^3)
84.60	BOTTOM FOREBAY	303	0	0
84.60	BOTTOM WET CELL	1,501	0	0
86.14	--	3,512	3,777	0
86.35	**PERM POOL**	**3,999**	**4,565**	**0**
86.56	--	4,529	5,463	898
86.70	--	5,316	6,142	1,578
86.75	--	5,400	6,410	1,846
86.80		**5,484**	**6,682**	**2,118**
86.85	EXT DET	5,569	6,959	2,394
86.90	--	5,654	7,239	2,675
86.95	--	5,740	7,524	2,959
87.00		5,826	7,813	3,249
87.05	--	5,912	8,107	3,542
87.10	--	6,000	8,404	3,840
87.15	--	6,087	8,707	4,142
87.20	--	6,175	9,013	4,448
87.25		6,263	9,324	4,759
87.30		6,352	9,639	5,075
87.35		6,442	9,959	5,395
87.40		6,531	10,284	5,719
87.45	2-YR	6,621	10,612	6,048
87.50	--	6,712	10,946	6,381
87.55	--	6,803	11,284	6,719
87.60		6,895	11,626	7,061
87.65		6,987	11,973	7,408
87.70		7,079	12,325	7,760
87.75		7,172	12,681	8,116
87.80		7,265	13,042	8,477
87.85	**5-YR**	7,359	13,408	8,843
87.90		7,454	13,778	9,213
87.95		7,548	14,153	9,588
88.00		7,643	14,533	9,968
88.05		7,739	14,917	10,353
88.10	**10-YR**	7,835	15,307	10,742
88.15		7,932	15,701	11,136
88.20		8,028	16,100	11,535
88.25		8,126	16,504	11,939
88.30		8,224	16,912	12,348
88.35	**25-YR**	8,322	17,326	12,761
88.40		8,421	17,745	13,180
88.45		8,520	18,168	13,603
88.50		8,620	18,597	14,032
88.55		8,720	19,030	14,465
88.60	**50-YR**	8,820	19,469	14,904
88.65		8,921	19,912	15,348
88.70		9,023	20,361	15,796
88.75		9,125	20,814	16,250

88.80		9,227	21,273	16,709
88.85	**100-YR**	9,330	21,737	17,173
89.25	--	10,170	25,635	21,070
89.60	**EMERGENCY**	10,210	29,201	24,637
89.90	--	10,245	32,270	27,706

Design Target

Event	Volume	Discharge	Description
PERM POOL	182 m^3/ha	-	(Modified for 68.93% imperv.)
EXT DET	25 mm storm event - VO5	0.058 m^3/s	Revised Target - Erosion Threshold Unit Flow Rate (shown in Extended Detention Pond Target Calculation Sheet)

ORIGINAL SCUBESS TARGETS - SUPERSEDED

EXT DET	296 m^3 /imperv ha [SCUBI	0.0006 m^3/s/ha [SCUBE]	[SCUBE - 15% of 2-yr]
2 YR	422 m^3 /imperv. ha [SCUE	0.0043 m^3/s/ha [SCUBE]	[SCUBE]
100 YR	1134 m^3 /imperv. ha [SCUE	0.0174 m^3/s/ha [SCUBE]	[SCUBE]

**** Quantity storage tagets include extended detention storage.**

Wet Pond ***(Per MOE Stormwater Management Planning and Design Manual 2003, Table 3.2)***

Impervious Level	Water Quality Storage Vol	Extended Detention	Permanent Pool
(%)	**m^3/ha**	**m^3/ha**	**m^3/ha**
35%	140	40	100
55%	190	40	150
70%	225	40	185
85%	250	40	210
Interpolated Storage Requirement			
0.69	**222**	40	**182**

	Area [ha]	IMP%
Total Contributing Area	18.56	68.93%
Quantity Control Only	18.56	68.93%
Quality Control Only	18.56	68.93%

Return Period	Stage [m]	Original SCUBE Required Volume [m^3]	Original SCUBE Target Discharge [m^3/s]	Revised Required Volume [Based on Scenario 2] [m^3]	Revised Target Discharge [Based on Scenario 2] [m^3/s]	Provided Storage [m^3]
PERM POOL	86.35	3387	-	3,387	-	4,565
EXT DET	86.85	3787	0.011	2,334	0.013	2,394
2-YR	87.45	5399	0.080	5,770	0.015	6,048
5-YR	87.85	*N/A*	*N/A*	8,486	0.019	8,843
10-YR	88.10	*N/A*	*N/A*	10,327	0.024	10,742
25-YR	88.35	*N/A*	*N/A*	12,320	0.029	12,761
50-YR	88.60	*N/A*	*N/A*	14,307	0.032	14,904
100-YR	88.85	14507	0.323	16,273	0.036	17,173
EMERGENCY *	89.60					24,637

*Emergency flow target is the larger of the 100-Year uncontrolled and Regional Storm even

HW#	100-Yr Uncontrolled Flow (m^3/s)	Regional Flow (m^3/s)
HW1	3.614	2.455

EXTENDED DETENTION POND TARGET - EROSION THRESHOLD

Project Name:	Fruitland Winona BSS Area #3	**Prepared by:**	J.L
Municipality:	City of Hamilton	**Checked by:**	AF
Project No.:	12-062W	**Submission #:**	3rd Submission
Date:	14-Jan-20		

POND 3 (East of Lewis)

Extended Detention Pond Target:

To be based on the Erosion Threshold determined by the GEO Morphix studies for Node 10 (where flows merge downstream of Venetian Meats' Channel) under existing conditions, which is **0.609 m^3/s.**

NODE 10:

0.609 m^3/s - Erosion Threshold Target to Define Unit Flow Rates from SWM Facilities for Extended Detention Flows
193.05 ha - Existing Drainage area to Node 10
0.00315 $m^3/s/ha$ Unit Flow Rate

P3 (East):

18.5 ha (total) [is all included within the ex. Drainage area to Node 10]:
18.5 ha
0.058 m^3/s

SWM POND TARGET SCENARIOS

Project Name: Fruitland Winona BSS Area #3
Municipality: City of Hamilton
Project No.: 12-062W
Date: 14-Jan-20

Prepared by: J.L
Checked by: AF
Submission #: 3rd Submission

POND 3 (East of Lewis)

Scenario 2

Pond Level	Existing Catchment 202 (Node 6) Flow (m^3/s)	Post (VO5 - revised outlet structure) Flow (m^3/s)	VO5 Required Storage m3
ED (ET)		0.013	2,334
2	0.304	0.015	5,770
5	0.473	0.019	8,486
10	0.595	0.024	10,327
25	0.759	0.029	12,320
50	0.886	0.032	14,307
100	1.016	0.036	16,273

Storm Event	Pond-2 (East) Area = 18.56 ha; IMP%=69%			
	Unit Volume m^3/ha	Volume m^3	Unit Release Rates L/s/ha	Flow m^3/s
Permanent Pool	182	3,387	-	-
Erosion Control	265	2,334	3.144	0.013
2-Year	451	5,770	0.808	0.015
100-Year	604	16,273	1.940	0.036

SWM POND DESIGN CALCULATIONS
SWMF-2: Drawdown Time

Project Name: Fruitland Winona BSS Area #3
Municipality: City of Hamilton

Project No.: 12-062W
Date: 14-Jan-20

Prepared by: J.L
Checked by: AF

Submission #: 3rd Submission

POND 3 (East of Lewis)

Detention Time Calculations

$t = (0.66C_2h^{1.5}+2C_3h^{0.5})/2.75Ao$ *(MOECC Eq'n 4.11)*

t=	**277372**	*drawdown time in seconds*
t=	**77.0**	*drawdown time in hours*
d=	0.1	*diameter of the orifice (m)*
A_0=	0.008	*cross-sectional area of the orifice (m^2)*
h=	0.450	*maximum water elevation above orifice (m)*
$Q_{ext\ det}$=	0.014	*proposed extended detention release rate (m3/s)*
Q_{target}=	0.058	*based on Erosion threshold UFR*
C_2=	3140.00	*slope coefficient from the area-depth linear regression*
C_3=	3999	*intercept from the area-depth linear regression*

Pond area-depth relationship:

	Elevation (m)	Area (m^2)	Depth (m)
PERM POOL	86.35	3999	0.00
EXT DET	86.85	5569	0.50

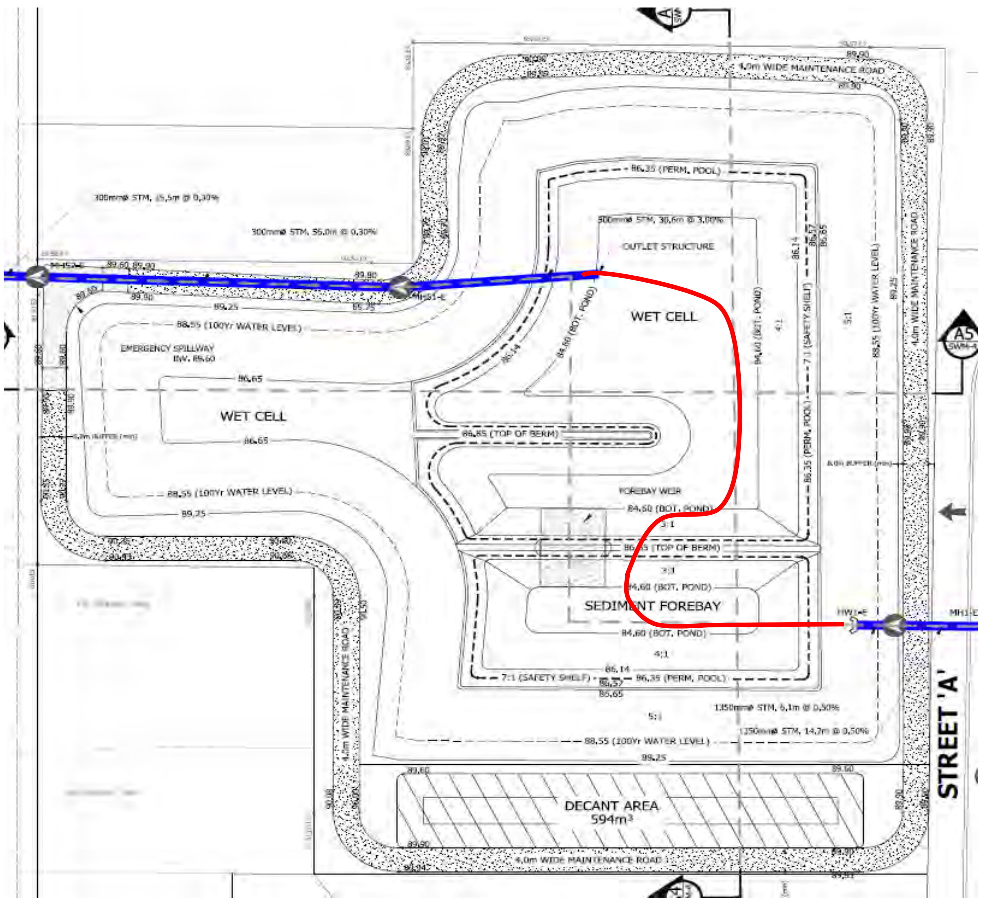
The drawdown time for POND 3 (East of Lewis) is 77 hours (3.2 days)
The drawdown time is greater than the target of 48 hours.

DESIGN CALCULATIONS
SWMF-3a: Forebay Length to Width Ratio Calculation

Project Name: Fruitland Winona BSS Area #3
Municipality: City of Hamilton
Project No.: 12-062W
Date: 14-Jan-20

Prepared by: J.L
Checked by: AF
Submission #: 3rd Submission

POND 3 (East of Lewis)



*Flow path shown in red

Total Provided Permanent Pool Volume= **4565** m^3
Required Permanent Pool Volume= **3387** m^3

	Length:	Width	Criteria	Provided Ratio
Forebay	**56.0m**	**21.0m**	2.00:1	**2.67 : 1**
Wet Cell	**96.0m**	**24.8m**		**3.87 : 1**
Weighted Average			3.00:1	**3.32 : 1**

SWM POND DESIGN CALCULATIONS
SWMF-3: Sediment Forebay Sizing

Project Name: Fruitland Winona BSS Area #3
Municipality: City of Hamilton
Project No.: 12-062W
Date: 14-Jan-20

Prepared by: J.L
Checked by: AF
Submission #: 3rd Submission

POND 3 (East of Lewis)

Drainage Area (ha)	
HW	17.05

Settling Calcs (MOECC 2003, Wet Pond)
$Dist_R = (rQ_p/V_s)^{0.5}$ *(MOECC Eq'n 4.5)*

Parameter	HW		Description
r =	2.67		*Proposed length-to-width ratio of forebay*
Q_p =	0.014		*Proposed Extended Detention Release Rate (m3/s)*
V_s =	0.0003		*Settling velocity (0.0003 m/s most cases)*
$Dist_R$ =	11		*Forebay Length Required (m)*
$Dist_P$ =	56		*Forebay Length Provided (m)*

SUFFICIENT FOREBAY LENGTH PROVIDED.

Note: Forebay should not exceed one-third of pond surface area

Minor and Major system flow approximation (from Design Sheet)			
Area (ha)		Q (m^3/s)	Q100 (m^3/s)
HW	17.05	2.37	4.42

Dispersion Length (MOECC 2003, Wet Pond)
$Dist_R = 8*Q/d/V_r$ *(MOECC Eq'n 4.6)*

Parameter	HW		Description
Q	4.42		*Major System inlet flowrate (m^3/s)*
d	1.75		*Depth of permanent pool in forebay (m)*
V_r	0.5		*Desired velocity of forebay (m/s)*
$Dist_R$	40		*Dispersion Length Required (m)*
$Dist_P$	56		*Dispersion Length Provided (m)*

SUFFICIENT FOREBAY LENGTH PROVIDED

SWM DESIGN CALCULATIONS
SWMF-5 EMERGENCY SPILLWAY WEIR

Project Name:	Fruitland Winona BSS Area #3	**Prepared by:**	J.L
Municipality:	City of Hamilton	**Checked by:**	AF
Project No.:	12-062W	**Submission #:**	3rd Submission
Date:	14-Jan-20		

POND 3 (East of Lewis)

Input Parameters:

Side Slope, S_1	10	:1 (2%)
Side Slope, S_2	10	:1 (2%)
Spillway Invert	89.6	m
Water Level	89.9	m
Flow Depth, H	0.30	m
Bottom Width, B:	15.0	m

Weir equation: $Q = BxC_dxH^{3/2} + SxC_dxH^{5/2}$

$C_d = 1.5$

where:
Q=flow rate (m3/s)
H= head on the weir (m)
B=width of the weir (m)
S = side slopes of weir (H:V)

Computed Values:

Capacity, Q at 89.9m	**4.44**	m^3/s
Emergency Flow Required via Spillway	**3.61**	m^3/s

The proposed emergency spillway provides sufficient capacity.

SWM DESIGN CALCULATIONS
SWMF-6 DECANTING AREA

Project Name: Fruitland Winona BSS Area #3
Municipality: City of Hamilton
Project No.: 12-062W
Date: 14-Jan-20

Prepared by: J.L
Checked by: AF
Submission #: 3rd Submission

POND 3 (East of Lewis)

Drainage Area to POND 3 (East of Lewis)	18.56	ha	
Imperviousness=	69%		
Required Protection level=	70	% TSS Removal (Normal)	
Required storage volume for Normal level of protection (70% TSS Removal)=	89	m3/ha	*(MOECC-Table 3.2)*
Required permanent storage volume for Normal level of protection (70% TSS Removal)=	1657	m3	*(SWMF-1)*
Provided permanent pool storage volume	4565	m3	*(SWMF-1)*
Required storage volume for Basic level of protection (60% TSS Removal)=	44	m3/ha	*(MOECC-Table 3.2)*
Required storage volume for Basic level of protection (60% TSS Removal)=	819	m3	
Required Storage Volume for 65% TSS Removal=	67	m3/ha	
Required Storage Volume for 65% TSS Removal=	1238	m3	
Storage volume equivalent to 5% TSS reduction=	**3327**	m3	
Annual Sediment Loading (from MOE-Table 6.3)=	2.76	m3/ha/yr based on %IMP	
	51.29	m3/yr	

Theoretical Cleanout Frequency= 65 yrs

Volume provided in the decanting area=	594	m3
Maximum Depth of Decanting Area=	1	m
Slope in Decanting Area=	4	:1

Proposed Cleanout Frequency= (Annual sediment loading/Storage volume)
11.6 yrs

APPENDIX H-2
Figure 7.1 Stormwater Management Strategy

KEY MAP

Legend

- Study Area
- SCUBE Development Lands
- Watercourse
- Proposed Lewis Road Channel
- Possible Watercourse 7.2 Diversion Channel
- Sand/Gravel Soils

Proposed Landuse

- Residential
- Employment

NOTES:

0 125 250 500 750
Meters

Aquafor Beech Limited

77 James Street North
Hamilton ON
L8R 2K3
Phone: (905) 546-2424

Hamilton

SCUBE East Subwatershed Study
Stormwater Management Strategy

FIGURE No. 7.1

DATE: November 2010

APPENDIX I
SANITARY SEWER DESIGN SHEETS

I-1 Sanitary Sewer Design Sheets

urbantech

SANITARY SEWER DESIGN SHEET

[EAST]

Branthaven-Fruitland Winona

[City of Hamilton]

PROJECT DETAILS

Project No: 12-062W
Date: [19-08-12]
Designed by: [RAM]
Checked by: [RBTM]

DESIGN CRITERIA

Min Diameter =	250	mm	Avg. Domestic Flow =	360.0	l/c/d
Mannings 'n'=	0.015		Infiltration =	0.600	l/s/ha
Min. Velocity =	0.75	m/s	Max. Peaking Factor =	5.00	
Max. Velocity =	2.75	m/s	Min. Peaking Factor=	2.00	
Factor of Safety =	15	%			

NOMINAL PIPE SIZE USED

				RESIDENTIAL							COMMERCIAL/INDUSTRIAL/INSTITUTIONAL						FLOW CALCULATIONS							PIPE DATA					
AREA ID	STREET	FROM MH	TO MH	AREA (ha)	ACC. AREA (ha)	UNITS (#)	DENISTY (P/ha)	DENSITY (P/unit)	POP	ACCUM. RES. POP.	AREA (ha)	ACC. AREA (ha)	EQUIV. POP. (p/ha)	FLOW RATE (l/s/ha)	EQUIV. POP.	ACCUM. EQUIV. POP.	INFILTRATION (l/s)	TOTAL ACCUM. POP.	PEAKING FACTOR	RES. FLOW (l/s)	COMM. FLOW (l/s)	ACCUM. COMM. FLOW (l/s)	TOTAL FLOW (l/s)	SLOPE (%)	PIPE DIAMETER (mm)	FULL FLOW CAPACITY (l/s)	FULL FLOW VELOCITY (m/s)	ACTUAL VELOCITY (m/s)	PERCENT FULL (%)
8	STREET 'F'	MH13A-E	MH12A-E	1.10	1.10		60		66	66							0.7	66	5.00	1.4			2.0	1.00	250	51.5	1.05	0.49	4%
9	STREET 'G'	MH14A-E	MH12A-E	0.58	0.58		60		35	35							0.3	35	5.00	0.7			1.1	1.00	250	51.5	1.05	0.37	2%
10	STREET 'F-K'	MH15A-E	MH12A-E	1.04	1.04		60		63	63							0.6	63	5.00	1.3			1.9	1.00	250	51.5	1.05	0.49	4%
11	STREET 'F'	MH36A-E	MH12A-E	0.54	0.54		60		33	33							0.3	33	5.00	0.7			1.0	1.00	250	51.5	1.05	0.37	2%
7	COLLECTOR ROAD 'D'	MH12A-E	MH8A-E	1.23	4.49		60		74	271							2.7	271	5.00	5.6			8.3	0.50	250	36.4	0.74	0.59	23%
12	STREET 'H'	MH16A-E	MH8A-E	0.35	0.35		60		21	21							0.2	21	5.00	0.4			0.6	1.00	250	51.5	1.05	0.33	1%
13	STREET 'L'	MH37A-E	MH8A-E	0.24	0.24		60		15	15							0.1	15	5.00	0.3			0.5	1.00	250	51.5	1.05	0.27	1%
17	STREET 'E'	MH22A-E	MH21A-E	1.27	1.27		60		77	77							0.8	77	5.00	1.6			2.4	1.00	250	51.5	1.05	0.51	5%
16	STREET 'A'	MH21A-E	MH19A-E	0.79	2.06		60		48	125							1.2	125	5.00	2.6			3.8	1.00	250	51.5	1.05	0.60	7%
15	STREET 'C'	MH18A-E	MH19A-E	1.27	1.27		60		77	77							0.8	77	5.00	1.6			2.4	1.00	250	51.5	1.05	0.51	5%
14	STREET 'B'	MH19A-E	MH8A-E	1.13	4.46		60		68	270							2.7	270	5.00	5.6			8.3	0.50	250	36.4	0.74	0.59	23%
6	COLLECTOR ROAD 'D'	MH8A-E	MH5A-E	0.58	10.12		60		35	612							6.1	612	5.00	12.8			18.8	0.50	250	36.4	0.74	0.73	52%
18	STREET 'A'	MH35A-E	MH5A-E	1.48	1.48		60		89	89							0.9	89	5.00	1.9			2.7	1.00	250	51.5	1.05	0.55	5%
21	WINONA ROAD	MH25A-E	MH23A-E	3.03	3.03		83		252	252							1.8	252	5.00	5.3			7.1	0.50	250	36.4	0.74	0.56	19%
20	STREET 'I'	MH24A-E	MH23A-E	1.73	1.73		60		104	104							1.0	104	5.00	2.2			3.2	1.00	250	51.5	1.05	0.57	6%
19	STREET 'J'	MH23A-E	MH5A-E	0.28	5.04		60		17	373							3.0	373	5.00	7.8			10.8	1.00	250	51.5	1.05	0.81	21%
5	COLLECTOR ROAD 'D'	MH5A-E	MH4A-E	0.30	16.94					1074							10.2	1074	4.93	22.1			32.2	0.50	300	59.3	0.84	0.83	54%
EX2	BARTON STREET	EX.MH6A	MH4A-E	1.35	1.35		60		81	81							0.8	81	5.00	1.7			2.5	1.00	300	83.8	1.19	0.50	3%
4	BARTON STREET	MH4A-E	MH3A-E	0.05	18.34					1155							11.0	1155	4.86	23.4			34.4	0.50	450	174.7	1.10	0.85	20%
3	BARTON STREET	MH3A-E	MH2A-E	1.80	20.14		250		450	1605							12.1	1605	4.55	30.4			42.5	0.50	450	174.7	1.10	0.89	24%
2	BARTON STREET	MH2A-E	MH1A-E	1.22	21.36		250		305	1910							12.8	1910	4.39	35.0			47.8	0.50	450	174.7	1.10	0.91	27%
1/EX 1	BARTON STREET	MH1A-E	EX.SMH007A	0.64	22.00		250		160	2070	3.00	3.00	250		750	750	15.0	2820	4.06	47.7			62.7	0.50	450	174.7	1.10	0.99	36%

Urbantech Consulting, A Division of Leighton-Sytsma Ltd.
2030 Bristol Circle, Suite 105 Oakvile, Ontario L6H 6P5
TEL: 905.829.8818 FAX: 905.829.4804
www.urbantech.com

F:\Projects\12-062W (Branthaven-Fruitland Winona)\Design\Sanitary\12-062W SAN (EAST) (19-08-12):SAN

urbantech

SANITARY SEWER DESIGN SHEET

[EAST OPTION 2]

Branthaven-Fruitland Winona

[City of Hamilton]

PROJECT DETAILS

Project No: 12-062W
Date: [19-08-12]
Designed by: [RAM]
Checked by: [RBTM]

DESIGN CRITERIA

Min Diameter = 250 mm
Mannings 'n'= 0.015
Min. Velocity = 0.75 m/s
Max. Velocity = 2.75 m/s
Factor of Safety = 15 %

Avg. Domestic Flow = 360.0 l/c/d
Infiltration = 0.600 l/s/ha
Max. Peaking Factor = 5.00
Min. Peaking Factor= 2.00

NOMINAL PIPE SIZE USED

				RESIDENTIAL							COMMERCIAL/INDUSTRIAL/INSTITUTIONAL						FLOW CALCULATIONS							PIPE DATA						
AREA ID	STREET	FROM MH	TO MH	AREA (ha)	ACC. AREA (ha)	UNITS (#)	DENISTY (P/ha)	DENSITY (P/unit)	POP	ACCUM. RES. POP.	AREA (ha)	ACC. AREA (ha)	EQUIV. POP. (p/ha)	FLOW RATE (l/s/ha)	EQUIV. POP.	ACCUM. EQUIV. POP.	INFILTRATION (l/s)	TOTAL ACCUM. POP.	PEAKING FACTOR	RES. FLOW (l/s)	COMM. FLOW (l/s)	ACCUM. COMM. FLOW (l/s)	TOTAL FLOW (l/s)	SLOPE (%)	PIPE DIAMETER (mm)	FULL FLOW CAPACITY (l/s)	FULL FLOW VELOCITY (m/s)	ACTUAL VELOCITY (m/s)	PERCENT FULL (%)
8	STREET 'F'	MH13A-E	MH12A-E	1.10	1.10		150		165	165							0.7	165	5.00	3.4			4.1	1.00	250	51.5	1.05	0.62	8%
9	STREET 'G'	MH14A-E	MH12A-E	0.58	0.58		150		87	87							0.3	87	5.00	1.8			2.2	1.00	250	51.5	1.05	0.49	4%
10	STREET 'F-K'	MH15A-E	MH12A-E	1.04	1.04		150		156	156							0.6	156	5.00	3.3			3.9	1.00	250	51.5	1.05	0.62	8%
11	STREET 'F'	MH36A-E	MH12A-E	0.54	0.54		150		81	81							0.3	81	5.00	1.7			2.0	1.00	250	51.5	1.05	0.49	4%
7	COLLECTOR ROAD 'D'	MH12A-E	MH8A-E	1.23	4.49		110		136	625							2.7	625	5.00	13.0			15.7	0.50	250	36.4	0.74	0.69	43%
12	STREET 'H'	MH16A-E	MH8A-E	0.35	0.35		110		39	39							0.2	39	5.00	0.8			1.0	1.00	250	51.5	1.05	0.37	2%
13	STREET 'L'	MH37A-E	MH8A-E	0.24	0.24		110		27	27							0.1	27	5.00	0.6			0.7	1.00	250	51.5	1.05	0.33	1%
17	STREET 'E'	MH22A-E	MH21A-E	1.27	1.27		124		158	158							0.8	158	5.00	3.3			4.1	1.00	250	51.5	1.05	0.62	8%
16	STREET 'A'	MH21A-E	MH19A-E	0.79	2.06		110		87	245							1.2	245	5.00	5.1			6.3	1.00	250	51.5	1.05	0.70	12%
15	STREET 'C'	MH18A-E	MH19A-E	1.27	1.27		110		140	140							0.8	140	5.00	2.9			3.7	1.00	250	51.5	1.05	0.60	7%
14	STREET 'B'	MH19A-E	MH8A-E	1.13	4.46		110		125	510							2.7	510	5.00	10.6			13.3	0.50	250	36.4	0.74	0.67	36%
6	COLLECTOR ROAD 'D'	MH8A-E	MH5A-E	0.58	10.12		110		64	1265							6.1	1265	4.77	25.1			31.2	0.50	300	59.3	0.84	0.83	53%
18	STREET 'A'	MH35A-E	MH5A-E	1.48	1.48		201		298	298							0.9	298	5.00	6.2			7.1	1.00	250	51.5	1.05	0.73	14%
21	WINONA ROAD	MH25A-E	MH23A-E	3.03	3.03		83		252	252							1.8	252	5.00	5.3			7.1	0.50	250	36.4	0.74	0.56	19%
20	STREET 'I'	MH24A-E	MH23A-E	1.73	1.73		110		191	191							1.0	191	5.00	4.0			5.0	1.00	250	51.5	1.05	0.67	10%
19	STREET 'J'	MH23A-E	MH5A-E	0.28	5.04		110		31	474							3.0	474	5.00	9.9			12.9	1.00	250	51.5	1.05	0.85	25%
5	COLLECTOR ROAD 'D'	MH5A-E	MH4A-E	0.30	16.94					2037							10.2	2037	4.34	36.8			47.0	0.50	375	107.4	0.97	0.90	44%
EX2	BARTON STREET	EX.MH6A	MH4A-E	1.35	1.35		110		149	149							0.8	149	5.00	3.1			3.9	1.00	300	83.8	1.19	0.58	5%
4	BARTON STREET	MH4A-E	MH3A-E	0.05	18.34					2186							11.0	2186	4.28	38.9			50.0	0.50	450	174.7	1.10	0.93	29%
3	BARTON STREET	MH3A-E	MH2A-E	1.80	20.14		250		450	2636							12.1	2636	4.12	45.2			57.3	0.50	450	174.7	1.10	0.96	33%
2	BARTON STREET	MH2A-E	MH1A-E	1.22	21.36		250		305	2941							12.8	2941	4.03	49.4			62.2	0.50	450	174.7	1.10	0.99	36%
1/EX 1	BARTON STREET	MH1A-E	EX.SMH007A	0.64	22.00		250		160	3101	3.00	3.00	250		750	750	15.0	3851	3.82	61.3			76.3	0.50	450	174.7	1.10	1.02	44%

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F:\Projects\12-062W (Branthaven-Fruitland Winona)\Design\Sanitary\12-062W SAN (EAST) (19-08-12) OPTION 2:SAN

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SANITARY SEWER DESIGN SHEET
[WEST] OPTION 1
[Branthaven-Fruitland Winona]
[City of Hamilton]

PROJECT DETAILS	
Project No:	12-062W
Date:	[19-12-17]
Designed by:	[RAM]
Checked by:	[RBTM]

DESIGN CRITERIA					
Min Diameter =	250	mm	Avg. Domestic Flow =	360.0	l/c/d
Mannings 'n'=	0.015		Infiltration =	0.600	l/s/ha
Min. Velocity =	0.75	m/s	Max. Peaking Factor =	5.00	
Max. Velocity =	2.75	m/s	Min. Peaking Factor=	2.00	
Factor of Safety =	15	%			

NOMINAL PIPE SIZE USED

				RESIDENTIAL							COMMERCIAL/INDUSTRIAL/INSTITUTIONAL						FLOW CALCULATIONS							PIPE DATA					
AREA ID	STREET	FROM MH	TO MH	AREA (ha)	ACC. AREA (ha)	UNITS (#)	DENISTY (P/ha)	DENSITY (P/unit)	POP	ACCUM. RES. POP.	AREA (ha)	ACC. AREA (ha)	EQUIV. POP. (p/ha)	FLOW RATE (l/s/ha)	EQUIV. POP.	ACCUM. EQUIV. POP.	INFILTRATION (l/s)	TOTAL ACCUM. POP.	PEAKING FACTOR	RES. FLOW (l/s)	COMM. FLOW (l/s)	ACCUM. COMM. FLOW (l/s)	TOTAL FLOW (l/s)	SLOPE (%)	PIPE DIAMETER (mm)	FULL FLOW CAPACITY (l/s)	FULL FLOW VELOCITY (m/s)	ACTUAL VELOCITY (m/s)	PERCENT FULL (%)
WEST CONDO	STREET 'P'	WEST CONDO	MH23A-W	4.33	4.33		110		477	477							2.6	477	5.00	9.9			12.5	1.00	250	51.5	1.05	0.85	24%
COMM 1	STREET 'P'	COMM 1A	MH23A-W								0.23	0.23	250		58	58	0.1	58	5.00	1.2			1.3	1.00	250	51.5	1.05	0.41	3%
PARK 1	STREET 'P'	PARK 1A	MH23A-W	2.94	2.94		25		74	74							1.8	74	5.00	1.5			3.3	1.00	250	51.5	1.05	0.57	6%
8	STREET 'P'	MH23A-W	MH13A-W	1.77	9.04		60		107	658		0.23				58	5.6	716	5.00	14.9			20.5	0.50	250	36.4	0.74	0.75	56%
7	COLLECTOR ROAD 'E' WEST	MH14A-W	MH13A-W	0.81	0.81		60		49	49							0.5	49	5.00	1.0			1.5	1.00	250	51.5	1.05	0.44	3%
9	STREET 'O'	MH17A-W	MH13A-W	0.44	0.44		60		27	27							0.3	27	5.00	0.6			0.8	0.50	250	36.4	0.74	0.29	2%
6	COLLECTOR ROAD 'E' WEST	MH13A-W	MH12A-W	0.18	10.47					734		0.23				58	6.4	792	5.00	16.5			22.9	0.50	250	36.4	0.74	0.76	63%
19	COLLECTOR ROAD 'D' WEST	MH15A-W	MH24A-W	0.58	0.58		60		35	35							0.3	35	5.00	0.7			1.1	1.00	250	51.5	1.05	0.37	2%
18	COLLECTOR ROAD 'D' WEST	MH24A-W	MH12A-W	0.75	1.33		60		45	80							0.8	80	5.00	1.7			2.5	0.50	250	36.4	0.74	0.42	7%
16	STREET 'N'	MH24A-W(1)	MH12A-W	1.42	1.42		60		86	86							0.9	86	5.00	1.8			2.6	0.50	250	36.4	0.74	0.42	7%
		CONDO 2.1A	MH17A-W(1)	0.83	0.83		110		92	92							0.5	92	5.00	1.9			2.4	1.00	250	51.5	1.05	0.51	5%
		CONDO 2.2A	MH17A-W(1)	0.59	0.59		110		65	65							0.4	65	5.00	1.4			1.7	1.00	250	51.5	1.05	0.47	3%
21	STREET 'O'	MH17A-W(1)	MH16A-W	0.57	1.99		60		35	192							1.2	192	5.00	4.0			5.2	1.00	250	51.5	1.05	0.67	10%
22	STREET 'O'	MH18A-W	MH16A-W	1.47	1.47		60		89	89							0.9	89	5.00	1.9			2.7	1.00	250	51.5	1.05	0.55	5%
20	STREET 'M'	MH16A-W	MH15A-W	0.14	3.60					281							2.2	281	5.00	5.9			8.0	0.50	250	36.4	0.74	0.59	22%
23	STREET 'O'	MH21A-W	MH19A-W	0.28	0.28		60		17	17							0.2	17	5.00	0.4			0.5	1.00	250	51.5	1.05	0.27	1%
25	COLLECTOR ROAD 'D' WEST	MH20A-W	MH19A-W	0.44	0.44		60		27	27							0.3	27	5.00	0.6			0.8	0.50	250	36.4	0.74	0.29	2%
		PARK 2A	MH19A-W	3.00	3.00		25		75	75							1.8	75	5.00	1.6			3.4	1.00	250	51.5	1.05	0.60	7%
24	COLLECTOR ROAD 'D' WEST	MH19A-W	MH15A-W	1.12	4.84		60		68	187							2.9	187	5.00	3.9			6.8	0.50	250	36.4	0.74	0.56	19%
17	STREET 'M'	MH15A-W	MH12-A	2.41	10.85		60		145	613							6.5	613	5.00	12.8			19.3	0.50	250	36.4	0.74	0.73	53%
5	COLLECTOR ROAD 'E' WEST	MH12A-W	MH9A-W	1.48	14.70		60		89	989		0.23				58	9.0	1047	4.95	21.6			30.6	0.50	300	59.3	0.84	0.83	52%
15	STREET 'L'	MH22A-W	MH9A-W	1.19	1.19		60		72	72							0.7	72	5.00	1.5			2.2	0.50	250	36.4	0.74	0.40	6%
4	COLLECTOR ROAD 'E' WEST	MH9A-W	MH5A-W	0.35	16.24					1061		0.23				58	9.9	1119	4.89	22.8			32.7	0.50	375	107.4	0.97	0.85	30%
1/1.1	BARTON STREET	MH5A-W	EX.SMH007A	3.21	19.45		110		354	1415	4.23	4.46	125		529	587	14.3	2002	4.35	36.3			50.6	0.50	450	174.7	1.10	0.93	29%
EX 15	HIGHWAY 8	EX.MH30	EX.MH28	3.44	3.44				85	85							2.1	85	5.00	1.8			3.8	1.00	250	51.5	1.05	0.60	7%
EX 14	HIGHWAY 8	EX.MH28	EX.MH25	9.70	13.14				70	155							7.9	155	5.00	3.2			11.1	0.50	300	59.3	0.84	0.64	19%
		COMM2A	EX.MH25								0.92	0.92	250		230	230	0.6	230	5.00	4.8			5.3	1.00	250	51.5	1.05	0.67	10%
EX 13	HIGHWAY 8	EX.MH25	EX.MH23	11.55	24.69				70	225		0.92				230	15.4	455	5.00	9.5			24.8	0.50	375	107.4	0.97	0.77	23%

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F:\Projects\12-062W (Branthaven-Fruitland Winona)\Design\Sanitary\12-062W SAN (WEST):SAN

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AREA ID	STREET	FROM MH	TO MH	RESIDENTIAL AREA (ha)	ACC. AREA (ha)	UNITS (#)	DENISTY (P/ha)	DENSITY (P/unit)	POP	ACCUM. RES. POP.	COMMERCIAL/INDUSTRIAL/INSTITUTIONAL AREA (ha)	ACC. AREA (ha)	EQUIV. POP. (p/ha)	FLOW RATE (l/s/ha)	EQUIV. POP.	ACCUM. EQUIV. POP.	FLOW CALCULATIONS INFILTRATION (l/s)	TOTAL ACCUM. POP.	PEAKING FACTOR	RES. FLOW (l/s)	COMM. FLOW (l/s)	ACCUM. COMM. FLOW (l/s)	TOTAL FLOW (l/s)	PIPE DATA SLOPE (%)	PIPE DIAMETER (mm)	FULL FLOW CAPACITY (l/s)	FULL FLOW VELOCITY (m/s)	ACTUAL VELOCITY (m/s)	PERCENT FULL (%)
		COMM3A	EX.MH23								0.47	0.47	250		118	118	0.3	118	5.00	2.5			2.7	1.00	250	51.5	1.05	0.55	5%
EX 12	HIGHWAY 8	EX.MH23	EX.MH10	16.50	41.19				75	300		1.39				348	25.5	648	5.00	13.5			39.0	0.50	375	107.4	0.97	0.88	36%
EX 11	LEWIS ROAD	EX.MH11	EX.MH10	7.80	7.80				120	120							4.7	120	5.00	2.5			7.2	0.60	300	64.9	0.92	0.61	11%
EX 10		HWY 8	EX.MH10	20.45	20.45				70	70							12.3	70	5.00	1.5			13.7	0.50	250	36.4	0.74	0.67	38%
EX 5	LEWIS ROAD	EX.MH10	EX.MH9	0.66	70.10		60		40	530		1.39				348	42.9	878	5.00	18.3			61.2	0.60	450	191.4	1.20	1.05	32%
EX 6	LEWIS ROAD	EX.MH9	EX.MH8	0.84	70.94		60		51	581		1.39				348	43.4	929	5.00	19.4			62.8	0.60	450	191.4	1.20	1.05	33%
EX 7	LEWIS ROAD	EX.MH8	EX.SMH005A	1.07	72.01		60		65	646		1.39				348	44.0	994	5.00	20.7			64.7	0.60	450	191.4	1.20	1.05	34%
EX 8	LEWIS ROAD	EX.SMH005A	EX.SMH006A	0.52	72.53		60		32	678		1.39				348	44.4	1026	4.97	21.3			65.6	0.82	450	223.8	1.41	1.20	29%
EX 9	LEWIS ROAD	EX.SMH006A	EX.SMH007A		72.53					678	4.13	5.52	125		517	865	46.8	1543	4.58	29.5			76.3	1.02	450	249.6	1.57	1.37	31%
	BARTON STREET	EAST	EX.SMH007A	25.00	25.00				2820	2820							15.0	2820	4.06	47.7			62.7		450				
EX 0	LEWIS ROAD	EX.SMH007A	EX.SMH010A	10.10	127.08				150	5063		9.98				1452	82.2	6515	3.44	93.3			175.5	0.40	600	336.6	1.19	1.18	52%
		ARVIN AVE	EX.SMH010A	16.91	16.91				3069	3069							6.8	3069	4.00	51.1			57.9		600				
	LEWIS ROAD	EX.SMH010A	SOUTH LEWIS		143.99					8132		9.98				1452	92.4	9584	3.18	127.1			219.4	0.40	600	336.6	1.19	1.25	65%

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SANITARY SEWER DESIGN SHEET

[WEST] OPTION 2

[Branthaven-Fruitland Winona]

[City of Hamilton]

PROJECT DETAILS

Project No: 12-062W
Date: [19-12-17]
Designed by: [RAM]
Checked by: [RBTM]

DESIGN CRITERIA

Min Diameter = 250 mm
Mannings 'n'= 0.015
Min. Velocity = 0.75 m/s
Max. Velocity = 2.75 m/s
Factor of Safety = 25 %

Avg. Domestic Flow = 360.0 l/c/d
Infiltration = 0.600 l/s/ha
Max. Peaking Factor = 5.00
Min. Peaking Factor= 2.00

NOMINAL PIPE SIZE USED

				RESIDENTIAL							COMMERCIAL/INDUSTRIAL/INSTITUTIONAL						FLOW CALCULATIONS							PIPE DATA						
AREA ID	STREET	FROM MH	TO MH	AREA (ha)	ACC. AREA (ha)	UNITS (#)	DENISTY (P/ha)	DENSITY (P/unit)	POP	ACCUM. RES. POP.	AREA (ha)	ACC. AREA (ha)	EQUIV. POP. (p/ha)	FLOW RATE (l/s/ha)	EQUIV. POP.	ACCUM. EQUIV. POP.	INFILTRATION (l/s)	TOTAL ACCUM. POP.	PEAKING FACTOR	RES. FLOW (l/s)	COMM. FLOW (l/s)	ACCUM. COMM. FLOW (l/s)	TOTAL FLOW (l/s)	SLOPE (%)	PIPE DIAMETER (mm)	FULL FLOW CAPACITY (l/s)	FULL FLOW VELOCITY (m/s)	ACTUAL VELOCITY (m/s)	PERCENT FULL (%)
WEST CONDO	STREET 'P'	WEST CONDO	MH23A-W	4.33	4.33		150		650	650							2.6	650	5.00	13.5			16.1	1.00	250	51.5	1.05	0.91	31%
COMM 1	STREET 'P'	COMM 1A	MH23A-W								0.23	0.23	250		58	58	0.1	58	5.00	1.2			1.3	1.00	250	51.5	1.05	0.41	3%
PARK 1	STREET 'P'	PARK 1A	MH23A-W	2.94	2.94		25		74	74							1.8	74	5.00	1.5			3.3	1.00	250	51.5	1.05	0.57	6%
8	STREET 'P'	MH23A-W	MH13A-W	1.77	9.04		142		252	976		0.23				58	5.6	1034	4.97	21.4			27.0	0.50	250	36.4	0.74	0.79	74%
7	COLLECTOR ROAD 'E' WEST	MH14A-W	MH13A-W	0.81	0.81		150		122	122							0.5	122	5.00	2.5			3.0	1.00	250	51.5	1.05	0.57	6%
9	STREET 'O'	MH17A-W	MH13A-W	0.44	0.44		150		66	66							0.3	66	5.00	1.4			1.6	0.50	250	36.4	0.74	0.36	4%
6	COLLECTOR ROAD 'E' WEST	MH13A-W	MH12A-W	0.18	10.47					1164		0.23				58	6.4	1222	4.80	24.5			30.9	0.50	300	59.3	0.84	0.83	52%
19	COLLECTOR ROAD 'D' WEST	MH15A-W	MH24A-W	0.58	0.58		150		87	87							0.3	87	5.00	1.8			2.2	1.00	250	51.5	1.05	0.49	4%
18	COLLECTOR ROAD 'D' WEST	MH24A-W	MH12A-W	0.75	1.33		150		113	200							0.8	200	5.00	4.2			5.0	0.50	250	36.4	0.74	0.52	14%
16	STREET 'N'	MH24A-W(1)	MH12A-W	1.42	1.42		110		157	157							0.9	157	5.00	3.3			4.1	0.50	250	36.4	0.74	0.49	11%
		CONDO 2.1A	MH17A-W(1)	0.83	0.83		150		125	125							0.5	125	5.00	2.6			3.1	1.00	250	51.5	1.05	0.57	6%
		CONDO 2.2A	MH17A-W(1)	0.59	0.59		150		89	89							0.4	89	5.00	1.9			2.2	1.00	250	51.5	1.05	0.51	4%
21	STREET 'O'	MH17A-W(1)	MH16A-W	0.57	1.99		150		86	300							1.2	300	5.00	6.3			7.4	1.00	250	51.5	1.05	0.73	14%
22	STREET 'O'	MH18A-W	MH16A-W	1.47	1.47		150		221	221							0.9	221	5.00	4.6			5.5	1.00	250	51.5	1.05	0.69	11%
20	STREET 'M'	MH16A-W	MH15A-W	0.14	3.60					521							2.2	521	5.00	10.9			13.0	0.50	250	36.4	0.74	0.67	36%
23	STREET 'O'	MH21A-W	MH19A-W	0.28	0.28		150		42	42							0.2	42	5.00	0.9			1.0	1.00	250	51.5	1.05	0.37	2%
25	COLLECTOR ROAD 'D' WEST	MH20A-W	MH19A-W	0.44	0.44		150		66	66							0.3	66	5.00	1.4			1.6	0.50	250	36.4	0.74	0.36	4%
		PARK 2A	MH19A-W	3.00	3.00		25		75	75							1.8	75	5.00	1.6			3.4	1.00	250	51.5	1.05	0.60	7%
24	COLLECTOR ROAD 'D' WEST	MH19A-W	MH15A-W	1.12	4.84		150		168	351							2.9	351	5.00	7.3			10.2	0.50	250	36.4	0.74	0.63	28%
17	STREET 'M'	MH15A-W	MH12-A	2.41	10.85		110		266	1138							6.5	1138	4.87	23.1			29.6	0.50	300	59.3	0.84	0.83	50%
5	COLLECTOR ROAD 'E' WEST	MH12A-W	MH9A-W	1.48	14.70		110		89	1610		0.23				58	9.0	1668	4.51	31.4			40.3	0.50	300	59.3	0.84	0.88	68%
15	STREET 'L'	MH22A-W	MH9A-W	1.19	1.19		140		167	167							0.7	167	5.00	3.5			4.2	0.50	250	36.4	0.74	0.50	12%
4	COLLECTOR ROAD 'E' WEST	MH9A-W	MH5A-W	0.35	16.24					1777		0.23				58	9.9	1835	4.43	33.9			43.7	0.50	375	107.4	0.97	0.90	41%
1/1.1	BARTON STREET	MH5A-W	EX.SMH007A	3.21	19.45		250		803	2580	4.23	4.46	125		529	587	14.3	3167	3.97	52.4			66.7	0.50	450	174.7	1.10	0.99	38%
EX 15	HIGHWAY 8	EX.MH30	EX.MH28	3.44	3.44				85	85							2.1	85	5.00	1.8			3.8	1.00	250	51.5	1.05	0.60	7%
EX 14	HIGHWAY 8	EX.MH28	EX.MH25	9.70	13.14				70	155							7.9	155	5.00	3.2			11.1	0.50	300	59.3	0.84	0.64	19%
		COMM2A	EX.MH25								0.92	0.92	250		230	230	0.6	230	5.00	4.8			5.3	1.00	250	51.5	1.05	0.67	10%
EX 13	HIGHWAY 8	EX.MH25	EX.MH23	11.55	24.69				70	225		0.92				230	15.4	455	5.00	9.5			24.8	0.50	375	107.4	0.97	0.77	23%

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F:\Projects\12-062W (Branthaven-Fruitland Winona)\Design\Sanitary\12-062W SAN (WEST) OPTION 2:SAN

AREA ID	STREET	FROM MH	TO MH	RESIDENTIAL AREA (ha)	ACC. AREA (ha)	UNITS (#)	DENISTY (P/ha)	DENSITY (P/unit)	POP	ACCUM. RES. POP.	COMMERCIAL/INDUSTRIAL/INSTITUTIONAL AREA (ha)	ACC. AREA (ha)	EQUIV. POP. (p/ha)	FLOW RATE (l/s/ha)	EQUIV. POP.	ACCUM. EQUIV. POP.	FLOW CALCULATIONS INFILTRATION (l/s)	TOTAL ACCUM. POP.	PEAKING FACTOR	RES. FLOW (l/s)	COMM. FLOW (l/s)	ACCUM. COMM. FLOW (l/s)	TOTAL FLOW (l/s)	PIPE DATA SLOPE (%)	PIPE DIAMETER (mm)	FULL FLOW CAPACITY (l/s)	FULL FLOW VELOCITY (m/s)	ACTUAL VELOCITY (m/s)	PERCENT FULL (%)
		COMM3A	EX.MH23								0.47	0.47	250		118	118	0.3	118	5.00	2.5			2.7	1.00	250	51.5	1.05	0.55	5%
EX 12	HIGHWAY 8	EX.MH23	EX.MH10	16.50	41.19				75	300		1.39				348	25.5	648	5.00	13.5			39.0	0.50	375	107.4	0.97	0.88	36%
EX 11	LEWIS ROAD	EX.MH11	EX.MH10	7.80	7.80				120	120							4.7	120	5.00	2.5			7.2	0.60	300	64.9	0.92	0.61	11%
EX 10		HWY 8	EX.MH10	20.45	20.45				70	70							12.3	70	5.00	1.5			13.7	0.50	250	36.4	0.74	0.67	38%
EX 5	LEWIS ROAD	EX.MH10	EX.MH9	0.66	70.10		60		40	530		1.39				348	42.9	878	5.00	18.3			61.2	0.60	450	191.4	1.20	1.05	32%
EX 6	LEWIS ROAD	EX.MH9	EX.MH8	0.84	70.94		60		51	581		1.39				348	43.4	929	5.00	19.4			62.8	0.60	450	191.4	1.20	1.05	33%
EX 7	LEWIS ROAD	EX.MH8	EX.SMH005A	1.07	72.01		60		65	646		1.39				348	44.0	994	5.00	20.7			64.7	0.60	450	191.4	1.20	1.05	34%
EX 8	LEWIS ROAD	EX.SMH005A	EX.SMH006A	0.52	72.53		60		32	678		1.39				348	44.4	1026	4.97	21.3			65.6	0.82	450	223.8	1.41	1.20	29%
EX 9	LEWIS ROAD	EX.SMH006A	EX.SMH007A		72.53					678	4.13	5.52	125		517	865	46.8	1543	4.58	29.5			76.3	1.02	450	249.6	1.57	1.37	31%
	BARTON STREET	EAST	EX.SMH007A	25.00	25.00				3851	3851							15.0	3851	3.82	61.3			76.3		450				
EX 0	LEWIS ROAD	EX.SMH007A	EX.SMH010A	10.10	127.08				150	7259		9.98				1452	82.2	8711	3.24	117.7			199.9	0.40	600	336.6	1.19	1.20	59%
		ARVIN AVE	EX.SMH010A	16.91	16.91				3069	3069							6.8	3069	4.00	51.1			57.9		600				
	LEWIS ROAD	EX.SMH010A	SOUTH LEWIS		143.99					10328		9.98				1452	92.4	11780	3.05	149.9			242.2	0.40	600	336.6	1.19	1.27	72%

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SANITARY SEWER DESIGN SHEET

[WEST] McNeilly OPTION 1

[Branthaven-Fruitland Winona]

[City of Hamilton]

PROJECT DETAILS

Project No: 12-062W
Date: [19-08-12]
Designed by: [RAM]
Checked by: [RBTM]

DESIGN CRITERIA

Min Diameter =	250	mm	Avg. Domestic Flow =	360.0	l/c/d
Mannings 'n'=	0.015		Infiltration =	0.600	l/s/ha
Min. Velocity =	0.75	m/s	Max. Peaking Factor =	5.00	
Max. Velocity =	2.75	m/s	Min. Peaking Factor=	2.00	
Factor of Safety =	15	%			

NOMINAL PIPE SIZE USED

AREA ID	STREET	FROM MH	TO MH	RESIDENTIAL AREA (ha)	ACC. AREA (ha)	UNITS (#)	DENISTY (P/ha)	DENSITY (P/unit)	POP	ACCUM. RES. POP.	COMMERCIAL/INDUSTRIAL/INSTITUTIONAL AREA (ha)	ACC. AREA (ha)	EQUIV. POP. (p/ha)	FLOW RATE (l/s/ha)	EQUIV. POP.	ACCUM. EQUIV. POP.	FLOW CALCULATIONS INFILTRATION (l/s)	TOTAL ACCUM. POP.	PEAKING FACTOR	RES. FLOW (l/s)	COMM. FLOW (l/s)	ACCUM. COMM. FLOW (l/s)	TOTAL FLOW (l/s)	PIPE DATA SLOPE (%)	PIPE DIAMETER (mm)	FULL FLOW CAPACITY (l/s)	FULL FLOW VELOCITY (m/s)	ACTUAL VELOCITY (m/s)	PERCENT FULL (%)
10	COLLECTOR ROAD 'D' WEST	MH33A-W	MH31A-W	1.18	1.18		60		71	71							0.7	71	5.00	1.5			2.2	1.00	250	51.5	1.05	0.49	4%
10.1	COLLECTOR ROAD 'D' WEST	MH32A-W	MH31A-W	1.44	1.44		60		87	87							0.9	87	5.00	1.8			2.7	1.00	250	51.5	1.05	0.55	5%
13.1	STREET 'Q'	MH31A-W	MH30A-W	0.14	2.76					158							1.7	158	5.00	3.3			4.9	1.00	250	51.5	1.05	0.67	10%
13	STREET 'R'	MH30A-W	MH26A-W	1.86	4.62		60		112	270							2.8	270	5.00	5.6			8.4	0.50	250	36.4	0.74	0.59	23%
11	STREET 'S'	MH30A-W(1)	MH29A-W	2.10	2.10		60		126	126							1.3	126	5.00	2.6			3.9	0.50	250	36.4	0.74	0.49	11%
12	STREET 'Q'	MH30A-W(2)	MH29A-W	1.01	1.01		60		61	61							0.6	61	5.00	1.3			1.9	0.50	250	36.4	0.74	0.39	5%
14	STREET 'L'	MH29A-W	MH26A-W	1.51	4.62		60		91	278							2.8	278	5.00	5.8			8.6	0.50	250	36.4	0.74	0.59	23%
14.1	STREET 'R'	MH26A-W	MH25A-W	0.47	9.71		60		29	577							5.8	577	5.00	12.0			17.8	0.50	250	36.4	0.74	0.71	49%
	EASEMENT	MH25A-W	MH7A-W		9.71					577							5.8	577	5.00	12.0			17.8	0.50	250	36.4	0.74	0.71	49%
2/2.1	BARTON STREET	MH8A-W	MH7A-W	2.83	2.83		110		312	312	2.10	2.10	125		263	263	3.0	575	5.00	12.0			14.9	0.50	450	174.7	1.10	0.68	9%
3/3.1	BARTON STREET	MH7A-W	EX.SMH005	0.62	13.16		60		38	927	0.45	2.55	125		57	320	9.4	1247	4.78	24.9			34.3	0.50	450	174.7	1.10	0.85	20%
EX20	McNEILLY	OUTH OF HWY	EX.MH9	14.95	14.95		75		1122	1122							9.0	1122	4.89	22.8			31.8	1.50	250	63.1	1.29	1.27	50%
EX19	McNEILLY	EX.MH9	EX.MH6	3.30	18.25		75		248	1370							11.0	1370	4.69	26.8			37.8	1.50	250	63.1	1.29	1.32	60%
EX18	McNEILLY	EX.MH6	EX.MH3	3.30	21.55		75		248	1618							12.9	1618	4.54	30.6			43.5	0.70	300	70.1	0.99	1.02	62%
EX17	McNEILLY	EX.MH3	EX.SMH005	3.10	24.65		75		233	1851							14.8	1851	4.42	34.1			48.9	0.70	300	70.1	0.99	1.06	70%
EX16	BARTON STREET	WEST BARTON	EX.SMH005	41.10	41.10		80.47		3308	3308							24.7	3308	3.94	54.3			78.9	0.40	450	156.3	0.98	0.97	50%
	McNEILLY	EX.SMH005	ORTH OF BARTO		78.91					6086		2.55				320	48.9	6406	3.45	92.1			140.9	0.18	525	158.1	0.73	0.81	89%

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SANITARY SEWER DESIGN SHEET

[WEST] McNeilly OPTION 2

[Branthaven-Fruitland Winona]

[City of Hamilton]

PROJECT DETAILS

Project No: 12-062W
Date: [19-08-12]
Designed by: [RAM]
Checked by: [RBTM]

DESIGN CRITERIA

Min Diameter = 250 mm
Mannings 'n'= 0.015
Min. Velocity = 0.75 m/s
Max. Velocity = 2.75 m/s
Factor of Safety = 15 %

Avg. Domestic Flow = 360.0 l/c/d
Infiltration = 0.600 l/s/ha
Max. Peaking Factor = 5.00
Min. Peaking Factor= 2.00

NOMINAL PIPE SIZE USED

				RESIDENTIAL							COMMERCIAL/INDUSTRIAL/INSTITUTIONAL						FLOW CALCULATIONS							PIPE DATA					
AREA ID	STREET	FROM MH	TO MH	AREA (ha)	ACC. AREA (ha)	UNITS (#)	DENISTY (P/ha)	DENSITY (P/unit)	POP	ACCUM. RES. POP.	AREA (ha)	ACC. AREA (ha)	EQUIV. POP. (p/ha)	FLOW RATE (l/s/ha)	EQUIV. POP.	ACCUM. EQUIV. POP.	INFILTRATION (l/s)	TOTAL ACCUM. POP.	PEAKING FACTOR	RES. FLOW (l/s)	COMM. FLOW (l/s)	ACCUM. COMM. FLOW (l/s)	TOTAL FLOW (l/s)	SLOPE (%)	PIPE DIAMETER (mm)	FULL FLOW CAPACITY (l/s)	FULL FLOW VELOCITY (m/s)	ACTUAL VELOCITY (m/s)	PERCENT FULL (%)
10	COLLECTOR ROAD 'D' WEST	MH33A-W	MH31A-W	1.18	1.18		150		177	177							0.7	177	5.00	3.7			4.4	1.00	250	51.5	1.05	0.65	9%
10.1	COLLECTOR ROAD 'D' WEST	MH32A-W	MH31A-W	1.44	1.44		150		216	216							0.9	216	5.00	4.5			5.4	1.00	250	51.5	1.05	0.67	10%
13.1	STREET 'Q'	MH31A-W	MH30A-W	0.14	2.76					393							1.7	393	5.00	8.2			9.8	1.00	250	51.5	1.05	0.80	19%
13	STREET 'R'	MH30A-W	MH26A-W	1.86	4.62		121		226	619							2.8	619	5.00	12.9			15.7	0.50	250	36.4	0.74	0.69	43%
11	STREET 'S'	MH30A-W(1)	MH29A-W	2.10	2.10		110		231	231							1.3	231	5.00	4.8			6.1	0.50	250	36.4	0.74	0.55	17%
12	STREET 'Q'	MH30A-W(2)	MH29A-W	1.01	1.01		110		112	112							0.6	112	5.00	2.3			2.9	0.50	250	36.4	0.74	0.44	8%
14	STREET 'L'	MH29A-W	MH26A-W	1.51	4.62		150		227	570							2.8	570	5.00	11.9			14.6	0.50	250	36.4	0.74	0.69	40%
14.1	STREET 'R'	MH26A-W	MH25A-W	0.47	9.71		121		57	1246							5.8	1246	4.78	24.8			30.7	0.50	250	36.4	0.74	0.82	84%
	EASEMENT	MH25A-W	MH7A-W		9.71					1246							5.8	1246	4.78	24.8			30.7	0.50	250	36.4	0.74	0.82	84%
2/2.1	BARTON STREET	MH8A-W	MH7A-W	2.83	2.83		250		708	708	2.10	2.10	125		263	263	3.0	971	5.00	20.2			23.2	0.50	450	174.7	1.10	0.76	13%
3/3.1	BARTON STREET	MH7A-W	EX.SMH005	0.62	13.16		150		93	2047	0.45	2.55	125		57	320	9.4	2367	4.21	41.5			50.9	0.50	450	174.7	1.10	0.93	29%
EX20	McNEILLY	OUTH OF HWY	EX.MH9	14.95	14.95		75		1122	1122							9.0	1122	4.89	22.8			31.8	1.50	250	63.1	1.29	1.27	50%
EX19	McNEILLY	EX.MH9	EX.MH6	3.30	18.25		75		248	1370							11.0	1370	4.69	26.8			37.8	1.50	250	63.1	1.29	1.32	60%
EX18	McNEILLY	EX.MH6	EX.MH3	3.30	21.55		75		248	1618							12.9	1618	4.54	30.6			43.5	0.70	300	70.1	0.99	1.02	62%
EX17	McNEILLY	EX.MH3	EX.SMH005	3.10	24.65		75		233	1851							14.8	1851	4.42	34.1			48.9	0.70	300	70.1	0.99	1.06	70%
EX16	BARTON STREET	WEST BARTON	EX.SMH005	41.10	41.10		80.47		3308	3308							24.7	3308	3.94	54.3			78.9	0.40	450	156.3	0.98	0.97	50%
	McNEILLY	EX.SMH005	ORTH OF BARTO		78.91					7206		2.55				320	48.9	7526	3.34	104.7			153.6	0.18	525	158.1	0.73	0.83	97%

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F:\Projects\12-062W (Branthaven-Fruitland Winona)\Design\Sanitary\12-062W SAN (WEST) (MCNEILLY CONN) OPTION 2:SAN

APPENDIX J
WATERMAIN CALCULATIONS AND REPORT

J-1 Water Servicing Study (WSP, December 2019)

Project No: 181-10203-00

December 16th, 2019

Block 3 BSS Group of Landowners
c/o Urbantech West
2030 Bristol Circle, Suite 201
Oakville, ON, L6H 0H2

Subject:Lower Stoney Creek Block Servicing Study (Water Servicing) – City of Hamilton

Dear Mr. Merwin,

WSP Canada Inc. (WSP) is pleased to present the results of its updated Block Servicing Study for the proposed Lower Stoney Creek Neighbourhood in the City of Hamilton. This revision addressed comments provided by the City of Hamilton, received by WSP in October 2019.

The analysis in this report includes the hydraulic examination of the Average Day, Maximum Day, Peak Hour and Maximum Day plus Fire Flow demand conditions of the development under present (2011), and ultimate buildout (2031) planning horizons. The hydraulic analysis was completed using a WaterGEMs model of the City of Hamilton water distribution network for Pressure District 1 (PD1).

The modeling shows that the development can achieve the hydraulic requirements prescribed by the City of Hamilton, the Ministry of the Environment and Climate Change design criteria and the Fire Underwriters Survey required fire flows.

If you have any questions, please do not hesitate to write or call.

Sincerely,

WSP Canada Inc.

LICENSED PROFESSIONAL ENGINEER
J-L E. DAVIAU
Dec. 16, 2019
PROVINCE OF ONTARIO

Jean-Luc Daviau, M.A.Sc., P.Eng.
Sr. Hydraulic Specialist
Manager, Hydraulics

Antoine Lahaie, B.Eng, EIT
Project Manager, Hydraulics

Comment 1: Include the logic for excluding HA12S002 here or cross reference to where this is documented.

WSP Response: WSP's report included a justification/logic for excluding Hydrant HA12S002 from the analysis. This discussion is part of section 4.2. Urbantech to make sure references to WSP's report are included.

Comment 2: Provide a Diagram showing the recommended upgrades

WSP Response: The recommendations are strictly conceptual in the event that available fire flows need to be increased at a later stage. These "upgrades" were not considered in this analysis and results do not reflect these upgrades. WSP has added figures to section 4.2 showing these possible upgrades.

Comment 3: Include Fire flow of xxx L/s applied in this analysis in the conclusion

WSP Response: The Winona Hills Development had a Required Fire Flow of 217 L/s. Everything outside of this development was not evaluated against a Required Fire Flow. Available Fire Flows were shown throughout the neighborhood for information. Required Fire Flows (in future works) will need to be compared to the Available Fire Flows (in this work) when more details are available. This is discussed in section 2.3

Comment 4: indicate if these conclusions are based on implementation of the recommended upgrades or are exclusive of the recommended upgrades for clarity.

WSP Response: The results in this report do not include the recommended upgrades discussed in section 4.2. See response to comment 2 above. If these upgrades are to be implemented, the analysis will need to be updated accordingly

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TABLES

FIGURES

APPENDICES

1 INTRODUCTION

WSP was retained by The Block 3 BSS Group of Landowners (Client) to perform a Block Servicing Study (BSS) for the proposed development located in the Lower Stoney Creek area of the City of Hamilton. The Lower Stoney Creek Development will neighbour the Winona Hills community, and will be bounded by Highway 8 to the north, McNeilly Road to the east and Barton Street to the south.

The purpose of this report is to examine the water servicing capacity of the proposed neighbourhood, which is estimated to have more than 2,300 low and medium density residential units, local commercial areas, community parks and a storm water management pond. The total servicing area is approximately 64 hectares.

The proposed development is located within Pressure District 1 (PD1) of the City of Hamilton water network. It will be serviced by the existing watermain along Highway 8 (which is 300 mm from McNeilly Road to Lewis Road and then is reduced to a 200mm east of Lewis Road); the 200mm watermain on Barton Street; the 200mm watermain on McNeilly Road and the 150mm watermain on Lewis Road.

The site location is shown on a Google Earth Pro image in **Figure 1** while a Concept Plan of the proposed development site is shown in **Figure 2**. **Figure 3** shows the proposed system layout.

Figure 1 Lower Stoney Creek Development Site Location

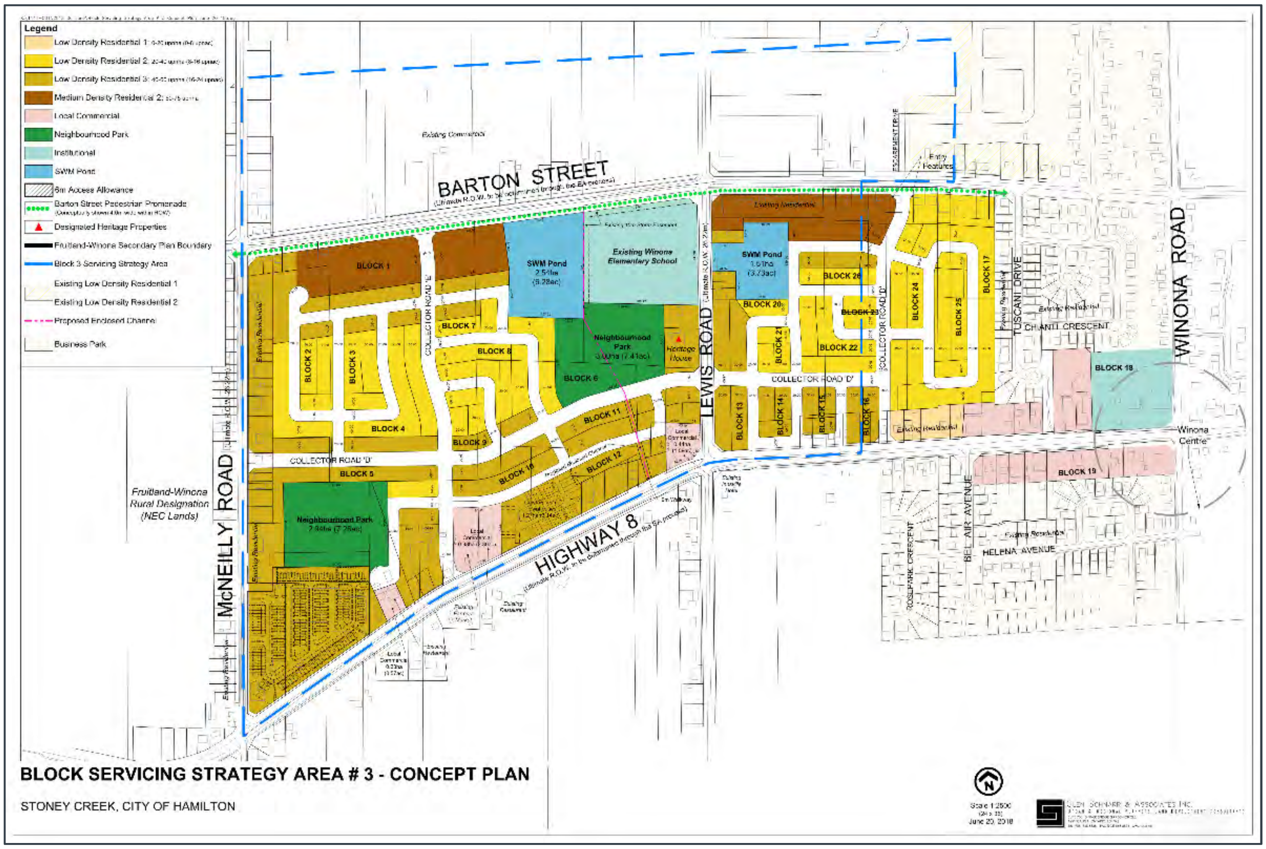


Figure 2 Lower Stoney Creek Concept Plan of the Proposed Development

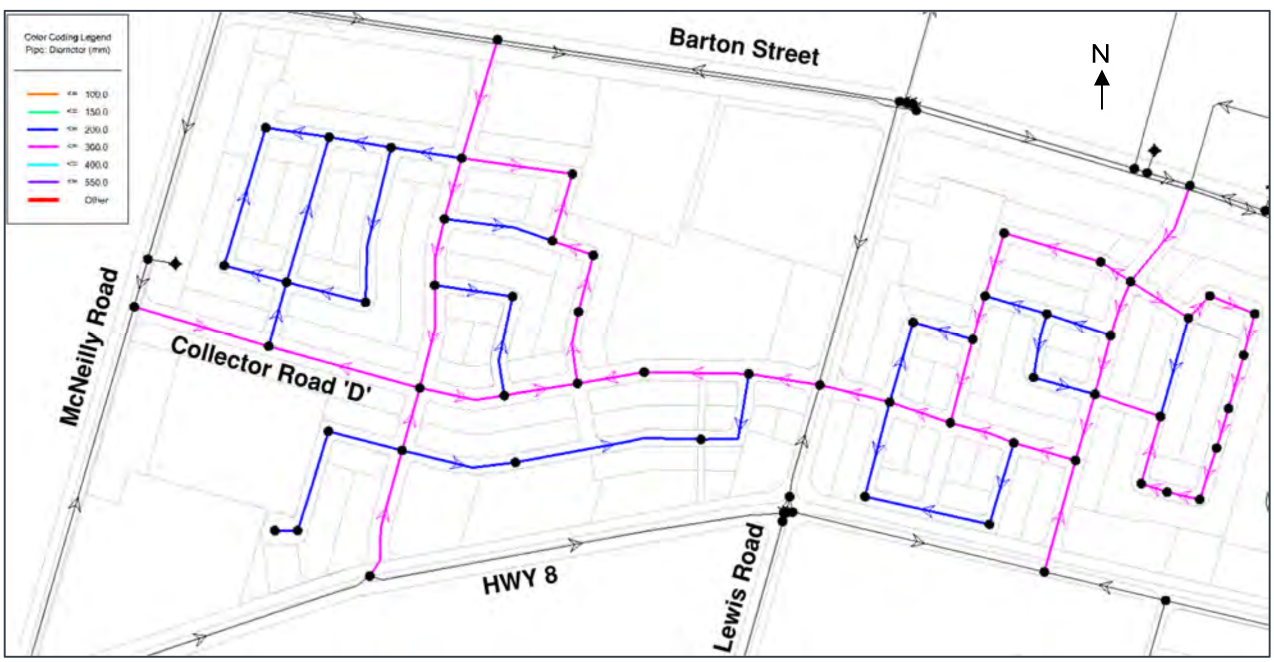


Figure 3 Proposed Water Distribution System Layout with Proposed Pipe Diameters

2 DESIGN CRITERIA

2.1 WATER DEMANDS

This proposed development in the Lower Stoney Creek area will be made up of multiple planning zones with various development densities. Each of these planning zones are identified and were taken from the Lower Stoney Creek Concept Plan drawing provided by Urbantech. The plan includes:

- Low Density Residential 1; 0-20 upnha
- Low Density Residential 2; 20-40 upnha
- Low Density Residential 3; 40-60 upnha
- Medium Density Residential 2; 60-75 upnha
- Local Commercial
- Local Institutional
- Park
- SWM Pond

Demands for the Lower Stoney Creek Development were calculated using criteria from the City of Hamilton's Engineering Guidelines for Servicing Land under Development Applications, December 2012. Populations were determined according to the City of Hamilton Development Charge Background Study by Watson & Associates Economists Ltd. Accordingly, the persons per unit (PPU) for low density and medium density residential homes were taken as 3.39 PPU and 2.45 PPU respectively; the employee population for commercial areas was taken as 400 sq.ft. per employee; the employee population for institutional areas was taken as 700 sq.ft. per employee; the population for Park and SWM Pond areas was taken as 0 sq.ft. per employee, which is the most recent available data. **Table 1** lists the factors used to determine the demands for the development.

Table 1 - Demand Criteria from 2006 Water and Wastewater Master Plan

Persons Per Units	
Low Density Residential Homes	3.39 PPU
Medium Density Residential Homes	2.45 PPU
Commercial Population Rate	400 sq.ft./employee
Institutional Population Rate	700 sq.ft./employee
Park and SWM Pond Population Rate	0 sq.ft./employee
Average Day Demand	
Residential	360 L/persons/day
Employment	260 L/persons/day
Peaking Factors	
Maximum Day	1.9
Peak Hour	3.0

Detailed calculations of domestic demands are shown in **Appendix A**. Residential demands were calculated by measuring the surface area of the development zones using the Concept Plan drawing; converting the area to residential units; counting the number of units for each sub-block (Figure **2**) and allocating the demands of each block to the closest node in the water model. In calculating the demands for this development, some conservatism was added to the calculation:

The higher value of the residential unit per hectare range shown above was used. e.g. for Low Density Residential 2 area, a rate of 40 unit per hectare was used

On the east side of the Lower Stoney Creek Development, there are five junctions (WH_3, WH_4, WH_5, WH_6, WH_7) that overlap with the Winona Hills Development. WSP completed a watermain analysis for the proposed Winona Hills Development and submitted a report in October 2018. Demands from this report were included in the demand calculations for the Lower Stoney Creek Development.

The overall demands in the water distribution district external to the development were unchanged.

2.2 PRESSURES

As outlined in the City of Hamilton Water and Waste Water Master Plan (WWWMP), November 2006, the acceptable pressures under normal conditions are between 275 kPa (40 psi) and 690 kPa (100 psi).

During a fire flow, pressures in the development and at all points in the system must not be lower than 140 kPa (20 psi)

2.3 FIRE FLOW

The Required Fire Flows (RFF) for the blocks used in the analysis were calculated using the procedure outlined in: "Water Supply for Public Fire Protection" by the Fire Underwriters Survey (FUS), 1999.

RFF were not calculated for the other blocks within the Lower Stoney Creek Development as the block servicing strategy does not provide sufficient information (ie. building footprints, exposure distances, construction material) for calculating RFF per the procedure noted above.

On the east side of the Lower Stoney Creek Development, there are five junctions (WH_3, WH_4, WH_5, WH_6, WH_7) that overlap with the Winona Hills Development. WSP completed a watermain analysis for the proposed Winona Hills Development and submitted a report in October 2018. For the blocks associated with these junctions, RFF from this report were considered for the Lower Stoney Creek Development.

Based on this information, the largest RFF within this development was calculated as 217 L/s (retrieved from the Winona Hills Report) and was applied at the nodes overlapping with the Lower Stoney Creek Development. RFF were not considered for all other nodes within the Stoney Creek Development. Upon provision of sufficient building information, RFF calculations will need to be performed and checked against modeled fire flows prior to construction.

3 HYDRAULIC MODEL

The development was added to an existing watermain model for the City of Hamilton received by WSP in January 2010. Two separate models were integrated to produce a model of PD1 as follows.

— Coarse_Trunk_System_v7_2_transfer.MDB
— Model_Sept02_2009.MDB

It is our understanding that the Coarse Trunk System model is derived from the Hamilton WWWMP 2006 while Model_Sept02_2009 is a full pipe model of the Hamilton system but does not include supply or demand information.

Demands were extracted from the Coarse Trunk System model and inserted into the full pipe Model_Sept02_2009 file to produce a complete PD1 model. All physical pipe and node characteristics (excluding demands) were kept from the full pipe Model_Sept02_2009.

The proposed watermains were added to the PD1 model along the street layout of the proposed development taken from the site plan provided. Junction elevations were taken as ground elevations from a survey provided by Urbantech.

Friction factors for all new pipes added to the model were assigned according to the Ministry of the Environment and Climate Change (MOECC) watermain Design Criteria as listed in **Table 2.**

Table 2 - Hazen-Williams C-Factors

Diameter (Nominal)	C-Factor
150 mm	100
200 mm	110
300 mm to 600 mm	120

3.1 BOUNDARY CONDITIONS

Three modeling alternatives, characterised by the initial water levels in tanks HDR01, HDR1B and HDR1C, were considered as part of this analysis. The first alternative had all previously mentioned tanks at 50% full: that is 129.0m, 128.0m and 129.0m respectively. The second alternative had all previously mentioned tanks at 75% full: that is 131.2m, 130.7m and 131.2m respectively. Finally, the third alternative had all previously mentioned tanks at approximately 90% full: that is 132.5m, 132.3m, and 132.5m respectively.

Table 3 through **Table 8** indicate the pumping conditions at the Woodward Pump station during the alternatives when tanks were set to 50%, 75%, and 90% full.

Table 3 - Initial pumping conditions at Woodward Station for the 2011 Planning Horizon with Tanks 50% Full

2011 – Reservoirs 50%

System Component	Average Day	Maximum Day	Maximum Day + FF	Peak Hour
HWHWLP-PMP-1	OFF	OFF	OFF	OFF
HWHWLP-PMP-2	OFF	OFF	OFF	OFF
HWHWLP-PMP-3	OFF	OFF	OFF	OFF
HWHWLP-PMP-4	OFF	OFF	OFF	OFF
HWHWLP-PMP-5	OFF	OFF	OFF	OFF
HWHWLP-PMP-6	OFF	OFF	OFF	OFF

Table 4 - Initial pumping conditions at Woodward Station for the 2031 Planning Horizon with Tanks 50% Full

2031 – Reservoirs 50%

System Component	Average Day	Maximum Day	Maximum Day + FF	Peak Hour
HWHWLP-PMP-1	OFF	OFF	OFF	OFF
HWHWLP-PMP-2	OFF	OFF	OFF	OFF
HWHWLP-PMP-3	OFF	OFF	OFF	OFF
HWHWLP-PMP-4	OFF	OFF	OFF	OFF
HWHWLP-PMP-5	OFF	OFF	OFF	OFF
HWHWLP-PMP-6	OFF	OFF	OFF	OFF

Table 5 - Initial pumping conditions at Woodward Station for the 2011 Planning Horizon with Tank 75% Full

2011 – Reservoirs 75%

System Component	Average Day	Maximum Day	Maximum Day + FF	Peak Hour
HWHWLP-PMP-1	OFF	OFF	OFF	OFF
HWHWLP-PMP-2	OFF	OFF	OFF	OFF
HWHWLP-PMP-3	OFF	OFF	OFF	OFF
HWHWLP-PMP-4	OFF	OFF	OFF	OFF
HWHWLP-PMP-5	OFF	OFF	OFF	OFF
HWHWLP-PMP-6	OFF	OFF	OFF	OFF

Table 6 - Initial pumping conditions at Woodward Station for the 2031 planning horizon with tanks 75% Full

2031 – Reservoirs 75%

System Component	Average Day	Maximum Day	Maximum Day + FF	Peak Hour
HWHWLP-PMP-1	OFF	OFF	OFF	OFF
HWHWLP-PMP-2	OFF	OFF	OFF	OFF
HWHWLP-PMP-3	OFF	OFF	OFF	OFF
HWHWLP-PMP-4	OFF	OFF	OFF	OFF
HWHWLP-PMP-5	OFF	OFF	OFF	OFF
HWHWLP-PMP-6	OFF	OFF	OFF	OFF

Table 7 - Initial pumping conditions at Woodward Station for the 2011 planning horizon with tanks 90% Full

<u>2011 – Reservoirs 90%</u>

System Component	Average Day	Maximum Day	Maximum Day + FF	Peak Hour
HWHWLP-PMP-1	OFF	OFF	OFF	OFF
HWHWLP-PMP-2	OFF	OFF	OFF	OFF
HWHWLP-PMP-3	OFF	OFF	OFF	OFF
HWHWLP-PMP-4	OFF	OFF	OFF	OFF
HWHWLP-PMP-5	OFF	OFF	OFF	OFF
HWHWLP-PMP-6	OFF	OFF	OFF	OFF

Table 8 - Initial pumping conditions at Woodward Station for the 2031 planning horizon with tanks 90% Full

<u>2031 – Reservoirs 90%</u>

System Component	Average Day	Maximum Day	Maximum Day + FF	Peak Hour
HWHWLP-PMP-1	OFF	OFF	OFF	OFF
HWHWLP-PMP-2	OFF	OFF	OFF	OFF
HWHWLP-PMP-3	OFF	OFF	OFF	OFF
HWHWLP-PMP-4	OFF	OFF	OFF	OFF
HWHWLP-PMP-5	OFF	OFF	OFF	OFF
HWHWLP-PMP-6	OFF	OFF	OFF	OFF

3.2 MODEL CALIBRATION

The calibration of the model was verified using results of four (4) hydrant flow tests provided by the City of Hamilton. Test information for each test is provided in **Table 9**.

Table 9 – Hydrant Flow Test Calibration Information

Location	Hydrant ID	Date of Test
244 McNeilly Road	SB02H036	July 5, 2016
257 McNeilly Road	SB02H037	July 5, 2016
1217 Barton Street	SA02H015	June 28, 2016
Barton Street	SA02H016	June 28, 2016

A comparison between the hydrant flow test results and their respective modeled hydrant curves were completed at the locations in question.

It was found that the modeled static pressure, was lower than the static pressure of the hydrant flow test and that the modeled flow at 20 psi were conservative. The results of this test, and how it compares to the model simulated data can be referred to in **Appendix E**.

4 HYDRAULIC ANALYSIS

The suggested watermain layout was modelled for Average Day, Maximum Day, Maximum Day plus Fire Flow and Peak Hour under the present (2011) and ultimate buildout (2031) planning horizons using a WaterGEMS V8i model of the PD1 network as described in Section 3. It should be noted that PD1 also feeds other pressure districts and the demands for those districts were also included in the analysis.

Pipes in the Lower Stoney Creek Development were sized to meet the greater requirement of Peak Hour Demands or Maximum Day Demand plus Fire Flow requirements. A detailed summary of demands is shown in **Appendix A** as well as the proposed pipe diameters within the development.

4.1 SYSTEM PRESSURES

For the modeled demand scenarios, **Table 10** and **Table 11** show the computer simulations predicted pressures. From these tables, it can be said that simulated pressures under all planning horizons are in the acceptable pressure range according to both the MOECC and the City of Hamilton. Furthermore, the nodes everywhere else in PD1 were checked and remain above 275 kPa during the simulation of all alternatives presented herein. A complete table of pipe and node data for all the simulated scenarios is included in **Appendix B**.

Table 10 - Simulated Pressure Ranges for the Present Day (2011) Planning Horizon - All Pumps are OFF at Woodward PS.

Scenario	Average Day (kPa)	Maximum Day (kPa)	Peak Hour (kPa)
Tanks 50% Full	319 - 388	312 - 381	296 - 365
Tanks 75% Full	345 - 414	337 - 406	320 - 390
Tanks 90% Full	360 - 429	351 - 420	335 - 404

Table 11 - Simulated Pressure Ranges for the Ultimate Buildout (2031) Planning Horizon - All Pumps are OFF at Woodward PS.

Scenario	Average Day (kPa)	Maximum Day (kPa)	Peak Hour (kPa)
Tanks 50% Full	317 - 386	302 - 371	276 - 346
Tanks 75% Full	342 - 411	327 - 396	300 - 370
Tanks 90% Full	357 - 426	341 - 411	314 - 384

4.2 AVAILABLE FIRE FLOW

The minimum allowable pressure under maximum day demand plus fire flow is 140 kPa (20 psi) at the location of the fire or anywhere else in the pressure district. The fire flow scenarios were simulated under Maximum Day demand conditions in the present (2011) and ultimate build out (2031) planning horizons. The available fire flow in the subdivision is different for each planning horizon and water level in PD1 tanks as shown in **Table 12** below – allow at least 20L/s margin between the RFF and table values to account for hydrant lead and isolation valve losses. A detailed analysis of fire flows available at all hydrants in the proposed system is included in **Appendix C**.

Table 12 - Simulated AFF Ranges at Nodes for 2011 and 2031 with All Pumps are OFF at Woodward PS

Scenario	2011 MDD+FF	2031 MDD+FF
Tanks 50% Full	102 – 439	98 - 353
Tanks 75% Full	110 – 468	105 - 439
Tanks 90% Full	114 - 489	110 - 455

Note: Junction HA12S002 was not included in PD1. Allow at least 20L/s for Hydrant AFF.

During the MDD + Fire Flow scenarios at 50% TWL, PD1 was not able to maintain the required pressure of 140 kPa resulting in zero flows at the subject area in the computer simulation. This is due to node HA12S002 located on Charleton Avenue (far from the development area) with an elevation of 114.20m and has a pressure that would constrain the AFF to zero in the Winona Hills area. This PD1 constraint would apply to all existing areas and developments during periods with reservoirs below 75%.

However, WSP understands node HA12S002 will be serviced from PD2 by the time the proposed development is constructed and, in addition, this one node does not now and will not in the future service dwellings in PD1. Therefore, WSP conducted a fire flow analysis without this junction in PD1.

Based on the simulations, WSP has determined that the system can maintain a minimum pressure of 140 kPa at ground level at all points in the PD1 distribution system under Maximum Day demand plus Fire Flow conditions at the subject site for the existing (2011) and ultimate buildout (2031) planning horizons when node HA12S002 is not included in PD1. The AFF reported above do not include any network improvements that may be considered (below).

As detailed subdivision plans advance and fire flow requirements become available, required fire flows may exceed available fire flows. At that time, it is recommended that the following system upgrades be implemented to increase the fire flow capacity of the system:

1. Upsize LSP-24 from 200 mm to 300 mm and LSP-16 from 200 mm to 300 mm to increase available fire flows for Blocks 1, 2, 3, and 4. **Figure 4** below shows watermains LSP-39 and LSP-40 before recommendation.

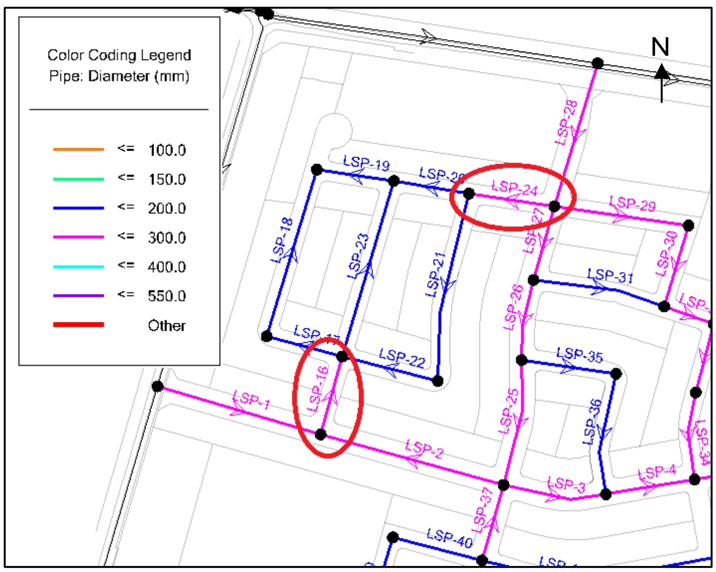


Figure 4 – Possible Watermain Upgrades (LSP-24 and LSP-16) to Increase AFF (Circled in Red)

2. Upsize LSP-39 from 200 mm to 300 mm and LSP-40 from 200 mm to 300 mm to increase available fire flows for Block 5. **Figure 5** shows watermains LSP-16 and LSP-24 before recommendation. Figure 6 shows the suggested layout when recommendation is implemented.

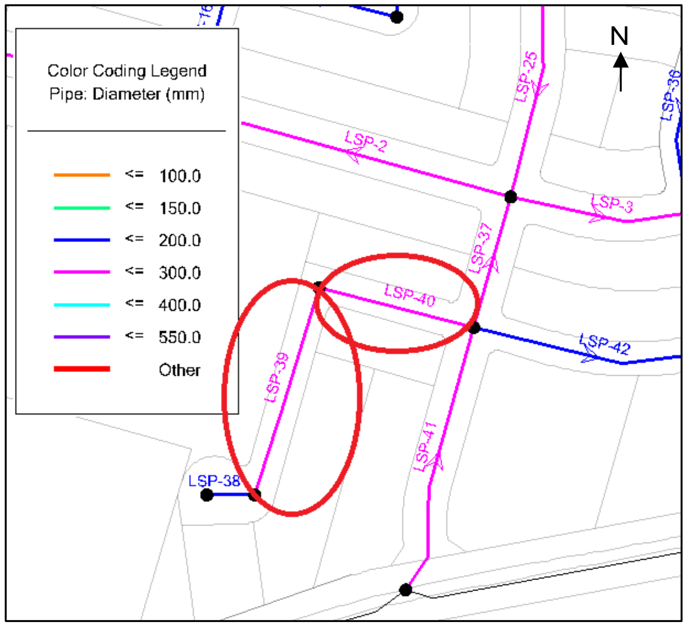


Figure 5 – Possible Watermain Upgrades (LSP-30 and LSP-40) to Increase AFF (Circled in Red)

3. Add a new watermain connecting LSJ-4 to LSP-43 to increase available fire flows for Blocks 10, 11, and 12. Figure 6 shows both watermains LSJ-4 and LSP-43 without any connecting watermain.

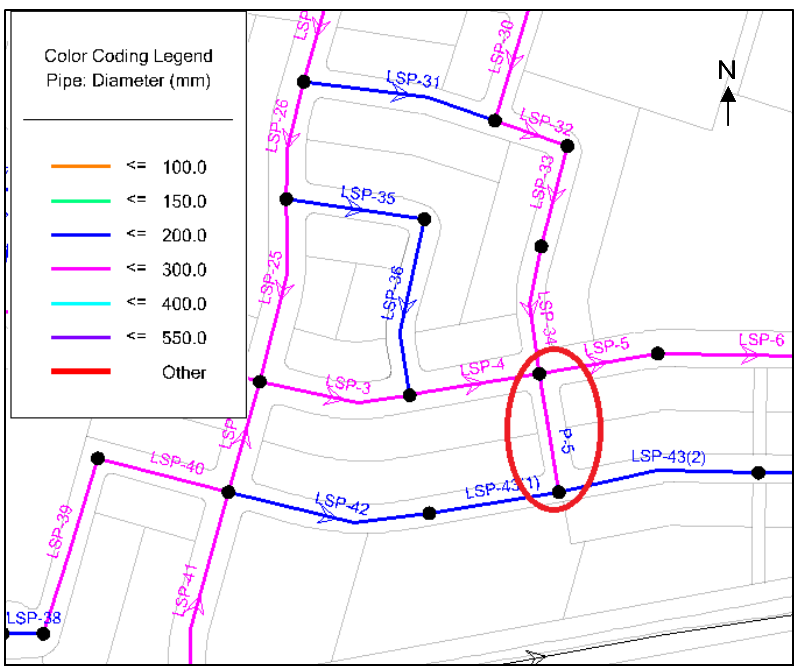


Figure 6 Possible Watermain Upgrade (between Watermains LSP-4 and LSP-43) to Increase AFF (Circled in Red)

4.3 TRANSIENT PRESSURES

According to the MOE Watermain Design Criteria, all watermains shall be designed so that pipes and joints are able to withstand the maximum operating pressure plus the surge pressure that would be created by stopping a water column moving at 0.6 m/s.

AWWA C900-compliant PVC pipe has a pressure rating of 150 psi (or greater) and this is consistent with the City of Hamilton's Specification for the Installation of Watermains (April 2014) that requires PVC pipe to be of Class 150 DR18. A PVC pipe with dimension ratio (DR) of 18 will experience a pressure surge of 240 kPa for a 0.6 m/s instantaneous flow velocity change (Joukowski). The maximum operating pressure plus transient pressure is calculated as approximately 669 kPa (429 kPa + 240 kPa) - well under 1030 kPa (150 psi). All pipe restraints and thrust blocks should be designed to a minimum 1030 kPa (150 psi) design pressure.

4.4 SYSTEM FLUSHING

A modeled flushing test was performed for the proposed water distribution network, under existing (2011) Average Day conditions for all phases of construction to determine the achievable flushing velocities of the system. The MOECC watermain design criterion requires a minimum flushing velocity of 0.8 m/s.

WaterGEMS software allows for testing of flushing by representing a modeled hydrant as a flow emitter with an emitter coefficient K equivalent to the components of the hydrant including the lateral, valve, bends and outlet. Hydrants were simulated in the model as junction with a K value taken as 11.2 $l/s/m^{0.5}$ (150 $gpm/psi^{0.5}$) which is the minimum value prescribed by the American Water Works Association (AWWA) standard for flow calculations through a single 60 mm (2.5") outlet.

Based on the simulation, all watermains sections can meet the required flushing velocity of 0.8 m/s. To achieve this, two phases of flushing are required. The first phase of flushing requires all watermains to be open (no closed valves) with some hydrants being flushed with two ports open. The second phase of flushing requires unidirectional flushing for four pipes: LSP-9, LSP-12, LSP-13, LSP-31, and P-240. Unidirectional flushing of each pipe requires that a valve on a downstream pipe be closed. A summary of the flushing strategy for the second phase of flushing is depicted in **Table 13.**

Table 13 – Secondary Flushing Phase: Unidirectional Flushing Strategy

Pipe to be Unidirectionally Flushed	Pipe to be Closed
LSP-9	LSP-10
LSP-12	LSP-11
LSP-13	LSP-57
LSP-31	LSP-30
P-240	LSP-69

Although isolation strategies for unidirectional flushing are shown in **Table 13** and **Appendix D**, isolation strategies for watermains requiring unidirectional flushing should always be determined by the field crew responsible and are dependent on specific local system requirements at the time of flushing.

Note that since hydrant locations were not specified to WSP at the time of the analysis, 41 junctions were chosen as flow emitters. All of these junctions are within 150m of each other which is in line with the hydrant placement requirements.

With the requirements listed above, flushing velocities ranging between 0.80 and 2.54 m/s were simulated for the Lower Stoney Creek Development. A detailed flushing report, including all nodes which require two (2) port flushing and all pipes which require unidirectional flushing is provided in **Appendix D**.

5 CONCLUSIONS

The proposed watermain system for the Lower Stoney Creek Development site can achieve hydraulic requirements as prescribed by the Ministry of the Environment and Climate Change and the City of Hamilton watermain design criteria as summarized below:

1. The service pressures under existing conditions (2011), and ultimate build-out conditions (2031) are expected to range between 276 kPa and 429 kPa which are within standards established by the MOECC and City of Hamilton Guidelines;

2. The largest RFF within this development was calculated as 217 L/s (retrieved from the Winona Hills Report) and was applied at the nodes overlapping with the Lower Stoney Creek Development.

3. The Required Fire Flows of 217 L/s for the jucntions representing the Winona Hills Development can be achieved under Maximum Day Demand conditions for the proposed development under existing (2011) and ultimate buildout conditions (2031) provided that node HA12S002 will be omitted from PD1 fire constraints (based on a pending adjustment of the PD2/PD1 boundary as discussed in section 4.2). The AFF values reported herein do not include any network improvements that may be considered and require at least 20L/s of margin to allow for hydrant and lead losses;

4. Under Maximum Day plus Fire Flow for existing (2011) and ultimate buildout (2031) conditions the PD1 distribution system is able to maintain pressure above 140 kPa at ground level at all modeled nodes in the district;

5. Under the simulated conditions, all AWWA C900-compliant PVC pipe with a pressure rating of 150 psi (or greater) watermains in the proposed development can withstand transient pressure created by stopping a water column moving at 0.6 m/s plus maximum operating pressure; and,

6. All proposed watermains can achieve a minimum flushing velocity of 0.8 m/s given the requirements outlined in Section 4.4.

These conclusions remain valid as long as the proposed water distribution system and the City's network configuration remain as described herein. Furthermore, these conclusions are exclusive of the recommended upgrades but these would improve AFF and service pressures. If significant changes are contemplated, this analysis should be updated.

APPENDIX

A

DEMANDS AND PROPOSED SYSTEM LAYOUT

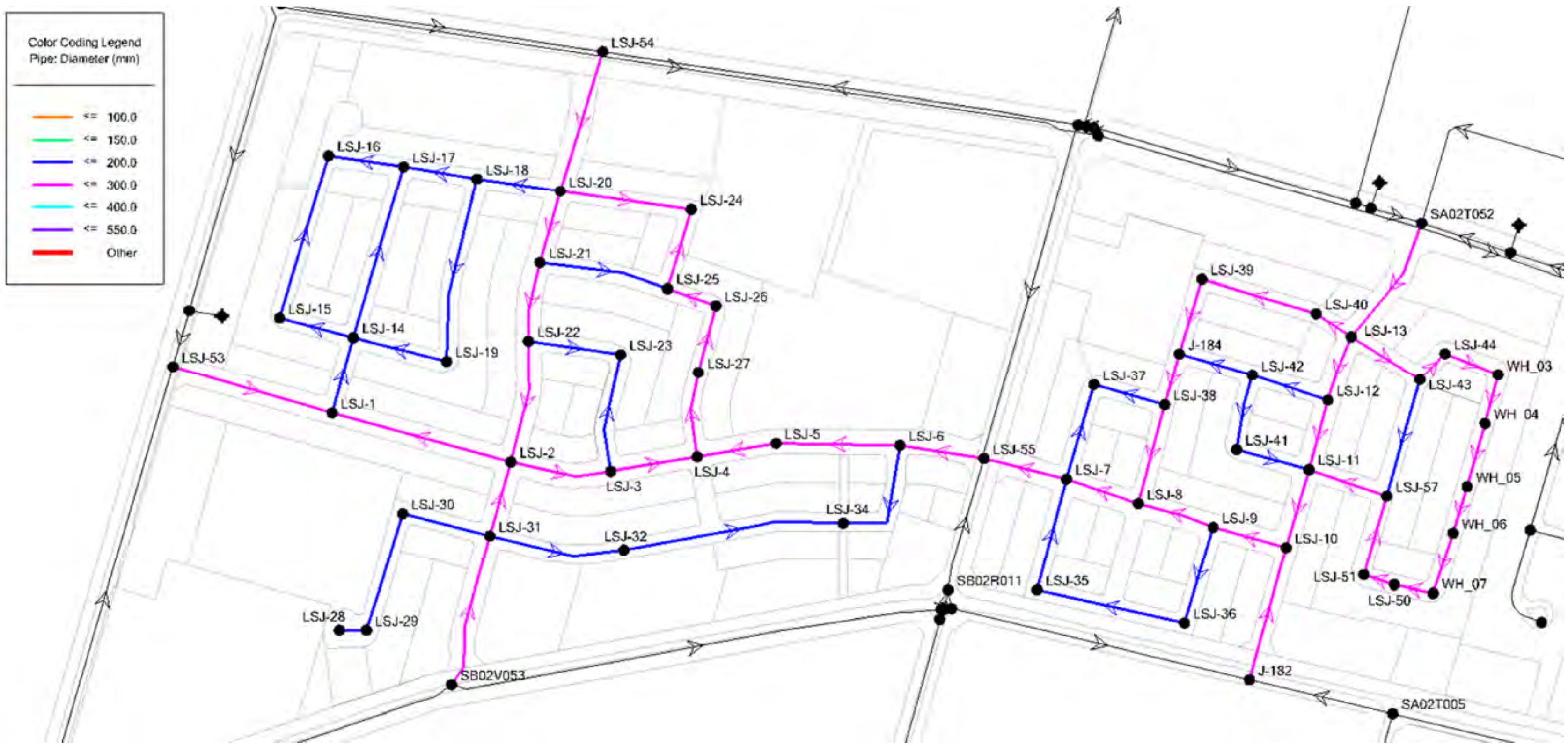


Figure A1 - Proposed System Layout with all Junction IDs

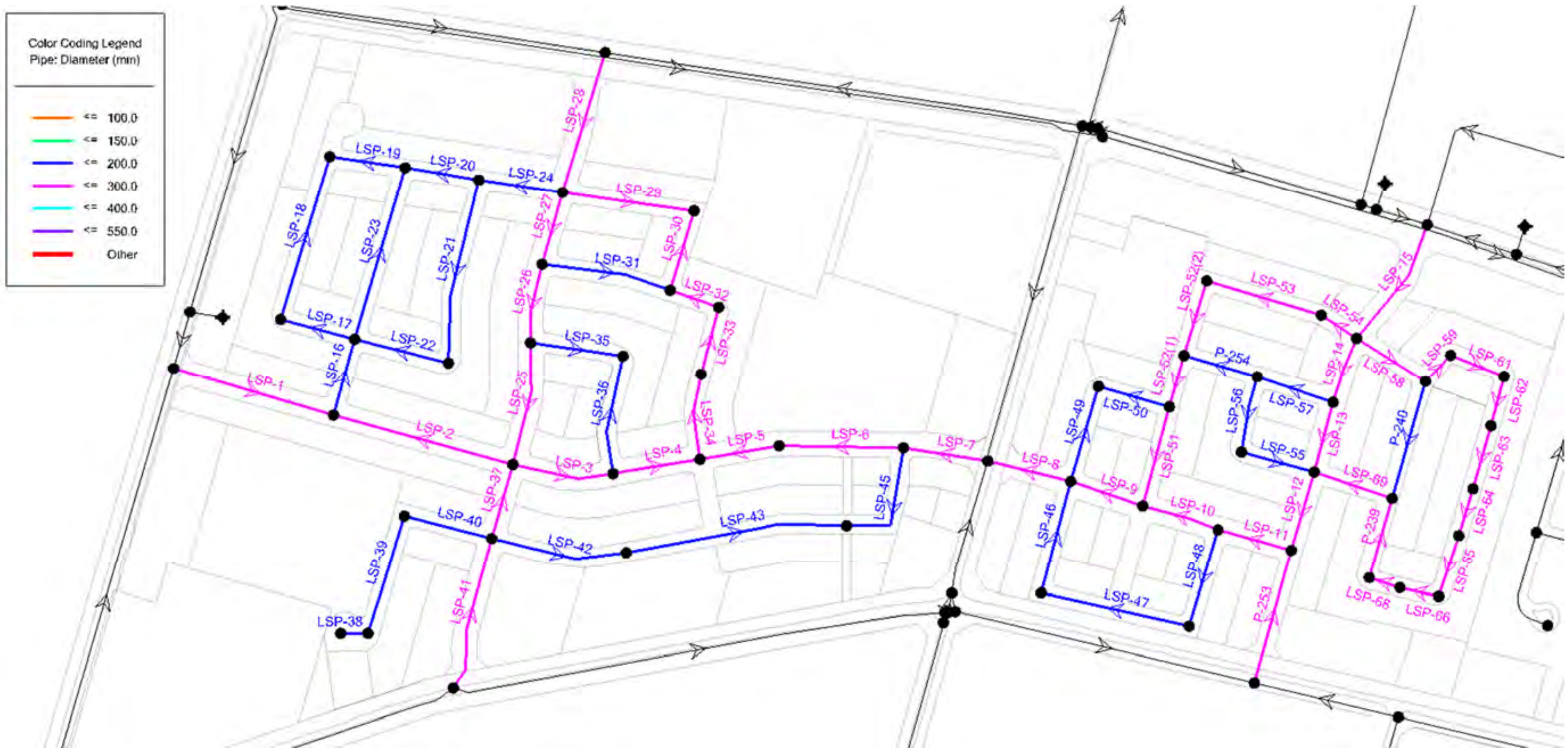


Figure A2 - Proposed System Layout with all Pipe IDs

Water Demands

Residential Unit Rate					Population Rate		Demand			Peaking Factors	
Class	Low Density 1	Low Density 2	Low Density 3	Med Density 2	3.39	LD-PPU	Residential	360	L/Person/day	Maximum Day	1.9
Rate (upnha)	20	40.0	60.0	75	2.45	MD-PPU	Employment	260			
Range (upnha)	0-20	20-40	40-60	60-75	400	ft^2/comm. empl.	Conservative Factor	100%		Maximum Hour	3.0
					700	ft^2/insti. empl.					

Notes:
Residential and Commercial Population rates used in calculating demands for the development were based on the City of Hamilton Study (October 1, 2014) by Watson & Associates Economists Ltd.
Block areas, proposed residential density, person per unit (ppu) for each density group were taken from drawing: Block Servicing Strategy Area # 3 Concept Plan June 2018 by Glen Schnarr & Associates Inc.
Employment demands based on the City of Hamilton's WWMP (2006) demand criteria.

Calculated Demands

Node	Block	Class	Area (sqm)	Area (ha)	Single-Family Units	Number of People	Average Day x 150% (L/day)	Average Day (L/s)	Maximum Day (L/s)	Peak Hour (L/s)
LSJ-16	1	Low Density 2	7676	0.77	31	104	37473	0.43	0.82	1.30
		Low Density 3	29953	3.00	180	609	219328	2.54	4.82	7.62
		Med Density 2	19242	1.92	144	354	127288	1.47	2.80	4.42
			56872	**5.69**	**355**	**1067**	**384089**	**4.45**	**8.45**	**13.34**
LSJ-15	2	Low Density 3	1655	0.17	10	34	12116	0.14	0.27	0.42
		Low Density 2	7910	0.79	32	107	38616	0.45	0.85	1.34
			9565	**0.96**	**42**	**141**	**50731**	**0.59**	**1.12**	**1.76**
LSJ-19	3	Low Density 3	1655	0.17	10	34	12116	0.14	0.27	0.42
		Low Density 2	9278	0.93	37	126	45293	0.52	1.00	1.57
			10933	**1.09**	**47**	**159**	**57408**	**0.66**	**1.26**	**1.99**
LSJ-22	4	Low Density 2	15731	1.57	63	213	76793	0.89	1.69	2.67
		Low Density 3	6341	0.63	38	129	46430	0.54	1.02	1.61
			22072	**2.21**	**101**	**342**	**123223**	**1.43**	**2.71**	**4.28**
LSJ-1	5	Low Density 3	76413	7.64	458	1554	559530	6.48	12.30	19.43
		Low Density 2	2767	0.28	11	38	13508	0.16	0.30	0.47
		Commercial	2291	0.23	0	62	16027	0.19	0.35	0.56
		Park	29400	2.94	0	0	0	0.00	0.00	0.00
			110871	**11.09**	**470**	**1653**	**589065**	**6.82**	**12.95**	**20.45**
LSJ-24	6	Med Density 2	11506	1.15	86	211	76113	0.88	1.67	2.64
		Low Density 3	11260	1.13	68	229	82451	0.95	1.81	2.86
		Low Density 2	6922	0.69	28	94	33792	0.39	0.74	1.17
		Park	29989	3.00	0	0	0	0.00	0.00	0.00
		SWM Pond	25404	2.54	0	0	0	0.00	0.00	0.00
		Institutional	37529	3.75	0	577	150042	1.74	3.30	5.21
			122610	**12.26**	**182**	**1111**	**342398**	**3.96**	**7.53**	**11.89**
LSJ-21	7	Low Density 2	4359	0.44	17	59	21277	0.25	0.47	0.74
		Low Density 3	2314	0.23	14	47	16947	0.20	0.37	0.59
			6673	**0.67**	**31**	**106**	**38225**	**0.44**	**0.84**	**1.33**
LSJ-27	8	Low Density 2	14410	1.44	58	195	70342	0.81	1.55	2.44
		Low Density 3	1978	0.20	12	40	14481	0.17	0.32	0.50
			16387	**1.64**	**70**	**236**	**84823**	**0.98**	**1.87**	**2.95**
LSJ-23	9	Low Density 3	1949	0.19	12	40	14270	0.17	0.31	0.50
		Low Density 2	5368	0.54	21	73	26203	0.30	0.58	0.91
			7316	**0.73**	**33**	**112**	**40473**	**0.47**	**0.89**	**1.41**
LSJ-32	10	Low Density 3	11513	1.15	69	234	84303	0.98	1.85	2.93
			11513	**1.15**	**69**	**234**	**84303**	**0.98**	**1.85**	**2.93**
LSJ-6	11	Low Density 3	10094	1.01	61	205	73915	0.86	1.63	2.57
			10094	**1.01**	**61**	**205**	**73915**	**0.86**	**1.63**	**2.57**
LSJ-34	12	Low Density 3	29507	2.95	177	600	216061	2.50	4.75	7.50
		Commercial	13716	1.37	0	369	95966	1.11	2.11	3.33
			43223	**4.32**	**177**	**969**	**312028**	**3.61**	**6.86**	**10.83**
LSJ-35	13	Low Density 3	6879	0.69	41	140	50367	0.58	1.11	1.75
			6879	**0.69**	**41**	**140**	**50367**	**0.58**	**1.11**	**1.75**
LSJ-8	14	Low Density 3	5425	0.54	33	110	39721	0.46	0.87	1.38
			5425	**0.54**	**33**	**110**	**39721**	**0.46**	**0.87**	**1.38**
LSJ-9	15	Low Density 3	5183	0.52	31	105	37955	0.44	0.83	1.32
			5183	**0.52**	**31**	**105**	**37955**	**0.44**	**0.83**	**1.32**
LSJ-10	16	Low Density 3	6044	0.60	36	123	44257	0.51	0.97	1.54
			6044	**0.60**	**36**	**123**	**44257**	**0.51**	**0.97**	**1.54**
LSJ-10	17	Low Density 2	34841	3.48	139	472	170079	1.97	3.74	5.91
		Low Density 1	7512	0.75	15	51	18336	0.21	0.40	0.64
		Commercial	8333	0.83	0	224	58303	0.67	1.28	2.02
			50686	**5.07**	**154**	**748**	**246718**	**2.86**	**5.43**	**8.57**
SA02T005	18	Commercial	10340	1.03	0	278	72347	0.84	1.59	2.51
		Institutional	20943	2.09	0	322	83729	0.97	1.84	2.91
			31283	**3.13**	**0**	**600**	**156076**	**1.81**	**3.43**	**5.42**
SA02T005	19	Commercial	19365	1.94	0	521	135486	1.57	2.98	4.70
			19365	**1.94**	**0**	**521**	**135486**	**1.57**	**2.98**	**4.70**
LSJ-37	20	Low Density 2	2512	0.25	10	34	12261	0.14	0.27	0.43
		Low Density 3	11166	1.12	67	227	81761	0.95	1.80	2.84
		Med Density 2	23949	2.39	180	440	158424	1.83	3.48	5.50
		SWM Pond	15061	1.51	0	0	0	0.00	0.00	0.00
			52688	**5.27**	**257**	**701**	**252446**	**2.92**	**5.55**	**8.77**
LSJ-38	21	Low Density 2	4975	0.50	20	67	24285	0.28	0.53	0.84
			4975	**0.50**	**20**	**67**	**24285**	**0.28**	**0.53**	**0.84**
LSJ-11	22	Low Density 2	12983	1.30	52	176	63378	0.73	1.39	2.20
			12983	**1.30**	**52**	**176**	**63378**	**0.73**	**1.39**	**2.20**
LSJ-12	23	Low Density 2	3545	0.35	14	48	17305	0.20	0.38	0.60
			3545	**0.35**	**14**	**48**	**17305**	**0.20**	**0.38**	**0.60**
LSJ-57	24	Low Density 2	6989	0.70	28	95	34119	0.39	0.75	1.18
			6989	**0.70**	**28**	**95**	**34119**	**0.39**	**0.75**	**1.18**
LSJ-43	25	Low Density 2	13402	1.34	54	182	65421	0.76	1.44	2.27
			13402	**1.34**	**54**	**182**	**65421**	**0.76**	**1.44**	**2.27**
LSJ-13	26	Low Density 2	4164	0.42	17	56	20329	0.24	0.45	0.71
		Low Density 3	4160	0.42	25	85	30459	0.35	0.67	1.06
			8324	**0.83**	**42**	**141**	**50788**	**0.59**	**1.12**	**1.76**
		Total:	**655900**	**65.59**	**2398**	**10095**	**3399004**	**39.34**	**74.75**	**118.02**

APPENDIX

B

PIPE AND JUNCTION TABLES

2011 Junctions Tables
PD1 Reservoir 50% Full + NO Pumps

2011 ADD Junction Results				
Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (kPa)
J-182	94.25	0.00	128	328
J-184	91.25	0.00	128	358
LSJ-1	91.00	6.82	128	360
LSJ-2	91.75	0.00	128	353
LSJ-3	91.50	0.00	128	355
LSJ-4	91.50	0.00	128	355
LSJ-5	90.25	0.00	128	368
LSJ-6	91.75	0.86	128	353
LSJ-7	92.25	0.00	128	348
LSJ-8	92.50	0.46	128	346
LSJ-9	92.75	0.44	128	343
LSJ-10	93.00	3.37	128	341
LSJ-11	92.00	0.73	128	350
LSJ-12	91.75	0.20	128	353
LSJ-13	91.25	0.59	128	358
LSJ-14	90.75	0.00	128	363
LSJ-15	91.50	0.59	128	355
LSJ-16	90.50	4.45	128	365
LSJ-17	90.75	0.00	128	363
LSJ-18	89.75	0.00	128	372
LSJ-19	91.00	0.66	128	360
LSJ-20	89.75	0.00	128	372
LSJ-21	90.50	0.44	128	365
LSJ-22	90.75	1.43	128	363
LSJ-23	90.50	0.47	128	365
LSJ-24	89.25	3.96	128	377
LSJ-25	89.75	0.00	128	372
LSJ-26	89.75	0.00	128	372
LSJ-27	90.50	0.98	128	365
LSJ-28	94.25	0.00	128	328
LSJ-29	94.00	0.00	128	331
LSJ-30	92.00	0.00	128	350
LSJ-31	92.75	0.00	128	343
LSJ-32	92.75	0.98	128	343
LSJ-34	91.25	3.61	128	358
LSJ-35	93.50	0.58	128	336
LSJ-36	94.00	0.00	128	331
LSJ-37	91.00	2.92	128	360
LSJ-38	91.50	0.28	128	355
LSJ-39	91.00	0.00	128	360
LSJ-40	91.25	0.00	128	358
LSJ-41	92.00	0.00	128	350
LSJ-42	91.50	0.00	128	355
LSJ-43	91.25	0.76	128	358
LSJ-44	91.75	0.00	128	353
LSJ-50	95.00	0.00	128	321
LSJ-51	94.00	0.00	128	331
LSJ-53	92.25	0.00	128	348
LSJ-54	88.18	0.00	128	388
LSJ-55	91.86	0.00	128	352
LSJ-57	92.25	0.39	128	348
SA02T005	95.10	4.03	128	320
SA02T052	91.00	0.00	128	360
SB02R011	94.00	0.00	128	331
SB02V053	95.20	0.00	128	319
WH_03	92.00	0.10	128	350
WH_04	92.00	0.13	128	350
WH_05	92.00	0.16	128	350
WH_06	93.00	0.11	128	341
WH_07	95.00	0.10	128	321

2011 Junctions Tables
PD1 Reservoir 50% Full + NO Pumps

2011 MDD Junction Results				
Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (kPa)
J-182	94.25	0.00	127	321
J-184	91.25	0.00	127	351
LSJ-1	91.00	12.95	127	353
LSJ-2	91.75	0.00	127	345
LSJ-3	91.50	0.00	127	348
LSJ-4	91.50	0.00	127	348
LSJ-5	90.25	0.00	127	360
LSJ-6	91.75	1.63	127	345
LSJ-7	92.25	0.00	127	341
LSJ-8	92.50	0.87	127	338
LSJ-9	92.75	0.83	127	336
LSJ-10	93.00	6.40	127	333
LSJ-11	92.00	1.39	127	343
LSJ-12	91.75	0.38	127	346
LSJ-13	91.25	1.12	127	351
LSJ-14	90.75	0.00	127	355
LSJ-15	91.50	1.12	127	347
LSJ-16	90.50	8.45	127	357
LSJ-17	90.75	0.00	127	355
LSJ-18	89.75	0.00	127	365
LSJ-19	91.00	1.26	127	353
LSJ-20	89.75	0.00	127	365
LSJ-21	90.50	0.84	127	358
LSJ-22	90.75	2.71	127	355
LSJ-23	90.50	0.89	127	358
LSJ-24	89.25	7.53	127	370
LSJ-25	89.75	0.00	127	365
LSJ-26	89.75	0.00	127	365
LSJ-27	90.50	1.87	127	358
LSJ-28	94.25	0.00	127	321
LSJ-29	94.00	0.00	127	323
LSJ-30	92.00	0.00	127	343
LSJ-31	92.75	0.00	127	336
LSJ-32	92.75	1.85	127	335
LSJ-34	91.25	6.86	127	350
LSJ-35	93.50	1.11	127	328
LSJ-36	94.00	0.00	127	324
LSJ-37	91.00	5.55	127	353
LSJ-38	91.50	0.53	127	348
LSJ-39	91.00	0.00	127	353
LSJ-40	91.25	0.00	127	351
LSJ-41	92.00	0.00	127	343
LSJ-42	91.50	0.00	127	348
LSJ-43	91.25	1.44	127	351
LSJ-44	91.75	0.00	127	346
LSJ-50	95.00	0.00	127	314
LSJ-51	94.00	0.00	127	324
LSJ-53	92.25	0.00	127	341
LSJ-54	88.18	0.00	127	381
LSJ-55	91.86	0.00	127	344
LSJ-57	92.25	0.75	127	341
SA02T005	95.10	7.66	127	313
SA02T052	91.00	0.00	127	354
SB02R011	94.00	0.00	127	324
SB02V053	95.20	0.00	127	312
WH_03	92.00	0.19	127	343
WH_04	92.00	0.24	127	343
WH_05	92.00	0.30	127	343
WH_06	93.00	0.21	127	333
WH_07	95.00	0.19	127	314

2011 Junctions Tables
PD1 Reservoir 50% Full + NO Pumps

2011 PHD Junction Results				
Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (kPa)
J-182	94.25	0.00	125	305
J-184	91.25	0.00	125	334
LSJ-1	91.00	20.45	125	336
LSJ-2	91.75	0.00	125	329
LSJ-3	91.50	0.00	125	331
LSJ-4	91.50	0.00	125	331
LSJ-5	90.25	0.00	125	344
LSJ-6	91.75	2.57	125	329
LSJ-7	92.25	0.00	125	324
LSJ-8	92.50	1.38	125	322
LSJ-9	92.75	1.32	125	319
LSJ-10	93.00	10.10	125	317
LSJ-11	92.00	2.20	125	327
LSJ-12	91.75	0.60	125	329
LSJ-13	91.25	1.76	125	335
LSJ-14	90.75	0.00	125	338
LSJ-15	91.50	1.76	125	331
LSJ-16	90.50	13.34	125	340
LSJ-17	90.75	0.00	125	338
LSJ-18	89.75	0.00	125	348
LSJ-19	91.00	1.99	125	336
LSJ-20	89.75	0.00	125	349
LSJ-21	90.50	1.33	125	341
LSJ-22	90.75	4.28	125	339
LSJ-23	90.50	1.41	125	341
LSJ-24	89.25	11.89	125	353
LSJ-25	89.75	0.00	125	349
LSJ-26	89.75	0.00	125	349
LSJ-27	90.50	2.95	125	341
LSJ-28	94.25	0.00	125	305
LSJ-29	94.00	0.00	125	307
LSJ-30	92.00	0.00	125	327
LSJ-31	92.75	0.00	125	319
LSJ-32	92.75	2.93	125	319
LSJ-34	91.25	10.83	125	333
LSJ-35	93.50	1.75	125	312
LSJ-36	94.00	0.00	125	307
LSJ-37	91.00	8.77	125	336
LSJ-38	91.50	0.84	125	332
LSJ-39	91.00	0.00	125	337
LSJ-40	91.25	0.00	125	334
LSJ-41	92.00	0.00	125	327
LSJ-42	91.50	0.00	125	332
LSJ-43	91.25	2.27	125	334
LSJ-44	91.75	0.00	125	330
LSJ-50	95.00	0.00	125	298
LSJ-51	94.00	0.00	125	307
LSJ-53	92.25	0.00	125	325
LSJ-54	88.18	0.00	125	365
LSJ-55	91.86	0.00	125	328
LSJ-57	92.25	1.18	125	325
SA02T005	95.10	12.28	125	297
SA02T052	91.00	0.00	126	338
SB02R011	94.00	0.00	125	307
SB02V053	95.20	0.00	125	296
WH_03	92.00	0.30	125	327
WH_04	92.00	0.38	125	327
WH_05	92.00	0.47	125	327
WH_06	93.00	0.34	125	317
WH_07	95.00	0.30	125	298

2031 Junctions Tables
PD1 Reservoir 50% Full + NO Pumps

2031 ADD Junction Results				
Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (kPa)
J-182	94.25	0.00	128	326
J-184	91.25	0.00	128	355
LSJ-1	91.00	6.82	128	358
LSJ-2	91.75	0.00	128	351
LSJ-3	91.50	0.00	128	353
LSJ-4	91.50	0.00	128	353
LSJ-5	90.25	0.00	128	365
LSJ-6	91.75	0.86	128	351
LSJ-7	92.25	0.00	128	346
LSJ-8	92.50	0.46	128	343
LSJ-9	92.75	0.44	128	341
LSJ-10	93.00	3.37	128	338
LSJ-11	92.00	0.73	128	348
LSJ-12	91.75	0.20	128	351
LSJ-13	91.25	0.59	128	355
LSJ-14	90.75	0.00	128	360
LSJ-15	91.50	0.59	128	353
LSJ-16	90.50	4.45	128	363
LSJ-17	90.75	0.00	128	360
LSJ-18	89.75	0.00	128	370
LSJ-19	91.00	0.66	128	358
LSJ-20	89.75	0.00	128	370
LSJ-21	90.50	0.44	128	363
LSJ-22	90.75	1.43	128	360
LSJ-23	90.50	0.47	128	363
LSJ-24	89.25	3.96	128	375
LSJ-25	89.75	0.00	128	370
LSJ-26	89.75	0.00	128	370
LSJ-27	90.50	0.98	128	363
LSJ-28	94.25	0.00	128	326
LSJ-29	94.00	0.00	128	329
LSJ-30	92.00	0.00	128	348
LSJ-31	92.75	0.00	128	341
LSJ-32	92.75	0.98	128	341
LSJ-34	91.25	3.61	128	355
LSJ-35	93.50	0.58	128	333
LSJ-36	94.00	0.00	128	329
LSJ-37	91.00	2.92	128	358
LSJ-38	91.50	0.28	128	353
LSJ-39	91.00	0.00	128	358
LSJ-40	91.25	0.00	128	355
LSJ-41	92.00	0.00	128	348
LSJ-42	91.50	0.00	128	353
LSJ-43	91.25	0.76	128	355
LSJ-44	91.75	0.00	128	351
LSJ-50	95.00	0.00	128	319
LSJ-51	94.00	0.00	128	329
LSJ-53	92.25	0.00	128	346
LSJ-54	88.18	0.00	128	386
LSJ-55	91.86	0.00	128	349
LSJ-57	92.25	0.39	128	346
SA02T005	95.10	6.78	128	318
SA02T052	91.00	0.00	128	358
SB02R011	94.00	0.00	128	328
SB02V053	95.20	0.00	128	317
WH_03	92.00	0.10	128	348
WH_04	92.00	0.13	128	348
WH_05	92.00	0.16	128	348
WH_06	93.00	0.11	128	338
WH_07	95.00	0.10	128	319

2031 Junctions Tables
PD1 Reservoir 50% Full + NO Pumps

2031 MDD Junction Results				
Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (kPa)
J-182	94.25	0.00	126	311
J-184	91.25	0.00	126	341
LSJ-1	91.00	12.95	126	343
LSJ-2	91.75	0.00	126	336
LSJ-3	91.50	0.00	126	338
LSJ-4	91.50	0.00	126	338
LSJ-5	90.25	0.00	126	350
LSJ-6	91.75	1.63	126	336
LSJ-7	92.25	0.00	126	331
LSJ-8	92.50	0.87	126	328
LSJ-9	92.75	0.83	126	326
LSJ-10	93.00	6.40	126	324
LSJ-11	92.00	1.39	126	333
LSJ-12	91.75	0.38	126	336
LSJ-13	91.25	1.12	126	341
LSJ-14	90.75	0.00	126	345
LSJ-15	91.50	1.12	126	338
LSJ-16	90.50	8.45	126	348
LSJ-17	90.75	0.00	126	345
LSJ-18	89.75	0.00	126	355
LSJ-19	91.00	1.26	126	343
LSJ-20	89.75	0.00	126	355
LSJ-21	90.50	0.84	126	348
LSJ-22	90.75	2.71	126	346
LSJ-23	90.50	0.89	126	348
LSJ-24	89.25	7.53	126	360
LSJ-25	89.75	0.00	126	355
LSJ-26	89.75	0.00	126	355
LSJ-27	90.50	1.87	126	348
LSJ-28	94.25	0.00	126	311
LSJ-29	94.00	0.00	126	314
LSJ-30	92.00	0.00	126	333
LSJ-31	92.75	0.00	126	326
LSJ-32	92.75	1.85	126	326
LSJ-34	91.25	6.86	126	340
LSJ-35	93.50	1.11	126	319
LSJ-36	94.00	0.00	126	314
LSJ-37	91.00	5.55	126	343
LSJ-38	91.50	0.53	126	338
LSJ-39	91.00	0.00	126	343
LSJ-40	91.25	0.00	126	341
LSJ-41	92.00	0.00	126	333
LSJ-42	91.50	0.00	126	338
LSJ-43	91.25	1.44	126	341
LSJ-44	91.75	0.00	126	336
LSJ-50	95.00	0.00	126	304
LSJ-51	94.00	0.00	126	314
LSJ-53	92.25	0.00	126	331
LSJ-54	88.18	0.00	126	371
LSJ-55	91.86	0.00	126	335
LSJ-57	92.25	0.75	126	331
SA02T005	95.10	12.90	126	303
SA02T052	91.00	0.00	126	344
SB02R011	94.00	0.00	126	314
SB02V053	95.20	0.00	126	302
WH_03	92.00	0.19	126	333
WH_04	92.00	0.24	126	333
WH_05	92.00	0.30	126	333
WH_06	93.00	0.21	126	324
WH_07	95.00	0.19	126	304

2031 Junctions Tables
PD1 Reservoir 50% Full + NO Pumps

2031 PHD Junction Results				
Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (kPa)
J-182	94.25	0.00	123	285
J-184	91.25	0.00	123	314
LSJ-1	91.00	20.45	123	316
LSJ-2	91.75	0.00	123	309
LSJ-3	91.50	0.00	123	311
LSJ-4	91.50	0.00	123	311
LSJ-5	90.25	0.00	123	324
LSJ-6	91.75	2.57	123	309
LSJ-7	92.25	0.00	123	304
LSJ-8	92.50	1.38	123	302
LSJ-9	92.75	1.32	123	299
LSJ-10	93.00	10.10	123	297
LSJ-11	92.00	2.20	123	307
LSJ-12	91.75	0.60	123	309
LSJ-13	91.25	1.76	123	314
LSJ-14	90.75	0.00	123	318
LSJ-15	91.50	1.76	123	311
LSJ-16	90.50	13.34	123	320
LSJ-17	90.75	0.00	123	318
LSJ-18	89.75	0.00	123	328
LSJ-19	91.00	1.99	123	316
LSJ-20	89.75	0.00	123	329
LSJ-21	90.50	1.33	123	321
LSJ-22	90.75	4.28	123	319
LSJ-23	90.50	1.41	123	321
LSJ-24	89.25	11.89	123	333
LSJ-25	89.75	0.00	123	329
LSJ-26	89.75	0.00	123	329
LSJ-27	90.50	2.95	123	321
LSJ-28	94.25	0.00	123	285
LSJ-29	94.00	0.00	123	287
LSJ-30	92.00	0.00	123	307
LSJ-31	92.75	0.00	123	299
LSJ-32	92.75	2.93	123	299
LSJ-34	91.25	10.83	123	313
LSJ-35	93.50	1.75	123	292
LSJ-36	94.00	0.00	123	287
LSJ-37	91.00	8.77	123	316
LSJ-38	91.50	0.84	123	312
LSJ-39	91.00	0.00	123	317
LSJ-40	91.25	0.00	123	314
LSJ-41	92.00	0.00	123	307
LSJ-42	91.50	0.00	123	312
LSJ-43	91.25	2.27	123	314
LSJ-44	91.75	0.00	123	309
LSJ-50	95.00	0.00	123	278
LSJ-51	94.00	0.00	123	287
LSJ-53	92.25	0.00	123	305
LSJ-54	88.18	0.00	124	346
LSJ-55	91.86	0.00	123	308
LSJ-57	92.25	1.18	123	304
SA02T005	95.10	19.88	123	276
SA02T052	91.00	0.00	124	319
SB02R011	94.00	0.00	123	287
SB02V053	95.20	0.00	123	276
WH_03	92.00	0.30	123	307
WH_04	92.00	0.38	123	307
WH_05	92.00	0.47	123	307
WH_06	93.00	0.34	123	297
WH_07	95.00	0.30	123	278

2011 Pipe Tables
PD1 Reservoir 50% Full + NO Pumps

2011 ADD Pipe Results								
Label	Start Node	Stop Node	Length (m)	Diameter (mm)	Hazen-Williams C	Flow (L/s)	Velocity (m/s)	Headloss Gradient (m/km)
LSP-1	LSJ-53	LSJ-1	172.80	300	120	6.62	0.09	0.05
LSP-2	LSJ-1	LSJ-2	192.90	300	120	-2.95	0.04	0.01
LSP-3	LSJ-2	LSJ-3	106.10	300	120	0.49	0.01	0.00
LSP-4	LSJ-3	LSJ-4	91.10	300	120	0.32	0.00	0.00
LSP-5	LSJ-4	LSJ-5	83.20	300	120	-0.85	0.01	0.00
LSP-6	LSJ-5	LSJ-6	128.90	300	120	-0.85	0.01	0.00
LSP-7	LSJ-6	LSJ-55	88.40	300	120	-4.27	0.06	0.02
LSP-8	LSJ-55	LSJ-7	88.40	300	120	-2.00	0.03	0.01
LSP-9	LSJ-7	LSJ-8	78.90	300	120	-3.07	0.04	0.01
LSP-10	LSJ-9	LSJ-8	82.00	300	120	1.51	0.02	0.00
LSP-11	LSJ-9	LSJ-10	78.90	300	120	-2.53	0.04	0.01
LSP-12	LSJ-10	LSJ-11	84.70	300	120	-3.95	0.06	0.02
LSP-13	LSJ-11	LSJ-12	75.00	300	120	-3.16	0.04	0.01
LSP-14	LSJ-12	LSJ-13	71.00	300	120	-4.30	0.06	0.02
LSP-15	LSJ-13	SA02T052	140.50	300	120	-11.36	0.16	0.13
LSP-16	LSJ-14	LSJ-1	82.00	200	110	-2.75	0.09	0.08
LSP-17	LSJ-15	LSJ-14	79.20	200	110	-2.12	0.07	0.05
LSP-18	LSJ-16	LSJ-15	176.80	200	110	-1.53	0.05	0.03
LSP-19	LSJ-17	LSJ-16	78.90	200	110	2.92	0.09	0.09
LSP-20	LSJ-18	LSJ-17	77.40	200	110	2.07	0.07	0.05
LSP-21	LSJ-19	LSJ-18	193.90	200	110	-0.88	0.03	0.01
LSP-22	LSJ-14	LSJ-19	100.30	200	110	-0.22	0.01	0.00
LSP-23	LSJ-14	LSJ-17	185.90	200	110	0.85	0.03	0.01
LSP-24	LSJ-20	LSJ-18	87.80	200	110	2.95	0.09	0.09
LSP-25	LSJ-22	LSJ-2	129.20	300	120	0.28	0.00	0.00
LSP-26	LSJ-21	LSJ-22	82.90	300	120	2.00	0.03	0.01
LSP-27	LSJ-20	LSJ-21	77.70	300	120	3.06	0.04	0.01
LSP-28	LSJ-54	LSJ-20	151.80	300	120	9.17	0.13	0.09
LSP-29	LSJ-24	LSJ-20	137.80	300	120	-3.15	0.04	0.01
LSP-30	LSJ-25	LSJ-24	86.00	300	120	0.81	0.01	0.00
LSP-31	LSJ-21	LSJ-25	136.20	200	110	0.62	0.02	0.01
LSP-32	LSJ-25	LSJ-26	53.30	300	120	-0.19	0.00	0.00
LSP-33	LSJ-26	LSJ-27	71.90	300	120	-0.19	0.00	0.00
LSP-34	LSJ-27	LSJ-4	89.60	300	120	-1.17	0.02	0.00
LSP-35	LSJ-22	LSJ-23	96.90	200	110	0.29	0.01	0.00
LSP-36	LSJ-3	LSJ-23	124.70	200	110	0.18	0.01	0.00
LSP-37	LSJ-2	LSJ-31	79.90	300	120	-3.17	0.04	0.01
LSP-38	LSJ-29	LSJ-28	28.00	200	110	0.00	0.00	0.00
LSP-39	LSJ-29	LSJ-30	127.40	200	110	0.00	0.00	0.00
LSP-40	LSJ-30	LSJ-31	93.60	200	110	0.00	0.00	0.00
LSP-41	LSJ-31	SB02V053	161.80	300	120	-5.20	0.07	0.03
LSP-42	LSJ-31	LSJ-32	142.30	200	110	2.04	0.06	0.05
LSP-43	LSJ-32	LSJ-34	231.30	200	110	1.06	0.03	0.01
LSP-45	LSJ-34	LSJ-6	126.80	200	110	-2.55	0.08	0.07
LSP-46	LSJ-7	LSJ-35	120.10	200	110	0.00	0.00	0.00
LSP-47	LSJ-35	LSJ-36	157.30	200	110	-0.58	0.02	0.01
LSP-48	LSJ-9	LSJ-36	104.20	200	110	0.58	0.02	0.01
LSP-49	LSJ-7	LSJ-37	102.40	200	110	1.07	0.03	0.01
LSP-50	LSJ-37	LSJ-38	76.50	200	110	-1.85	0.06	0.04
LSP-51	LSJ-8	LSJ-38	106.40	300	120	-2.02	0.03	0.01
LSP-52(1)	LSJ-38	J-184	55.80	300	120	-4.14	0.06	0.02
LSP-52(2)	J-184	LSJ-39	81.10	300	120	-3.26	0.05	0.01
LSP-53	LSJ-39	LSJ-40	124.10	300	120	-3.26	0.05	0.01
LSP-54	LSJ-40	LSJ-13	43.90	300	120	-3.26	0.05	0.01
LSP-55	LSJ-41	LSJ-11	78.30	200	110	0.05	0.00	0.00
LSP-56	LSJ-42	LSJ-41	80.20	200	110	0.05	0.00	0.00
LSP-57	LSJ-42	LSJ-12	82.90	200	110	-0.94	0.03	0.01
LSP-58	LSJ-13	LSJ-43	84.40	300	120	3.21	0.05	0.01
LSP-59	LSJ-43	LSJ-44	37.80	300	120	1.60	0.02	0.00
LSP-61	LSJ-44	WH_03	59.40	300	120	1.60	0.02	0.00
LSP-62	WH_03	WH_04	53.00	300	120	1.50	0.02	0.00
LSP-63	WH_04	WH_05	68.00	300	120	1.38	0.02	0.00
LSP-64	WH_05	WH_06	50.90	300	120	1.22	0.02	0.00
LSP-65	WH_06	WH_07	66.40	300	120	1.11	0.02	0.00
LSP-66	WH_07	LSJ-50	41.10	300	120	1.01	0.01	0.00
LSP-68	LSJ-50	LSJ-51	33.50	300	120	1.01	0.01	0.00
LSP-69	LSJ-57	LSJ-11	85.30	300	120	1.47	0.02	0.00
P-239	LSJ-51	LSJ-57	86.00	300	120	1.01	0.01	0.00
P-240	LSJ-57	LSJ-43	126.20	200	110	-0.85	0.03	0.01
P-253	J-182	LSJ-10	142.30	300	120	1.95	0.03	0.01
P-254	J-184	LSJ-42	79.20	200	110	-0.89	0.03	0.01

2011 Pipe Tables
PD1 Reservoir 50% Full + NO Pumps

2011 MDD Pipe Results								
Label	Start Node	Stop Node	Length (m)	Diameter (mm)	Hazen-Williams C	Flow (L/s)	Velocity (m/s)	Headloss Gradient (m/km)
LSP-1	LSJ-53	LSJ-1	172.80	300	120	12.52	0.18	0.16
LSP-2	LSJ-1	LSJ-2	192.90	300	120	-5.64	0.08	0.04
LSP-3	LSJ-2	LSJ-3	106.10	300	120	0.85	0.01	0.00
LSP-4	LSJ-3	LSJ-4	91.10	300	120	0.51	0.01	0.00
LSP-5	LSJ-4	LSJ-5	83.20	300	120	-1.69	0.02	0.00
LSP-6	LSJ-5	LSJ-6	128.90	300	120	-1.69	0.02	0.00
LSP-7	LSJ-6	LSJ-55	88.40	300	120	-8.18	0.12	0.07
LSP-8	LSJ-55	LSJ-7	88.40	300	120	-3.86	0.05	0.02
LSP-9	LSJ-7	LSJ-8	78.90	300	120	-5.89	0.08	0.04
LSP-10	LSJ-9	LSJ-8	82.00	300	120	2.88	0.04	0.01
LSP-11	LSJ-9	LSJ-10	78.90	300	120	-4.82	0.07	0.03
LSP-12	LSJ-10	LSJ-11	84.70	300	120	-7.59	0.11	0.06
LSP-13	LSJ-11	LSJ-12	75.00	300	120	-6.06	0.09	0.04
LSP-14	LSJ-12	LSJ-13	71.00	300	120	-8.24	0.12	0.07
LSP-15	LSJ-13	SA02T052	140.50	300	120	-21.73	0.31	0.44
LSP-16	LSJ-14	LSJ-1	82.00	200	110	-5.21	0.17	0.27
LSP-17	LSJ-15	LSJ-14	79.20	200	110	-4.03	0.13	0.17
LSP-18	LSJ-16	LSJ-15	176.80	200	110	-2.91	0.09	0.09
LSP-19	LSJ-17	LSJ-16	78.90	200	110	5.54	0.18	0.30
LSP-20	LSJ-18	LSJ-17	77.40	200	110	3.93	0.13	0.16
LSP-21	LSJ-19	LSJ-18	193.90	200	110	-1.69	0.05	0.03
LSP-22	LSJ-14	LSJ-19	100.30	200	110	-0.43	0.01	0.00
LSP-23	LSJ-14	LSJ-17	185.90	200	110	1.61	0.05	0.03
LSP-24	LSJ-20	LSJ-18	87.80	200	110	5.62	0.18	0.31
LSP-25	LSJ-22	LSJ-2	129.20	300	120	0.60	0.01	0.00
LSP-26	LSJ-21	LSJ-22	82.90	300	120	3.86	0.05	0.02
LSP-27	LSJ-20	LSJ-21	77.70	300	120	5.88	0.08	0.04
LSP-28	LSJ-54	LSJ-20	151.80	300	120	17.52	0.25	0.30
LSP-29	LSJ-24	LSJ-20	137.80	300	120	-6.02	0.09	0.04
LSP-30	LSJ-25	LSJ-24	86.00	300	120	1.51	0.02	0.00
LSP-31	LSJ-21	LSJ-25	136.20	200	110	1.18	0.04	0.02
LSP-32	LSJ-25	LSJ-26	53.30	300	120	-0.33	0.00	0.00
LSP-33	LSJ-26	LSJ-27	71.90	300	120	-0.33	0.00	0.00
LSP-34	LSJ-27	LSJ-4	89.60	300	120	-2.20	0.03	0.01
LSP-35	LSJ-22	LSJ-23	96.90	200	110	0.55	0.02	0.00
LSP-36	LSJ-3	LSJ-23	124.70	200	110	0.34	0.01	0.00
LSP-37	LSJ-2	LSJ-31	79.90	300	120	-5.89	0.08	0.04
LSP-38	LSJ-29	LSJ-28	28.00	200	110	0.00	0.00	0.00
LSP-39	LSJ-29	LSJ-30	127.40	200	110	0.00	0.00	0.00
LSP-40	LSJ-30	LSJ-31	93.60	200	110	0.00	0.00	0.00
LSP-41	LSJ-31	SB02V053	161.80	300	120	-9.74	0.14	0.10
LSP-42	LSJ-31	LSJ-32	142.30	200	110	3.85	0.12	0.15
LSP-43	LSJ-32	LSJ-34	231.30	200	110	2.00	0.06	0.05
LSP-45	LSJ-34	LSJ-6	126.80	200	110	-4.86	0.15	0.23
LSP-46	LSJ-7	LSJ-35	120.10	200	110	0.00	0.00	0.00
LSP-47	LSJ-35	LSJ-36	157.30	200	110	-1.11	0.04	0.02
LSP-48	LSJ-9	LSJ-36	104.20	200	110	1.11	0.04	0.02
LSP-49	LSJ-7	LSJ-37	102.40	200	110	2.03	0.06	0.05
LSP-50	LSJ-37	LSJ-38	76.50	200	110	-3.52	0.11	0.13
LSP-51	LSJ-8	LSJ-38	106.40	300	120	-3.89	0.05	0.02
LSP-52(1)	LSJ-38	J-184	55.80	300	120	-7.93	0.11	0.07
LSP-52(2)	J-184	LSJ-39	81.10	300	120	-6.24	0.09	0.04
LSP-53	LSJ-39	LSJ-40	124.10	300	120	-6.24	0.09	0.04
LSP-54	LSJ-40	LSJ-13	43.90	300	120	-6.24	0.09	0.04
LSP-55	LSJ-41	LSJ-11	78.30	200	110	0.11	0.00	0.00
LSP-56	LSJ-42	LSJ-41	80.20	200	110	0.11	0.00	0.00
LSP-57	LSJ-42	LSJ-12	82.90	200	110	-1.80	0.06	0.04
LSP-58	LSJ-13	LSJ-43	84.40	300	120	6.13	0.09	0.04
LSP-59	LSJ-43	LSJ-44	37.80	300	120	3.07	0.04	0.01
LSP-61	LSJ-44	WH_03	59.40	300	120	3.07	0.04	0.01
LSP-62	WH_03	WH_04	53.00	300	120	2.88	0.04	0.01
LSP-63	WH_04	WH_05	68.00	300	120	2.64	0.04	0.01
LSP-64	WH_05	WH_06	50.90	300	120	2.34	0.03	0.01
LSP-65	WH_06	WH_07	66.40	300	120	2.13	0.03	0.01
LSP-66	WH_07	LSJ-50	41.10	300	120	1.94	0.03	0.01
LSP-68	LSJ-50	LSJ-51	33.50	300	120	1.94	0.03	0.01
LSP-69	LSJ-57	LSJ-11	85.30	300	120	2.82	0.04	0.01
P-239	LSJ-51	LSJ-57	86.00	300	120	1.94	0.03	0.01
P-240	LSJ-57	LSJ-43	126.20	200	110	-1.63	0.05	0.03
P-253	J-182	LSJ-10	142.30	300	120	3.62	0.05	0.02
P-254	J-184	LSJ-42	79.20	200	110	-1.69	0.05	0.03

2011 PHD Pipe Results								
Label	Start Node	Stop Node	Length (m)	Diameter (mm)	Hazen-Williams C	Flow (L/s)	Velocity (m/s)	Headloss Gradient (m/km)
LSP-1	LSJ-53	LSJ-1	172.80	300	120	20.13	0.28	0.38
LSP-2	LSJ-1	LSJ-2	192.90	300	120	-8.58	0.12	0.08
LSP-3	LSJ-2	LSJ-3	106.10	300	120	1.82	0.03	0.00
LSP-4	LSJ-3	LSJ-4	91.10	300	120	1.33	0.02	0.00
LSP-5	LSJ-4	LSJ-5	83.20	300	120	-2.06	0.03	0.01
LSP-6	LSJ-5	LSJ-6	128.90	300	120	-2.06	0.03	0.01
LSP-7	LSJ-6	LSJ-55	88.40	300	120	-12.28	0.17	0.15
LSP-8	LSJ-55	LSJ-7	88.40	300	120	-5.47	0.08	0.03
LSP-9	LSJ-7	LSJ-8	78.90	300	120	-8.84	0.13	0.08
LSP-10	LSJ-9	LSJ-8	82.00	300	120	4.35	0.06	0.02
LSP-11	LSJ-9	LSJ-10	78.90	300	120	-7.34	0.10	0.06
LSP-12	LSJ-10	LSJ-11	84.70	300	120	-11.63	0.16	0.14
LSP-13	LSJ-11	LSJ-12	75.00	300	120	-9.35	0.13	0.09
LSP-14	LSJ-12	LSJ-13	71.00	300	120	-12.73	0.18	0.16
LSP-15	LSJ-13	SA02T052	140.50	300	120	-33.62	0.48	0.99
LSP-16	LSJ-14	LSJ-1	82.00	200	110	-8.26	0.26	0.62
LSP-17	LSJ-15	LSJ-14	79.20	200	110	-6.36	0.20	0.38
LSP-18	LSJ-16	LSJ-15	176.80	200	110	-4.60	0.15	0.21
LSP-19	LSJ-17	LSJ-16	78.90	200	110	8.74	0.28	0.69
LSP-20	LSJ-18	LSJ-17	77.40	200	110	6.19	0.20	0.37
LSP-21	LSJ-19	LSJ-18	193.90	200	110	-2.64	0.08	0.08
LSP-22	LSJ-14	LSJ-19	100.30	200	110	-0.65	0.02	0.01
LSP-23	LSJ-14	LSJ-17	185.90	200	110	2.55	0.08	0.07
LSP-24	LSJ-20	LSJ-18	87.80	200	110	8.83	0.28	0.70
LSP-25	LSJ-22	LSJ-2	129.20	300	120	0.84	0.01	0.00
LSP-26	LSJ-21	LSJ-22	82.90	300	120	6.04	0.09	0.04
LSP-27	LSJ-20	LSJ-21	77.70	300	120	9.27	0.13	0.09
LSP-28	LSJ-54	LSJ-20	151.80	300	120	27.64	0.39	0.69
LSP-29	LSJ-24	LSJ-20	137.80	300	120	-9.55	0.14	0.10
LSP-30	LSJ-25	LSJ-24	86.00	300	120	2.34	0.03	0.01
LSP-31	LSJ-21	LSJ-25	136.20	200	110	1.90	0.06	0.04
LSP-32	LSJ-25	LSJ-26	53.30	300	120	-0.44	0.01	0.00
LSP-33	LSJ-26	LSJ-27	71.90	300	120	-0.44	0.01	0.00
LSP-34	LSJ-27	LSJ-4	89.60	300	120	-3.39	0.05	0.01
LSP-35	LSJ-22	LSJ-23	96.90	200	110	0.92	0.03	0.01
LSP-36	LSJ-3	LSJ-23	124.70	200	110	0.49	0.02	0.00
LSP-37	LSJ-2	LSJ-31	79.90	300	120	-9.56	0.14	0.10
LSP-38	LSJ-29	LSJ-28	28.00	200	110	0.00	0.00	0.00
LSP-39	LSJ-29	LSJ-30	127.40	200	110	0.00	0.00	0.00
LSP-40	LSJ-30	LSJ-31	93.60	200	110	0.00	0.00	0.00
LSP-41	LSJ-31	SB02V053	161.80	300	120	-15.68	0.22	0.24
LSP-42	LSJ-31	LSJ-32	142.30	200	110	6.12	0.19	0.36
LSP-43	LSJ-32	LSJ-34	231.30	200	110	3.19	0.10	0.11
LSP-45	LSJ-34	LSJ-6	126.80	200	110	-7.64	0.24	0.54
LSP-46	LSJ-7	LSJ-35	120.10	200	110	0.08	0.00	0.00
LSP-47	LSJ-35	LSJ-36	157.30	200	110	-1.67	0.05	0.03
LSP-48	LSJ-9	LSJ-36	104.20	200	110	1.67	0.05	0.03
LSP-49	LSJ-7	LSJ-37	102.40	200	110	3.29	0.10	0.11
LSP-50	LSJ-37	LSJ-38	76.50	200	110	-5.48	0.17	0.29
LSP-51	LSJ-8	LSJ-38	106.40	300	120	-5.87	0.08	0.04
LSP-52(1)	LSJ-38	J-184	55.80	300	120	-12.19	0.17	0.15
LSP-52(2)	J-184	LSJ-39	81.10	300	120	-9.61	0.14	0.10
LSP-53	LSJ-39	LSJ-40	124.10	300	120	-9.61	0.14	0.10
LSP-54	LSJ-40	LSJ-13	43.90	300	120	-9.61	0.14	0.10
LSP-55	LSJ-41	LSJ-11	78.30	200	110	0.19	0.01	0.00
LSP-56	LSJ-42	LSJ-41	80.20	200	110	0.19	0.01	0.00
LSP-57	LSJ-42	LSJ-12	82.90	200	110	-2.78	0.09	0.08
LSP-58	LSJ-13	LSJ-43	84.40	300	120	9.53	0.13	0.10
LSP-59	LSJ-43	LSJ-44	37.80	300	120	4.75	0.07	0.03
LSP-61	LSJ-44	WH_03	59.40	300	120	4.75	0.07	0.03
LSP-62	WH_03	WH_04	53.00	300	120	4.45	0.06	0.02
LSP-63	WH_04	WH_05	68.00	300	120	4.07	0.06	0.02
LSP-64	WH_05	WH_06	50.90	300	120	3.60	0.05	0.02
LSP-65	WH_06	WH_07	66.40	300	120	3.26	0.05	0.01
LSP-66	WH_07	LSJ-50	41.10	300	120	2.96	0.04	0.01
LSP-68	LSJ-50	LSJ-51	33.50	300	120	2.96	0.04	0.01
LSP-69	LSJ-57	LSJ-11	85.30	300	120	4.29	0.06	0.02
P-239	LSJ-51	LSJ-57	86.00	300	120	2.96	0.04	0.01
P-240	LSJ-57	LSJ-43	126.20	200	110	-2.50	0.08	0.07
P-253	J-182	LSJ-10	142.30	300	120	5.81	0.08	0.04
P-254	J-184	LSJ-42	79.20	200	110	-2.59	0.08	0.07

2031 Pipe Tables
PD1 Reservoir 50% Full + NO Pumps

2031 ADD Pipe Results								
Label	Start Node	Stop Node	Length (m)	Diameter (mm)	Hazen-Williams C	Flow (L/s)	Velocity (m/s)	Headloss Gradient (m/km)
LSP-1	LSJ-53	LSJ-1	172.80	300	120	7.87	0.11	0.07
LSP-2	LSJ-1	LSJ-2	192.90	300	120	-1.70	0.02	0.00
LSP-3	LSJ-2	LSJ-3	106.10	300	120	1.10	0.02	0.00
LSP-4	LSJ-3	LSJ-4	91.10	300	120	1.16	0.02	0.00
LSP-5	LSJ-4	LSJ-5	83.20	300	120	1.25	0.02	0.00
LSP-6	LSJ-5	LSJ-6	128.90	300	120	1.25	0.02	0.00
LSP-7	LSJ-6	LSJ-55	88.40	300	120	-2.14	0.03	0.01
LSP-8	LSJ-55	LSJ-7	88.40	300	120	-0.36	0.01	0.00
LSP-9	LSJ-7	LSJ-8	78.90	300	120	-1.75	0.02	0.00
LSP-10	LSJ-9	LSJ-8	82.00	300	120	-0.12	0.00	0.00
LSP-11	LSJ-9	LSJ-10	78.90	300	120	-0.66	0.01	0.00
LSP-12	LSJ-10	LSJ-11	84.70	300	120	-5.07	0.07	0.03
LSP-13	LSJ-11	LSJ-12	75.00	300	120	-3.72	0.05	0.02
LSP-14	LSJ-12	LSJ-13	71.00	300	120	-4.97	0.07	0.03
LSP-15	LSJ-13	SA02T052	140.50	300	120	-12.71	0.18	0.16
LSP-16	LSJ-14	LSJ-1	82.00	200	110	-2.75	0.09	0.08
LSP-17	LSJ-15	LSJ-14	79.20	200	110	-2.12	0.07	0.05
LSP-18	LSJ-16	LSJ-15	176.80	200	110	-1.53	0.05	0.03
LSP-19	LSJ-17	LSJ-16	78.90	200	110	2.92	0.09	0.09
LSP-20	LSJ-18	LSJ-17	77.40	200	110	2.07	0.07	0.05
LSP-21	LSJ-19	LSJ-18	193.90	200	110	-0.88	0.03	0.01
LSP-22	LSJ-14	LSJ-19	100.30	200	110	-0.22	0.01	0.00
LSP-23	LSJ-14	LSJ-17	185.90	200	110	0.85	0.03	0.01
LSP-24	LSJ-20	LSJ-18	87.80	200	110	2.95	0.09	0.09
LSP-25	LSJ-22	LSJ-2	129.20	300	120	0.99	0.01	0.00
LSP-26	LSJ-21	LSJ-22	82.90	300	120	2.95	0.04	0.01
LSP-27	LSJ-20	LSJ-21	77.70	300	120	4.23	0.06	0.02
LSP-28	LSJ-54	LSJ-20	151.80	300	120	11.38	0.16	0.13
LSP-29	LSJ-24	LSJ-20	137.80	300	120	-4.19	0.06	0.02
LSP-30	LSJ-25	LSJ-24	86.00	300	120	-0.23	0.00	0.00
LSP-31	LSJ-21	LSJ-25	136.20	200	110	0.84	0.03	0.01
LSP-32	LSJ-25	LSJ-26	53.30	300	120	1.08	0.02	0.00
LSP-33	LSJ-26	LSJ-27	71.90	300	120	1.08	0.02	0.00
LSP-34	LSJ-27	LSJ-4	89.60	300	120	0.10	0.00	0.00
LSP-35	LSJ-22	LSJ-23	96.90	200	110	0.53	0.02	0.00
LSP-36	LSJ-3	LSJ-23	124.70	200	110	-0.06	0.00	0.00
LSP-37	LSJ-2	LSJ-31	79.90	300	120	-1.81	0.03	0.00
LSP-38	LSJ-29	LSJ-28	28.00	200	110	0.00	0.00	0.00
LSP-39	LSJ-29	LSJ-30	127.40	200	110	0.00	0.00	0.00
LSP-40	LSJ-30	LSJ-31	93.60	200	110	0.00	0.00	0.00
LSP-41	LSJ-31	SB02V053	161.80	300	120	-3.86	0.05	0.02
LSP-42	LSJ-31	LSJ-32	142.30	200	110	2.06	0.07	0.05
LSP-43	LSJ-32	LSJ-34	231.30	200	110	1.08	0.03	0.01
LSP-45	LSJ-34	LSJ-6	126.80	200	110	-2.53	0.08	0.07
LSP-46	LSJ-7	LSJ-35	120.10	200	110	0.24	0.01	0.00
LSP-47	LSJ-35	LSJ-36	157.30	200	110	-0.34	0.01	0.00
LSP-48	LSJ-9	LSJ-36	104.20	200	110	0.34	0.01	0.00
LSP-49	LSJ-7	LSJ-37	102.40	200	110	1.15	0.04	0.02
LSP-50	LSJ-37	LSJ-38	76.50	200	110	-1.77	0.06	0.04
LSP-51	LSJ-8	LSJ-38	106.40	300	120	-2.33	0.03	0.01
LSP-52(1)	LSJ-38	J-184	55.80	300	120	-4.38	0.06	0.02
LSP-52(2)	J-184	LSJ-39	81.10	300	120	-3.56	0.05	0.02
LSP-53	LSJ-39	LSJ-40	124.10	300	120	-3.56	0.05	0.02
LSP-54	LSJ-40	LSJ-13	43.90	300	120	-3.56	0.05	0.02
LSP-55	LSJ-41	LSJ-11	78.30	200	110	0.23	0.01	0.00
LSP-56	LSJ-42	LSJ-41	80.20	200	110	0.23	0.01	0.00
LSP-57	LSJ-42	LSJ-12	82.90	200	110	-1.05	0.03	0.01
LSP-58	LSJ-13	LSJ-43	84.40	300	120	3.60	0.05	0.02
LSP-59	LSJ-43	LSJ-44	37.80	300	120	1.84	0.03	0.01
LSP-61	LSJ-44	WH_03	59.40	300	120	1.84	0.03	0.01
LSP-62	WH_03	WH_04	53.00	300	120	1.74	0.02	0.00
LSP-63	WH_04	WH_05	68.00	300	120	1.61	0.02	0.00
LSP-64	WH_05	WH_06	50.90	300	120	1.45	0.02	0.00
LSP-65	WH_06	WH_07	66.40	300	120	1.34	0.02	0.00
LSP-66	WH_07	LSJ-50	41.10	300	120	1.24	0.02	0.00
LSP-68	LSJ-50	LSJ-51	33.50	300	120	1.24	0.02	0.00
LSP-69	LSJ-57	LSJ-11	85.30	300	120	1.85	0.03	0.01
P-239	LSJ-51	LSJ-57	86.00	300	120	1.24	0.02	0.00
P-240	LSJ-57	LSJ-43	126.20	200	110	-1.00	0.03	0.01
P-253	J-182	LSJ-10	142.30	300	120	-1.04	0.01	0.00
P-254	J-184	LSJ-42	79.20	200	110	-0.82	0.03	0.01

2031 Pipe Tables
PD1 Reservoir 50% Full + NO Pumps

2031 MDD Pipe Results								
Label	Start Node	Stop Node	Length (m)	Diameter (mm)	Hazen-Williams C	Flow (L/s)	Velocity (m/s)	Headloss Gradient (m/km)
LSP-1	LSJ-53	LSJ-1	172.80	300	120	14.89	0.21	0.22
LSP-2	LSJ-1	LSJ-2	192.90	300	120	-3.27	0.05	0.01
LSP-3	LSJ-2	LSJ-3	106.10	300	120	1.99	0.03	0.01
LSP-4	LSJ-3	LSJ-4	91.10	300	120	2.09	0.03	0.01
LSP-5	LSJ-4	LSJ-5	83.20	300	120	2.27	0.03	0.01
LSP-6	LSJ-5	LSJ-6	128.90	300	120	2.27	0.03	0.01
LSP-7	LSJ-6	LSJ-55	88.40	300	120	-4.18	0.06	0.02
LSP-8	LSJ-55	LSJ-7	88.40	300	120	-0.80	0.01	0.00
LSP-9	LSJ-7	LSJ-8	78.90	300	120	-3.43	0.05	0.01
LSP-10	LSJ-9	LSJ-8	82.00	300	120	-0.17	0.00	0.00
LSP-11	LSJ-9	LSJ-10	78.90	300	120	-1.32	0.02	0.00
LSP-12	LSJ-10	LSJ-11	84.70	300	120	-9.69	0.14	0.10
LSP-13	LSJ-11	LSJ-12	75.00	300	120	-7.10	0.10	0.06
LSP-14	LSJ-12	LSJ-13	71.00	300	120	-9.49	0.13	0.10
LSP-15	LSJ-13	SA02T052	140.50	300	120	-24.27	0.34	0.54
LSP-16	LSJ-14	LSJ-1	82.00	200	110	-5.21	0.17	0.27
LSP-17	LSJ-15	LSJ-14	79.20	200	110	-4.03	0.13	0.17
LSP-18	LSJ-16	LSJ-15	176.80	200	110	-2.91	0.09	0.09
LSP-19	LSJ-17	LSJ-16	78.90	200	110	5.54	0.18	0.30
LSP-20	LSJ-18	LSJ-17	77.40	200	110	3.93	0.13	0.16
LSP-21	LSJ-19	LSJ-18	193.90	200	110	-1.69	0.05	0.03
LSP-22	LSJ-14	LSJ-19	100.30	200	110	-0.43	0.01	0.00
LSP-23	LSJ-14	LSJ-17	185.90	200	110	1.61	0.05	0.03
LSP-24	LSJ-20	LSJ-18	87.80	200	110	5.62	0.18	0.31
LSP-25	LSJ-22	LSJ-2	129.20	300	120	1.94	0.03	0.01
LSP-26	LSJ-21	LSJ-22	82.90	300	120	5.65	0.08	0.04
LSP-27	LSJ-20	LSJ-21	77.70	300	120	8.08	0.11	0.07
LSP-28	LSJ-54	LSJ-20	151.80	300	120	21.69	0.31	0.44
LSP-29	LSJ-24	LSJ-20	137.80	300	120	-7.98	0.11	0.07
LSP-30	LSJ-25	LSJ-24	86.00	300	120	-0.45	0.01	0.00
LSP-31	LSJ-21	LSJ-25	136.20	200	110	1.60	0.05	0.03
LSP-32	LSJ-25	LSJ-26	53.30	300	120	2.05	0.03	0.01
LSP-33	LSJ-26	LSJ-27	71.90	300	120	2.05	0.03	0.01
LSP-34	LSJ-27	LSJ-4	89.60	300	120	0.18	0.00	0.00
LSP-35	LSJ-22	LSJ-23	96.90	200	110	0.99	0.03	0.01
LSP-36	LSJ-3	LSJ-23	124.70	200	110	-0.10	0.00	0.00
LSP-37	LSJ-2	LSJ-31	79.90	300	120	-3.31	0.05	0.01
LSP-38	LSJ-29	LSJ-28	28.00	200	110	0.00	0.00	0.00
LSP-39	LSJ-29	LSJ-30	127.40	200	110	0.00	0.00	0.00
LSP-40	LSJ-30	LSJ-31	93.60	200	110	0.00	0.00	0.00
LSP-41	LSJ-31	SB02V053	161.80	300	120	-7.20	0.10	0.06
LSP-42	LSJ-31	LSJ-32	142.30	200	110	3.89	0.12	0.15
LSP-43	LSJ-32	LSJ-34	231.30	200	110	2.04	0.06	0.05
LSP-45	LSJ-34	LSJ-6	126.80	200	110	-4.82	0.15	0.23
LSP-46	LSJ-7	LSJ-35	120.10	200	110	0.46	0.01	0.00
LSP-47	LSJ-35	LSJ-36	157.30	200	110	-0.65	0.02	0.01
LSP-48	LSJ-9	LSJ-36	104.20	200	110	0.65	0.02	0.01
LSP-49	LSJ-7	LSJ-37	102.40	200	110	2.18	0.07	0.05
LSP-50	LSJ-37	LSJ-38	76.50	200	110	-3.37	0.11	0.12
LSP-51	LSJ-8	LSJ-38	106.40	300	120	-4.47	0.06	0.02
LSP-52(1)	LSJ-38	J-184	55.80	300	120	-8.37	0.12	0.08
LSP-52(2)	J-184	LSJ-39	81.10	300	120	-6.80	0.10	0.05
LSP-53	LSJ-39	LSJ-40	124.10	300	120	-6.80	0.10	0.05
LSP-54	LSJ-40	LSJ-13	43.90	300	120	-6.80	0.10	0.05
LSP-55	LSJ-41	LSJ-11	78.30	200	110	0.44	0.01	0.00
LSP-56	LSJ-42	LSJ-41	80.20	200	110	0.44	0.01	0.00
LSP-57	LSJ-42	LSJ-12	82.90	200	110	-2.00	0.06	0.05
LSP-58	LSJ-13	LSJ-43	84.40	300	120	6.86	0.10	0.05
LSP-59	LSJ-43	LSJ-44	37.80	300	120	3.51	0.05	0.02
LSP-61	LSJ-44	WH_03	59.40	300	120	3.51	0.05	0.02
LSP-62	WH_03	WH_04	53.00	300	120	3.32	0.05	0.01
LSP-63	WH_04	WH_05	68.00	300	120	3.08	0.04	0.01
LSP-64	WH_05	WH_06	50.90	300	120	2.78	0.04	0.01
LSP-65	WH_06	WH_07	66.40	300	120	2.57	0.04	0.01
LSP-66	WH_07	LSJ-50	41.10	300	120	2.38	0.03	0.01
LSP-68	LSJ-50	LSJ-51	33.50	300	120	2.38	0.03	0.01
LSP-69	LSJ-57	LSJ-11	85.30	300	120	3.54	0.05	0.02
P-239	LSJ-51	LSJ-57	86.00	300	120	2.38	0.03	0.01
P-240	LSJ-57	LSJ-43	126.20	200	110	-1.91	0.06	0.04
P-253	J-182	LSJ-10	142.30	300	120	-1.97	0.03	0.01
P-254	J-184	LSJ-42	79.20	200	110	-1.57	0.05	0.03

2031 Pipe Tables
PD1 Reservoir 50% Full + NO Pumps

2031 PHD Pipe Results								
Label	Start Node	Stop Node	Length (m)	Diameter (mm)	Hazen-Williams C	Flow (L/s)	Velocity (m/s)	Headloss Gradient (m/km)
LSP-1	LSJ-53	LSJ-1	172.80	300	120	23.28	0.33	0.50
LSP-2	LSJ-1	LSJ-2	192.90	300	120	-5.41	0.08	0.03
LSP-3	LSJ-2	LSJ-3	106.10	300	120	3.17	0.04	0.01
LSP-4	LSJ-3	LSJ-4	91.10	300	120	3.27	0.05	0.01
LSP-5	LSJ-4	LSJ-5	83.20	300	120	3.26	0.05	0.01
LSP-6	LSJ-5	LSJ-6	128.90	300	120	3.26	0.05	0.01
LSP-7	LSJ-6	LSJ-55	88.40	300	120	-6.93	0.10	0.05
LSP-8	LSJ-55	LSJ-7	88.40	300	120	-1.53	0.02	0.00
LSP-9	LSJ-7	LSJ-8	78.90	300	120	-5.66	0.08	0.04
LSP-10	LSJ-9	LSJ-8	82.00	300	120	0.09	0.00	0.00
LSP-11	LSJ-9	LSJ-10	78.90	300	120	-2.47	0.03	0.01
LSP-12	LSJ-10	LSJ-11	84.70	300	120	-15.09	0.21	0.22
LSP-13	LSJ-11	LSJ-12	75.00	300	120	-11.11	0.16	0.13
LSP-14	LSJ-12	LSJ-13	71.00	300	120	-14.84	0.21	0.22
LSP-15	LSJ-13	SA02T052	140.50	300	120	-37.99	0.54	1.24
LSP-16	LSJ-14	LSJ-1	82.00	200	110	-8.24	0.26	0.62
LSP-17	LSJ-15	LSJ-14	79.20	200	110	-6.36	0.20	0.38
LSP-18	LSJ-16	LSJ-15	176.80	200	110	-4.60	0.15	0.21
LSP-19	LSJ-17	LSJ-16	78.90	200	110	8.74	0.28	0.69
LSP-20	LSJ-18	LSJ-17	77.40	200	110	6.20	0.20	0.37
LSP-21	LSJ-19	LSJ-18	193.90	200	110	-2.65	0.08	0.08
LSP-22	LSJ-14	LSJ-19	100.30	200	110	-0.66	0.02	0.01
LSP-23	LSJ-14	LSJ-17	185.90	200	110	2.54	0.08	0.07
LSP-24	LSJ-20	LSJ-18	87.80	200	110	8.85	0.28	0.71
LSP-25	LSJ-22	LSJ-2	129.20	300	120	2.85	0.04	0.01
LSP-26	LSJ-21	LSJ-22	82.90	300	120	8.65	0.12	0.08
LSP-27	LSJ-20	LSJ-21	77.70	300	120	12.46	0.18	0.16
LSP-28	LSJ-54	LSJ-20	151.80	300	120	33.66	0.48	0.99
LSP-29	LSJ-24	LSJ-20	137.80	300	120	-12.35	0.17	0.16
LSP-30	LSJ-25	LSJ-24	86.00	300	120	-0.46	0.01	0.00
LSP-31	LSJ-21	LSJ-25	136.20	200	110	2.48	0.08	0.07
LSP-32	LSJ-25	LSJ-26	53.30	300	120	2.94	0.04	0.01
LSP-33	LSJ-26	LSJ-27	71.90	300	120	2.94	0.04	0.01
LSP-34	LSJ-27	LSJ-4	89.60	300	120	-0.01	0.00	0.00
LSP-35	LSJ-22	LSJ-23	96.90	200	110	1.52	0.05	0.03
LSP-36	LSJ-3	LSJ-23	124.70	200	110	-0.11	0.00	0.00
LSP-37	LSJ-2	LSJ-31	79.90	300	120	-5.73	0.08	0.04
LSP-38	LSJ-29	LSJ-28	28.00	200	110	0.00	0.00	0.00
LSP-39	LSJ-29	LSJ-30	127.40	200	110	0.00	0.00	0.00
LSP-40	LSJ-30	LSJ-31	93.60	200	110	0.00	0.00	0.00
LSP-41	LSJ-31	SB02V053	161.80	300	120	-11.87	0.17	0.14
LSP-42	LSJ-31	LSJ-32	142.30	200	110	6.14	0.20	0.36
LSP-43	LSJ-32	LSJ-34	231.30	200	110	3.21	0.10	0.11
LSP-45	LSJ-34	LSJ-6	126.80	200	110	-7.62	0.24	0.54
LSP-46	LSJ-7	LSJ-35	120.10	200	110	0.69	0.02	0.01
LSP-47	LSJ-35	LSJ-36	157.30	200	110	-1.06	0.03	0.01
LSP-48	LSJ-9	LSJ-36	104.20	200	110	1.06	0.03	0.01
LSP-49	LSJ-7	LSJ-37	102.40	200	110	3.44	0.11	0.12
LSP-50	LSJ-37	LSJ-38	76.50	200	110	-5.33	0.17	0.28
LSP-51	LSJ-8	LSJ-38	106.40	300	120	-6.95	0.10	0.05
LSP-52(1)	LSJ-38	J-184	55.80	300	120	-13.11	0.19	0.17
LSP-52(2)	J-184	LSJ-39	81.10	300	120	-10.65	0.15	0.12
LSP-53	LSJ-39	LSJ-40	124.10	300	120	-10.65	0.15	0.12
LSP-54	LSJ-40	LSJ-13	43.90	300	120	-10.65	0.15	0.12
LSP-55	LSJ-41	LSJ-11	78.30	200	110	0.67	0.02	0.01
LSP-56	LSJ-42	LSJ-41	80.20	200	110	0.67	0.02	0.01
LSP-57	LSJ-42	LSJ-12	82.90	200	110	-3.14	0.10	0.10
LSP-58	LSJ-13	LSJ-43	84.40	300	120	10.74	0.15	0.12
LSP-59	LSJ-43	LSJ-44	37.80	300	120	5.49	0.08	0.03
LSP-61	LSJ-44	WH_03	59.40	300	120	5.49	0.08	0.03
LSP-62	WH_03	WH_04	53.00	300	120	5.19	0.07	0.03
LSP-63	WH_04	WH_05	68.00	300	120	4.81	0.07	0.03
LSP-64	WH_05	WH_06	50.90	300	120	4.34	0.06	0.02
LSP-65	WH_06	WH_07	66.40	300	120	4.00	0.06	0.02
LSP-66	WH_07	LSJ-50	41.10	300	120	3.71	0.05	0.02
LSP-68	LSJ-50	LSJ-51	33.50	300	120	3.71	0.05	0.02
LSP-69	LSJ-57	LSJ-11	85.30	300	120	5.51	0.08	0.04
P-239	LSJ-51	LSJ-57	86.00	300	120	3.71	0.05	0.02
P-240	LSJ-57	LSJ-43	126.20	200	110	-2.99	0.10	0.10
P-253	J-182	LSJ-10	142.30	300	120	-2.52	0.04	0.01
P-254	J-184	LSJ-42	79.20	200	110	-2.47	0.08	0.07

2011 Junctions Tables
PD1 Reservoir 75% Full + NO Pumps

2011 ADD Junction Results				
Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (kPa)
J-182	94.25	0.00	130	354
J-184	91.25	0.00	130	384
LSJ-1	91.00	6.82	130	386
LSJ-2	91.75	0.00	130	379
LSJ-3	91.50	0.00	130	381
LSJ-4	91.50	0.00	130	381
LSJ-5	90.25	0.00	130	393
LSJ-6	91.75	0.86	130	379
LSJ-7	92.25	0.00	130	374
LSJ-8	92.50	0.46	130	371
LSJ-9	92.75	0.44	130	369
LSJ-10	93.00	3.37	130	367
LSJ-11	92.00	0.73	130	376
LSJ-12	91.75	0.20	130	379
LSJ-13	91.25	0.59	130	384
LSJ-14	90.75	0.00	130	388
LSJ-15	91.50	0.59	130	381
LSJ-16	90.50	4.45	130	391
LSJ-17	90.75	0.00	130	388
LSJ-18	89.75	0.00	130	398
LSJ-19	91.00	0.66	130	386
LSJ-20	89.75	0.00	130	398
LSJ-21	90.50	0.44	130	391
LSJ-22	90.75	1.43	130	389
LSJ-23	90.50	0.47	130	391
LSJ-24	89.25	3.96	130	403
LSJ-25	89.75	0.00	130	398
LSJ-26	89.75	0.00	130	398
LSJ-27	90.50	0.98	130	391
LSJ-28	94.25	0.00	130	354
LSJ-29	94.00	0.00	130	357
LSJ-30	92.00	0.00	130	376
LSJ-31	92.75	0.00	130	369
LSJ-32	92.75	0.98	130	369
LSJ-34	91.25	3.61	130	384
LSJ-35	93.50	0.58	130	362
LSJ-36	94.00	0.00	130	357
LSJ-37	91.00	2.92	130	386
LSJ-38	91.50	0.28	130	381
LSJ-39	91.00	0.00	130	386
LSJ-40	91.25	0.00	130	384
LSJ-41	92.00	0.00	130	376
LSJ-42	91.50	0.00	130	381
LSJ-43	91.25	0.76	130	384
LSJ-44	91.75	0.00	130	379
LSJ-50	95.00	0.00	130	347
LSJ-51	94.00	0.00	130	357
LSJ-53	92.25	0.00	130	374
LSJ-54	88.18	0.00	130	414
LSJ-55	91.86	0.00	130	378
LSJ-57	92.25	0.39	130	374
SA02T005	95.10	4.03	130	346
SA02T052	91.00	0.00	130	386
SB02R011	94.00	0.00	130	357
SB02V053	95.20	0.00	130	345
WH_03	92.00	0.10	130	376
WH_04	92.00	0.13	130	376
WH_05	92.00	0.16	130	376
WH_06	93.00	0.11	130	367
WH_07	95.00	0.10	130	347

2011 Junctions Tables
PD1 Reservoir 75% Full + NO Pumps

2011 MDD Junction Results				
Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (kPa)
J-182	94.25	0.00	130	346
J-184	91.25	0.00	130	375
LSJ-1	91.00	12.95	130	378
LSJ-2	91.75	0.00	130	370
LSJ-3	91.50	0.00	130	373
LSJ-4	91.50	0.00	130	373
LSJ-5	90.25	0.00	130	385
LSJ-6	91.75	1.63	130	370
LSJ-7	92.25	0.00	130	366
LSJ-8	92.50	0.87	130	363
LSJ-9	92.75	0.83	130	361
LSJ-10	93.00	6.40	130	358
LSJ-11	92.00	1.39	130	368
LSJ-12	91.75	0.38	130	371
LSJ-13	91.25	1.12	130	376
LSJ-14	90.75	0.00	130	380
LSJ-15	91.50	1.12	130	372
LSJ-16	90.50	8.45	130	382
LSJ-17	90.75	0.00	130	380
LSJ-18	89.75	0.00	130	390
LSJ-19	91.00	1.26	130	377
LSJ-20	89.75	0.00	130	390
LSJ-21	90.50	0.84	130	383
LSJ-22	90.75	2.71	130	380
LSJ-23	90.50	0.89	130	383
LSJ-24	89.25	7.53	130	395
LSJ-25	89.75	0.00	130	390
LSJ-26	89.75	0.00	130	390
LSJ-27	90.50	1.87	130	383
LSJ-28	94.25	0.00	130	346
LSJ-29	94.00	0.00	130	348
LSJ-30	92.00	0.00	130	368
LSJ-31	92.75	0.00	130	361
LSJ-32	92.75	1.85	130	360
LSJ-34	91.25	6.86	130	375
LSJ-35	93.50	1.11	130	353
LSJ-36	94.00	0.00	130	348
LSJ-37	91.00	5.55	130	378
LSJ-38	91.50	0.53	130	373
LSJ-39	91.00	0.00	130	378
LSJ-40	91.25	0.00	130	376
LSJ-41	92.00	0.00	130	368
LSJ-42	91.50	0.00	130	373
LSJ-43	91.25	1.44	130	376
LSJ-44	91.75	0.00	130	371
LSJ-50	95.00	0.00	130	339
LSJ-51	94.00	0.00	130	349
LSJ-53	92.25	0.00	130	366
LSJ-54	88.18	0.00	130	406
LSJ-55	91.86	0.00	130	369
LSJ-57	92.25	0.75	130	366
SA02T005	95.10	7.66	130	338
SA02T052	91.00	0.00	130	379
SB02R011	94.00	0.00	130	349
SB02V053	95.20	0.00	130	337
WH_03	92.00	0.19	130	368
WH_04	92.00	0.24	130	368
WH_05	92.00	0.30	130	368
WH_06	93.00	0.21	130	358
WH_07	95.00	0.19	130	339

2011 Junctions Tables
PD1 Reservoir 75% Full + NO Pumps

2011 PHD Junction Results				
Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (kPa)
J-182	94.25	0.00	128	330
J-184	91.25	0.00	128	359
LSJ-1	91.00	20.45	128	361
LSJ-2	91.75	0.00	128	354
LSJ-3	91.50	0.00	128	356
LSJ-4	91.50	0.00	128	356
LSJ-5	90.25	0.00	128	368
LSJ-6	91.75	2.57	128	354
LSJ-7	92.25	0.00	128	349
LSJ-8	92.50	1.38	128	347
LSJ-9	92.75	1.32	128	344
LSJ-10	93.00	10.10	128	342
LSJ-11	92.00	2.20	128	352
LSJ-12	91.75	0.60	128	354
LSJ-13	91.25	1.76	128	359
LSJ-14	90.75	0.00	128	363
LSJ-15	91.50	1.76	128	355
LSJ-16	90.50	13.34	128	365
LSJ-17	90.75	0.00	128	363
LSJ-18	89.75	0.00	128	373
LSJ-19	91.00	1.99	128	360
LSJ-20	89.75	0.00	128	373
LSJ-21	90.50	1.33	128	366
LSJ-22	90.75	4.28	128	363
LSJ-23	90.50	1.41	128	366
LSJ-24	89.25	11.89	128	378
LSJ-25	89.75	0.00	128	373
LSJ-26	89.75	0.00	128	373
LSJ-27	90.50	2.95	128	366
LSJ-28	94.25	0.00	128	329
LSJ-29	94.00	0.00	128	332
LSJ-30	92.00	0.00	128	351
LSJ-31	92.75	0.00	128	344
LSJ-32	92.75	2.93	128	343
LSJ-34	91.25	10.83	128	358
LSJ-35	93.50	1.75	128	337
LSJ-36	94.00	0.00	128	332
LSJ-37	91.00	8.77	128	361
LSJ-38	91.50	0.84	128	356
LSJ-39	91.00	0.00	128	361
LSJ-40	91.25	0.00	128	359
LSJ-41	92.00	0.00	128	352
LSJ-42	91.50	0.00	128	356
LSJ-43	91.25	2.27	128	359
LSJ-44	91.75	0.00	128	354
LSJ-50	95.00	0.00	128	322
LSJ-51	94.00	0.00	128	332
LSJ-53	92.25	0.00	128	349
LSJ-54	88.18	0.00	128	390
LSJ-55	91.86	0.00	128	353
LSJ-57	92.25	1.18	128	349
SA02T005	95.10	12.28	128	322
SA02T052	91.00	0.00	128	363
SB02R011	94.00	0.00	128	332
SB02V053	95.20	0.00	128	320
WH_03	92.00	0.30	128	352
WH_04	92.00	0.38	128	352
WH_05	92.00	0.47	128	352
WH_06	93.00	0.34	128	342
WH_07	95.00	0.30	128	322

2031 Junctions Tables
PD1 Reservoir 75% Full + NO Pumps

2031 ADD Junction Results				
Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (kPa)
J-182	94.25	0.00	130	352
J-184	91.25	0.00	130	381
LSJ-1	91.00	6.82	130	383
LSJ-2	91.75	0.00	130	376
LSJ-3	91.50	0.00	130	378
LSJ-4	91.50	0.00	130	378
LSJ-5	90.25	0.00	130	391
LSJ-6	91.75	0.86	130	376
LSJ-7	92.25	0.00	130	371
LSJ-8	92.50	0.46	130	369
LSJ-9	92.75	0.44	130	366
LSJ-10	93.00	3.37	130	364
LSJ-11	92.00	0.73	130	374
LSJ-12	91.75	0.20	130	376
LSJ-13	91.25	0.59	130	381
LSJ-14	90.75	0.00	130	386
LSJ-15	91.50	0.59	130	378
LSJ-16	90.50	4.45	130	388
LSJ-17	90.75	0.00	130	386
LSJ-18	89.75	0.00	130	396
LSJ-19	91.00	0.66	130	383
LSJ-20	89.75	0.00	130	396
LSJ-21	90.50	0.44	130	388
LSJ-22	90.75	1.43	130	386
LSJ-23	90.50	0.47	130	388
LSJ-24	89.25	3.96	130	400
LSJ-25	89.75	0.00	130	396
LSJ-26	89.75	0.00	130	396
LSJ-27	90.50	0.98	130	388
LSJ-28	94.25	0.00	130	352
LSJ-29	94.00	0.00	130	354
LSJ-30	92.00	0.00	130	374
LSJ-31	92.75	0.00	130	366
LSJ-32	92.75	0.98	130	366
LSJ-34	91.25	3.61	130	381
LSJ-35	93.50	0.58	130	359
LSJ-36	94.00	0.00	130	354
LSJ-37	91.00	2.92	130	383
LSJ-38	91.50	0.28	130	378
LSJ-39	91.00	0.00	130	383
LSJ-40	91.25	0.00	130	381
LSJ-41	92.00	0.00	130	374
LSJ-42	91.50	0.00	130	379
LSJ-43	91.25	0.76	130	381
LSJ-44	91.75	0.00	130	376
LSJ-50	95.00	0.00	130	344
LSJ-51	94.00	0.00	130	354
LSJ-53	92.25	0.00	130	371
LSJ-54	88.18	0.00	130	411
LSJ-55	91.86	0.00	130	375
LSJ-57	92.25	0.39	130	371
SA02T005	95.10	6.78	130	343
SA02T052	91.00	0.00	130	384
SB02R011	94.00	0.00	130	354
SB02V053	95.20	0.00	130	342
WH_03	92.00	0.10	130	374
WH_04	92.00	0.13	130	374
WH_05	92.00	0.16	130	374
WH_06	93.00	0.11	130	364
WH_07	95.00	0.10	130	344

2031 Junctions Tables
PD1 Reservoir 75% Full + NO Pumps

2031 MDD Junction Results				
Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (kPa)
J-182	94.25	0.00	129	336
J-184	91.25	0.00	129	365
LSJ-1	91.00	12.95	129	368
LSJ-2	91.75	0.00	129	360
LSJ-3	91.50	0.00	129	363
LSJ-4	91.50	0.00	129	363
LSJ-5	90.25	0.00	129	375
LSJ-6	91.75	1.63	129	360
LSJ-7	92.25	0.00	129	356
LSJ-8	92.50	0.87	129	353
LSJ-9	92.75	0.83	129	351
LSJ-10	93.00	6.40	129	348
LSJ-11	92.00	1.39	129	358
LSJ-12	91.75	0.38	129	361
LSJ-13	91.25	1.12	129	366
LSJ-14	90.75	0.00	129	370
LSJ-15	91.50	1.12	129	363
LSJ-16	90.50	8.45	129	372
LSJ-17	90.75	0.00	129	370
LSJ-18	89.75	0.00	129	380
LSJ-19	91.00	1.26	129	368
LSJ-20	89.75	0.00	129	380
LSJ-21	90.50	0.84	129	373
LSJ-22	90.75	2.71	129	370
LSJ-23	90.50	0.89	129	373
LSJ-24	89.25	7.53	129	385
LSJ-25	89.75	0.00	129	380
LSJ-26	89.75	0.00	129	380
LSJ-27	90.50	1.87	129	373
LSJ-28	94.25	0.00	129	336
LSJ-29	94.00	0.00	129	338
LSJ-30	92.00	0.00	129	358
LSJ-31	92.75	0.00	129	351
LSJ-32	92.75	1.85	129	350
LSJ-34	91.25	6.86	129	365
LSJ-35	93.50	1.11	129	343
LSJ-36	94.00	0.00	129	338
LSJ-37	91.00	5.55	129	368
LSJ-38	91.50	0.53	129	363
LSJ-39	91.00	0.00	129	368
LSJ-40	91.25	0.00	129	366
LSJ-41	92.00	0.00	129	358
LSJ-42	91.50	0.00	129	363
LSJ-43	91.25	1.44	129	366
LSJ-44	91.75	0.00	129	361
LSJ-50	95.00	0.00	129	329
LSJ-51	94.00	0.00	129	339
LSJ-53	92.25	0.00	129	356
LSJ-54	88.18	0.00	129	396
LSJ-55	91.86	0.00	129	359
LSJ-57	92.25	0.75	129	356
SA02T005	95.10	12.90	129	328
SA02T052	91.00	0.00	129	369
SB02R011	94.00	0.00	129	338
SB02V053	95.20	0.00	129	327
WH_03	92.00	0.19	129	358
WH_04	92.00	0.24	129	358
WH_05	92.00	0.30	129	358
WH_06	93.00	0.21	129	348
WH_07	95.00	0.19	129	329

2031 Junctions Tables
PD1 Reservoir 75% Full + NO Pumps

2031 PHD Junction Results				
Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (kPa)
J-182	94.25	0.00	126	309
J-184	91.25	0.00	126	339
LSJ-1	91.00	20.45	126	341
LSJ-2	91.75	0.00	126	333
LSJ-3	91.50	0.00	126	336
LSJ-4	91.50	0.00	126	336
LSJ-5	90.25	0.00	126	348
LSJ-6	91.75	2.57	126	333
LSJ-7	92.25	0.00	126	329
LSJ-8	92.50	1.38	126	326
LSJ-9	92.75	1.32	126	324
LSJ-10	93.00	10.10	126	321
LSJ-11	92.00	2.20	126	331
LSJ-12	91.75	0.60	126	334
LSJ-13	91.25	1.76	126	339
LSJ-14	90.75	0.00	126	343
LSJ-15	91.50	1.76	126	335
LSJ-16	90.50	13.34	126	344
LSJ-17	90.75	0.00	126	343
LSJ-18	89.75	0.00	126	353
LSJ-19	91.00	1.99	126	340
LSJ-20	89.75	0.00	126	353
LSJ-21	90.50	1.33	126	346
LSJ-22	90.75	4.28	126	343
LSJ-23	90.50	1.41	126	346
LSJ-24	89.25	11.89	126	358
LSJ-25	89.75	0.00	126	353
LSJ-26	89.75	0.00	126	353
LSJ-27	90.50	2.95	126	346
LSJ-28	94.25	0.00	126	309
LSJ-29	94.00	0.00	126	311
LSJ-30	92.00	0.00	126	331
LSJ-31	92.75	0.00	126	324
LSJ-32	92.75	2.93	126	323
LSJ-34	91.25	10.83	126	338
LSJ-35	93.50	1.75	126	316
LSJ-36	94.00	0.00	126	311
LSJ-37	91.00	8.77	126	341
LSJ-38	91.50	0.84	126	336
LSJ-39	91.00	0.00	126	341
LSJ-40	91.25	0.00	126	339
LSJ-41	92.00	0.00	126	331
LSJ-42	91.50	0.00	126	336
LSJ-43	91.25	2.27	126	339
LSJ-44	91.75	0.00	126	334
LSJ-50	95.00	0.00	126	302
LSJ-51	94.00	0.00	126	312
LSJ-53	92.25	0.00	126	329
LSJ-54	88.18	0.00	126	370
LSJ-55	91.86	0.00	126	332
LSJ-57	92.25	1.18	126	329
SA02T005	95.10	19.88	126	301
SA02T052	91.00	0.00	126	343
SB02R011	94.00	0.00	126	311
SB02V053	95.20	0.00	126	300
WH_03	92.00	0.30	126	331
WH_04	92.00	0.38	126	331
WH_05	92.00	0.47	126	331
WH_06	93.00	0.34	126	322
WH_07	95.00	0.30	126	302

2011 Pipe Tables
PD1 Reservoir 75% Full + NO Pumps

2011 ADD Pipe Results								
Label	Start Node	Stop Node	Length (m)	Diameter (mm)	Hazen-Williams C	Flow (L/s)	Velocity (m/s)	Headloss Gradient (m/km)
LSP-1	LSJ-53	LSJ-1	172.80	300	120	6.60	0.09	0.05
LSP-2	LSJ-1	LSJ-2	192.90	300	120	-2.96	0.04	0.01
LSP-3	LSJ-2	LSJ-3	106.10	300	120	0.46	0.01	0.00
LSP-4	LSJ-3	LSJ-4	91.10	300	120	0.28	0.00	0.00
LSP-5	LSJ-4	LSJ-5	83.20	300	120	-0.88	0.01	0.00
LSP-6	LSJ-5	LSJ-6	128.90	300	120	-0.88	0.01	0.00
LSP-7	LSJ-6	LSJ-55	88.40	300	120	-4.30	0.06	0.02
LSP-8	LSJ-55	LSJ-7	88.40	300	120	-2.02	0.03	0.01
LSP-9	LSJ-7	LSJ-8	78.90	300	120	-3.09	0.04	0.01
LSP-10	LSJ-9	LSJ-8	82.00	300	120	1.51	0.02	0.00
LSP-11	LSJ-9	LSJ-10	78.90	300	120	-2.54	0.04	0.01
LSP-12	LSJ-10	LSJ-11	84.70	300	120	-3.98	0.06	0.02
LSP-13	LSJ-11	LSJ-12	75.00	300	120	-3.18	0.04	0.01
LSP-14	LSJ-12	LSJ-13	71.00	300	120	-4.33	0.06	0.02
LSP-15	LSJ-13	SA02T052	140.50	300	120	-11.42	0.16	0.13
LSP-16	LSJ-14	LSJ-1	82.00	200	110	-2.74	0.09	0.08
LSP-17	LSJ-15	LSJ-14	79.20	200	110	-2.12	0.07	0.05
LSP-18	LSJ-16	LSJ-15	176.80	200	110	-1.53	0.05	0.03
LSP-19	LSJ-17	LSJ-16	78.90	200	110	2.92	0.09	0.09
LSP-20	LSJ-18	LSJ-17	77.40	200	110	2.07	0.07	0.05
LSP-21	LSJ-19	LSJ-18	193.90	200	110	-0.89	0.03	0.01
LSP-22	LSJ-14	LSJ-19	100.30	200	110	-0.23	0.01	0.00
LSP-23	LSJ-14	LSJ-17	185.90	200	110	0.85	0.03	0.01
LSP-24	LSJ-20	LSJ-18	87.80	200	110	2.96	0.09	0.09
LSP-25	LSJ-22	LSJ-2	129.20	300	120	0.31	0.00	0.00
LSP-26	LSJ-21	LSJ-22	82.90	300	120	2.03	0.03	0.01
LSP-27	LSJ-20	LSJ-21	77.70	300	120	3.09	0.04	0.01
LSP-28	LSJ-54	LSJ-20	151.80	300	120	9.20	0.13	0.09
LSP-29	LSJ-24	LSJ-20	137.80	300	120	-3.16	0.04	0.01
LSP-30	LSJ-25	LSJ-24	86.00	300	120	0.80	0.01	0.00
LSP-31	LSJ-21	LSJ-25	136.20	200	110	0.62	0.02	0.01
LSP-32	LSJ-25	LSJ-26	53.30	300	120	-0.18	0.00	0.00
LSP-33	LSJ-26	LSJ-27	71.90	300	120	-0.18	0.00	0.00
LSP-34	LSJ-27	LSJ-4	89.60	300	120	-1.16	0.02	0.00
LSP-35	LSJ-22	LSJ-23	96.90	200	110	0.29	0.01	0.00
LSP-36	LSJ-3	LSJ-23	124.70	200	110	0.18	0.01	0.00
LSP-37	LSJ-2	LSJ-31	79.90	300	120	-3.12	0.04	0.01
LSP-38	LSJ-29	LSJ-28	28.00	200	110	0.00	0.00	0.00
LSP-39	LSJ-29	LSJ-30	127.40	200	110	0.00	0.00	0.00
LSP-40	LSJ-30	LSJ-31	93.60	200	110	0.00	0.00	0.00
LSP-41	LSJ-31	SB02V053	161.80	300	120	-5.15	0.07	0.03
LSP-42	LSJ-31	LSJ-32	142.30	200	110	2.03	0.06	0.05
LSP-43	LSJ-32	LSJ-34	231.30	200	110	1.05	0.03	0.01
LSP-45	LSJ-34	LSJ-6	126.80	200	110	-2.56	0.08	0.07
LSP-46	LSJ-7	LSJ-35	120.10	200	110	0.00	0.00	0.00
LSP-47	LSJ-35	LSJ-36	157.30	200	110	-0.58	0.02	0.01
LSP-48	LSJ-9	LSJ-36	104.20	200	110	0.58	0.02	0.01
LSP-49	LSJ-7	LSJ-37	102.40	200	110	1.07	0.03	0.01
LSP-50	LSJ-37	LSJ-38	76.50	200	110	-1.85	0.06	0.04
LSP-51	LSJ-8	LSJ-38	106.40	300	120	-2.04	0.03	0.01
LSP-52(1)	LSJ-38	J-184	55.80	300	120	-4.17	0.06	0.02
LSP-52(2)	J-184	LSJ-39	81.10	300	120	-3.28	0.05	0.01
LSP-53	LSJ-39	LSJ-40	124.10	300	120	-3.28	0.05	0.01
LSP-54	LSJ-40	LSJ-13	43.90	300	120	-3.28	0.05	0.01
LSP-55	LSJ-41	LSJ-11	78.30	200	110	0.06	0.00	0.00
LSP-56	LSJ-42	LSJ-41	80.20	200	110	0.06	0.00	0.00
LSP-57	LSJ-42	LSJ-12	82.90	200	110	-0.95	0.03	0.01
LSP-58	LSJ-13	LSJ-43	84.40	300	120	3.22	0.05	0.01
LSP-59	LSJ-43	LSJ-44	37.80	300	120	1.61	0.02	0.00
LSP-61	LSJ-44	WH_03	59.40	300	120	1.61	0.02	0.00
LSP-62	WH_03	WH_04	53.00	300	120	1.51	0.02	0.00
LSP-63	WH_04	WH_05	68.00	300	120	1.38	0.02	0.00
LSP-64	WH_05	WH_06	50.90	300	120	1.23	0.02	0.00
LSP-65	WH_06	WH_07	66.40	300	120	1.12	0.02	0.00
LSP-66	WH_07	LSJ-50	41.10	300	120	1.02	0.01	0.00
LSP-68	LSJ-50	LSJ-51	33.50	300	120	1.02	0.01	0.00
LSP-69	LSJ-57	LSJ-11	85.30	300	120	1.48	0.02	0.00
P-239	LSJ-51	LSJ-57	86.00	300	120	1.02	0.01	0.00
P-240	LSJ-57	LSJ-43	126.20	200	110	-0.85	0.03	0.01
P-253	J-182	LSJ-10	142.30	300	120	1.92	0.03	0.01
P-254	J-184	LSJ-42	79.20	200	110	-0.89	0.03	0.01

2011 Pipe Tables
PD1 Reservoir 75% Full + NO Pumps

2011 MDD Pipe Results								
Label	Start Node	Stop Node	Length (m)	Diameter (mm)	Hazen-Williams C	Flow (L/s)	Velocity (m/s)	Headloss Gradient (m/km)
LSP-1	LSJ-53	LSJ-1	172.80	300	120	12.51	0.18	0.16
LSP-2	LSJ-1	LSJ-2	192.90	300	120	-5.65	0.08	0.04
LSP-3	LSJ-2	LSJ-3	106.10	300	120	0.83	0.01	0.00
LSP-4	LSJ-3	LSJ-4	91.10	300	120	0.49	0.01	0.00
LSP-5	LSJ-4	LSJ-5	83.20	300	120	-1.70	0.02	0.00
LSP-6	LSJ-5	LSJ-6	128.90	300	120	-1.70	0.02	0.00
LSP-7	LSJ-6	LSJ-55	88.40	300	120	-8.19	0.12	0.07
LSP-8	LSJ-55	LSJ-7	88.40	300	120	-3.87	0.05	0.02
LSP-9	LSJ-7	LSJ-8	78.90	300	120	-5.90	0.08	0.04
LSP-10	LSJ-9	LSJ-8	82.00	300	120	2.88	0.04	0.01
LSP-11	LSJ-9	LSJ-10	78.90	300	120	-4.82	0.07	0.03
LSP-12	LSJ-10	LSJ-11	84.70	300	120	-7.61	0.11	0.06
LSP-13	LSJ-11	LSJ-12	75.00	300	120	-6.07	0.09	0.04
LSP-14	LSJ-12	LSJ-13	71.00	300	120	-8.25	0.12	0.07
LSP-15	LSJ-13	SA02T052	140.50	300	120	-21.76	0.31	0.44
LSP-16	LSJ-14	LSJ-1	82.00	200	110	-5.21	0.17	0.27
LSP-17	LSJ-15	LSJ-14	79.20	200	110	-4.03	0.13	0.17
LSP-18	LSJ-16	LSJ-15	176.80	200	110	-2.91	0.09	0.09
LSP-19	LSJ-17	LSJ-16	78.90	200	110	5.54	0.18	0.30
LSP-20	LSJ-18	LSJ-17	77.40	200	110	3.93	0.13	0.16
LSP-21	LSJ-19	LSJ-18	193.90	200	110	-1.69	0.05	0.03
LSP-22	LSJ-14	LSJ-19	100.30	200	110	-0.43	0.01	0.00
LSP-23	LSJ-14	LSJ-17	185.90	200	110	1.61	0.05	0.03
LSP-24	LSJ-20	LSJ-18	87.80	200	110	5.62	0.18	0.31
LSP-25	LSJ-22	LSJ-2	129.20	300	120	0.61	0.01	0.00
LSP-26	LSJ-21	LSJ-22	82.90	300	120	3.87	0.05	0.02
LSP-27	LSJ-20	LSJ-21	77.70	300	120	5.89	0.08	0.04
LSP-28	LSJ-54	LSJ-20	151.80	300	120	17.53	0.25	0.30
LSP-29	LSJ-24	LSJ-20	137.80	300	120	-6.02	0.09	0.04
LSP-30	LSJ-25	LSJ-24	86.00	300	120	1.51	0.02	0.00
LSP-31	LSJ-21	LSJ-25	136.20	200	110	1.18	0.04	0.02
LSP-32	LSJ-25	LSJ-26	53.30	300	120	-0.33	0.00	0.00
LSP-33	LSJ-26	LSJ-27	71.90	300	120	-0.33	0.00	0.00
LSP-34	LSJ-27	LSJ-4	89.60	300	120	-2.20	0.03	0.01
LSP-35	LSJ-22	LSJ-23	96.90	200	110	0.55	0.02	0.00
LSP-36	LSJ-3	LSJ-23	124.70	200	110	0.34	0.01	0.00
LSP-37	LSJ-2	LSJ-31	79.90	300	120	-5.87	0.08	0.04
LSP-38	LSJ-29	LSJ-28	28.00	200	110	0.00	0.00	0.00
LSP-39	LSJ-29	LSJ-30	127.40	200	110	0.00	0.00	0.00
LSP-40	LSJ-30	LSJ-31	93.60	200	110	0.00	0.00	0.00
LSP-41	LSJ-31	SB02V053	161.80	300	120	-9.72	0.14	0.10
LSP-42	LSJ-31	LSJ-32	142.30	200	110	3.85	0.12	0.15
LSP-43	LSJ-32	LSJ-34	231.30	200	110	2.00	0.06	0.05
LSP-45	LSJ-34	LSJ-6	126.80	200	110	-4.86	0.15	0.23
LSP-46	LSJ-7	LSJ-35	120.10	200	110	0.00	0.00	0.00
LSP-47	LSJ-35	LSJ-36	157.30	200	110	-1.11	0.04	0.02
LSP-48	LSJ-9	LSJ-36	104.20	200	110	1.11	0.04	0.02
LSP-49	LSJ-7	LSJ-37	102.40	200	110	2.03	0.06	0.05
LSP-50	LSJ-37	LSJ-38	76.50	200	110	-3.52	0.11	0.13
LSP-51	LSJ-8	LSJ-38	106.40	300	120	-3.89	0.06	0.02
LSP-52(1)	LSJ-38	J-184	55.80	300	120	-7.94	0.11	0.07
LSP-52(2)	J-184	LSJ-39	81.10	300	120	-6.25	0.09	0.04
LSP-53	LSJ-39	LSJ-40	124.10	300	120	-6.25	0.09	0.04
LSP-54	LSJ-40	LSJ-13	43.90	300	120	-6.25	0.09	0.04
LSP-55	LSJ-41	LSJ-11	78.30	200	110	0.11	0.00	0.00
LSP-56	LSJ-42	LSJ-41	80.20	200	110	0.11	0.00	0.00
LSP-57	LSJ-42	LSJ-12	82.90	200	110	-1.80	0.06	0.04
LSP-58	LSJ-13	LSJ-43	84.40	300	120	6.14	0.09	0.04
LSP-59	LSJ-43	LSJ-44	37.80	300	120	3.07	0.04	0.01
LSP-61	LSJ-44	WH_03	59.40	300	120	3.07	0.04	0.01
LSP-62	WH_03	WH_04	53.00	300	120	2.89	0.04	0.01
LSP-63	WH_04	WH_05	68.00	300	120	2.64	0.04	0.01
LSP-64	WH_05	WH_06	50.90	300	120	2.35	0.03	0.01
LSP-65	WH_06	WH_07	66.40	300	120	2.13	0.03	0.01
LSP-66	WH_07	LSJ-50	41.10	300	120	1.95	0.03	0.01
LSP-68	LSJ-50	LSJ-51	33.50	300	120	1.95	0.03	0.01
LSP-69	LSJ-57	LSJ-11	85.30	300	120	2.82	0.04	0.01
P-239	LSJ-51	LSJ-57	86.00	300	120	1.95	0.03	0.01
P-240	LSJ-57	LSJ-43	126.20	200	110	-1.63	0.05	0.03
P-253	J-182	LSJ-10	142.30	300	120	3.61	0.05	0.02
P-254	J-184	LSJ-42	79.20	200	110	-1.69	0.05	0.03

2011 Pipe Tables
PD1 Reservoir 75% Full + NO Pumps

2011 PHD Pipe Results								
Label	Start Node	Stop Node	Length (m)	Diameter (mm)	Hazen-Williams C	Flow (L/s)	Velocity (m/s)	Headloss Gradient (m/km)
LSP-1	LSJ-53	LSJ-1	172.80	300	120	20.13	0.28	0.38
LSP-2	LSJ-1	LSJ-2	192.90	300	120	-8.58	0.12	0.08
LSP-3	LSJ-2	LSJ-3	106.10	300	120	1.81	0.03	0.00
LSP-4	LSJ-3	LSJ-4	91.10	300	120	1.32	0.02	0.00
LSP-5	LSJ-4	LSJ-5	83.20	300	120	-2.08	0.03	0.01
LSP-6	LSJ-5	LSJ-6	128.90	300	120	-2.08	0.03	0.01
LSP-7	LSJ-6	LSJ-55	88.40	300	120	-12.29	0.17	0.15
LSP-8	LSJ-55	LSJ-7	88.40	300	120	-5.48	0.08	0.03
LSP-9	LSJ-7	LSJ-8	78.90	300	120	-8.85	0.13	0.08
LSP-10	LSJ-9	LSJ-8	82.00	300	120	4.35	0.06	0.02
LSP-11	LSJ-9	LSJ-10	78.90	300	120	-7.34	0.10	0.06
LSP-12	LSJ-10	LSJ-11	84.70	300	120	-11.64	0.16	0.14
LSP-13	LSJ-11	LSJ-12	75.00	300	120	-9.36	0.13	0.09
LSP-14	LSJ-12	LSJ-13	71.00	300	120	-12.73	0.18	0.16
LSP-15	LSJ-13	SA02T052	140.50	300	120	-33.64	0.48	0.99
LSP-16	LSJ-14	LSJ-1	82.00	200	110	-8.26	0.26	0.62
LSP-17	LSJ-15	LSJ-14	79.20	200	110	-6.36	0.20	0.38
LSP-18	LSJ-16	LSJ-15	176.80	200	110	-4.60	0.15	0.21
LSP-19	LSJ-17	LSJ-16	78.90	200	110	8.74	0.28	0.69
LSP-20	LSJ-18	LSJ-17	77.40	200	110	6.19	0.20	0.37
LSP-21	LSJ-19	LSJ-18	193.90	200	110	-2.64	0.08	0.08
LSP-22	LSJ-14	LSJ-19	100.30	200	110	-0.65	0.02	0.01
LSP-23	LSJ-14	LSJ-17	185.90	200	110	2.55	0.08	0.07
LSP-24	LSJ-20	LSJ-18	87.80	200	110	8.83	0.28	0.70
LSP-25	LSJ-22	LSJ-2	129.20	300	120	0.85	0.01	0.00
LSP-26	LSJ-21	LSJ-22	82.90	300	120	6.05	0.09	0.04
LSP-27	LSJ-20	LSJ-21	77.70	300	120	9.27	0.13	0.09
LSP-28	LSJ-54	LSJ-20	151.80	300	120	27.65	0.39	0.69
LSP-29	LSJ-24	LSJ-20	137.80	300	120	-9.55	0.14	0.10
LSP-30	LSJ-25	LSJ-24	86.00	300	120	2.34	0.03	0.01
LSP-31	LSJ-21	LSJ-25	136.20	200	110	1.90	0.06	0.04
LSP-32	LSJ-25	LSJ-26	53.30	300	120	-0.44	0.01	0.00
LSP-33	LSJ-26	LSJ-27	71.90	300	120	-0.44	0.01	0.00
LSP-34	LSJ-27	LSJ-4	89.60	300	120	-3.39	0.05	0.01
LSP-35	LSJ-22	LSJ-23	96.90	200	110	0.92	0.03	0.01
LSP-36	LSJ-3	LSJ-23	124.70	200	110	0.49	0.02	0.00
LSP-37	LSJ-2	LSJ-31	79.90	300	120	-9.54	0.14	0.10
LSP-38	LSJ-29	LSJ-28	28.00	200	110	0.00	0.00	0.00
LSP-39	LSJ-29	LSJ-30	127.40	200	110	0.00	0.00	0.00
LSP-40	LSJ-30	LSJ-31	93.60	200	110	0.00	0.00	0.00
LSP-41	LSJ-31	SB02V053	161.80	300	120	-15.66	0.22	0.24
LSP-42	LSJ-31	LSJ-32	142.30	200	110	6.12	0.19	0.36
LSP-43	LSJ-32	LSJ-34	231.30	200	110	3.19	0.10	0.11
LSP-45	LSJ-34	LSJ-6	126.80	200	110	-7.64	0.24	0.54
LSP-46	LSJ-7	LSJ-35	120.10	200	110	0.08	0.00	0.00
LSP-47	LSJ-35	LSJ-36	157.30	200	110	-1.67	0.05	0.03
LSP-48	LSJ-9	LSJ-36	104.20	200	110	1.67	0.05	0.03
LSP-49	LSJ-7	LSJ-37	102.40	200	110	3.29	0.10	0.11
LSP-50	LSJ-37	LSJ-38	76.50	200	110	-5.48	0.17	0.29
LSP-51	LSJ-8	LSJ-38	106.40	300	120	-5.87	0.08	0.04
LSP-52(1)	LSJ-38	J-184	55.80	300	120	-12.20	0.17	0.15
LSP-52(2)	J-184	LSJ-39	81.10	300	120	-9.61	0.14	0.10
LSP-53	LSJ-39	LSJ-40	124.10	300	120	-9.61	0.14	0.10
LSP-54	LSJ-40	LSJ-13	43.90	300	120	-9.61	0.14	0.10
LSP-55	LSJ-41	LSJ-11	78.30	200	110	0.19	0.01	0.00
LSP-56	LSJ-42	LSJ-41	80.20	200	110	0.19	0.01	0.00
LSP-57	LSJ-42	LSJ-12	82.90	200	110	-2.78	0.09	0.08
LSP-58	LSJ-13	LSJ-43	84.40	300	120	9.53	0.13	0.10
LSP-59	LSJ-43	LSJ-44	37.80	300	120	4.76	0.07	0.03
LSP-61	LSJ-44	WH_03	59.40	300	120	4.76	0.07	0.03
LSP-62	WH_03	WH_04	53.00	300	120	4.46	0.06	0.02
LSP-63	WH_04	WH_05	68.00	300	120	4.08	0.06	0.02
LSP-64	WH_05	WH_06	50.90	300	120	3.61	0.05	0.02
LSP-65	WH_06	WH_07	66.40	300	120	3.27	0.05	0.01
LSP-66	WH_07	LSJ-50	41.10	300	120	2.97	0.04	0.01
LSP-68	LSJ-50	LSJ-51	33.50	300	120	2.97	0.04	0.01
LSP-69	LSJ-57	LSJ-11	85.30	300	120	4.29	0.06	0.02
P-239	LSJ-51	LSJ-57	86.00	300	120	2.97	0.04	0.01
P-240	LSJ-57	LSJ-43	126.20	200	110	-2.51	0.08	0.07
P-253	J-182	LSJ-10	142.30	300	120	5.81	0.08	0.04
P-254	J-184	LSJ-42	79.20	200	110	-2.59	0.08	0.07

2031 Pipe Tables
PD1 Reservoir 75% Full + NO Pumps

2031 ADD Pipe Results								
Label	Start Node	Stop Node	Length (m)	Diameter (mm)	Hazen-Williams C	Flow (L/s)	Velocity (m/s)	Headloss Gradient (m/km)
LSP-1	LSJ-53	LSJ-1	172.80	300	120	7.85	0.11	0.07
LSP-2	LSJ-1	LSJ-2	192.90	300	120	-1.71	0.02	0.00
LSP-3	LSJ-2	LSJ-3	106.10	300	120	1.06	0.02	0.00
LSP-4	LSJ-3	LSJ-4	91.10	300	120	1.12	0.02	0.00
LSP-5	LSJ-4	LSJ-5	83.20	300	120	1.22	0.02	0.00
LSP-6	LSJ-5	LSJ-6	128.90	300	120	1.22	0.02	0.00
LSP-7	LSJ-6	LSJ-55	88.40	300	120	-2.18	0.03	0.01
LSP-8	LSJ-55	LSJ-7	88.40	300	120	-0.40	0.01	0.00
LSP-9	LSJ-7	LSJ-8	78.90	300	120	-1.79	0.03	0.00
LSP-10	LSJ-9	LSJ-8	82.00	300	120	-0.10	0.00	0.00
LSP-11	LSJ-9	LSJ-10	78.90	300	120	-0.68	0.01	0.00
LSP-12	LSJ-10	LSJ-11	84.70	300	120	-5.09	0.07	0.03
LSP-13	LSJ-11	LSJ-12	75.00	300	120	-3.73	0.05	0.02
LSP-14	LSJ-12	LSJ-13	71.00	300	120	-4.99	0.07	0.03
LSP-15	LSJ-13	SA02T052	140.50	300	120	-12.75	0.18	0.16
LSP-16	LSJ-14	LSJ-1	82.00	200	110	-2.74	0.09	0.08
LSP-17	LSJ-15	LSJ-14	79.20	200	110	-2.12	0.07	0.05
LSP-18	LSJ-16	LSJ-15	176.80	200	110	-1.53	0.05	0.03
LSP-19	LSJ-17	LSJ-16	78.90	200	110	2.92	0.09	0.09
LSP-20	LSJ-18	LSJ-17	77.40	200	110	2.07	0.07	0.05
LSP-21	LSJ-19	LSJ-18	193.90	200	110	-0.89	0.03	0.01
LSP-22	LSJ-14	LSJ-19	100.30	200	110	-0.23	0.01	0.00
LSP-23	LSJ-14	LSJ-17	185.90	200	110	0.85	0.03	0.01
LSP-24	LSJ-20	LSJ-18	87.80	200	110	2.96	0.09	0.09
LSP-25	LSJ-22	LSJ-2	129.20	300	120	1.01	0.01	0.00
LSP-26	LSJ-21	LSJ-22	82.90	300	120	2.97	0.04	0.01
LSP-27	LSJ-20	LSJ-21	77.70	300	120	4.25	0.06	0.02
LSP-28	LSJ-54	LSJ-20	151.80	300	120	11.40	0.16	0.13
LSP-29	LSJ-24	LSJ-20	137.80	300	120	-4.20	0.06	0.02
LSP-30	LSJ-25	LSJ-24	86.00	300	120	-0.24	0.00	0.00
LSP-31	LSJ-21	LSJ-25	136.20	200	110	0.84	0.03	0.01
LSP-32	LSJ-25	LSJ-26	53.30	300	120	1.08	0.02	0.00
LSP-33	LSJ-26	LSJ-27	71.90	300	120	1.08	0.02	0.00
LSP-34	LSJ-27	LSJ-4	89.60	300	120	0.10	0.00	0.00
LSP-35	LSJ-22	LSJ-23	96.90	200	110	0.52	0.02	0.00
LSP-36	LSJ-3	LSJ-23	124.70	200	110	-0.05	0.00	0.00
LSP-37	LSJ-2	LSJ-31	79.90	300	120	-1.76	0.02	0.00
LSP-38	LSJ-29	LSJ-28	28.00	200	110	0.00	0.00	0.00
LSP-39	LSJ-29	LSJ-30	127.40	200	110	0.00	0.00	0.00
LSP-40	LSJ-30	LSJ-31	93.60	200	110	0.00	0.00	0.00
LSP-41	LSJ-31	SB02V053	161.80	300	120	-3.81	0.05	0.02
LSP-42	LSJ-31	LSJ-32	142.30	200	110	2.05	0.07	0.05
LSP-43	LSJ-32	LSJ-34	231.30	200	110	1.07	0.03	0.01
LSP-45	LSJ-34	LSJ-6	126.80	200	110	-2.54	0.08	0.07
LSP-46	LSJ-7	LSJ-35	120.10	200	110	0.24	0.01	0.00
LSP-47	LSJ-35	LSJ-36	157.30	200	110	-0.34	0.01	0.00
LSP-48	LSJ-9	LSJ-36	104.20	200	110	0.34	0.01	0.00
LSP-49	LSJ-7	LSJ-37	102.40	200	110	1.15	0.04	0.02
LSP-50	LSJ-37	LSJ-38	76.50	200	110	-1.77	0.06	0.04
LSP-51	LSJ-8	LSJ-38	106.40	300	120	-2.35	0.03	0.01
LSP-52(1)	LSJ-38	J-184	55.80	300	120	-4.40	0.06	0.02
LSP-52(2)	J-184	LSJ-39	81.10	300	120	-3.57	0.05	0.02
LSP-53	LSJ-39	LSJ-40	124.10	300	120	-3.57	0.05	0.02
LSP-54	LSJ-40	LSJ-13	43.90	300	120	-3.57	0.05	0.02
LSP-55	LSJ-41	LSJ-11	78.30	200	110	0.23	0.01	0.00
LSP-56	LSJ-42	LSJ-41	80.20	200	110	0.23	0.01	0.00
LSP-57	LSJ-42	LSJ-12	82.90	200	110	-1.05	0.03	0.01
LSP-58	LSJ-13	LSJ-43	84.40	300	120	3.60	0.05	0.02
LSP-59	LSJ-43	LSJ-44	37.80	300	120	1.84	0.03	0.00
LSP-61	LSJ-44	WH_03	59.40	300	120	1.84	0.03	0.01
LSP-62	WH_03	WH_04	53.00	300	120	1.74	0.02	0.00
LSP-63	WH_04	WH_05	68.00	300	120	1.62	0.02	0.00
LSP-64	WH_05	WH_06	50.90	300	120	1.46	0.02	0.00
LSP-65	WH_06	WH_07	66.40	300	120	1.35	0.02	0.00
LSP-66	WH_07	LSJ-50	41.10	300	120	1.25	0.02	0.00
LSP-68	LSJ-50	LSJ-51	33.50	300	120	1.25	0.02	0.00
LSP-69	LSJ-57	LSJ-11	85.30	300	120	1.86	0.03	0.01
P-239	LSJ-51	LSJ-57	86.00	300	120	1.25	0.02	0.00
P-240	LSJ-57	LSJ-43	126.20	200	110	-1.00	0.03	0.01
P-253	J-182	LSJ-10	142.30	300	120	-1.04	0.01	0.00
P-254	J-184	LSJ-42	79.20	200	110	-0.82	0.03	0.01

2031 Pipe Tables
PD1 Reservoir 75% Full + NO Pumps

2031 MDD Pipe Results								
Label	Start Node	Stop Node	Length (m)	Diameter (mm)	Hazen-Williams C	Flow (L/s)	Velocity (m/s)	Headloss Gradient (m/km)
LSP-1	LSJ-53	LSJ-1	172.80	300	120	14.89	0.21	0.22
LSP-2	LSJ-1	LSJ-2	192.90	300	120	-3.27	0.05	0.01
LSP-3	LSJ-2	LSJ-3	106.10	300	120	1.97	0.03	0.01
LSP-4	LSJ-3	LSJ-4	91.10	300	120	2.07	0.03	0.01
LSP-5	LSJ-4	LSJ-5	83.20	300	120	2.25	0.03	0.01
LSP-6	LSJ-5	LSJ-6	128.90	300	120	2.25	0.03	0.01
LSP-7	LSJ-6	LSJ-55	88.40	300	120	-4.20	0.06	0.02
LSP-8	LSJ-55	LSJ-7	88.40	300	120	-0.82	0.01	0.00
LSP-9	LSJ-7	LSJ-8	78.90	300	120	-3.45	0.05	0.02
LSP-10	LSJ-9	LSJ-8	82.00	300	120	-0.16	0.00	0.00
LSP-11	LSJ-9	LSJ-10	78.90	300	120	-1.33	0.02	0.00
LSP-12	LSJ-10	LSJ-11	84.70	300	120	-9.70	0.14	0.10
LSP-13	LSJ-11	LSJ-12	75.00	300	120	-7.11	0.10	0.06
LSP-14	LSJ-12	LSJ-13	71.00	300	120	-9.50	0.13	0.10
LSP-15	LSJ-13	SA02T052	140.50	300	120	-24.28	0.34	0.54
LSP-16	LSJ-14	LSJ-1	82.00	200	110	-5.21	0.17	0.27
LSP-17	LSJ-15	LSJ-14	79.20	200	110	-4.03	0.13	0.17
LSP-18	LSJ-16	LSJ-15	176.80	200	110	-2.91	0.09	0.09
LSP-19	LSJ-17	LSJ-16	78.90	200	110	5.54	0.18	0.30
LSP-20	LSJ-18	LSJ-17	77.40	200	110	3.93	0.13	0.16
LSP-21	LSJ-19	LSJ-18	193.90	200	110	-1.69	0.05	0.03
LSP-22	LSJ-14	LSJ-19	100.30	200	110	-0.43	0.01	0.00
LSP-23	LSJ-14	LSJ-17	185.90	200	110	1.60	0.05	0.03
LSP-24	LSJ-20	LSJ-18	87.80	200	110	5.62	0.18	0.31
LSP-25	LSJ-22	LSJ-2	129.20	300	120	1.95	0.03	0.01
LSP-26	LSJ-21	LSJ-22	82.90	300	120	5.65	0.08	0.04
LSP-27	LSJ-20	LSJ-21	77.70	300	120	8.09	0.11	0.07
LSP-28	LSJ-54	LSJ-20	151.80	300	120	21.69	0.31	0.44
LSP-29	LSJ-24	LSJ-20	137.80	300	120	-7.98	0.11	0.07
LSP-30	LSJ-25	LSJ-24	86.00	300	120	-0.45	0.01	0.00
LSP-31	LSJ-21	LSJ-25	136.20	200	110	1.60	0.05	0.03
LSP-32	LSJ-25	LSJ-26	53.30	300	120	2.05	0.03	0.01
LSP-33	LSJ-26	LSJ-27	71.90	300	120	2.05	0.03	0.01
LSP-34	LSJ-27	LSJ-4	89.60	300	120	0.18	0.00	0.00
LSP-35	LSJ-22	LSJ-23	96.90	200	110	0.99	0.03	0.01
LSP-36	LSJ-3	LSJ-23	124.70	200	110	-0.10	0.00	0.00
LSP-37	LSJ-2	LSJ-31	79.90	300	120	-3.29	0.05	0.01
LSP-38	LSJ-29	LSJ-28	28.00	200	110	0.00	0.00	0.00
LSP-39	LSJ-29	LSJ-30	127.40	200	110	0.00	0.00	0.00
LSP-40	LSJ-30	LSJ-31	93.60	200	110	0.00	0.00	0.00
LSP-41	LSJ-31	SB02V053	161.80	300	120	-7.18	0.10	0.06
LSP-42	LSJ-31	LSJ-32	142.30	200	110	3.89	0.12	0.15
LSP-43	LSJ-32	LSJ-34	231.30	200	110	2.04	0.06	0.05
LSP-45	LSJ-34	LSJ-6	126.80	200	110	-4.82	0.15	0.23
LSP-46	LSJ-7	LSJ-35	120.10	200	110	0.45	0.01	0.00
LSP-47	LSJ-35	LSJ-36	157.30	200	110	-0.66	0.02	0.01
LSP-48	LSJ-9	LSJ-36	104.20	200	110	0.66	0.02	0.01
LSP-49	LSJ-7	LSJ-37	102.40	200	110	2.18	0.07	0.05
LSP-50	LSJ-37	LSJ-38	76.50	200	110	-3.37	0.11	0.12
LSP-51	LSJ-8	LSJ-38	106.40	300	120	-4.48	0.06	0.02
LSP-52(1)	LSJ-38	J-184	55.80	300	120	-8.38	0.12	0.08
LSP-52(2)	J-184	LSJ-39	81.10	300	120	-6.81	0.10	0.05
LSP-53	LSJ-39	LSJ-40	124.10	300	120	-6.81	0.10	0.05
LSP-54	LSJ-40	LSJ-13	43.90	300	120	-6.81	0.10	0.05
LSP-55	LSJ-41	LSJ-11	78.30	200	110	0.44	0.01	0.00
LSP-56	LSJ-42	LSJ-41	80.20	200	110	0.44	0.01	0.00
LSP-57	LSJ-42	LSJ-12	82.90	200	110	-2.01	0.06	0.05
LSP-58	LSJ-13	LSJ-43	84.40	300	120	6.86	0.10	0.05
LSP-59	LSJ-43	LSJ-44	37.80	300	120	3.51	0.05	0.02
LSP-61	LSJ-44	WH_03	59.40	300	120	3.51	0.05	0.02
LSP-62	WH_03	WH_04	53.00	300	120	3.32	0.05	0.01
LSP-63	WH_04	WH_05	68.00	300	120	3.08	0.04	0.01
LSP-64	WH_05	WH_06	50.90	300	120	2.78	0.04	0.01
LSP-65	WH_06	WH_07	66.40	300	120	2.57	0.04	0.01
LSP-66	WH_07	LSJ-50	41.10	300	120	2.38	0.03	0.01
LSP-68	LSJ-50	LSJ-51	33.50	300	120	2.38	0.03	0.01
LSP-69	LSJ-57	LSJ-11	85.30	300	120	3.54	0.05	0.02
P-239	LSJ-51	LSJ-57	86.00	300	120	2.38	0.03	0.01
P-240	LSJ-57	LSJ-43	126.20	200	110	-1.91	0.06	0.04
P-253	J-182	LSJ-10	142.30	300	120	-1.97	0.03	0.01
P-254	J-184	LSJ-42	79.20	200	110	-1.57	0.05	0.03

2031 Pipe Tables
PD1 Reservoir 75% Full + NO Pumps

2031 PHD Pipe Results								
Label	Start Node	Stop Node	Length (m)	Diameter (mm)	Hazen-Williams C	Flow (L/s)	Velocity (m/s)	Headloss Gradient (m/km)
LSP-1	LSJ-53	LSJ-1	172.80	300	120	23.27	0.33	0.50
LSP-2	LSJ-1	LSJ-2	192.90	300	120	-5.42	0.08	0.03
LSP-3	LSJ-2	LSJ-3	106.10	300	120	3.16	0.04	0.01
LSP-4	LSJ-3	LSJ-4	91.10	300	120	3.26	0.05	0.01
LSP-5	LSJ-4	LSJ-5	83.20	300	120	3.25	0.05	0.01
LSP-6	LSJ-5	LSJ-6	128.90	300	120	3.25	0.05	0.01
LSP-7	LSJ-6	LSJ-55	88.40	300	120	-6.94	0.10	0.05
LSP-8	LSJ-55	LSJ-7	88.40	300	120	-1.54	0.02	0.00
LSP-9	LSJ-7	LSJ-8	78.90	300	120	-5.67	0.08	0.04
LSP-10	LSJ-9	LSJ-8	82.00	300	120	0.10	0.00	0.00
LSP-11	LSJ-9	LSJ-10	78.90	300	120	-2.48	0.04	0.01
LSP-12	LSJ-10	LSJ-11	84.70	300	120	-15.10	0.21	0.23
LSP-13	LSJ-11	LSJ-12	75.00	300	120	-11.11	0.16	0.13
LSP-14	LSJ-12	LSJ-13	71.00	300	120	-14.85	0.21	0.22
LSP-15	LSJ-13	SA02T052	140.50	300	120	-38.01	0.54	1.24
LSP-16	LSJ-14	LSJ-1	82.00	200	110	-8.24	0.26	0.62
LSP-17	LSJ-15	LSJ-14	79.20	200	110	-6.36	0.20	0.38
LSP-18	LSJ-16	LSJ-15	176.80	200	110	-4.60	0.15	0.21
LSP-19	LSJ-17	LSJ-16	78.90	200	110	8.74	0.28	0.69
LSP-20	LSJ-18	LSJ-17	77.40	200	110	6.20	0.20	0.37
LSP-21	LSJ-19	LSJ-18	193.90	200	110	-2.65	0.08	0.08
LSP-22	LSJ-14	LSJ-19	100.30	200	110	-0.66	0.02	0.01
LSP-23	LSJ-14	LSJ-17	185.90	200	110	2.54	0.08	0.07
LSP-24	LSJ-20	LSJ-18	87.80	200	110	8.85	0.28	0.71
LSP-25	LSJ-22	LSJ-2	129.20	300	120	2.85	0.04	0.01
LSP-26	LSJ-21	LSJ-22	82.90	300	120	8.65	0.12	0.08
LSP-27	LSJ-20	LSJ-21	77.70	300	120	12.46	0.18	0.16
LSP-28	LSJ-54	LSJ-20	151.80	300	120	33.66	0.48	0.99
LSP-29	LSJ-24	LSJ-20	137.80	300	120	-12.35	0.17	0.16
LSP-30	LSJ-25	LSJ-24	86.00	300	120	-0.46	0.01	0.00
LSP-31	LSJ-21	LSJ-25	136.20	200	110	2.48	0.08	0.07
LSP-32	LSJ-25	LSJ-26	53.30	300	120	2.94	0.04	0.01
LSP-33	LSJ-26	LSJ-27	71.90	300	120	2.94	0.04	0.01
LSP-34	LSJ-27	LSJ-4	89.60	300	120	-0.01	0.00	0.00
LSP-35	LSJ-22	LSJ-23	96.90	200	110	1.52	0.05	0.03
LSP-36	LSJ-3	LSJ-23	124.70	200	110	-0.11	0.00	0.00
LSP-37	LSJ-2	LSJ-31	79.90	300	120	-5.72	0.08	0.04
LSP-38	LSJ-29	LSJ-28	28.00	200	110	0.00	0.00	0.00
LSP-39	LSJ-29	LSJ-30	127.40	200	110	0.00	0.00	0.00
LSP-40	LSJ-30	LSJ-31	93.60	200	110	0.00	0.00	0.00
LSP-41	LSJ-31	SB02V053	161.80	300	120	-11.86	0.17	0.14
LSP-42	LSJ-31	LSJ-32	142.30	200	110	6.14	0.20	0.36
LSP-43	LSJ-32	LSJ-34	231.30	200	110	3.21	0.10	0.11
LSP-45	LSJ-34	LSJ-6	126.80	200	110	-7.62	0.24	0.54
LSP-46	LSJ-7	LSJ-35	120.10	200	110	0.69	0.02	0.01
LSP-47	LSJ-35	LSJ-36	157.30	200	110	-1.06	0.03	0.01
LSP-48	LSJ-9	LSJ-36	104.20	200	110	1.06	0.03	0.01
LSP-49	LSJ-7	LSJ-37	102.40	200	110	3.44	0.11	0.12
LSP-50	LSJ-37	LSJ-38	76.50	200	110	-5.33	0.17	0.28
LSP-51	LSJ-8	LSJ-38	106.40	300	120	-6.95	0.10	0.05
LSP-52(1)	LSJ-38	J-184	55.80	300	120	-13.12	0.19	0.17
LSP-52(2)	J-184	LSJ-39	81.10	300	120	-10.65	0.15	0.12
LSP-53	LSJ-39	LSJ-40	124.10	300	120	-10.65	0.15	0.12
LSP-54	LSJ-40	LSJ-13	43.90	300	120	-10.65	0.15	0.12
LSP-55	LSJ-41	LSJ-11	78.30	200	110	0.67	0.02	0.01
LSP-56	LSJ-42	LSJ-41	80.20	200	110	0.67	0.02	0.01
LSP-57	LSJ-42	LSJ-12	82.90	200	110	-3.14	0.10	0.10
LSP-58	LSJ-13	LSJ-43	84.40	300	120	10.75	0.15	0.12
LSP-59	LSJ-43	LSJ-44	37.80	300	120	5.49	0.08	0.03
LSP-61	LSJ-44	WH_03	59.40	300	120	5.49	0.08	0.04
LSP-62	WH_03	WH_04	53.00	300	120	5.19	0.07	0.03
LSP-63	WH_04	WH_05	68.00	300	120	4.81	0.07	0.03
LSP-64	WH_05	WH_06	50.90	300	120	4.34	0.06	0.02
LSP-65	WH_06	WH_07	66.40	300	120	4.01	0.06	0.02
LSP-66	WH_07	LSJ-50	41.10	300	120	3.71	0.05	0.02
LSP-68	LSJ-50	LSJ-51	33.50	300	120	3.71	0.05	0.02
LSP-69	LSJ-57	LSJ-11	85.30	300	120	5.52	0.08	0.04
P-239	LSJ-51	LSJ-57	86.00	300	120	3.71	0.05	0.02
P-240	LSJ-57	LSJ-43	126.20	200	110	-2.99	0.10	0.10
P-253	J-182	LSJ-10	142.30	300	120	-2.52	0.04	0.01
P-254	J-184	LSJ-42	79.20	200	110	-2.47	0.08	0.07

2011 Junctions Tables
PD1 Reservoir 90% Full + NO Pumps

2011 ADD Junction Results				
Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (kPa)
J-182	94.25	0.00	132	369
J-184	91.25	0.00	132	399
LSJ-1	91.00	6.82	132	401
LSJ-2	91.75	0.00	132	394
LSJ-3	91.50	0.00	132	396
LSJ-4	91.50	0.00	132	396
LSJ-5	90.25	0.00	132	408
LSJ-6	91.75	0.86	132	394
LSJ-7	92.25	0.00	132	389
LSJ-8	92.50	0.46	132	386
LSJ-9	92.75	0.44	132	384
LSJ-10	93.00	3.37	132	382
LSJ-11	92.00	0.73	132	391
LSJ-12	91.75	0.20	132	394
LSJ-13	91.25	0.59	132	399
LSJ-14	90.75	0.00	132	403
LSJ-15	91.50	0.59	132	396
LSJ-16	90.50	4.45	132	406
LSJ-17	90.75	0.00	132	403
LSJ-18	89.75	0.00	132	413
LSJ-19	91.00	0.66	132	401
LSJ-20	89.75	0.00	132	413
LSJ-21	90.50	0.44	132	406
LSJ-22	90.75	1.43	132	404
LSJ-23	90.50	0.47	132	406
LSJ-24	89.25	3.96	132	418
LSJ-25	89.75	0.00	132	413
LSJ-26	89.75	0.00	132	413
LSJ-27	90.50	0.98	132	406
LSJ-28	94.25	0.00	132	369
LSJ-29	94.00	0.00	132	372
LSJ-30	92.00	0.00	132	391
LSJ-31	92.75	0.00	132	384
LSJ-32	92.75	0.98	132	384
LSJ-34	91.25	3.61	132	399
LSJ-35	93.50	0.58	132	377
LSJ-36	94.00	0.00	132	372
LSJ-37	91.00	2.92	132	401
LSJ-38	91.50	0.28	132	396
LSJ-39	91.00	0.00	132	401
LSJ-40	91.25	0.00	132	399
LSJ-41	92.00	0.00	132	391
LSJ-42	91.50	0.00	132	396
LSJ-43	91.25	0.76	132	399
LSJ-44	91.75	0.00	132	394
LSJ-50	95.00	0.00	132	362
LSJ-51	94.00	0.00	132	372
LSJ-53	92.25	0.00	132	389
LSJ-54	88.18	0.00	132	429
LSJ-55	91.86	0.00	132	393
LSJ-57	92.25	0.39	132	389
SA02T005	95.10	4.03	132	361
SA02T052	91.00	0.00	132	401
SB02R011	94.00	0.00	132	372
SB02V053	95.20	0.00	132	360
WH_03	92.00	0.10	132	391
WH_04	92.00	0.13	132	391
WH_05	92.00	0.16	132	391
WH_06	93.00	0.11	132	382
WH_07	95.00	0.10	132	362

2011 Junctions Tables
PD1 Reservoir 90% Full + NO Pumps

2011 MDD Junction Results				
Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (kPa)
J-182	94.25	0.00	131	361
J-184	91.25	0.00	131	390
LSJ-1	91.00	12.95	131	392
LSJ-2	91.75	0.00	131	385
LSJ-3	91.50	0.00	131	387
LSJ-4	91.50	0.00	131	387
LSJ-5	90.25	0.00	131	400
LSJ-6	91.75	1.63	131	385
LSJ-7	92.25	0.00	131	380
LSJ-8	92.50	0.87	131	378
LSJ-9	92.75	0.83	131	375
LSJ-10	93.00	6.40	131	373
LSJ-11	92.00	1.39	131	383
LSJ-12	91.75	0.38	131	385
LSJ-13	91.25	1.12	131	390
LSJ-14	90.75	0.00	131	394
LSJ-15	91.50	1.12	131	387
LSJ-16	90.50	8.45	131	397
LSJ-17	90.75	0.00	131	394
LSJ-18	89.75	0.00	131	404
LSJ-19	91.00	1.26	131	392
LSJ-20	89.75	0.00	131	405
LSJ-21	90.50	0.84	131	397
LSJ-22	90.75	2.71	131	395
LSJ-23	90.50	0.89	131	397
LSJ-24	89.25	7.53	131	409
LSJ-25	89.75	0.00	131	405
LSJ-26	89.75	0.00	131	405
LSJ-27	90.50	1.87	131	397
LSJ-28	94.25	0.00	131	361
LSJ-29	94.00	0.00	131	363
LSJ-30	92.00	0.00	131	383
LSJ-31	92.75	0.00	131	375
LSJ-32	92.75	1.85	131	375
LSJ-34	91.25	6.86	131	390
LSJ-35	93.50	1.11	131	368
LSJ-36	94.00	0.00	131	363
LSJ-37	91.00	5.55	131	392
LSJ-38	91.50	0.53	131	388
LSJ-39	91.00	0.00	131	393
LSJ-40	91.25	0.00	131	390
LSJ-41	92.00	0.00	131	383
LSJ-42	91.50	0.00	131	388
LSJ-43	91.25	1.44	131	390
LSJ-44	91.75	0.00	131	385
LSJ-50	95.00	0.00	131	353
LSJ-51	94.00	0.00	131	363
LSJ-53	92.25	0.00	131	380
LSJ-54	88.18	0.00	131	420
LSJ-55	91.86	0.00	131	384
LSJ-57	92.25	0.75	131	380
SA02T005	95.10	7.66	131	353
SA02T052	91.00	0.00	131	393
SB02R011	94.00	0.00	131	363
SB02V053	95.20	0.00	131	351
WH_03	92.00	0.19	131	383
WH_04	92.00	0.24	131	383
WH_05	92.00	0.30	131	383
WH_06	93.00	0.21	131	373
WH_07	95.00	0.19	131	353

2011 Junctions Tables
PD1 Reservoir 90% Full + NO Pumps

2011 PHD Junction Results				
Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (kPa)
J-182	94.25	0.00	129	344
J-184	91.25	0.00	129	373
LSJ-1	91.00	20.45	129	375
LSJ-2	91.75	0.00	129	368
LSJ-3	91.50	0.00	129	371
LSJ-4	91.50	0.00	129	371
LSJ-5	90.25	0.00	129	383
LSJ-6	91.75	2.57	129	368
LSJ-7	92.25	0.00	129	363
LSJ-8	92.50	1.38	129	361
LSJ-9	92.75	1.32	129	359
LSJ-10	93.00	10.10	129	356
LSJ-11	92.00	2.20	129	366
LSJ-12	91.75	0.60	129	369
LSJ-13	91.25	1.76	129	374
LSJ-14	90.75	0.00	129	377
LSJ-15	91.50	1.76	129	370
LSJ-16	90.50	13.34	129	379
LSJ-17	90.75	0.00	129	377
LSJ-18	89.75	0.00	129	387
LSJ-19	91.00	1.99	129	375
LSJ-20	89.75	0.00	129	388
LSJ-21	90.50	1.33	129	380
LSJ-22	90.75	4.28	129	378
LSJ-23	90.50	1.41	129	380
LSJ-24	89.25	11.89	129	393
LSJ-25	89.75	0.00	129	388
LSJ-26	89.75	0.00	129	388
LSJ-27	90.50	2.95	129	380
LSJ-28	94.25	0.00	129	344
LSJ-29	94.00	0.00	129	346
LSJ-30	92.00	0.00	129	366
LSJ-31	92.75	0.00	129	358
LSJ-32	92.75	2.93	129	358
LSJ-34	91.25	10.83	129	372
LSJ-35	93.50	1.75	129	351
LSJ-36	94.00	0.00	129	346
LSJ-37	91.00	8.77	129	375
LSJ-38	91.50	0.84	129	371
LSJ-39	91.00	0.00	129	376
LSJ-40	91.25	0.00	129	374
LSJ-41	92.00	0.00	129	366
LSJ-42	91.50	0.00	129	371
LSJ-43	91.25	2.27	129	373
LSJ-44	91.75	0.00	129	369
LSJ-50	95.00	0.00	129	337
LSJ-51	94.00	0.00	129	347
LSJ-53	92.25	0.00	129	364
LSJ-54	88.18	0.00	129	404
LSJ-55	91.86	0.00	129	367
LSJ-57	92.25	1.18	129	364
SA02T005	95.10	12.28	129	336
SA02T052	91.00	0.00	130	377
SB02R011	94.00	0.00	129	346
SB02V053	95.20	0.00	129	335
WH_03	92.00	0.30	129	366
WH_04	92.00	0.38	129	366
WH_05	92.00	0.47	129	366
WH_06	93.00	0.34	129	356
WH_07	95.00	0.30	129	337

2031 Junctions Tables
PD1 Reservoir 90% Full + NO Pumps

2031 ADD Junction Results				
Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (kPa)
J-182	94.25	0.00	132	366
J-184	91.25	0.00	132	396
LSJ-1	91.00	6.82	132	398
LSJ-2	91.75	0.00	132	391
LSJ-3	91.50	0.00	132	393
LSJ-4	91.50	0.00	132	393
LSJ-5	90.25	0.00	132	405
LSJ-6	91.75	0.86	132	391
LSJ-7	92.25	0.00	132	386
LSJ-8	92.50	0.46	132	383
LSJ-9	92.75	0.44	132	381
LSJ-10	93.00	3.37	132	379
LSJ-11	92.00	0.73	132	388
LSJ-12	91.75	0.20	132	391
LSJ-13	91.25	0.59	132	396
LSJ-14	90.75	0.00	132	400
LSJ-15	91.50	0.59	132	393
LSJ-16	90.50	4.45	132	403
LSJ-17	90.75	0.00	132	400
LSJ-18	89.75	0.00	132	410
LSJ-19	91.00	0.66	132	398
LSJ-20	89.75	0.00	132	410
LSJ-21	90.50	0.44	132	403
LSJ-22	90.75	1.43	132	401
LSJ-23	90.50	0.47	132	403
LSJ-24	89.25	3.96	132	415
LSJ-25	89.75	0.00	132	410
LSJ-26	89.75	0.00	132	410
LSJ-27	90.50	0.98	132	403
LSJ-28	94.25	0.00	132	366
LSJ-29	94.00	0.00	132	369
LSJ-30	92.00	0.00	132	388
LSJ-31	92.75	0.00	132	381
LSJ-32	92.75	0.98	132	381
LSJ-34	91.25	3.61	132	396
LSJ-35	93.50	0.58	132	374
LSJ-36	94.00	0.00	132	369
LSJ-37	91.00	2.92	132	398
LSJ-38	91.50	0.28	132	393
LSJ-39	91.00	0.00	132	398
LSJ-40	91.25	0.00	132	396
LSJ-41	92.00	0.00	132	388
LSJ-42	91.50	0.00	132	393
LSJ-43	91.25	0.76	132	396
LSJ-44	91.75	0.00	132	391
LSJ-50	95.00	0.00	132	359
LSJ-51	94.00	0.00	132	369
LSJ-53	92.25	0.00	132	386
LSJ-54	88.18	0.00	132	426
LSJ-55	91.86	0.00	132	390
LSJ-57	92.25	0.39	132	386
SA02T005	95.10	6.78	132	358
SA02T052	91.00	0.00	132	398
SB02R011	94.00	0.00	132	369
SB02V053	95.20	0.00	132	357
WH_03	92.00	0.10	132	388
WH_04	92.00	0.13	132	388
WH_05	92.00	0.16	132	388
WH_06	93.00	0.11	132	379
WH_07	95.00	0.10	132	359

2031 Junctions Tables
PD1 Reservoir 90% Full + NO Pumps

2031 MDD Junction Results				
Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (kPa)
J-182	94.25	0.00	130	350
J-184	91.25	0.00	130	380
LSJ-1	91.00	12.95	130	382
LSJ-2	91.75	0.00	130	375
LSJ-3	91.50	0.00	130	377
LSJ-4	91.50	0.00	130	377
LSJ-5	90.25	0.00	130	390
LSJ-6	91.75	1.63	130	375
LSJ-7	92.25	0.00	130	370
LSJ-8	92.50	0.87	130	368
LSJ-9	92.75	0.83	130	365
LSJ-10	93.00	6.40	130	363
LSJ-11	92.00	1.39	130	373
LSJ-12	91.75	0.38	130	375
LSJ-13	91.25	1.12	130	380
LSJ-14	90.75	0.00	130	385
LSJ-15	91.50	1.12	130	377
LSJ-16	90.50	8.45	130	387
LSJ-17	90.75	0.00	130	384
LSJ-18	89.75	0.00	130	394
LSJ-19	91.00	1.26	130	382
LSJ-20	89.75	0.00	130	395
LSJ-21	90.50	0.84	130	387
LSJ-22	90.75	2.71	130	385
LSJ-23	90.50	0.89	130	387
LSJ-24	89.25	7.53	130	399
LSJ-25	89.75	0.00	130	395
LSJ-26	89.75	0.00	130	395
LSJ-27	90.50	1.87	130	387
LSJ-28	94.25	0.00	130	350
LSJ-29	94.00	0.00	130	353
LSJ-30	92.00	0.00	130	373
LSJ-31	92.75	0.00	130	365
LSJ-32	92.75	1.85	130	365
LSJ-34	91.25	6.86	130	380
LSJ-35	93.50	1.11	130	358
LSJ-36	94.00	0.00	130	353
LSJ-37	91.00	5.55	130	382
LSJ-38	91.50	0.53	130	377
LSJ-39	91.00	0.00	130	382
LSJ-40	91.25	0.00	130	380
LSJ-41	92.00	0.00	130	373
LSJ-42	91.50	0.00	130	377
LSJ-43	91.25	1.44	130	380
LSJ-44	91.75	0.00	130	375
LSJ-50	95.00	0.00	130	343
LSJ-51	94.00	0.00	130	353
LSJ-53	92.25	0.00	130	370
LSJ-54	88.18	0.00	130	411
LSJ-55	91.86	0.00	130	374
LSJ-57	92.25	0.75	130	370
SA02T005	95.10	12.90	130	342
SA02T052	91.00	0.00	130	383
SB02R011	94.00	0.00	130	353
SB02V053	95.20	0.00	130	341
WH_03	92.00	0.19	130	373
WH_04	92.00	0.24	130	373
WH_05	92.00	0.30	130	373
WH_06	93.00	0.21	130	363
WH_07	95.00	0.19	130	343

2031 Junctions Tables
PD1 Reservoir 90% Full + NO Pumps

2031 PHD Junction Results				
Label	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (kPa)
J-182	94.25	0.00	127	323
J-184	91.25	0.00	127	353
LSJ-1	91.00	20.45	127	355
LSJ-2	91.75	0.00	127	348
LSJ-3	91.50	0.00	127	350
LSJ-4	91.50	0.00	127	350
LSJ-5	90.25	0.00	127	363
LSJ-6	91.75	2.57	127	348
LSJ-7	92.25	0.00	127	343
LSJ-8	92.50	1.38	127	341
LSJ-9	92.75	1.32	127	338
LSJ-10	93.00	10.10	127	336
LSJ-11	92.00	2.20	127	346
LSJ-12	91.75	0.60	127	348
LSJ-13	91.25	1.76	127	353
LSJ-14	90.75	0.00	127	357
LSJ-15	91.50	1.76	127	349
LSJ-16	90.50	13.34	127	359
LSJ-17	90.75	0.00	127	357
LSJ-18	89.75	0.00	127	367
LSJ-19	91.00	1.99	127	355
LSJ-20	89.75	0.00	127	368
LSJ-21	90.50	1.33	127	360
LSJ-22	90.75	4.28	127	358
LSJ-23	90.50	1.41	127	360
LSJ-24	89.25	11.89	127	372
LSJ-25	89.75	0.00	127	367
LSJ-26	89.75	0.00	127	367
LSJ-27	90.50	2.95	127	360
LSJ-28	94.25	0.00	127	323
LSJ-29	94.00	0.00	127	326
LSJ-30	92.00	0.00	127	345
LSJ-31	92.75	0.00	127	338
LSJ-32	92.75	2.93	127	338
LSJ-34	91.25	10.83	127	352
LSJ-35	93.50	1.75	127	331
LSJ-36	94.00	0.00	127	326
LSJ-37	91.00	8.77	127	355
LSJ-38	91.50	0.84	127	350
LSJ-39	91.00	0.00	127	355
LSJ-40	91.25	0.00	127	353
LSJ-41	92.00	0.00	127	346
LSJ-42	91.50	0.00	127	351
LSJ-43	91.25	2.27	127	353
LSJ-44	91.75	0.00	127	348
LSJ-50	95.00	0.00	127	316
LSJ-51	94.00	0.00	127	326
LSJ-53	92.25	0.00	127	344
LSJ-54	88.18	0.00	127	384
LSJ-55	91.86	0.00	127	347
LSJ-57	92.25	1.18	127	343
SA02T005	95.10	19.88	127	315
SA02T052	91.00	0.00	128	357
SB02R011	94.00	0.00	127	326
SB02V053	95.20	0.00	127	314
WH_03	92.00	0.30	127	346
WH_04	92.00	0.38	127	346
WH_05	92.00	0.47	127	346
WH_06	93.00	0.34	127	336
WH_07	95.00	0.30	127	316

2011 Pipe Tables
PD1 Reservoir 90% Full + NO Pumps

2011 ADD Pipe Results								
Label	Start Node	Stop Node	Length (m)	Diameter (mm)	Hazen-Williams C	Flow (L/s)	Velocity (m/s)	Headloss Gradient (m/km)
LSP-1	LSJ-53	LSJ-1	172.80	300	120	6.59	0.09	0.05
LSP-2	LSJ-1	LSJ-2	192.90	300	120	-2.97	0.04	0.01
LSP-3	LSJ-2	LSJ-3	106.10	300	120	0.44	0.01	0.00
LSP-4	LSJ-3	LSJ-4	91.10	300	120	0.26	0.00	0.00
LSP-5	LSJ-4	LSJ-5	83.20	300	120	-0.89	0.01	0.00
LSP-6	LSJ-5	LSJ-6	128.90	300	120	-0.89	0.01	0.00
LSP-7	LSJ-6	LSJ-55	88.40	300	120	-4.31	0.06	0.02
LSP-8	LSJ-55	LSJ-7	88.40	300	120	-2.04	0.03	0.01
LSP-9	LSJ-7	LSJ-8	78.90	300	120	-3.10	0.04	0.01
LSP-10	LSJ-9	LSJ-8	82.00	300	120	1.51	0.02	0.00
LSP-11	LSJ-9	LSJ-10	78.90	300	120	-2.54	0.04	0.01
LSP-12	LSJ-10	LSJ-11	84.70	300	120	-4.00	0.06	0.02
LSP-13	LSJ-11	LSJ-12	75.00	300	120	-3.19	0.05	0.01
LSP-14	LSJ-12	LSJ-13	71.00	300	120	-4.34	0.06	0.02
LSP-15	LSJ-13	SA02T052	140.50	300	120	-11.45	0.16	0.14
LSP-16	LSJ-14	LSJ-1	82.00	200	110	-2.74	0.09	0.08
LSP-17	LSJ-15	LSJ-14	79.20	200	110	-2.12	0.07	0.05
LSP-18	LSJ-16	LSJ-15	176.80	200	110	-1.53	0.05	0.03
LSP-19	LSJ-17	LSJ-16	78.90	200	110	2.92	0.09	0.09
LSP-20	LSJ-18	LSJ-17	77.40	200	110	2.07	0.07	0.05
LSP-21	LSJ-19	LSJ-18	193.90	200	110	-0.89	0.03	0.01
LSP-22	LSJ-14	LSJ-19	100.30	200	110	-0.23	0.01	0.00
LSP-23	LSJ-14	LSJ-17	185.90	200	110	0.85	0.03	0.01
LSP-24	LSJ-20	LSJ-18	87.80	200	110	2.96	0.09	0.09
LSP-25	LSJ-22	LSJ-2	129.20	300	120	0.32	0.00	0.00
LSP-26	LSJ-21	LSJ-22	82.90	300	120	2.04	0.03	0.01
LSP-27	LSJ-20	LSJ-21	77.70	300	120	3.10	0.04	0.01
LSP-28	LSJ-54	LSJ-20	151.80	300	120	9.22	0.13	0.09
LSP-29	LSJ-24	LSJ-20	137.80	300	120	-3.17	0.04	0.01
LSP-30	LSJ-25	LSJ-24	86.00	300	120	0.79	0.01	0.00
LSP-31	LSJ-21	LSJ-25	136.20	200	110	0.62	0.02	0.01
LSP-32	LSJ-25	LSJ-26	53.30	300	120	-0.17	0.00	0.00
LSP-33	LSJ-26	LSJ-27	71.90	300	120	-0.17	0.00	0.00
LSP-34	LSJ-27	LSJ-4	89.60	300	120	-1.15	0.02	0.00
LSP-35	LSJ-22	LSJ-23	96.90	200	110	0.29	0.01	0.00
LSP-36	LSJ-3	LSJ-23	124.70	200	110	0.18	0.01	0.00
LSP-37	LSJ-2	LSJ-31	79.90	300	120	-3.09	0.04	0.01
LSP-38	LSJ-29	LSJ-28	28.00	200	110	0.00	0.00	0.00
LSP-39	LSJ-29	LSJ-30	127.40	200	110	0.00	0.00	0.00
LSP-40	LSJ-30	LSJ-31	93.60	200	110	0.00	0.00	0.00
LSP-41	LSJ-31	SB02V053	161.80	300	120	-5.13	0.07	0.03
LSP-42	LSJ-31	LSJ-32	142.30	200	110	2.03	0.06	0.05
LSP-43	LSJ-32	LSJ-34	231.30	200	110	1.05	0.03	0.01
LSP-45	LSJ-34	LSJ-6	126.80	200	110	-2.56	0.08	0.07
LSP-46	LSJ-7	LSJ-35	120.10	200	110	0.00	0.00	0.00
LSP-47	LSJ-35	LSJ-36	157.30	200	110	-0.58	0.02	0.01
LSP-48	LSJ-9	LSJ-36	104.20	200	110	0.58	0.02	0.01
LSP-49	LSJ-7	LSJ-37	102.40	200	110	1.07	0.03	0.01
LSP-50	LSJ-37	LSJ-38	76.50	200	110	-1.85	0.06	0.04
LSP-51	LSJ-8	LSJ-38	106.40	300	120	-2.05	0.03	0.01
LSP-52(1)	LSJ-38	J-184	55.80	300	120	-4.18	0.06	0.02
LSP-52(2)	J-184	LSJ-39	81.10	300	120	-3.29	0.05	0.01
LSP-53	LSJ-39	LSJ-40	124.10	300	120	-3.29	0.05	0.01
LSP-54	LSJ-40	LSJ-13	43.90	300	120	-3.29	0.05	0.01
LSP-55	LSJ-41	LSJ-11	78.30	200	110	0.06	0.00	0.00
LSP-56	LSJ-42	LSJ-41	80.20	200	110	0.06	0.00	0.00
LSP-57	LSJ-42	LSJ-12	82.90	200	110	-0.95	0.03	0.01
LSP-58	LSJ-13	LSJ-43	84.40	300	120	3.23	0.05	0.01
LSP-59	LSJ-43	LSJ-44	37.80	300	120	1.62	0.02	0.00
LSP-61	LSJ-44	WH_03	59.40	300	120	1.62	0.02	0.00
LSP-62	WH_03	WH_04	53.00	300	120	1.52	0.02	0.00
LSP-63	WH_04	WH_05	68.00	300	120	1.39	0.02	0.00
LSP-64	WH_05	WH_06	50.90	300	120	1.23	0.02	0.00
LSP-65	WH_06	WH_07	66.40	300	120	1.12	0.02	0.00
LSP-66	WH_07	LSJ-50	41.10	300	120	1.02	0.01	0.00
LSP-68	LSJ-50	LSJ-51	33.50	300	120	1.02	0.01	0.00
LSP-69	LSJ-57	LSJ-11	85.30	300	120	1.49	0.02	0.00
P-239	LSJ-51	LSJ-57	86.00	300	120	1.02	0.01	0.00
P-240	LSJ-57	LSJ-43	126.20	200	110	-0.86	0.03	0.01
P-253	J-182	LSJ-10	142.30	300	120	1.90	0.03	0.01
P-254	J-184	LSJ-42	79.20	200	110	-0.89	0.03	0.01

2011 Pipe Tables
PD1 Reservoir 90% Full + NO Pumps

2011 MDD Pipe Results								
Label	Start Node	Stop Node	Length (m)	Diameter (mm)	Hazen-Williams C	Flow (L/s)	Velocity (m/s)	Headloss Gradient (m/km)
LSP-1	LSJ-53	LSJ-1	172.80	300	120	12.51	0.18	0.16
LSP-2	LSJ-1	LSJ-2	192.90	300	120	-5.65	0.08	0.04
LSP-3	LSJ-2	LSJ-3	106.10	300	120	0.83	0.01	0.00
LSP-4	LSJ-3	LSJ-4	91.10	300	120	0.48	0.01	0.00
LSP-5	LSJ-4	LSJ-5	83.20	300	120	-1.71	0.02	0.00
LSP-6	LSJ-5	LSJ-6	128.90	300	120	-1.71	0.02	0.00
LSP-7	LSJ-6	LSJ-55	88.40	300	120	-8.20	0.12	0.07
LSP-8	LSJ-55	LSJ-7	88.40	300	120	-3.88	0.05	0.02
LSP-9	LSJ-7	LSJ-8	78.90	300	120	-5.91	0.08	0.04
LSP-10	LSJ-9	LSJ-8	82.00	300	120	2.88	0.04	0.01
LSP-11	LSJ-9	LSJ-10	78.90	300	120	-4.82	0.07	0.03
LSP-12	LSJ-10	LSJ-11	84.70	300	120	-7.62	0.11	0.06
LSP-13	LSJ-11	LSJ-12	75.00	300	120	-6.07	0.09	0.04
LSP-14	LSJ-12	LSJ-13	71.00	300	120	-8.26	0.12	0.07
LSP-15	LSJ-13	SA02T052	140.50	300	120	-21.78	0.31	0.44
LSP-16	LSJ-14	LSJ-1	82.00	200	110	-5.21	0.17	0.27
LSP-17	LSJ-15	LSJ-14	79.20	200	110	-4.03	0.13	0.17
LSP-18	LSJ-16	LSJ-15	176.80	200	110	-2.91	0.09	0.09
LSP-19	LSJ-17	LSJ-16	78.90	200	110	5.54	0.18	0.30
LSP-20	LSJ-18	LSJ-17	77.40	200	110	3.93	0.13	0.16
LSP-21	LSJ-19	LSJ-18	193.90	200	110	-1.69	0.05	0.03
LSP-22	LSJ-14	LSJ-19	100.30	200	110	-0.43	0.01	0.00
LSP-23	LSJ-14	LSJ-17	185.90	200	110	1.61	0.05	0.03
LSP-24	LSJ-20	LSJ-18	87.80	200	110	5.62	0.18	0.31
LSP-25	LSJ-22	LSJ-2	129.20	300	120	0.62	0.01	0.00
LSP-26	LSJ-21	LSJ-22	82.90	300	120	3.88	0.05	0.02
LSP-27	LSJ-20	LSJ-21	77.70	300	120	5.90	0.08	0.04
LSP-28	LSJ-54	LSJ-20	151.80	300	120	17.54	0.25	0.30
LSP-29	LSJ-24	LSJ-20	137.80	300	120	-6.02	0.09	0.04
LSP-30	LSJ-25	LSJ-24	86.00	300	120	1.51	0.02	0.00
LSP-31	LSJ-21	LSJ-25	136.20	200	110	1.18	0.04	0.02
LSP-32	LSJ-25	LSJ-26	53.30	300	120	-0.32	0.00	0.00
LSP-33	LSJ-26	LSJ-27	71.90	300	120	-0.32	0.00	0.00
LSP-34	LSJ-27	LSJ-4	89.60	300	120	-2.19	0.03	0.01
LSP-35	LSJ-22	LSJ-23	96.90	200	110	0.55	0.02	0.00
LSP-36	LSJ-3	LSJ-23	124.70	200	110	0.34	0.01	0.00
LSP-37	LSJ-2	LSJ-31	79.90	300	120	-5.86	0.08	0.04
LSP-38	LSJ-29	LSJ-28	28.00	200	110	0.00	0.00	0.00
LSP-39	LSJ-29	LSJ-30	127.40	200	110	0.00	0.00	0.00
LSP-40	LSJ-30	LSJ-31	93.60	200	110	0.00	0.00	0.00
LSP-41	LSJ-31	SB02V053	161.80	300	120	-9.71	0.14	0.10
LSP-42	LSJ-31	LSJ-32	142.30	200	110	3.85	0.12	0.15
LSP-43	LSJ-32	LSJ-34	231.30	200	110	2.00	0.06	0.05
LSP-45	LSJ-34	LSJ-6	126.80	200	110	-4.86	0.15	0.23
LSP-46	LSJ-7	LSJ-35	120.10	200	110	0.00	0.00	0.00
LSP-47	LSJ-35	LSJ-36	157.30	200	110	-1.11	0.04	0.02
LSP-48	LSJ-9	LSJ-36	104.20	200	110	1.11	0.04	0.02
LSP-49	LSJ-7	LSJ-37	102.40	200	110	2.03	0.06	0.05
LSP-50	LSJ-37	LSJ-38	76.50	200	110	-3.52	0.11	0.13
LSP-51	LSJ-8	LSJ-38	106.40	300	120	-3.90	0.06	0.02
LSP-52(1)	LSJ-38	J-184	55.80	300	120	-7.95	0.11	0.07
LSP-52(2)	J-184	LSJ-39	81.10	300	120	-6.25	0.09	0.04
LSP-53	LSJ-39	LSJ-40	124.10	300	120	-6.25	0.09	0.04
LSP-54	LSJ-40	LSJ-13	43.90	300	120	-6.25	0.09	0.04
LSP-55	LSJ-41	LSJ-11	78.30	200	110	0.11	0.00	0.00
LSP-56	LSJ-42	LSJ-41	80.20	200	110	0.11	0.00	0.00
LSP-57	LSJ-42	LSJ-12	82.90	200	110	-1.81	0.06	0.04
LSP-58	LSJ-13	LSJ-43	84.40	300	120	6.15	0.09	0.04
LSP-59	LSJ-43	LSJ-44	37.80	300	120	3.08	0.04	0.01
LSP-61	LSJ-44	WH_03	59.40	300	120	3.08	0.04	0.01
LSP-62	WH_03	WH_04	53.00	300	120	2.89	0.04	0.01
LSP-63	WH_04	WH_05	68.00	300	120	2.65	0.04	0.01
LSP-64	WH_05	WH_06	50.90	300	120	2.35	0.03	0.01
LSP-65	WH_06	WH_07	66.40	300	120	2.14	0.03	0.01
LSP-66	WH_07	LSJ-50	41.10	300	120	1.95	0.03	0.01
LSP-68	LSJ-50	LSJ-51	33.50	300	120	1.95	0.03	0.01
LSP-69	LSJ-57	LSJ-11	85.30	300	120	2.83	0.04	0.01
P-239	LSJ-51	LSJ-57	86.00	300	120	1.95	0.03	0.01
P-240	LSJ-57	LSJ-43	126.20	200	110	-1.63	0.05	0.03
P-253	J-182	LSJ-10	142.30	300	120	3.60	0.05	0.02
P-254	J-184	LSJ-42	79.20	200	110	-1.70	0.05	0.03

2011 Pipe Tables
PD1 Reservoir 90% Full + NO Pumps

2011 PHD Pipe Results								
Label	Start Node	Stop Node	Length (m)	Diameter (mm)	Hazen-Williams C	Flow (L/s)	Velocity (m/s)	Headloss Gradient (m/km)
LSP-1	LSJ-53	LSJ-1	172.80	300	120	20.12	0.28	0.38
LSP-2	LSJ-1	LSJ-2	192.90	300	120	-8.59	0.12	0.08
LSP-3	LSJ-2	LSJ-3	106.10	300	120	1.80	0.03	0.00
LSP-4	LSJ-3	LSJ-4	91.10	300	120	1.31	0.02	0.00
LSP-5	LSJ-4	LSJ-5	83.20	300	120	-2.08	0.03	0.01
LSP-6	LSJ-5	LSJ-6	128.90	300	120	-2.08	0.03	0.01
LSP-7	LSJ-6	LSJ-55	88.40	300	120	-12.29	0.17	0.15
LSP-8	LSJ-55	LSJ-7	88.40	300	120	-5.49	0.08	0.04
LSP-9	LSJ-7	LSJ-8	78.90	300	120	-8.85	0.13	0.08
LSP-10	LSJ-9	LSJ-8	82.00	300	120	4.35	0.06	0.02
LSP-11	LSJ-9	LSJ-10	78.90	300	120	-7.35	0.10	0.06
LSP-12	LSJ-10	LSJ-11	84.70	300	120	-11.64	0.16	0.14
LSP-13	LSJ-11	LSJ-12	75.00	300	120	-9.36	0.13	0.09
LSP-14	LSJ-12	LSJ-13	71.00	300	120	-12.74	0.18	0.16
LSP-15	LSJ-13	SA02T052	140.50	300	120	-33.65	0.48	0.99
LSP-16	LSJ-14	LSJ-1	82.00	200	110	-8.26	0.26	0.62
LSP-17	LSJ-15	LSJ-14	79.20	200	110	-6.36	0.20	0.38
LSP-18	LSJ-16	LSJ-15	176.80	200	110	-4.60	0.15	0.21
LSP-19	LSJ-17	LSJ-16	78.90	200	110	8.74	0.28	0.69
LSP-20	LSJ-18	LSJ-17	77.40	200	110	6.19	0.20	0.37
LSP-21	LSJ-19	LSJ-18	193.90	200	110	-2.64	0.08	0.08
LSP-22	LSJ-14	LSJ-19	100.30	200	110	-0.65	0.02	0.01
LSP-23	LSJ-14	LSJ-17	185.90	200	110	2.55	0.08	0.07
LSP-24	LSJ-20	LSJ-18	87.80	200	110	8.83	0.28	0.70
LSP-25	LSJ-22	LSJ-2	129.20	300	120	0.85	0.01	0.00
LSP-26	LSJ-21	LSJ-22	82.90	300	120	6.05	0.09	0.04
LSP-27	LSJ-20	LSJ-21	77.70	300	120	9.28	0.13	0.09
LSP-28	LSJ-54	LSJ-20	151.80	300	120	27.66	0.39	0.69
LSP-29	LSJ-24	LSJ-20	137.80	300	120	-9.55	0.14	0.10
LSP-30	LSJ-25	LSJ-24	86.00	300	120	2.34	0.03	0.01
LSP-31	LSJ-21	LSJ-25	136.20	200	110	1.90	0.06	0.04
LSP-32	LSJ-25	LSJ-26	53.30	300	120	-0.44	0.01	0.00
LSP-33	LSJ-26	LSJ-27	71.90	300	120	-0.44	0.01	0.00
LSP-34	LSJ-27	LSJ-4	89.60	300	120	-3.39	0.05	0.01
LSP-35	LSJ-22	LSJ-23	96.90	200	110	0.92	0.03	0.01
LSP-36	LSJ-3	LSJ-23	124.70	200	110	0.49	0.02	0.00
LSP-37	LSJ-2	LSJ-31	79.90	300	120	-9.54	0.13	0.10
LSP-38	LSJ-29	LSJ-28	28.00	200	110	0.00	0.00	0.00
LSP-39	LSJ-29	LSJ-30	127.40	200	110	0.00	0.00	0.00
LSP-40	LSJ-30	LSJ-31	93.60	200	110	0.00	0.00	0.00
LSP-41	LSJ-31	SB02V053	161.80	300	120	-15.65	0.22	0.24
LSP-42	LSJ-31	LSJ-32	142.30	200	110	6.12	0.19	0.36
LSP-43	LSJ-32	LSJ-34	231.30	200	110	3.19	0.10	0.11
LSP-45	LSJ-34	LSJ-6	126.80	200	110	-7.64	0.24	0.54
LSP-46	LSJ-7	LSJ-35	120.10	200	110	0.08	0.00	0.00
LSP-47	LSJ-35	LSJ-36	157.30	200	110	-1.67	0.05	0.03
LSP-48	LSJ-9	LSJ-36	104.20	200	110	1.67	0.05	0.03
LSP-49	LSJ-7	LSJ-37	102.40	200	110	3.28	0.10	0.11
LSP-50	LSJ-37	LSJ-38	76.50	200	110	-5.49	0.17	0.29
LSP-51	LSJ-8	LSJ-38	106.40	300	120	-5.88	0.08	0.04
LSP-52(1)	LSJ-38	J-184	55.80	300	120	-12.20	0.17	0.15
LSP-52(2)	J-184	LSJ-39	81.10	300	120	-9.62	0.14	0.10
LSP-53	LSJ-39	LSJ-40	124.10	300	120	-9.62	0.14	0.10
LSP-54	LSJ-40	LSJ-13	43.90	300	120	-9.62	0.14	0.10
LSP-55	LSJ-41	LSJ-11	78.30	200	110	0.19	0.01	0.00
LSP-56	LSJ-42	LSJ-41	80.20	200	110	0.19	0.01	0.00
LSP-57	LSJ-42	LSJ-12	82.90	200	110	-2.78	0.09	0.08
LSP-58	LSJ-13	LSJ-43	84.40	300	120	9.53	0.13	0.10
LSP-59	LSJ-43	LSJ-44	37.80	300	120	4.76	0.07	0.03
LSP-61	LSJ-44	WH_03	59.40	300	120	4.76	0.07	0.03
LSP-62	WH_03	WH_04	53.00	300	120	4.46	0.06	0.02
LSP-63	WH_04	WH_05	68.00	300	120	4.08	0.06	0.02
LSP-64	WH_05	WH_06	50.90	300	120	3.61	0.05	0.02
LSP-65	WH_06	WH_07	66.40	300	120	3.27	0.05	0.01
LSP-66	WH_07	LSJ-50	41.10	300	120	2.97	0.04	0.01
LSP-68	LSJ-50	LSJ-51	33.50	300	120	2.97	0.04	0.01
LSP-69	LSJ-57	LSJ-11	85.30	300	120	4.29	0.06	0.02
P-239	LSJ-51	LSJ-57	86.00	300	120	2.97	0.04	0.01
P-240	LSJ-57	LSJ-43	126.20	200	110	-2.51	0.08	0.07
P-253	J-182	LSJ-10	142.30	300	120	5.80	0.08	0.04
P-254	J-184	LSJ-42	79.20	200	110	-2.59	0.08	0.07

2031 Pipe Tables
PD1 Reservoir 90% Full + NO Pumps

2031 ADD Pipe Results								
Label	Start Node	Stop Node	Length (m)	Diameter (mm)	Hazen-Williams C	Flow (L/s)	Velocity (m/s)	Headloss Gradient (m/km)
LSP-1	LSJ-53	LSJ-1	172.80	300	120	7.84	0.11	0.07
LSP-2	LSJ-1	LSJ-2	192.90	300	120	-1.72	0.02	0.00
LSP-3	LSJ-2	LSJ-3	106.10	300	120	1.04	0.01	0.00
LSP-4	LSJ-3	LSJ-4	91.10	300	120	1.10	0.02	0.00
LSP-5	LSJ-4	LSJ-5	83.20	300	120	1.20	0.02	0.00
LSP-6	LSJ-5	LSJ-6	128.90	300	120	1.20	0.02	0.00
LSP-7	LSJ-6	LSJ-55	88.40	300	120	-2.20	0.03	0.01
LSP-8	LSJ-55	LSJ-7	88.40	300	120	-0.42	0.01	0.00
LSP-9	LSJ-7	LSJ-8	78.90	300	120	-1.81	0.03	0.00
LSP-10	LSJ-9	LSJ-8	82.00	300	120	-0.09	0.00	0.00
LSP-11	LSJ-9	LSJ-10	78.90	300	120	-0.70	0.01	0.00
LSP-12	LSJ-10	LSJ-11	84.70	300	120	-5.10	0.07	0.03
LSP-13	LSJ-11	LSJ-12	75.00	300	120	-3.74	0.05	0.02
LSP-14	LSJ-12	LSJ-13	71.00	300	120	-4.99	0.07	0.03
LSP-15	LSJ-13	SA02T052	140.50	300	120	-12.77	0.18	0.17
LSP-16	LSJ-14	LSJ-1	82.00	200	110	-2.74	0.09	0.08
LSP-17	LSJ-15	LSJ-14	79.20	200	110	-2.12	0.07	0.05
LSP-18	LSJ-16	LSJ-15	176.80	200	110	-1.53	0.05	0.03
LSP-19	LSJ-17	LSJ-16	78.90	200	110	2.92	0.09	0.09
LSP-20	LSJ-18	LSJ-17	77.40	200	110	2.07	0.07	0.05
LSP-21	LSJ-19	LSJ-18	193.90	200	110	-0.89	0.03	0.01
LSP-22	LSJ-14	LSJ-19	100.30	200	110	-0.23	0.01	0.00
LSP-23	LSJ-14	LSJ-17	185.90	200	110	0.85	0.03	0.01
LSP-24	LSJ-20	LSJ-18	87.80	200	110	2.96	0.09	0.09
LSP-25	LSJ-22	LSJ-2	129.20	300	120	1.02	0.01	0.00
LSP-26	LSJ-21	LSJ-22	82.90	300	120	2.97	0.04	0.01
LSP-27	LSJ-20	LSJ-21	77.70	300	120	4.25	0.06	0.02
LSP-28	LSJ-54	LSJ-20	151.80	300	120	11.41	0.16	0.13
LSP-29	LSJ-24	LSJ-20	137.80	300	120	-4.20	0.06	0.02
LSP-30	LSJ-25	LSJ-24	86.00	300	120	-0.24	0.00	0.00
LSP-31	LSJ-21	LSJ-25	136.20	200	110	0.84	0.03	0.01
LSP-32	LSJ-25	LSJ-26	53.30	300	120	1.08	0.02	0.00
LSP-33	LSJ-26	LSJ-27	71.90	300	120	1.08	0.02	0.00
LSP-34	LSJ-27	LSJ-4	89.60	300	120	0.10	0.00	0.00
LSP-35	LSJ-22	LSJ-23	96.90	200	110	0.52	0.02	0.00
LSP-36	LSJ-3	LSJ-23	124.70	200	110	-0.05	0.00	0.00
LSP-37	LSJ-2	LSJ-31	79.90	300	120	-1.74	0.02	0.00
LSP-38	LSJ-29	LSJ-28	28.00	200	110	0.00	0.00	0.00
LSP-39	LSJ-29	LSJ-30	127.40	200	110	0.00	0.00	0.00
LSP-40	LSJ-30	LSJ-31	93.60	200	110	0.00	0.00	0.00
LSP-41	LSJ-31	SB02V053	161.80	300	120	-3.79	0.05	0.02
LSP-42	LSJ-31	LSJ-32	142.30	200	110	2.05	0.07	0.05
LSP-43	LSJ-32	LSJ-34	231.30	200	110	1.07	0.03	0.01
LSP-45	LSJ-34	LSJ-6	126.80	200	110	-2.54	0.08	0.07
LSP-46	LSJ-7	LSJ-35	120.10	200	110	0.24	0.01	0.00
LSP-47	LSJ-35	LSJ-36	157.30	200	110	-0.34	0.01	0.00
LSP-48	LSJ-9	LSJ-36	104.20	200	110	0.34	0.01	0.00
LSP-49	LSJ-7	LSJ-37	102.40	200	110	1.15	0.04	0.02
LSP-50	LSJ-37	LSJ-38	76.50	200	110	-1.77	0.06	0.04
LSP-51	LSJ-8	LSJ-38	106.40	300	120	-2.35	0.03	0.01
LSP-52(1)	LSJ-38	J-184	55.80	300	120	-4.41	0.06	0.02
LSP-52(2)	J-184	LSJ-39	81.10	300	120	-3.58	0.05	0.02
LSP-53	LSJ-39	LSJ-40	124.10	300	120	-3.58	0.05	0.02
LSP-54	LSJ-40	LSJ-13	43.90	300	120	-3.58	0.05	0.02
LSP-55	LSJ-41	LSJ-11	78.30	200	110	0.23	0.01	0.00
LSP-56	LSJ-42	LSJ-41	80.20	200	110	0.23	0.01	0.00
LSP-57	LSJ-42	LSJ-12	82.90	200	110	-1.05	0.03	0.01
LSP-58	LSJ-13	LSJ-43	84.40	300	120	3.61	0.05	0.02
LSP-59	LSJ-43	LSJ-44	37.80	300	120	1.84	0.03	0.01
LSP-61	LSJ-44	WH_03	59.40	300	120	1.84	0.03	0.01
LSP-62	WH_03	WH_04	53.00	300	120	1.74	0.02	0.00
LSP-63	WH_04	WH_05	68.00	300	120	1.62	0.02	0.00
LSP-64	WH_05	WH_06	50.90	300	120	1.46	0.02	0.00
LSP-65	WH_06	WH_07	66.40	300	120	1.35	0.02	0.00
LSP-66	WH_07	LSJ-50	41.10	300	120	1.25	0.02	0.00
LSP-68	LSJ-50	LSJ-51	33.50	300	120	1.25	0.02	0.00
LSP-69	LSJ-57	LSJ-11	85.30	300	120	1.87	0.03	0.01
P-239	LSJ-51	LSJ-57	86.00	300	120	1.25	0.02	0.00
P-240	LSJ-57	LSJ-43	126.20	200	110	-1.00	0.03	0.01
P-253	J-182	LSJ-10	142.30	300	120	-1.03	0.01	0.00
P-254	J-184	LSJ-42	79.20	200	110	-0.83	0.03	0.01

2031 MDD Pipe Results								
Label	Start Node	Stop Node	Length (m)	Diameter (mm)	Hazen-Williams C	Flow (L/s)	Velocity (m/s)	Headloss Gradient (m/km)
LSP-1	LSJ-53	LSJ-1	172.80	300	120	14.88	0.21	0.22
LSP-2	LSJ-1	LSJ-2	192.90	300	120	-3.28	0.05	0.01
LSP-3	LSJ-2	LSJ-3	106.10	300	120	1.96	0.03	0.01
LSP-4	LSJ-3	LSJ-4	91.10	300	120	2.06	0.03	0.01
LSP-5	LSJ-4	LSJ-5	83.20	300	120	2.24	0.03	0.01
LSP-6	LSJ-5	LSJ-6	128.90	300	120	2.24	0.03	0.01
LSP-7	LSJ-6	LSJ-55	88.40	300	120	-4.21	0.06	0.02
LSP-8	LSJ-55	LSJ-7	88.40	300	120	-0.83	0.01	0.00
LSP-9	LSJ-7	LSJ-8	78.90	300	120	-3.46	0.05	0.02
LSP-10	LSJ-9	LSJ-8	82.00	300	120	-0.15	0.00	0.00
LSP-11	LSJ-9	LSJ-10	78.90	300	120	-1.34	0.02	0.00
LSP-12	LSJ-10	LSJ-11	84.70	300	120	-9.70	0.14	0.10
LSP-13	LSJ-11	LSJ-12	75.00	300	120	-7.11	0.10	0.06
LSP-14	LSJ-12	LSJ-13	71.00	300	120	-9.50	0.13	0.10
LSP-15	LSJ-13	SA02T052	140.50	300	120	-24.29	0.34	0.54
LSP-16	LSJ-14	LSJ-1	82.00	200	110	-5.21	0.17	0.27
LSP-17	LSJ-15	LSJ-14	79.20	200	110	-4.03	0.13	0.17
LSP-18	LSJ-16	LSJ-15	176.80	200	110	-2.91	0.09	0.09
LSP-19	LSJ-17	LSJ-16	78.90	200	110	5.54	0.18	0.30
LSP-20	LSJ-18	LSJ-17	77.40	200	110	3.93	0.13	0.16
LSP-21	LSJ-19	LSJ-18	193.90	200	110	-1.69	0.05	0.03
LSP-22	LSJ-14	LSJ-19	100.30	200	110	-0.43	0.01	0.00
LSP-23	LSJ-14	LSJ-17	185.90	200	110	1.60	0.05	0.03
LSP-24	LSJ-20	LSJ-18	87.80	200	110	5.62	0.18	0.31
LSP-25	LSJ-22	LSJ-2	129.20	300	120	1.96	0.03	0.01
LSP-26	LSJ-21	LSJ-22	82.90	300	120	5.66	0.08	0.04
LSP-27	LSJ-20	LSJ-21	77.70	300	120	8.09	0.11	0.07
LSP-28	LSJ-54	LSJ-20	151.80	300	120	21.70	0.31	0.44
LSP-29	LSJ-24	LSJ-20	137.80	300	120	-7.98	0.11	0.07
LSP-30	LSJ-25	LSJ-24	86.00	300	120	-0.45	0.01	0.00
LSP-31	LSJ-21	LSJ-25	136.20	200	110	1.60	0.05	0.03
LSP-32	LSJ-25	LSJ-26	53.30	300	120	2.05	0.03	0.01
LSP-33	LSJ-26	LSJ-27	71.90	300	120	2.05	0.03	0.01
LSP-34	LSJ-27	LSJ-4	89.60	300	120	0.18	0.00	0.00
LSP-35	LSJ-22	LSJ-23	96.90	200	110	0.99	0.03	0.01
LSP-36	LSJ-3	LSJ-23	124.70	200	110	-0.10	0.00	0.00
LSP-37	LSJ-2	LSJ-31	79.90	300	120	-3.28	0.05	0.01
LSP-38	LSJ-29	LSJ-28	28.00	200	110	0.00	0.00	0.00
LSP-39	LSJ-29	LSJ-30	127.40	200	110	0.00	0.00	0.00
LSP-40	LSJ-30	LSJ-31	93.60	200	110	0.00	0.00	0.00
LSP-41	LSJ-31	SB02V053	161.80	300	120	-7.17	0.10	0.06
LSP-42	LSJ-31	LSJ-32	142.30	200	110	3.89	0.12	0.15
LSP-43	LSJ-32	LSJ-34	231.30	200	110	2.04	0.06	0.05
LSP-45	LSJ-34	LSJ-6	126.80	200	110	-4.82	0.15	0.23
LSP-46	LSJ-7	LSJ-35	120.10	200	110	0.45	0.01	0.00
LSP-47	LSJ-35	LSJ-36	157.30	200	110	-0.66	0.02	0.01
LSP-48	LSJ-9	LSJ-36	104.20	200	110	0.66	0.02	0.01
LSP-49	LSJ-7	LSJ-37	102.40	200	110	2.18	0.07	0.05
LSP-50	LSJ-37	LSJ-38	76.50	200	110	-3.37	0.11	0.12
LSP-51	LSJ-8	LSJ-38	106.40	300	120	-4.48	0.06	0.02
LSP-52(1)	LSJ-38	J-184	55.80	300	120	-8.38	0.12	0.08
LSP-52(2)	J-184	LSJ-39	81.10	300	120	-6.81	0.10	0.05
LSP-53	LSJ-39	LSJ-40	124.10	300	120	-6.81	0.10	0.05
LSP-54	LSJ-40	LSJ-13	43.90	300	120	-6.81	0.10	0.05
LSP-55	LSJ-41	LSJ-11	78.30	200	110	0.44	0.01	0.00
LSP-56	LSJ-42	LSJ-41	80.20	200	110	0.44	0.01	0.00
LSP-57	LSJ-42	LSJ-12	82.90	200	110	-2.01	0.06	0.05
LSP-58	LSJ-13	LSJ-43	84.40	300	120	6.86	0.10	0.05
LSP-59	LSJ-43	LSJ-44	37.80	300	120	3.51	0.05	0.02
LSP-61	LSJ-44	WH_03	59.40	300	120	3.51	0.05	0.02
LSP-62	WH_03	WH_04	53.00	300	120	3.32	0.05	0.01
LSP-63	WH_04	WH_05	68.00	300	120	3.08	0.04	0.01
LSP-64	WH_05	WH_06	50.90	300	120	2.78	0.04	0.01
LSP-65	WH_06	WH_07	66.40	300	120	2.57	0.04	0.01
LSP-66	WH_07	LSJ-50	41.10	300	120	2.38	0.03	0.01
LSP-68	LSJ-50	LSJ-51	33.50	300	120	2.38	0.03	0.01
LSP-69	LSJ-57	LSJ-11	85.30	300	120	3.55	0.05	0.02
P-239	LSJ-51	LSJ-57	86.00	300	120	2.38	0.03	0.01
P-240	LSJ-57	LSJ-43	126.20	200	110	-1.91	0.06	0.04
P-253	J-182	LSJ-10	142.30	300	120	-1.97	0.03	0.01
P-254	J-184	LSJ-42	79.20	200	110	-1.57	0.05	0.03

2031 Pipe Tables
PD1 Reservoir 90% Full + NO Pumps

2031 PHD Pipe Results								
Label	Start Node	Stop Node	Length (m)	Diameter (mm)	Hazen-Williams C	Flow (L/s)	Velocity (m/s)	Headloss Gradient (m/km)
LSP-1	LSJ-53	LSJ-1	172.80	300	120	23.27	0.33	0.50
LSP-2	LSJ-1	LSJ-2	192.90	300	120	-5.42	0.08	0.03
LSP-3	LSJ-2	LSJ-3	106.10	300	120	3.15	0.04	0.01
LSP-4	LSJ-3	LSJ-4	91.10	300	120	3.26	0.05	0.01
LSP-5	LSJ-4	LSJ-5	83.20	300	120	3.24	0.05	0.01
LSP-6	LSJ-5	LSJ-6	128.90	300	120	3.24	0.05	0.01
LSP-7	LSJ-6	LSJ-55	88.40	300	120	-6.95	0.10	0.05
LSP-8	LSJ-55	LSJ-7	88.40	300	120	-1.54	0.02	0.00
LSP-9	LSJ-7	LSJ-8	78.90	300	120	-5.67	0.08	0.04
LSP-10	LSJ-9	LSJ-8	82.00	300	120	0.10	0.00	0.00
LSP-11	LSJ-9	LSJ-10	78.90	300	120	-2.48	0.04	0.01
LSP-12	LSJ-10	LSJ-11	84.70	300	120	-15.10	0.21	0.23
LSP-13	LSJ-11	LSJ-12	75.00	300	120	-11.11	0.16	0.13
LSP-14	LSJ-12	LSJ-13	71.00	300	120	-14.85	0.21	0.22
LSP-15	LSJ-13	SA02T052	140.50	300	120	-38.01	0.54	1.24
LSP-16	LSJ-14	LSJ-1	82.00	200	110	-8.24	0.26	0.62
LSP-17	LSJ-15	LSJ-14	79.20	200	110	-6.36	0.20	0.38
LSP-18	LSJ-16	LSJ-15	176.80	200	110	-4.60	0.15	0.21
LSP-19	LSJ-17	LSJ-16	78.90	200	110	8.74	0.28	0.69
LSP-20	LSJ-18	LSJ-17	77.40	200	110	6.20	0.20	0.37
LSP-21	LSJ-19	LSJ-18	193.90	200	110	-2.65	0.08	0.08
LSP-22	LSJ-14	LSJ-19	100.30	200	110	-0.66	0.02	0.01
LSP-23	LSJ-14	LSJ-17	185.90	200	110	2.54	0.08	0.07
LSP-24	LSJ-20	LSJ-18	87.80	200	110	8.85	0.28	0.71
LSP-25	LSJ-22	LSJ-2	129.20	300	120	2.86	0.04	0.01
LSP-26	LSJ-21	LSJ-22	82.90	300	120	8.65	0.12	0.08
LSP-27	LSJ-20	LSJ-21	77.70	300	120	12.46	0.18	0.16
LSP-28	LSJ-54	LSJ-20	151.80	300	120	33.66	0.48	0.99
LSP-29	LSJ-24	LSJ-20	137.80	300	120	-12.35	0.17	0.16
LSP-30	LSJ-25	LSJ-24	86.00	300	120	-0.46	0.01	0.00
LSP-31	LSJ-21	LSJ-25	136.20	200	110	2.48	0.08	0.07
LSP-32	LSJ-25	LSJ-26	53.30	300	120	2.94	0.04	0.01
LSP-33	LSJ-26	LSJ-27	71.90	300	120	2.94	0.04	0.01
LSP-34	LSJ-27	LSJ-4	89.60	300	120	-0.01	0.00	0.00
LSP-35	LSJ-22	LSJ-23	96.90	200	110	1.52	0.05	0.03
LSP-36	LSJ-3	LSJ-23	124.70	200	110	-0.11	0.00	0.00
LSP-37	LSJ-2	LSJ-31	79.90	300	120	-5.71	0.08	0.04
LSP-38	LSJ-29	LSJ-28	28.00	200	110	0.00	0.00	0.00
LSP-39	LSJ-29	LSJ-30	127.40	200	110	0.00	0.00	0.00
LSP-40	LSJ-30	LSJ-31	93.60	200	110	0.00	0.00	0.00
LSP-41	LSJ-31	SB02V053	161.80	300	120	-11.85	0.17	0.14
LSP-42	LSJ-31	LSJ-32	142.30	200	110	6.14	0.20	0.36
LSP-43	LSJ-32	LSJ-34	231.30	200	110	3.21	0.10	0.11
LSP-45	LSJ-34	LSJ-6	126.80	200	110	-7.62	0.24	0.54
LSP-46	LSJ-7	LSJ-35	120.10	200	110	0.69	0.02	0.01
LSP-47	LSJ-35	LSJ-36	157.30	200	110	-1.06	0.03	0.01
LSP-48	LSJ-9	LSJ-36	104.20	200	110	1.06	0.03	0.01
LSP-49	LSJ-7	LSJ-37	102.40	200	110	3.44	0.11	0.12
LSP-50	LSJ-37	LSJ-38	76.50	200	110	-5.33	0.17	0.28
LSP-51	LSJ-8	LSJ-38	106.40	300	120	-6.95	0.10	0.05
LSP-52(1)	LSJ-38	J-184	55.80	300	120	-13.12	0.19	0.17
LSP-52(2)	J-184	LSJ-39	81.10	300	120	-10.66	0.15	0.12
LSP-53	LSJ-39	LSJ-40	124.10	300	120	-10.66	0.15	0.12
LSP-54	LSJ-40	LSJ-13	43.90	300	120	-10.66	0.15	0.12
LSP-55	LSJ-41	LSJ-11	78.30	200	110	0.67	0.02	0.01
LSP-56	LSJ-42	LSJ-41	80.20	200	110	0.67	0.02	0.01
LSP-57	LSJ-42	LSJ-12	82.90	200	110	-3.14	0.10	0.10
LSP-58	LSJ-13	LSJ-43	84.40	300	120	10.75	0.15	0.12
LSP-59	LSJ-43	LSJ-44	37.80	300	120	5.49	0.08	0.03
LSP-61	LSJ-44	WH_03	59.40	300	120	5.49	0.08	0.04
LSP-62	WH_03	WH_04	53.00	300	120	5.19	0.07	0.03
LSP-63	WH_04	WH_05	68.00	300	120	4.81	0.07	0.03
LSP-64	WH_05	WH_06	50.90	300	120	4.35	0.06	0.02
LSP-65	WH_06	WH_07	66.40	300	120	4.01	0.06	0.02
LSP-66	WH_07	LSJ-50	41.10	300	120	3.71	0.05	0.02
LSP-68	LSJ-50	LSJ-51	33.50	300	120	3.71	0.05	0.02
LSP-69	LSJ-57	LSJ-11	85.30	300	120	5.52	0.08	0.04
P-239	LSJ-51	LSJ-57	86.00	300	120	3.71	0.05	0.02
P-240	LSJ-57	LSJ-43	126.20	200	110	-2.99	0.10	0.10
P-253	J-182	LSJ-10	142.30	300	120	-2.52	0.04	0.01
P-254	J-184	LSJ-42	79.20	200	110	-2.47	0.08	0.07

APPENDIX

C

FIRE FLOW REPORT

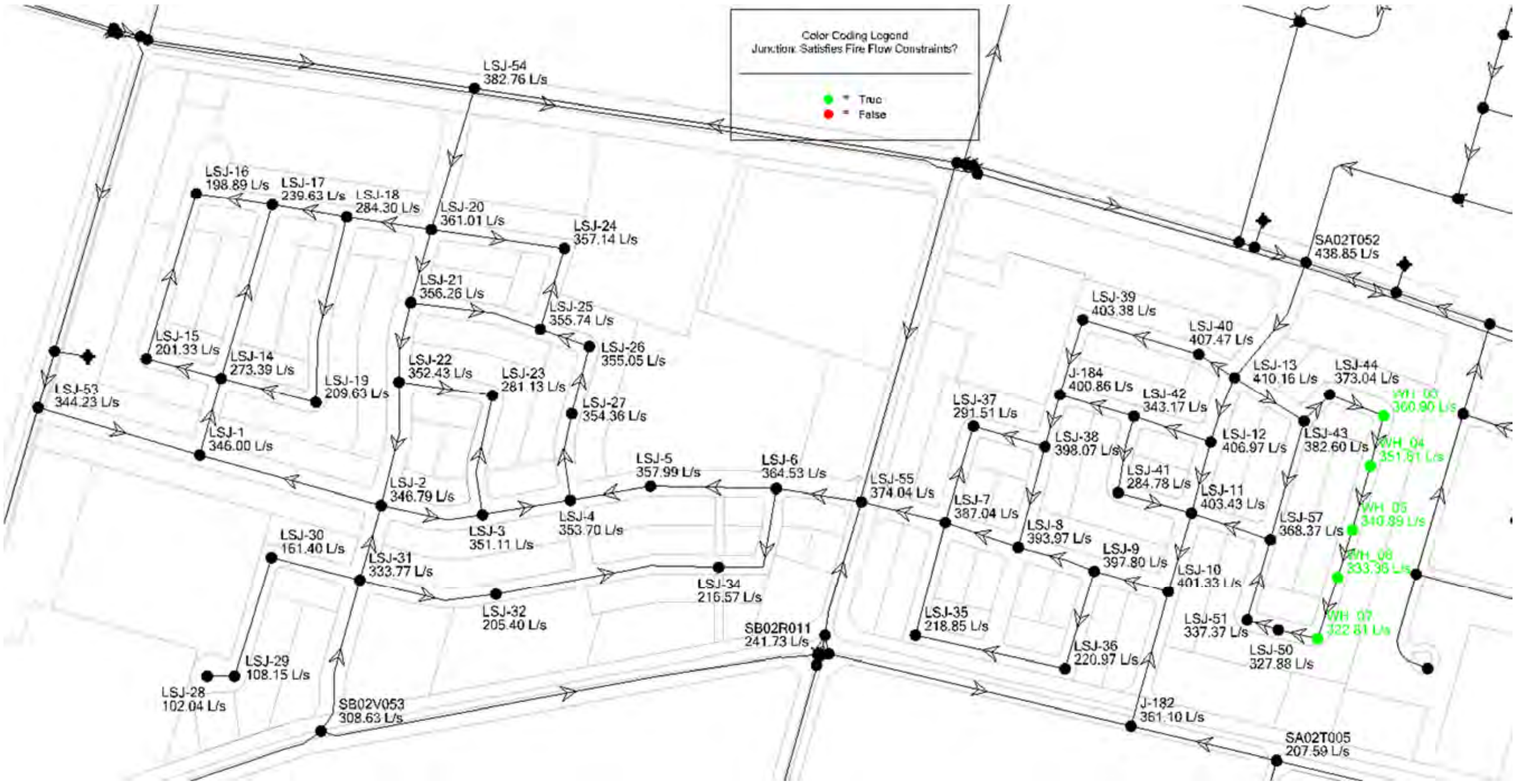


Figure C1 - Fire Flow Available During the 2011 MDD+FF Scenario with PD1 Reservoir at 50% Full and ALL Woodward Pumps set to OFF

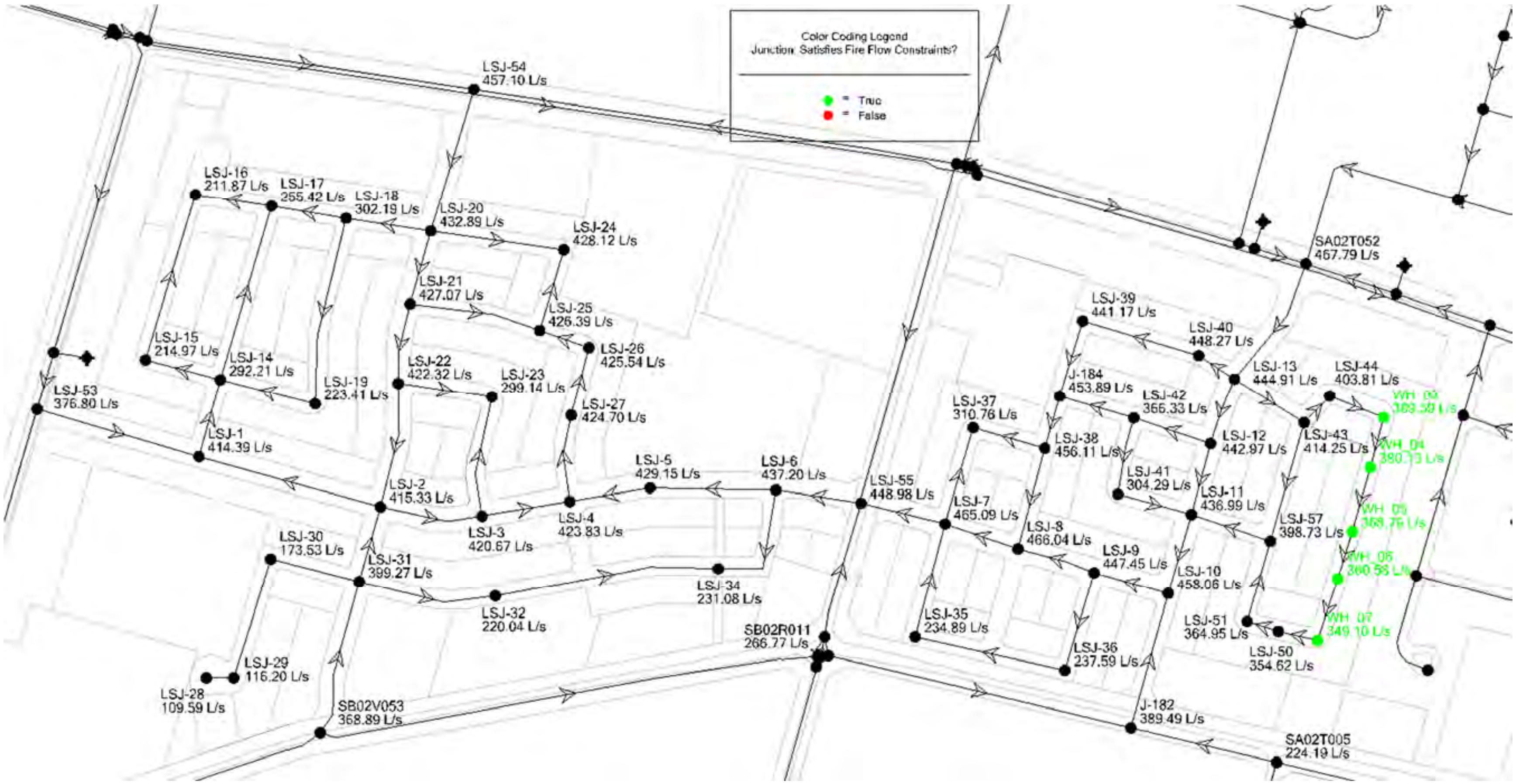


Figure C2 - Fire Flow Available During the 2011 MDD+FF Scenario with PD1 Reservoir at 75% Full and ALL Woodward Pumps set to OFF

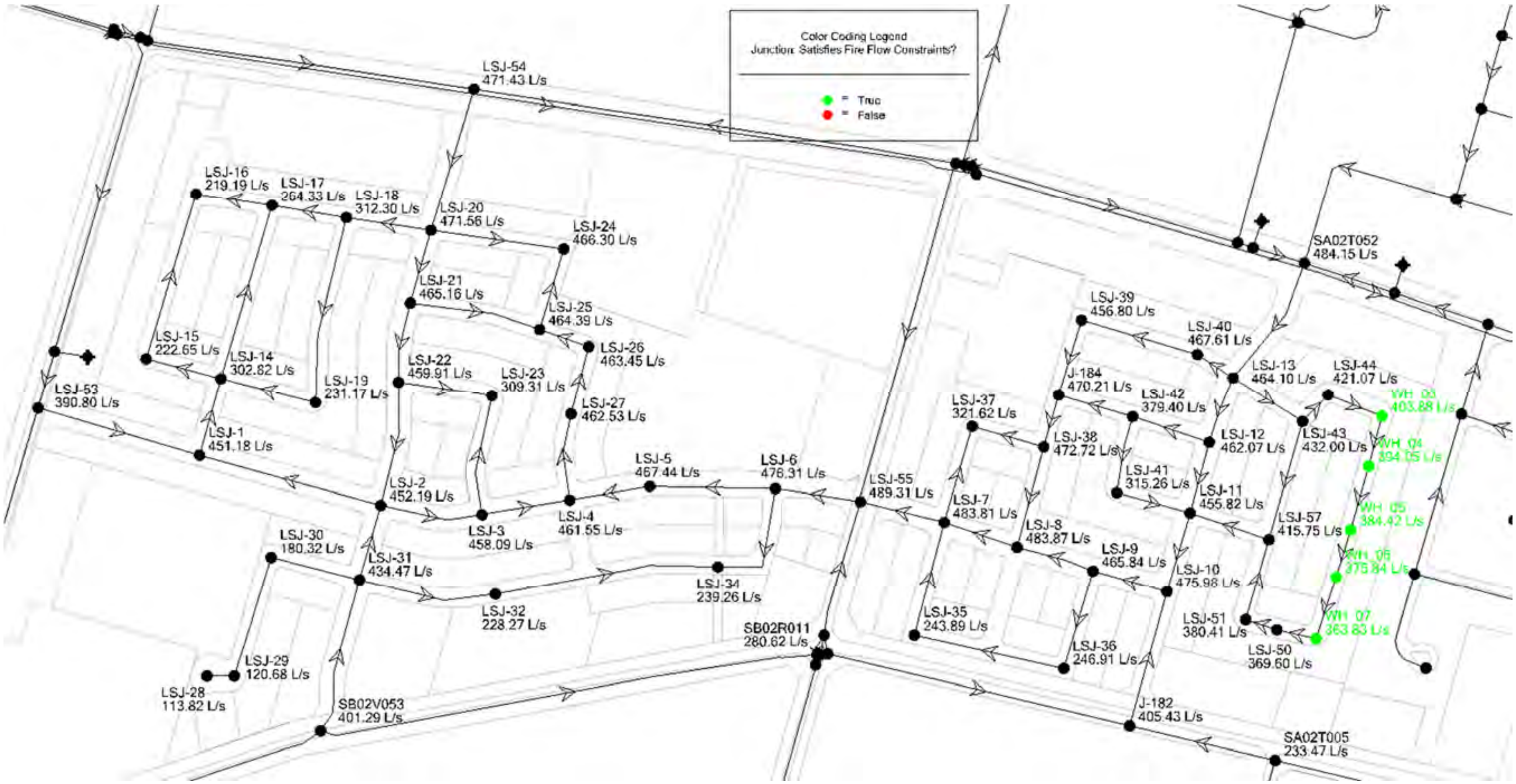


Figure C3 - Fire Flow Available During the 2011 MDD+FF Scenario with PD1 Reservoir at 90% Full and ALL Woodward Pumps set to OFF

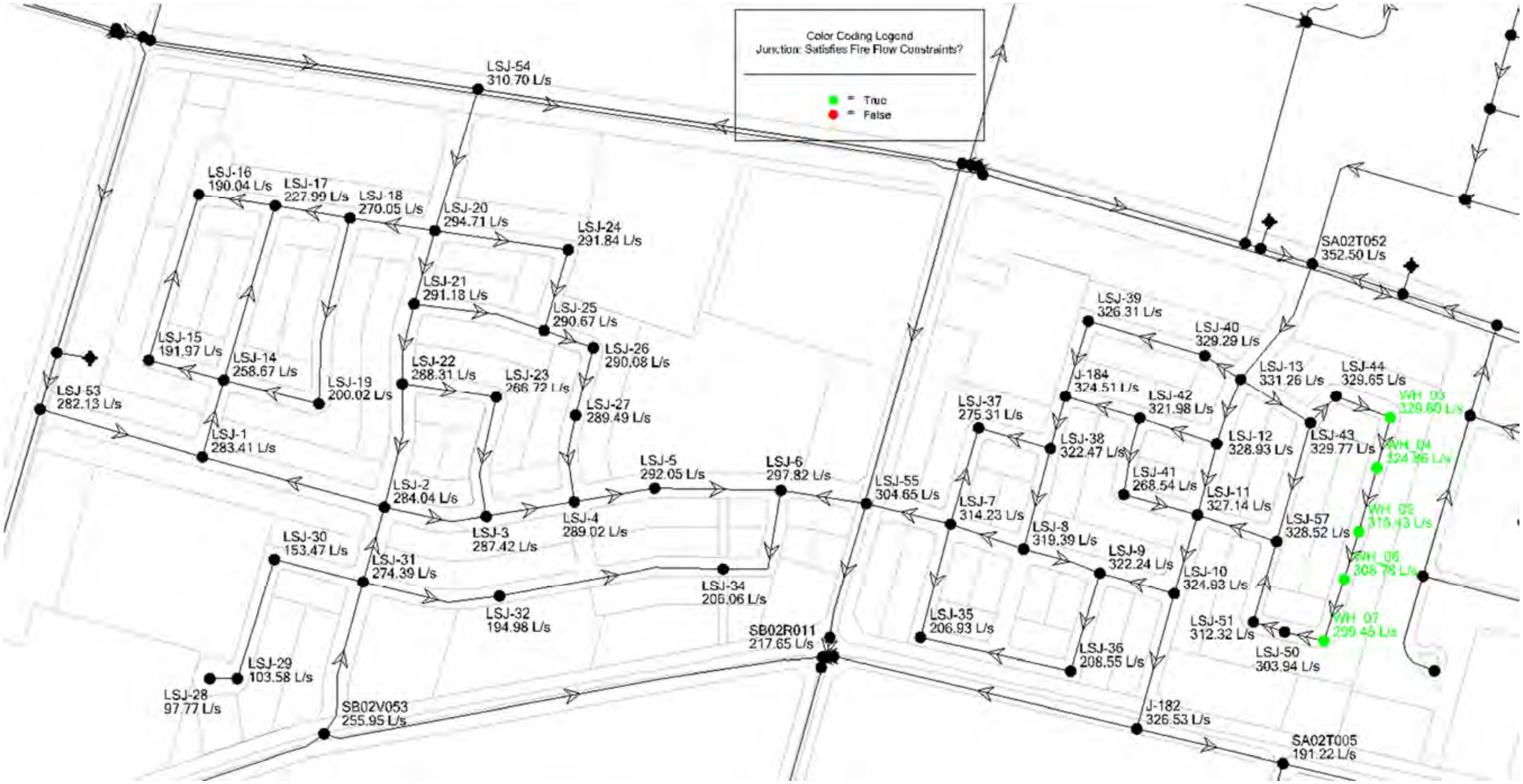


Figure C4 - Fire Flow Available During the 2031 MDD+FF Scenario with PD1 Reservoir at 50% Full and ALL Woodward Pumps set to OFF

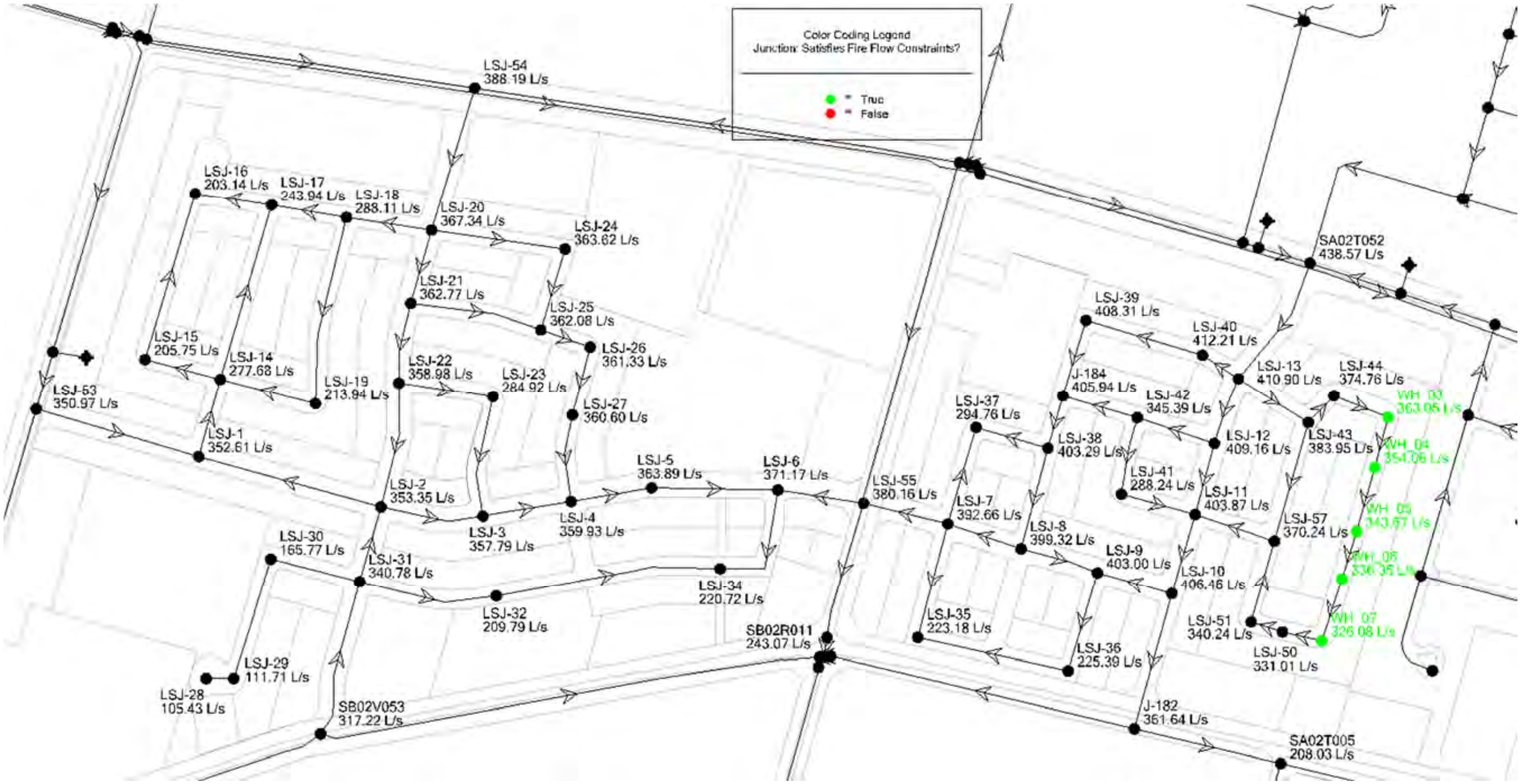


Figure C5 - Fire Flow Available During the 2031 MDD+FF Scenario with PD1 Reservoir at 75% Full and ALL Woodward Pumps set to OFF

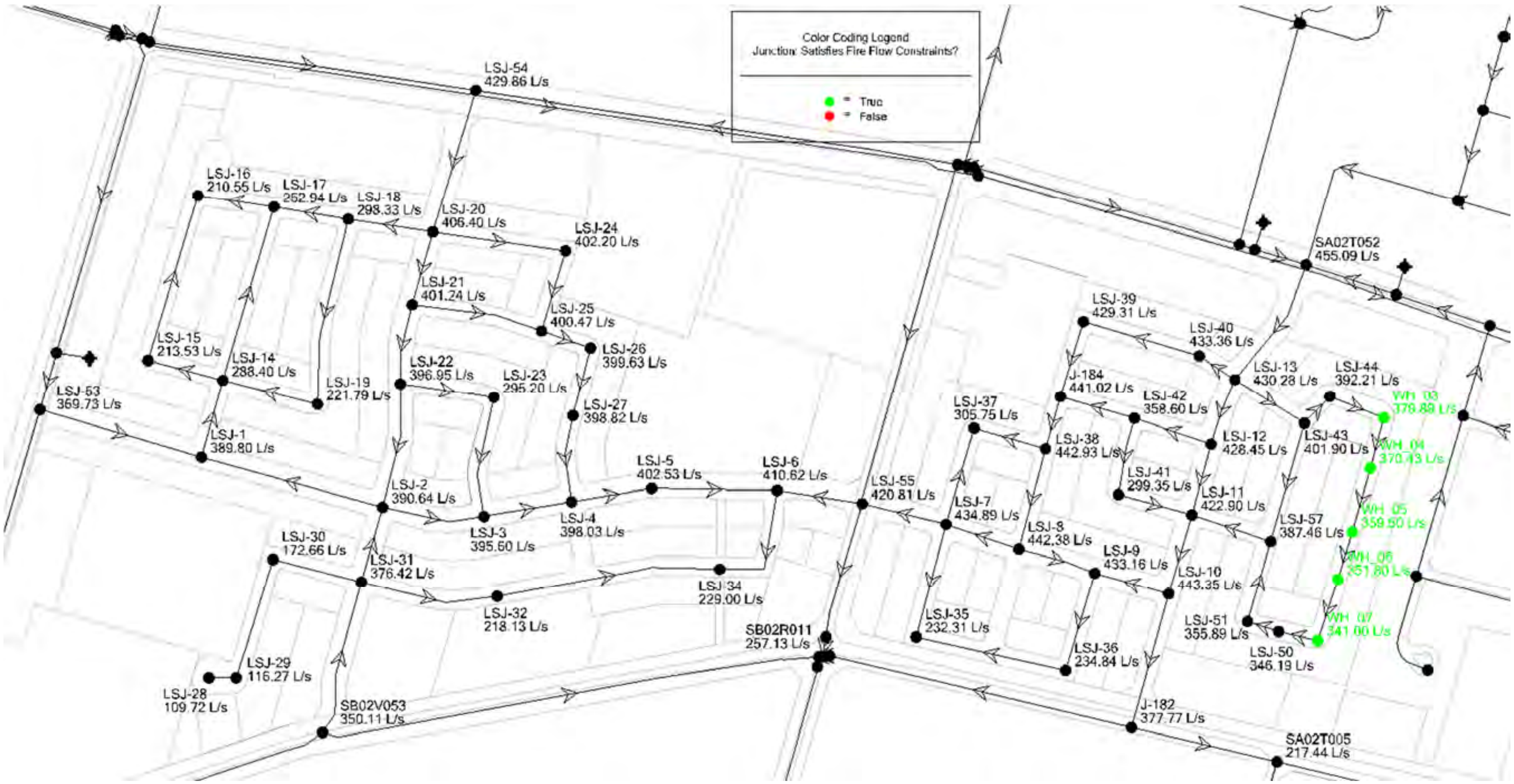


Figure C6 - Fire Flow Available During the 2031 MDD+FF Scenario with PD1 Reservoir at 90% Full and ALL Woodward Pumps set to OFF

Fire Flow Report
(Maximum Day + Fire Flow)
Lower Stoney Creek BSS

2011 MDD + FF - Reservoir 50% Full											
Label	Elevation (m)	Fire Flow (Needed) (L/s)	Fire Flow (Available) (L/s)	Satisfies Fire Flow Constraints?	Hydraulic Grade (m)	Pressure (Residual Lower Limit) (kPa)	Pressure (Zone Lower Limit) (kPa)	Pressure (Calculated Residual) (kPa)	Pressure (Calculated Zone Lower Limit) (kPa)	Junction w/ Minimum Pressure (Zone)	Junction w/ Minimum Pressure (System)
J-182	94.25	N/A	361	TRUE	127.06	140	140	140	151	SB02S008	SF05E005
J-184	91.25	N/A	401	TRUE	127.06	140	140	160	140	SB02S008	SF05E005
LSJ-1	91.00	N/A	346	TRUE	127.04	140	140	192	140	SB02S008	SF05E005
LSJ-2	91.75	N/A	347	TRUE	127.05	140	140	222	140	SB02S008	SF05E005
LSJ-3	91.50	N/A	351	TRUE	127.05	140	140	209	140	SB02S008	SF05E005
LSJ-4	91.50	N/A	354	TRUE	127.05	140	140	210	140	SB02S008	SF05E005
LSJ-5	90.25	N/A	358	TRUE	127.05	140	140	210	140	SB02S008	SF05E005
LSJ-6	91.75	N/A	365	TRUE	127.05	140	140	194	140	SB02S008	SF05E005
LSJ-7	92.25	N/A	387	TRUE	127.05	140	140	178	140	SB02S008	SF05E005
LSJ-8	92.50	N/A	394	TRUE	127.06	140	140	169	140	SB02S008	SF05E005
LSJ-9	92.75	N/A	398	TRUE	127.06	140	140	157	140	SB02S008	SF05E005
LSJ-10	93.00	N/A	401	TRUE	127.06	140	140	158	140	SB02S008	SF05E005
LSJ-11	92.00	N/A	403	TRUE	127.07	140	140	164	140	LSJ-50	SF05E005
LSJ-12	91.75	N/A	407	TRUE	127.07	140	140	158	140	SB02S008	SF05E005
LSJ-13	91.25	N/A	410	TRUE	127.07	140	140	172	140	SB02S008	SF05E005
LSJ-14	90.75	N/A	273	TRUE	127.02	140	140	143	140	LSJ-15	SF05E005
LSJ-15	91.50	N/A	201	TRUE	127.00	140	140	140	183	SB02S008	SF05E005
LSJ-16	90.50	N/A	199	TRUE	126.99	140	140	140	183	SB02S008	SF05E005
LSJ-17	90.75	N/A	240	TRUE	127.01	140	140	140	154	LSJ-16	SF05E005
LSJ-18	89.75	N/A	284	TRUE	127.02	140	140	140	155	LSJ-17	SF05E005
LSJ-19	91.00	N/A	210	TRUE	127.02	140	140	140	181	SB02S008	SF05E005
LSJ-20	89.75	N/A	361	TRUE	127.05	140	140	219	140	SB02S008	SF05E005
LSJ-21	90.50	N/A	356	TRUE	127.05	140	140	211	140	SB02S008	SF05E005
LSJ-22	90.75	N/A	352	TRUE	127.05	140	140	211	140	SB02S008	SF05E005
LSJ-23	90.50	N/A	281	TRUE	127.05	140	140	140	162	SB02S008	SF05E005
LSJ-24	89.25	N/A	357	TRUE	127.05	140	140	203	140	SB02S008	SF05E005
LSJ-25	89.75	N/A	356	TRUE	127.05	140	140	204	140	SB02S008	SF05E005
LSJ-26	89.75	N/A	355	TRUE	127.05	140	140	203	140	SB02S008	SF05E005
LSJ-27	90.50	N/A	354	TRUE	127.05	140	140	201	140	SB02S008	SF05E005
LSJ-28	94.25	N/A	102	TRUE	127.05	140	140	140	160	LSJ-29	SF05E005
LSJ-29	94.00	N/A	108	TRUE	127.05	140	140	143	140	LSJ-28	SF05E005
LSJ-30	92.00	N/A	161	TRUE	127.05	140	140	162	140	LSJ-28	SF05E005
LSJ-31	92.75	N/A	334	TRUE	127.05	140	140	212	140	SB02S008	SF05E005
LSJ-32	92.75	N/A	205	TRUE	127.03	140	140	140	181	SB02S008	SF05E005
LSJ-34	91.25	N/A	217	TRUE	127.02	140	140	140	180	SB02S008	SF05E005
LSJ-35	93.50	N/A	219	TRUE	127.05	140	140	140	183	SB02S008	SF05E005
LSJ-36	94.00	N/A	221	TRUE	127.06	140	140	140	183	SB02S008	SF05E005
LSJ-37	91.00	N/A	292	TRUE	127.05	140	140	140	167	SB02S008	SF05E005
LSJ-38	91.50	N/A	398	TRUE	127.06	140	140	163	140	SB02S008	SF05E005
LSJ-39	91.00	N/A	403	TRUE	127.07	140	140	149	140	SB02S008	SF05E005
LSJ-40	91.25	N/A	407	TRUE	127.07	140	140	157	140	SB02S008	SF05E005
LSJ-41	92.00	N/A	285	TRUE	127.07	140	140	140	171	SB02S008	SF05E005
LSJ-42	91.50	N/A	343	TRUE	127.07	140	140	140	157	SB02S008	SF05E005
LSJ-43	91.25	N/A	383	TRUE	127.07	140	140	161	140	WH_07	SF05E005
LSJ-44	91.75	N/A	373	TRUE	127.07	140	140	150	140	WH_07	SF05E005
LSJ-50	95.00	N/A	328	TRUE	127.07	140	140	140	144	WH_07	SF05E005
LSJ-51	94.00	N/A	337	TRUE	127.07	140	140	147	140	LSJ-50	SF05E005
LSJ-53	92.25	N/A	344	TRUE	127.07	140	140	147	140	SB02S008	SF05E005
LSJ-54	88.18	N/A	383	TRUE	127.10	140	140	185	140	SB02S008	SF05E005
LSJ-55	91.86	N/A	374	TRUE	127.05	140	140	191	140	SB02S008	SF05E005
LSJ-57	92.25	N/A	368	TRUE	127.07	140	140	161	140	LSJ-50	SF05E005
SA02T005	95.10	N/A	208	TRUE	127.08	140	140	140	184	HB15T003	SF05E005
SA02T052	91.00	N/A	439	TRUE	127.14	140	140	140	140	SB02S008	SF05E005
SB02R011	94.00	N/A	242	TRUE	127.06	140	140	182	140	SB02S010	SF05E005
SB02V053	95.20	N/A	309	TRUE	127.07	140	140	197	140	SB02S008	SF05E005
WH_03	92.00	217	361	TRUE	127.07	140	140	143	140	WH_07	SF05E005
WH_04	92.00	217	352	TRUE	127.07	140	140	144	140	WH_07	SF05E005
WH_05	92.00	217	341	TRUE	127.07	140	140	149	140	WH_07	SF05E005
WH_06	93.00	217	333	TRUE	127.07	140	140	146	140	WH_07	SF05E005
WH_07	95.00	217	323	TRUE	127.07	140	140	140	150	LSJ-50	SF05E005

Note - Required Fire Flows were only provided for the nodes overlapping with the Winona Hills Development. Required Fire Flows were not calculated for the other blocks within the Lower Stoney Creek Development as the block servicing strategy does not provide sufficient information (ie. building footprints, exposure distances, construction material) for calculating Required Fire Flows per the procedure outlined in: "Water Supply for Public Fire Protection" by the Fire Underwriter's Survey, 1999.

Fire Flow Report
(Maximum Day + Fire Flow)
Lower Stoney Creek BSS

2011 MDD + FF - Reservoir 75% Full											
Label	Elevation (m)	Fire Flow (Needed) (L/s)	Fire Flow (Available) (L/s)	Satisfies Fire Flow Constraints?	Hydraulic Grade (m)	Pressure (Residual Lower Limit) (kPa)	Pressure (Zone Lower Limit) (kPa)	Pressure (Calculated Residual) (kPa)	Pressure (Calculated Zone Lower Limit) (kPa)	Junction w/ Minimum Pressure (Zone)	Junction w/ Minimum Pressure (System)
J-182	94.25	N/A	389	TRUE	129.61	140	140	140	168	SB02S008	SF05E005
J-184	91.25	N/A	454	TRUE	129.61	140	140	140	144	WH_07	SF05E005
LSJ-1	91.00	N/A	414	TRUE	129.59	140	140	161	140	SB02S008	SF05E005
LSJ-2	91.75	N/A	415	TRUE	129.60	140	140	205	140	SB02S008	SF05E005
LSJ-3	91.50	N/A	421	TRUE	129.59	140	140	186	140	SB02S008	SF05E005
LSJ-4	91.50	N/A	424	TRUE	129.59	140	140	187	140	SB02S008	SF05E005
LSJ-5	90.25	N/A	429	TRUE	129.60	140	140	183	140	SB02S008	SF05E005
LSJ-6	91.75	N/A	437	TRUE	129.60	140	140	166	140	SB02S008	SF05E005
LSJ-7	92.25	N/A	465	TRUE	129.60	140	140	145	140	SB02S008	SF05E005
LSJ-8	92.50	N/A	466	TRUE	129.61	140	140	140	140	LSJ-36	SF05E005
LSJ-9	92.75	N/A	447	TRUE	129.61	140	140	144	140	LSJ-36	SF05E005
LSJ-10	93.00	N/A	458	TRUE	129.61	140	140	140	141	LSJ-50	SF05E005
LSJ-11	92.00	N/A	437	TRUE	129.62	140	140	163	140	LSJ-50	SF05E005
LSJ-12	91.75	N/A	443	TRUE	129.62	140	140	154	140	LSJ-50	SF05E005
LSJ-13	91.25	N/A	445	TRUE	129.62	140	140	171	140	WH_07	SF05E005
LSJ-14	90.75	N/A	292	TRUE	129.57	140	140	143	140	LSJ-15	SF05E005
LSJ-15	91.50	N/A	215	TRUE	129.55	140	140	140	204	SB02S008	SF05E005
LSJ-16	90.50	N/A	212	TRUE	129.54	140	140	140	205	SB02S008	SF05E005
LSJ-17	90.75	N/A	255	TRUE	129.56	140	140	140	156	LSJ-16	SF05E005
LSJ-18	89.75	N/A	302	TRUE	129.57	140	140	140	158	LSJ-17	SF05E005
LSJ-19	91.00	N/A	223	TRUE	129.57	140	140	140	202	SB02S008	SF05E005
LSJ-20	89.75	N/A	433	TRUE	129.60	140	140	193	140	SB02S008	SF05E005
LSJ-21	90.50	N/A	427	TRUE	129.60	140	140	185	140	SB02S008	SF05E005
LSJ-22	90.75	N/A	422	TRUE	129.60	140	140	186	140	SB02S008	SF05E005
LSJ-23	90.50	N/A	299	TRUE	129.59	140	140	140	181	SB02S008	SF05E005
LSJ-24	89.25	N/A	428	TRUE	129.59	140	140	170	140	SB02S008	SF05E005
LSJ-25	89.75	N/A	426	TRUE	129.59	140	140	173	140	SB02S008	SF05E005
LSJ-26	89.75	N/A	426	TRUE	129.59	140	140	171	140	SB02S008	SF05E005
LSJ-27	90.50	N/A	425	TRUE	129.59	140	140	171	140	SB02S008	SF05E005
LSJ-28	94.25	N/A	110	TRUE	129.60	140	140	140	163	LSJ-29	SF05E005
LSJ-29	94.00	N/A	116	TRUE	129.60	140	140	142	140	LSJ-28	SF05E005
LSJ-30	92.00	N/A	174	TRUE	129.60	140	140	162	140	LSJ-28	SF05E005
LSJ-31	92.75	N/A	399	TRUE	129.60	140	140	195	140	SB02S008	SF05E005
LSJ-32	92.75	N/A	220	TRUE	129.58	140	140	140	202	SB02S008	SF05E005
LSJ-34	91.25	N/A	231	TRUE	129.57	140	140	140	201	SB02S008	SF05E005
LSJ-35	93.50	N/A	235	TRUE	129.60	140	140	140	205	SB02S008	SF05E005
LSJ-36	94.00	N/A	238	TRUE	129.61	140	140	140	204	SB02S008	SF05E005
LSJ-37	91.00	N/A	311	TRUE	129.60	140	140	140	187	SB02S008	SF05E005
LSJ-38	91.50	N/A	456	TRUE	129.61	140	140	140	147	LSJ-50	SF05E005
LSJ-39	91.00	N/A	441	TRUE	129.62	140	140	140	150	WH_07	SF05E005
LSJ-40	91.25	N/A	448	TRUE	129.62	140	140	148	140	WH_07	SF05E005
LSJ-41	92.00	N/A	304	TRUE	129.62	140	140	140	191	SB02S008	SF05E005
LSJ-42	91.50	N/A	366	TRUE	129.62	140	140	140	175	SB02S008	SF05E005
LSJ-43	91.25	N/A	414	TRUE	129.62	140	140	158	140	WH_07	SF05E005
LSJ-44	91.75	N/A	404	TRUE	129.62	140	140	146	140	WH_07	SF05E005
LSJ-50	95.00	N/A	355	TRUE	129.62	140	140	140	145	WH_07	SF05E005
LSJ-51	94.00	N/A	365	TRUE	129.62	140	140	146	140	LSJ-50	SF05E005
LSJ-53	92.25	N/A	377	TRUE	129.62	140	140	140	153	SB02S008	SF05E005
LSJ-54	88.18	N/A	457	TRUE	129.64	140	140	140	141	SB02S008	SF05E005
LSJ-55	91.86	N/A	449	TRUE	129.60	140	140	162	140	SB02S008	SF05E005
LSJ-57	92.25	N/A	399	TRUE	129.62	140	140	160	140	LSJ-50	SF05E005
SA02T005	95.10	N/A	224	TRUE	129.63	140	140	140	207	HB15T003	SF05E005
SA02T052	91.00	N/A	468	TRUE	129.69	140	140	140	156	WH_07	SF05E005
SB02R011	94.00	N/A	267	TRUE	129.61	140	140	181	140	SB02S010	SF05E005
SB02V053	95.20	N/A	369	TRUE	129.61	140	140	183	140	SB02S008	SF05E005
WH_03	92.00	217	390	TRUE	129.62	140	140	140	141	WH_07	SF05E005
WH_04	92.00	217	380	TRUE	129.62	140	140	140	140	WH_07	SF05E005
WH_05	92.00	217	369	TRUE	129.62	140	140	146	140	WH_07	SF05E005
WH_06	93.00	217	361	TRUE	129.62	140	140	144	140	WH_07	SF05E005
WH_07	95.00	217	349	TRUE	129.62	140	140	140	151	LSJ-50	SF05E005

Note - Required Fire Flows were only provided for the nodes overlapping with the Winona Hills Development. Required Fire Flows were not calculated for the other blocks within the Lower Stoney Creek Development as the block servicing strategy does not provide sufficient information (ie. building footprints, exposure distances, construction material) for calculating Required Fire Flows per the procedure outlined in: "Water Supply for Public Fire Protection" by the Fire Underwriter's Survey, 1999.

wsp

Fire Flow Report
(Maximum Day + Fire Flow)
Lower Stoney Creek BSS

2011 MDD + FF - Reservoir 90% Full											
Label	Elevation (m)	Fire Flow (Needed) (L/s)	Fire Flow (Available) (L/s)	Satisfies Fire Flow Constraints?	Hydraulic Grade (m)	Pressure (Residual Lower Limit) (kPa)	Pressure (Zone Lower Limit) (kPa)	Pressure (Calculated Residual) (kPa)	Pressure (Calculated Zone Lower Limit) (kPa)	Junction w/ Minimum Pressure (Zone)	Junction w/ Minimum Pressure (System)
J-182	94.25	N/A	405	TRUE	131.10	140	140	140	178	SB02S008	SF05E005
J-184	91.25	N/A	470	TRUE	131.10	140	140	140	147	WH_07	SF05E005
LSJ-1	91.00	N/A	451	TRUE	131.08	140	140	142	140	SB02S008	SF05E005
LSJ-2	91.75	N/A	452	TRUE	131.08	140	140	195	140	SB02S008	SF05E005
LSJ-3	91.50	N/A	458	TRUE	131.08	140	140	172	140	SB02S008	SF05E005
LSJ-4	91.50	N/A	462	TRUE	131.08	140	140	174	140	SB02S008	SF05E005
LSJ-5	90.25	N/A	467	TRUE	131.08	140	140	167	140	SB02S008	SF05E005
LSJ-6	91.75	N/A	476	TRUE	131.09	140	140	149	140	SB02S008	SF05E005
LSJ-7	92.25	N/A	484	TRUE	131.09	140	140	144	140	LSJ-35	SF05E005
LSJ-8	92.50	N/A	484	TRUE	131.10	140	140	140	141	LSJ-36	SF05E005
LSJ-9	92.75	N/A	466	TRUE	131.10	140	140	143	140	LSJ-36	SF05E005
LSJ-10	93.00	N/A	476	TRUE	131.10	140	140	140	143	LSJ-50	SF05E005
LSJ-11	92.00	N/A	456	TRUE	131.10	140	140	162	140	LSJ-50	SF05E005
LSJ-12	91.75	N/A	462	TRUE	131.11	140	140	152	140	LSJ-50	SF05E005
LSJ-13	91.25	N/A	464	TRUE	131.11	140	140	170	140	WH_07	SF05E005
LSJ-14	90.75	N/A	303	TRUE	131.06	140	140	142	140	LSJ-15	SF05E005
LSJ-15	91.50	N/A	223	TRUE	131.04	140	140	140	214	LSJ-16	SF05E005
LSJ-16	90.50	N/A	219	TRUE	131.03	140	140	140	214	LSJ-15	SF05E005
LSJ-17	90.75	N/A	264	TRUE	131.05	140	140	140	157	LSJ-16	SF05E005
LSJ-18	89.75	N/A	312	TRUE	131.06	140	140	140	160	LSJ-17	SF05E005
LSJ-19	91.00	N/A	231	TRUE	131.06	140	140	140	214	SB02S008	SF05E005
LSJ-20	89.75	N/A	472	TRUE	131.09	140	140	178	140	SB02S008	SF05E005
LSJ-21	90.50	N/A	465	TRUE	131.09	140	140	169	140	SB02S008	SF05E005
LSJ-22	90.75	N/A	460	TRUE	131.08	140	140	171	140	SB02S008	SF05E005
LSJ-23	90.50	N/A	309	TRUE	131.08	140	140	140	192	SB02S008	SF05E005
LSJ-24	89.25	N/A	466	TRUE	131.08	140	140	150	140	SB02S008	SF05E005
LSJ-25	89.75	N/A	464	TRUE	131.08	140	140	154	140	SB02S008	SF05E005
LSJ-26	89.75	N/A	463	TRUE	131.08	140	140	152	140	SB02S008	SF05E005
LSJ-27	90.50	N/A	463	TRUE	131.08	140	140	153	140	SB02S008	SF05E005
LSJ-28	94.25	N/A	114	TRUE	131.09	140	140	140	164	LSJ-29	SF05E005
LSJ-29	94.00	N/A	121	TRUE	131.09	140	140	142	140	LSJ-28	SF05E005
LSJ-30	92.00	N/A	180	TRUE	131.09	140	140	162	140	LSJ-28	SF05E005
LSJ-31	92.75	N/A	434	TRUE	131.09	140	140	185	140	SB02S008	SF05E005
LSJ-32	92.75	N/A	228	TRUE	131.07	140	140	140	214	SB02S008	SF05E005
LSJ-34	91.25	N/A	239	TRUE	131.06	140	140	140	213	SB02S008	SF05E005
LSJ-35	93.50	N/A	244	TRUE	131.09	140	140	140	217	SB02S008	SF05E005
LSJ-36	94.00	N/A	247	TRUE	131.10	140	140	140	217	SB02S008	SF05E005
LSJ-37	91.00	N/A	322	TRUE	131.09	140	140	140	199	SB02S008	SF05E005
LSJ-38	91.50	N/A	473	TRUE	131.10	140	140	140	149	LSJ-50	SF05E005
LSJ-39	91.00	N/A	457	TRUE	131.11	140	140	140	153	WH_07	SF05E005
LSJ-40	91.25	N/A	468	TRUE	131.11	140	140	145	140	WH_07	SF05E005
LSJ-41	92.00	N/A	315	TRUE	131.10	140	140	140	202	SB02S008	SF05E005
LSJ-42	91.50	N/A	379	TRUE	131.10	140	140	140	183	LSJ-41	SF05E005
LSJ-43	91.25	N/A	432	TRUE	131.11	140	140	156	140	WH_07	SF05E005
LSJ-44	91.75	N/A	421	TRUE	131.11	140	140	144	140	WH_07	SF05E005
LSJ-50	95.00	N/A	370	TRUE	131.11	140	140	140	145	WH_07	SF05E005
LSJ-51	94.00	N/A	380	TRUE	131.11	140	140	146	140	LSJ-50	SF05E005
LSJ-53	92.25	N/A	391	TRUE	131.11	140	140	140	162	SB02S008	SF05E005
LSJ-54	88.18	N/A	471	TRUE	131.13	140	140	140	150	SB02S008	SF05E005
LSJ-55	91.86	N/A	489	TRUE	131.09	140	140	145	140	SB02S008	SF05E005
LSJ-57	92.25	N/A	416	TRUE	131.11	140	140	160	140	LSJ-50	SF05E005
SA02T005	95.10	N/A	233	TRUE	131.12	140	140	140	221	HB15T003	SF05E005
SA02T052	91.00	N/A	484	TRUE	131.18	140	140	140	160	WH_07	SF05E005
SB02R011	94.00	N/A	281	TRUE	131.10	140	140	181	140	SB02S010	SF05E005
SB02V053	95.20	N/A	401	TRUE	131.10	140	140	175	140	SB02S008	SF05E005
WH_03	92.00	217	404	TRUE	131.11	140	140	140	143	WH_07	SF05E005
WH_04	92.00	217	394	TRUE	131.11	140	140	140	142	WH_07	SF05E005
WH_05	92.00	217	384	TRUE	131.11	140	140	144	140	WH_07	SF05E005
WH_06	93.00	217	376	TRUE	131.11	140	140	143	140	WH_07	SF05E005
WH_07	95.00	217	364	TRUE	131.11	140	140	140	152	LSJ-50	SF05E005

Note - Required Fire Flows were only provided for the nodes overlapping with the Winona Hills Development. Required Fire Flows were not calculated for the other blocks within the Lower Stoney Creek Development as the block servicing strategy does not provide sufficient information (ie. building footprints, exposure distances, construction material) for calculating Required Fire Flows per the procedure outlined in: "Water Supply for Public Fire Protection" by the Fire Underwriter's Survey, 1999.

Fire Flow Report
(Maximum Day + Fire Flow)
Lower Stoney Creek BSS

2031 MDD + FF - Reservoir 50% Full											
Label	Elevation (m)	Fire Flow (Needed) (L/s)	Fire Flow (Available) (L/s)	Satisfies Fire Flow Constraints?	Hydraulic Grade (m)	Pressure (Residual Lower Limit) (kPa)	Pressure (Zone Lower Limit) (kPa)	Pressure (Calculated Residual) (kPa)	Pressure (Calculated Zone Lower Limit) (kPa)	Junction w/ Minimum Pressure (Zone)	Junction w/ Minimum Pressure (System)
J-182	94.25	N/A	327	TRUE	126.06	140	140	145	140	SB02S008	HB15T012
J-184	91.25	N/A	325	TRUE	126.07	140	140	194	140	SB02S008	HB15T012
LSJ-1	91.00	N/A	283	TRUE	126.06	140	140	217	140	SB02S008	HB15T012
LSJ-2	91.75	N/A	284	TRUE	126.06	140	140	235	140	SB02S008	HB15T012
LSJ-3	91.50	N/A	287	TRUE	126.06	140	140	227	140	SB02S008	HB15T012
LSJ-4	91.50	N/A	289	TRUE	126.06	140	140	228	140	SB02S008	HB15T012
LSJ-5	90.25	N/A	292	TRUE	126.06	140	140	232	140	SB02S008	HB15T012
LSJ-6	91.75	N/A	298	TRUE	126.06	140	140	216	140	SB02S008	HB15T012
LSJ-7	92.25	N/A	314	TRUE	126.06	140	140	203	140	SB02S008	HB15T012
LSJ-8	92.50	N/A	319	TRUE	126.06	140	140	197	140	SB02S008	HB15T012
LSJ-9	92.75	N/A	322	TRUE	126.06	140	140	188	140	SB02S008	HB15T012
LSJ-10	93.00	N/A	325	TRUE	126.06	140	140	187	140	SB02S008	HB15T012
LSJ-11	92.00	N/A	327	TRUE	126.07	140	140	194	140	SB02S008	HB15T012
LSJ-12	91.75	N/A	329	TRUE	126.07	140	140	192	140	SB02S008	HB15T012
LSJ-13	91.25	N/A	331	TRUE	126.08	140	140	203	140	SB02S008	HB15T012
LSJ-14	90.75	N/A	259	TRUE	126.04	140	140	144	140	LSJ-15	HB15T012
LSJ-15	91.50	N/A	192	TRUE	126.02	140	140	140	168	SB02S008	HB15T012
LSJ-16	90.50	N/A	190	TRUE	126.01	140	140	140	169	SB02S008	HB15T012
LSJ-17	90.75	N/A	228	TRUE	126.03	140	140	140	153	LSJ-16	HB15T012
LSJ-18	89.75	N/A	270	TRUE	126.04	140	140	140	146	SB02S008	HB15T012
LSJ-19	91.00	N/A	200	TRUE	126.04	140	140	140	166	SB02S008	HB15T012
LSJ-20	89.75	N/A	295	TRUE	126.07	140	140	240	140	SB02S008	HB15T012
LSJ-21	90.50	N/A	291	TRUE	126.06	140	140	232	140	SB02S008	HB15T012
LSJ-22	90.75	N/A	288	TRUE	126.06	140	140	231	140	SB02S008	HB15T012
LSJ-23	90.50	N/A	267	TRUE	126.06	140	140	140	147	SB02S008	HB15T012
LSJ-24	89.25	N/A	292	TRUE	126.06	140	140	230	140	SB02S008	HB15T012
LSJ-25	89.75	N/A	291	TRUE	126.06	140	140	230	140	SB02S008	HB15T012
LSJ-26	89.75	N/A	290	TRUE	126.06	140	140	229	140	SB02S008	HB15T012
LSJ-27	90.50	N/A	289	TRUE	126.06	140	140	225	140	SB02S008	HB15T012
LSJ-28	94.25	N/A	98	TRUE	126.06	140	140	140	159	LSJ-29	HB15T012
LSJ-29	94.00	N/A	104	TRUE	126.06	140	140	142	140	LSJ-28	HB15T012
LSJ-30	92.00	N/A	153	TRUE	126.06	140	140	162	140	LSJ-28	HB15T012
LSJ-31	92.75	N/A	274	TRUE	126.06	140	140	225	140	SB02S008	HB15T012
LSJ-32	92.75	N/A	195	TRUE	126.04	140	140	140	167	SB02S008	HB15T012
LSJ-34	91.25	N/A	206	TRUE	126.03	140	140	140	165	SB02S008	HB15T012
LSJ-35	93.50	N/A	207	TRUE	126.06	140	140	140	169	SB02S008	HB15T012
LSJ-36	94.00	N/A	209	TRUE	126.06	140	140	140	169	SB02S008	HB15T012
LSJ-37	91.00	N/A	275	TRUE	126.05	140	140	140	152	SB02S008	HB15T012
LSJ-38	91.50	N/A	322	TRUE	126.06	140	140	195	140	SB02S008	HB15T012
LSJ-39	91.00	N/A	326	TRUE	126.07	140	140	188	140	SB02S008	HB15T012
LSJ-40	91.25	N/A	329	TRUE	126.08	140	140	193	140	SB02S008	HB15T012
LSJ-41	92.00	N/A	269	TRUE	126.07	140	140	140	156	SB02S008	HB15T012
LSJ-42	91.50	N/A	322	TRUE	126.07	140	140	140	142	SB02S008	HB15T012
LSJ-43	91.25	N/A	330	TRUE	126.08	140	140	181	140	SB02S008	HB15T012
LSJ-44	91.75	N/A	330	TRUE	126.07	140	140	165	140	SB02S008	HB15T012
LSJ-50	95.00	N/A	304	TRUE	126.07	140	140	140	144	WH_07	HB15T012
LSJ-51	94.00	N/A	312	TRUE	126.07	140	140	147	140	LSJ-50	HB15T012
LSJ-53	92.25	N/A	282	TRUE	126.10	140	140	183	140	SB02S008	HB15T012
LSJ-54	88.18	N/A	311	TRUE	126.14	140	140	223	140	SB02S008	HB15T012
LSJ-55	91.86	N/A	305	TRUE	126.06	140	140	214	140	SB02S008	HB15T012
LSJ-57	92.25	N/A	329	TRUE	126.07	140	140	171	140	SB02S008	HB15T012
SA02T005	95.10	N/A	191	TRUE	126.06	140	140	140	180	SB02S008	HB15T012
SA02T052	91.00	N/A	353	TRUE	126.16	140	140	184	140	SB02S008	HB15T012
SB02R011	94.00	N/A	218	TRUE	126.05	140	140	183	140	SB02S010	HB15T012
SB02V053	95.20	N/A	256	TRUE	126.07	140	140	207	140	SB02S008	HB15T012
WH_03	92.00	217	330	TRUE	126.07	140	140	150	140	SB02S008	HB15T012
WH_04	92.00	217	325	TRUE	126.07	140	140	147	140	WH_07	HB15T012
WH_05	92.00	217	315	TRUE	126.07	140	140	152	140	WH_07	HB15T012
WH_06	93.00	217	309	TRUE	126.07	140	140	148	140	WH_07	HB15T012
WH_07	95.00	217	299	TRUE	126.07	140	140	140	148	SB02S008	HB15T012

Note - Required Fire Flows were only provided for the nodes overlapping with the Winona Hills Development. Required Fire Flows were not calculated for the other blocks within the Lower Stoney Creek Development as the block servicing strategy does not provide sufficient information (ie. building footprints, exposure distances, construction material) for calculating Required Fire Flows per the procedure outlined in: "Water Supply for Public Fire Protection" by the Fire Underwriter's Survey, 1999.

Fire Flow Report
(Maximum Day + Fire Flow)
Lower Stoney Creek BSS

2031 MDD + FF - Reservoir 75% Full											
Label	Elevation (m)	Fire Flow (Needed) (L/s)	Fire Flow (Available) (L/s)	Satisfies Fire Flow Constraints?	Hydraulic Grade (m)	Pressure (Residual Lower Limit) (kPa)	Pressure (Zone Lower Limit) (kPa)	Pressure (Calculated Residual) (kPa)	Pressure (Calculated Zone Lower Limit) (kPa)	Junction w/ Minimum Pressure (Zone)	Junction w/ Minimum Pressure (System)
J-182	94.25	N/A	362	TRUE	128.58	140	140	140	154	SB02S008	HB15T012
J-184	91.25	N/A	406	TRUE	128.59	140	140	156	140	SB02S008	HB15T012
LSJ-1	91.00	N/A	353	TRUE	128.58	140	140	190	140	SB02S008	HB15T012
LSJ-2	91.75	N/A	353	TRUE	128.58	140	140	221	140	SB02S008	HB15T012
LSJ-3	91.50	N/A	358	TRUE	128.58	140	140	207	140	SB02S008	HB15T012
LSJ-4	91.50	N/A	360	TRUE	128.58	140	140	208	140	SB02S008	HB15T012
LSJ-5	90.25	N/A	364	TRUE	128.58	140	140	208	140	SB02S008	HB15T012
LSJ-6	91.75	N/A	371	TRUE	128.58	140	140	191	140	SB02S008	HB15T012
LSJ-7	92.25	N/A	393	TRUE	128.58	140	140	175	140	SB02S008	HB15T012
LSJ-8	92.50	N/A	399	TRUE	128.58	140	140	166	140	SB02S008	HB15T012
LSJ-9	92.75	N/A	403	TRUE	128.58	140	140	154	140	SB02S008	HB15T012
LSJ-10	93.00	N/A	406	TRUE	128.58	140	140	154	140	SB02S008	HB15T012
LSJ-11	92.00	N/A	404	TRUE	128.59	140	140	164	140	LSJ-50	HB15T012
LSJ-12	91.75	N/A	409	TRUE	128.60	140	140	156	140	LSJ-50	HB15T012
LSJ-13	91.25	N/A	411	TRUE	128.60	140	140	172	140	WH_07	HB15T012
LSJ-14	90.75	N/A	278	TRUE	128.56	140	140	143	140	LSJ-15	HB15T012
LSJ-15	91.50	N/A	206	TRUE	128.54	140	140	140	189	SB02S008	HB15T012
LSJ-16	90.50	N/A	203	TRUE	128.53	140	140	140	190	SB02S008	HB15T012
LSJ-17	90.75	N/A	244	TRUE	128.55	140	140	140	155	LSJ-16	HB15T012
LSJ-18	89.75	N/A	288	TRUE	128.56	140	140	140	156	LSJ-17	HB15T012
LSJ-19	91.00	N/A	214	TRUE	128.56	140	140	140	187	SB02S008	HB15T012
LSJ-20	89.75	N/A	367	TRUE	128.59	140	140	218	140	SB02S008	HB15T012
LSJ-21	90.50	N/A	363	TRUE	128.59	140	140	209	140	SB02S008	HB15T012
LSJ-22	90.75	N/A	359	TRUE	128.58	140	140	209	140	SB02S008	HB15T012
LSJ-23	90.50	N/A	285	TRUE	128.58	140	140	140	165	SB02S008	HB15T012
LSJ-24	89.25	N/A	364	TRUE	128.58	140	140	201	140	SB02S008	HB15T012
LSJ-25	89.75	N/A	362	TRUE	128.58	140	140	202	140	SB02S008	HB15T012
LSJ-26	89.75	N/A	361	TRUE	128.58	140	140	201	140	SB02S008	HB15T012
LSJ-27	90.50	N/A	361	TRUE	128.58	140	140	199	140	SB02S008	HB15T012
LSJ-28	94.25	N/A	105	TRUE	128.58	140	140	140	162	LSJ-29	HB15T012
LSJ-29	94.00	N/A	112	TRUE	128.58	140	140	142	140	LSJ-28	HB15T012
LSJ-30	92.00	N/A	166	TRUE	128.58	140	140	162	140	LSJ-28	HB15T012
LSJ-31	92.75	N/A	341	TRUE	128.58	140	140	210	140	SB02S008	HB15T012
LSJ-32	92.75	N/A	210	TRUE	128.56	140	140	140	187	SB02S008	HB15T012
LSJ-34	91.25	N/A	221	TRUE	128.55	140	140	140	185	SB02S008	HB15T012
LSJ-35	93.50	N/A	223	TRUE	128.58	140	140	140	190	SB02S008	HB15T012
LSJ-36	94.00	N/A	225	TRUE	128.58	140	140	140	189	SB02S008	HB15T012
LSJ-37	91.00	N/A	295	TRUE	128.58	140	140	140	171	SB02S008	HB15T012
LSJ-38	91.50	N/A	403	TRUE	128.59	140	140	159	140	SB02S008	HB15T012
LSJ-39	91.00	N/A	408	TRUE	128.59	140	140	145	140	SB02S008	HB15T012
LSJ-40	91.25	N/A	412	TRUE	128.60	140	140	153	140	SB02S008	HB15T012
LSJ-41	92.00	N/A	288	TRUE	128.59	140	140	140	175	SB02S008	HB15T012
LSJ-42	91.50	N/A	345	TRUE	128.59	140	140	140	159	SB02S008	HB15T012
LSJ-43	91.25	N/A	384	TRUE	128.60	140	140	160	140	WH_07	HB15T012
LSJ-44	91.75	N/A	375	TRUE	128.60	140	140	149	140	WH_07	HB15T012
LSJ-50	95.00	N/A	331	TRUE	128.59	140	140	140	144	WH_07	HB15T012
LSJ-51	94.00	N/A	340	TRUE	128.59	140	140	147	140	LSJ-50	HB15T012
LSJ-53	92.25	N/A	351	TRUE	128.62	140	140	145	140	SB02S008	HB15T012
LSJ-54	88.18	N/A	388	TRUE	128.66	140	140	183	140	SB02S008	HB15T012
LSJ-55	91.86	N/A	380	TRUE	128.58	140	140	189	140	SB02S008	HB15T012
LSJ-57	92.25	N/A	370	TRUE	128.59	140	140	161	140	LSJ-50	HB15T012
SA02T005	95.10	N/A	208	TRUE	128.58	140	140	140	201	SB02S008	HB15T012
SA02T052	91.00	N/A	439	TRUE	128.68	140	140	140	141	SB02S008	HB15T012
SB02R011	94.00	N/A	243	TRUE	128.57	140	140	182	140	SB02S010	HB15T012
SB02V053	95.20	N/A	317	TRUE	128.59	140	140	195	140	SB02S008	HB15T012
WH_03	92.00	217	363	TRUE	128.60	140	140	143	140	WH_07	HB15T012
WH_04	92.00	217	354	TRUE	128.60	140	140	143	140	WH_07	HB15T012
WH_05	92.00	217	344	TRUE	128.59	140	140	149	140	WH_07	HB15T012
WH_06	93.00	217	336	TRUE	128.59	140	140	146	140	WH_07	HB15T012
WH_07	95.00	217	326	TRUE	128.59	140	140	140	150	LSJ-50	HB15T012

Note - Required Fire Flows were only provided for the nodes overlapping with the Winona Hills Development. Required Fire Flows were not calculated for the other blocks within the Lower Stoney Creek Development as the block servicing strategy does not provide sufficient information (ie. building footprints, exposure distances, construction material) for calculating Required Fire Flows per the procedure outlined in: "Water Supply for Public Fire Protection" by the Fire Underwriter's Survey, 1999.

Fire Flow Report
(Maximum Day + Fire Flow)
Lower Stoney Creek BSS

2031 MDD + FF - Reservoir 90% Full											
Label	Elevation (m)	Fire Flow (Needed) (L/s)	Fire Flow (Available) (L/s)	Satisfies Fire Flow Constraints?	Hydraulic Grade (m)	Pressure (Residual Lower Limit) (kPa)	Pressure (Zone Lower Limit) (kPa)	Pressure (Calculated Residual) (kPa)	Pressure (Calculated Zone Lower Limit) (kPa)	Junction w/ Minimum Pressure (Zone)	Junction w/ Minimum Pressure (System)
J-182	94.25	N/A	378	TRUE	130.06	140	140	140	164	SB02S008	HB15T012
J-184	91.25	N/A	441	TRUE	130.07	140	140	140	142	WH_07	HB15T012
LSJ-1	91.00	N/A	390	TRUE	130.06	140	140	173	140	SB02S008	HB15T012
LSJ-2	91.75	N/A	391	TRUE	130.06	140	140	212	140	SB02S008	HB15T012
LSJ-3	91.50	N/A	396	TRUE	130.06	140	140	195	140	SB02S008	HB15T012
LSJ-4	91.50	N/A	398	TRUE	130.06	140	140	196	140	SB02S008	HB15T012
LSJ-5	90.25	N/A	403	TRUE	130.06	140	140	194	140	SB02S008	HB15T012
LSJ-6	91.75	N/A	411	TRUE	130.06	140	140	177	140	SB02S008	HB15T012
LSJ-7	92.25	N/A	435	TRUE	130.06	140	140	157	140	SB02S008	HB15T012
LSJ-8	92.50	N/A	442	TRUE	130.06	140	140	147	140	SB02S008	HB15T012
LSJ-9	92.75	N/A	433	TRUE	130.06	140	140	144	140	LSJ-36	HB15T012
LSJ-10	93.00	N/A	443	TRUE	130.06	140	140	140	140	LSJ-50	HB15T012
LSJ-11	92.00	N/A	423	TRUE	130.07	140	140	163	140	LSJ-50	HB15T012
LSJ-12	91.75	N/A	428	TRUE	130.07	140	140	155	140	LSJ-50	HB15T012
LSJ-13	91.25	N/A	430	TRUE	130.08	140	140	171	140	WH_07	HB15T012
LSJ-14	90.75	N/A	288	TRUE	130.04	140	140	143	140	LSJ-15	HB15T012
LSJ-15	91.50	N/A	214	TRUE	130.02	140	140	140	201	SB02S008	HB15T012
LSJ-16	90.50	N/A	211	TRUE	130.01	140	140	140	202	SB02S008	HB15T012
LSJ-17	90.75	N/A	253	TRUE	130.03	140	140	140	156	LSJ-16	HB15T012
LSJ-18	89.75	N/A	298	TRUE	130.04	140	140	140	157	LSJ-17	HB15T012
LSJ-19	91.00	N/A	222	TRUE	130.04	140	140	140	199	SB02S008	HB15T012
LSJ-20	89.75	N/A	406	TRUE	130.07	140	140	204	140	SB02S008	HB15T012
LSJ-21	90.50	N/A	401	TRUE	130.06	140	140	195	140	SB02S008	HB15T012
LSJ-22	90.75	N/A	397	TRUE	130.06	140	140	196	140	SB02S008	HB15T012
LSJ-23	90.50	N/A	295	TRUE	130.06	140	140	140	176	SB02S008	HB15T012
LSJ-24	89.25	N/A	402	TRUE	130.06	140	140	183	140	SB02S008	HB15T012
LSJ-25	89.75	N/A	400	TRUE	130.06	140	140	186	140	SB02S008	HB15T012
LSJ-26	89.75	N/A	400	TRUE	130.06	140	140	184	140	SB02S008	HB15T012
LSJ-27	90.50	N/A	399	TRUE	130.06	140	140	183	140	SB02S008	HB15T012
LSJ-28	94.25	N/A	110	TRUE	130.06	140	140	140	163	LSJ-29	HB15T012
LSJ-29	94.00	N/A	116	TRUE	130.06	140	140	142	140	LSJ-28	HB15T012
LSJ-30	92.00	N/A	173	TRUE	130.06	140	140	162	140	LSJ-28	HB15T012
LSJ-31	92.75	N/A	376	TRUE	130.06	140	140	201	140	SB02S008	HB15T012
LSJ-32	92.75	N/A	218	TRUE	130.04	140	140	140	199	SB02S008	HB15T012
LSJ-34	91.25	N/A	229	TRUE	130.03	140	140	140	197	SB02S008	HB15T012
LSJ-35	93.50	N/A	232	TRUE	130.06	140	140	140	202	SB02S008	HB15T012
LSJ-36	94.00	N/A	235	TRUE	130.06	140	140	140	201	SB02S008	HB15T012
LSJ-37	91.00	N/A	306	TRUE	130.05	140	140	140	183	SB02S008	HB15T012
LSJ-38	91.50	N/A	443	TRUE	130.06	140	140	140	141	SB02S008	HB15T012
LSJ-39	91.00	N/A	429	TRUE	130.07	140	140	140	147	WH_07	HB15T012
LSJ-40	91.25	N/A	433	TRUE	130.08	140	140	149	140	WH_07	HB15T012
LSJ-41	92.00	N/A	299	TRUE	130.07	140	140	140	187	SB02S008	HB15T012
LSJ-42	91.50	N/A	359	TRUE	130.07	140	140	140	170	SB02S008	HB15T012
LSJ-43	91.25	N/A	402	TRUE	130.08	140	140	159	140	WH_07	HB15T012
LSJ-44	91.75	N/A	392	TRUE	130.08	140	140	148	140	WH_07	HB15T012
LSJ-50	95.00	N/A	346	TRUE	130.07	140	140	140	145	WH_07	HB15T012
LSJ-51	94.00	N/A	356	TRUE	130.07	140	140	146	140	LSJ-50	HB15T012
LSJ-53	92.25	N/A	370	TRUE	130.10	140	140	140	147	SB02S008	HB15T012
LSJ-54	88.18	N/A	430	TRUE	130.14	140	140	158	140	SB02S008	HB15T012
LSJ-55	91.86	N/A	421	TRUE	130.06	140	140	173	140	SB02S008	HB15T012
LSJ-57	92.25	N/A	387	TRUE	130.07	140	140	160	140	LSJ-50	HB15T012
SA02T005	95.10	N/A	217	TRUE	130.06	140	140	140	214	SB02S008	HB15T012
SA02T052	91.00	N/A	455	TRUE	130.16	140	140	140	151	SB02S008	HB15T012
SB02R011	94.00	N/A	257	TRUE	130.05	140	140	182	140	SB02S010	HB15T012
SB02V053	95.20	N/A	350	TRUE	130.07	140	140	187	140	SB02S008	HB15T012
WH_03	92.00	217	380	TRUE	130.07	140	140	141	140	WH_07	HB15T012
WH_04	92.00	217	370	TRUE	130.07	140	140	141	140	WH_07	HB15T012
WH_05	92.00	217	360	TRUE	130.07	140	140	147	140	WH_07	HB15T012
WH_06	93.00	217	352	TRUE	130.07	140	140	145	140	WH_07	HB15T012
WH_07	95.00	217	341	TRUE	130.07	140	140	140	151	LSJ-50	HB15T012

Note - Required Fire Flows were only provided for the nodes overlapping with the Winona Hills Development. Required Fire Flows were not calculated for the other blocks within the Lower Stoney Creek Development as the block servicing strategy does not provide sufficient information (ie. building footprints, exposure distances, construction material) for calculating Required Fire Flows per the procedure outlined in: "Water Supply for Public Fire Protection" by the Fire Underwriter's Survey, 1999.

APPENDIX

D

FLUSHING REPORT

Flushing Report
(2011 Average Day)
Lower Stoney Creek BSS

Label	Length (m)	Diameter (mm)	Flushing Event	Velocity (Maximum Flushing) (m/s)	Satisfies Flushing Target Velocity?	Flow (Absolute) (L/s)
LSP-1	172.80	300	Event [LSJ-53]	1.11	TRUE	6.62
LSP-2	192.90	300	Event [LSJ-53]	0.96	TRUE	2.95
LSP-3	106.10	300	Event [LSJ-3]	0.86	TRUE	0.49
LSP-4	91.10	300	Event [LSJ-3]	0.80	TRUE	0.32
LSP-5	83.20	300	Event [LSJ-5]	1.03	TRUE	0.85
LSP-6	128.90	300	Event [LSJ-5]	0.85	TRUE	0.85
LSP-7	88.40	300	Event [LSJ-6]	0.93	TRUE	4.27
LSP-8	88.40	300	Event [LSJ-8]	0.81	TRUE	2.00
LSP-9	78.90	300	Event [LSJ-8]	1.00	TRUE	2.28
LSP-10	82.00	300	Event [LSJ-9]	0.84	TRUE	1.51
LSP-11	78.90	300	Event [LSJ-9]	0.84	TRUE	2.53
LSP-12	84.70	300	Event [J-182]	1.09	TRUE	2.23
LSP-13	75.00	300	Event [LSJ-12]	0.88	TRUE	3.79
LSP-14	71.00	300	Event [LSJ-12]	0.86	TRUE	4.30
LSP-15	140.50	300	Event [SA02T052]	0.94	TRUE	11.36
LSP-16	82.00	200	Event [LSJ-17]	2.06	TRUE	2.75
LSP-17	79.20	200	Event [LSJ-17]	0.93	TRUE	2.12
LSP-18	176.80	200	Event [LSJ-17]	0.91	TRUE	1.53
LSP-19	78.90	200	Event [LSJ-16]	1.38	TRUE	2.92
LSP-20	77.40	200	Event [LSJ-17]	1.97	TRUE	2.07
LSP-21	193.90	200	Event [LSJ-19]	0.88	TRUE	0.88
LSP-22	100.30	200	Event [LSJ-19]	1.22	TRUE	0.22
LSP-23	185.90	200	Event [LSJ-17]	1.22	TRUE	0.85
LSP-24	87.80	200	Event [LSJ-17]	2.07	TRUE	2.95
LSP-25	129.20	300	Event [LSJ-22]	0.87	TRUE	0.28
LSP-26	82.90	300	Event [LSJ-22]	0.81	TRUE	2.00
LSP-27	77.70	300	Event [LSJ-21]	0.87	TRUE	3.06
LSP-28	151.80	300	Event [LSJ-54]	1.17	TRUE	9.17
LSP-29	137.80	300	Event [LSJ-24]	1.01	TRUE	3.15
LSP-30	86.00	300	Event [LSJ-24]	0.93	TRUE	0.81
LSP-31	136.20	200	Event [LSJ-26]	1.17	TRUE	0.37
LSP-32	53.30	300	Event [LSJ-26]	0.94	TRUE	0.19
LSP-33	71.90	300	Event [LSJ-26]	0.94	TRUE	0.19
LSP-34	89.60	300	Event [LSJ-26]	0.96	TRUE	1.17
LSP-35	96.90	200	Event [LSJ-23]	1.14	TRUE	0.29
LSP-36	124.70	200	Event [LSJ-23]	1.00	TRUE	0.18
LSP-37	79.90	300	Event [LSJ-31]	0.96	TRUE	3.17
LSP-38	28.00	200	Event [LSJ-28]	1.86	TRUE	0.00
LSP-39	127.40	200	Event [LSJ-28]	1.86	TRUE	0.00
LSP-40	93.60	200	Event [LSJ-28]	1.86	TRUE	0.00
LSP-41	161.80	300	Event [SB02V053]	0.81	TRUE	5.20
LSP-42	142.30	200	Event [LSJ-34]	1.45	TRUE	2.04
LSP-43	231.30	200	Event [LSJ-34]	1.45	TRUE	1.06
LSP-45	126.80	200	Event [LSJ-34]	2.54	TRUE	2.55
LSP-46	120.10	200	Event [LSJ-35]	1.24	TRUE	0.00
LSP-47	157.30	200	Event [LSJ-35]	0.81	TRUE	0.58
LSP-48	104.20	200	Event [LSJ-36]	1.27	TRUE	0.58
LSP-49	102.40	200	Event [LSJ-37]	1.03	TRUE	1.07
LSP-50	76.50	200	Event [LSJ-37]	1.18	TRUE	1.85
LSP-51	106.40	300	Event [LSJ-38]	0.87	TRUE	2.02
LSP-52(1)	55.80	300	Event [J-184]	0.91	TRUE	4.14
LSP-52(2)	81.10	300	Event [LSJ-39]	0.97	TRUE	3.26
LSP-53	124.10	300	Event [LSJ-39]	0.88	TRUE	3.26
LSP-54	43.90	300	Event [LSJ-39]	0.88	TRUE	3.26
LSP-55	78.30	200	Event [LSJ-42]	1.06	TRUE	0.05
LSP-56	80.20	200	Event [LSJ-42]	1.06	TRUE	0.05
LSP-57	82.90	200	Event [LSJ-42]	1.49	TRUE	0.94
LSP-58	84.40	300	Event [WH_03]	1.04	TRUE	3.21
LSP-59	37.80	300	Event [WH_03]	1.19	TRUE	1.60
LSP-61	59.40	300	Event [WH_03]	1.19	TRUE	1.60
LSP-62	53.00	300	Event [WH_05]	0.96	TRUE	1.50
LSP-63	68.00	300	Event [WH_05]	0.96	TRUE	1.38
LSP-64	50.90	300	Event [WH_05]	0.85	TRUE	1.22
LSP-65	66.40	300	Event [WH_05]	0.85	TRUE	1.11
LSP-66	41.10	300	Event [WH_05]	0.85	TRUE	1.01
LSP-68	33.50	300	Event [WH_05]	0.85	TRUE	1.01
LSP-69	85.30	300	Event [LSJ-57]	1.16	TRUE	1.47
P-239	86.00	300	Event [WH_05]	0.85	TRUE	1.01
P-240	126.20	200	Event [LSJ-57]	1.57	TRUE	0.28
P-253	142.30	300	Event [J-182]	1.13	TRUE	1.95
P-254	79.20	200	Event [LSJ-42]	1.54	TRUE	0.89
P-253	142.30	300	Event [J-182]	1.20	TRUE	1.16
P-254	79.20	200	Event [LSJ-42]	1.63	TRUE	0.81

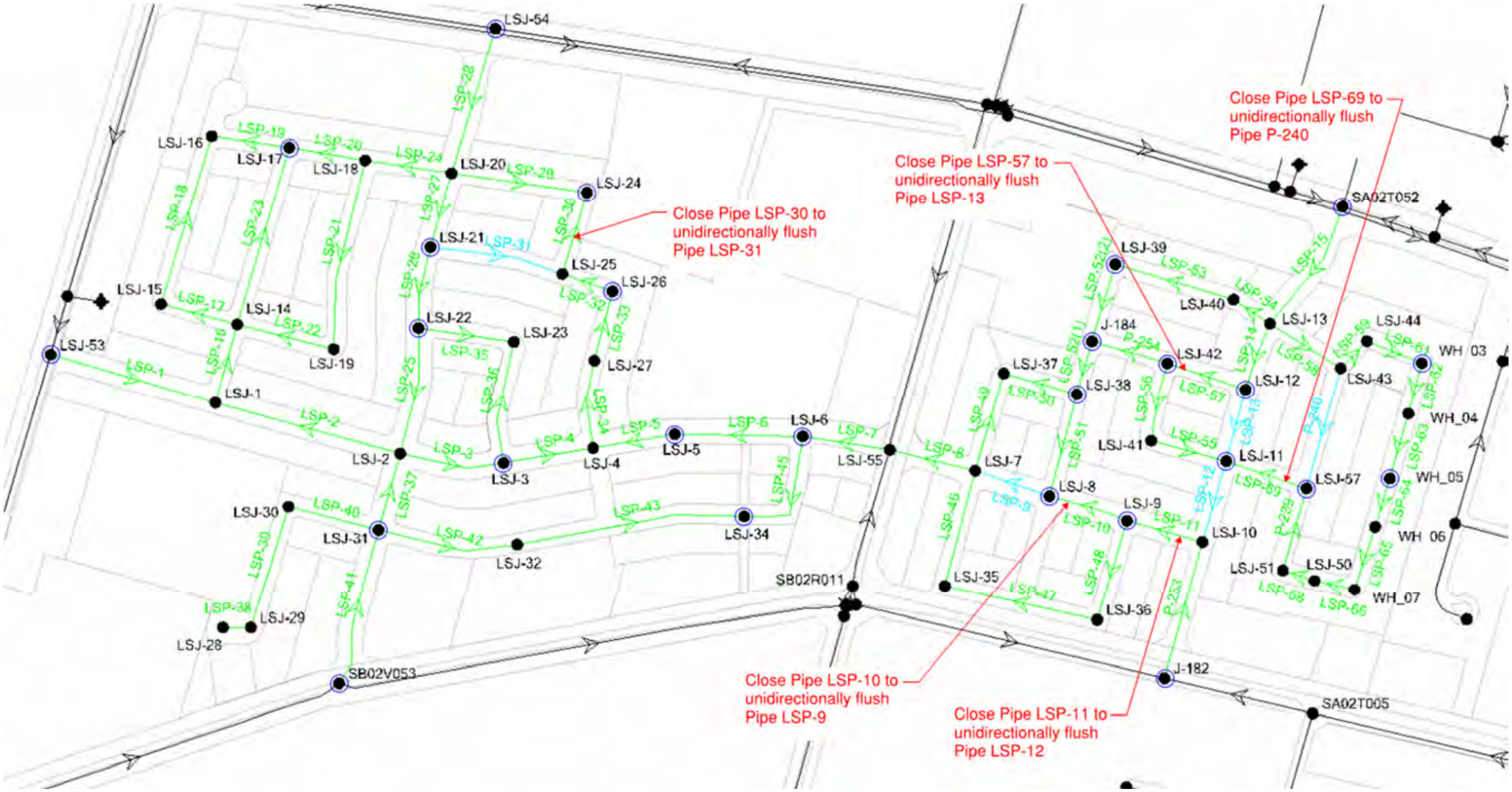


Figure D1 - Simulated Flushing Results for the Proposed Lower Stoney Creek Development during the 2011 Average Day Scenario. All Hydrants Circled in Blue Require Two Port Flushing, as Described in Section 4.4 of the Report. Watermains Highlighted in Blue Require Unidirectional Flushing.

APPENDIX

E

HYDRANT FLOW DATA

Table E1 – Hydrant Flow Test vs. Modeled Hydrant Curve: Hydrant SB02H036 @ 244 McNeilly Road

Source	Static Pressure (kPa)	Residual Pressure (kPa)	Test Flow (L/s)	Theoretical Flow Available at 20 psi Residual (L/s)
Hydrant Test	400	352	64	159
Model Curve	382	332	63	147

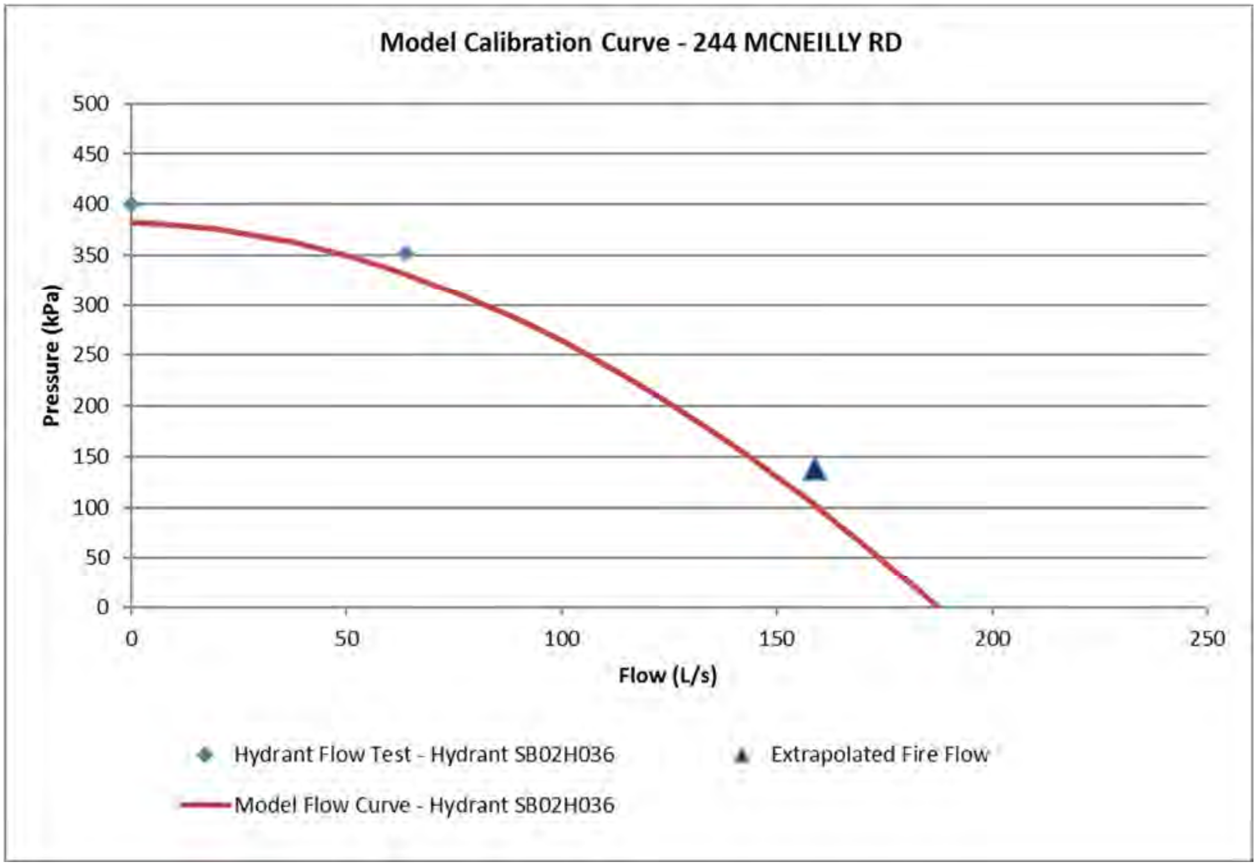


Figure E1 - Model Calibration Curve Verification (Hydrant Flow Test vs. Modeled Hydrant Curve)

Table E2 – Hydrant Flow Test vs. Modeled Hydrant Curve: Hydrant SB02H037 @ 257 McNeilly Road

Source	Static Pressure (kPa)	Residual Pressure (kPa)	Test Flow (L/s)	Theoretical Flow Available at 20 psi Residual (L/s)
Hydrant Test	414	372	65	181
Model Curve	396	345	63	152

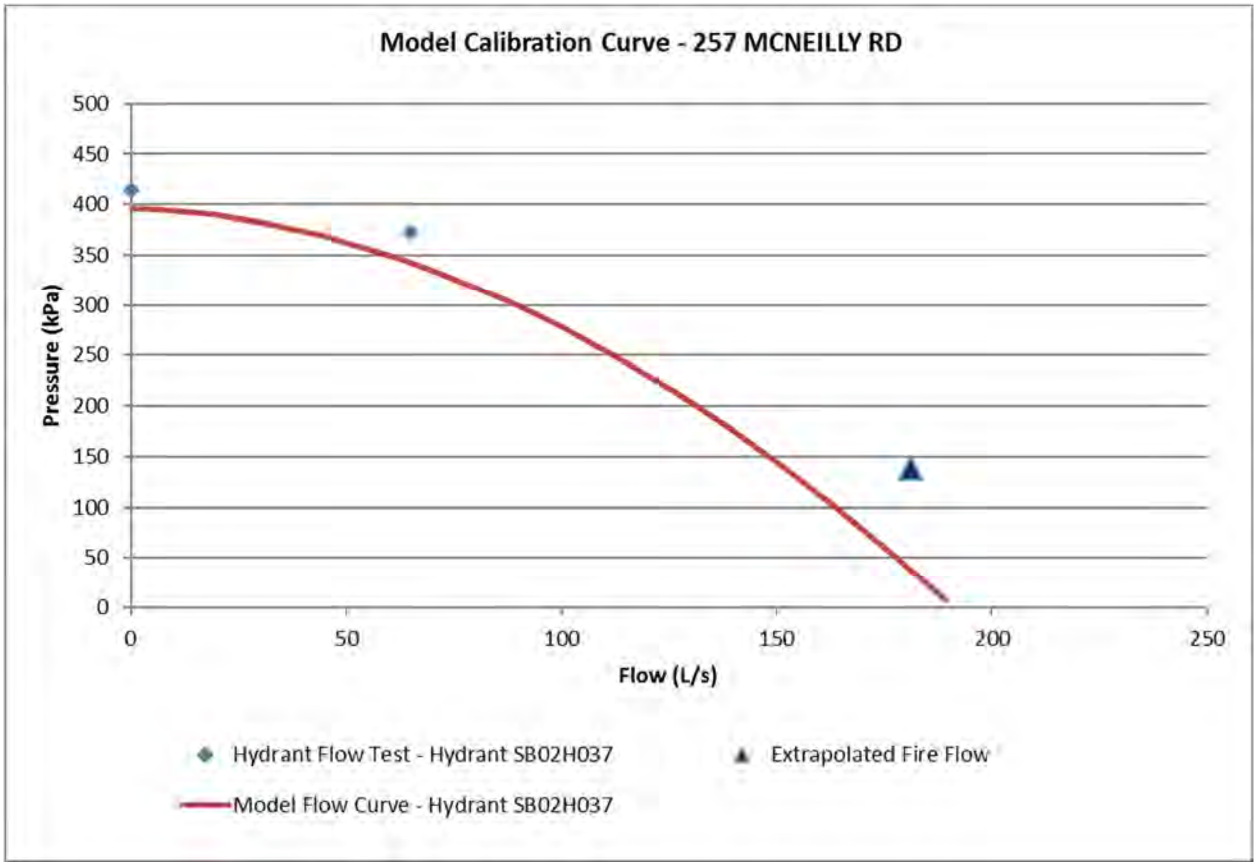


Figure E2 - Model Calibration Curve Verification (Hydrant Flow Test vs. Modeled Hydrant Curve)

Table E3 – Hydrant Flow Test vs. Modeled Hydrant Curve: Hydrant SA02H015 @ 1217 Barton Street

Source	Static Pressure (kPa)	Residual Pressure (kPa)	Test Flow (L/s)	Theoretical Flow Available at 20 psi Residual (L/s)
Hydrant Test	386	359	56	182
Model Curve	375	342	56	164

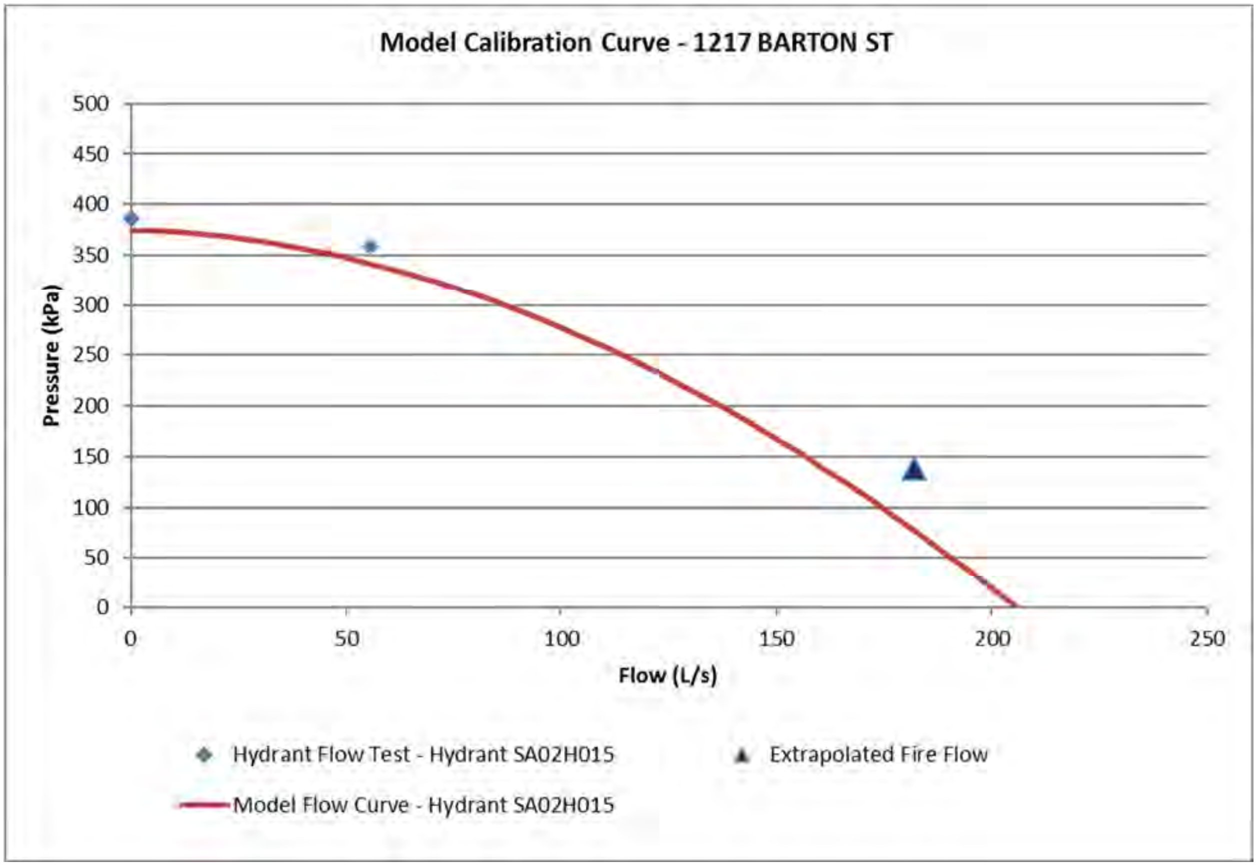


Figure E3 - Model Calibration Curve Verification (Hydrant Flow Test vs. Modeled Hydrant Curve)

Table E4 – Hydrant Flow Test vs. Modeled Hydrant Curve: Hydrant SA02H016 @ Barton Street

Source	Static Pressure (kPa)	Residual Pressure (kPa)	Test Flow (L/s)	Theoretical Flow Available at 20 psi Residual (L/s)
Hydrant Test	386	352	56	161
Model Curve	383	347	56	157

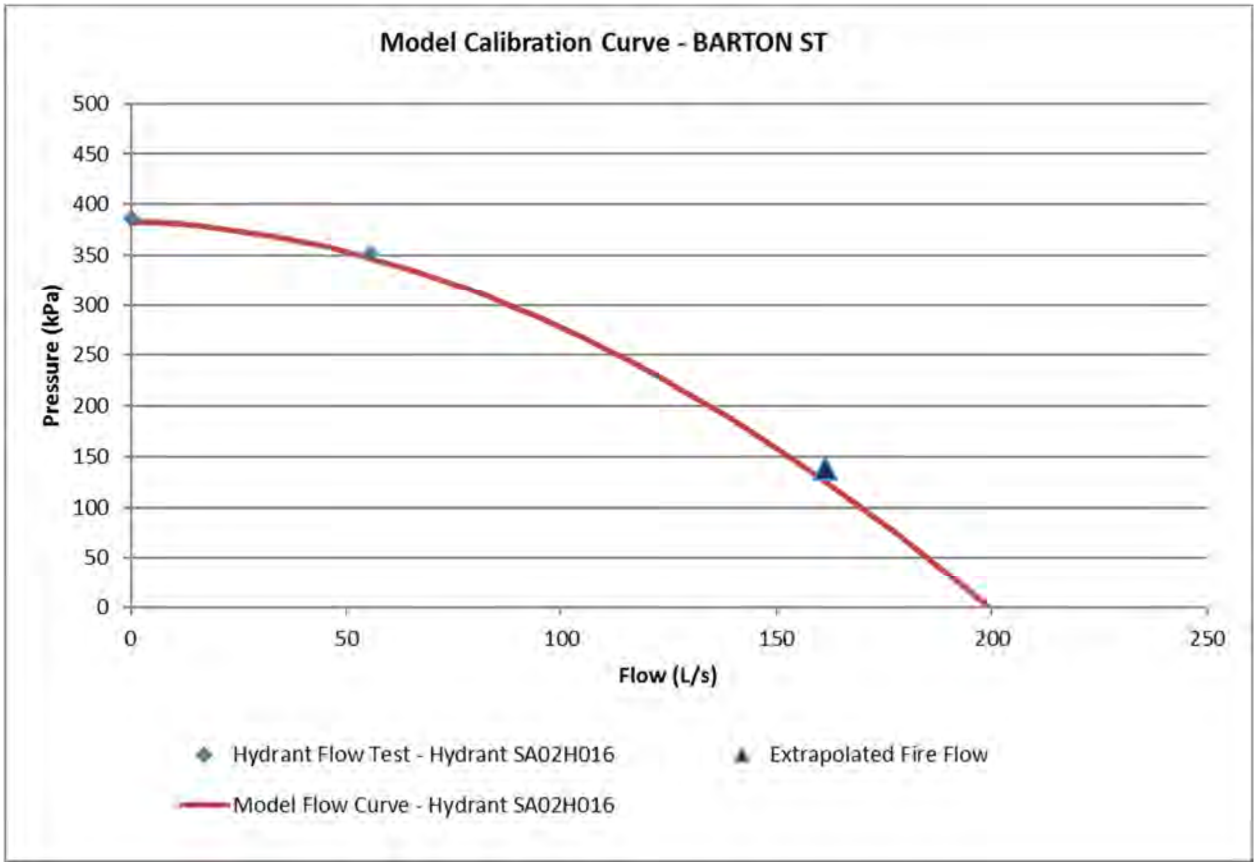


Figure E4 - Model Calibration Curve Verification (Hydrant Flow Test vs. Modeled Hydrant Curve)

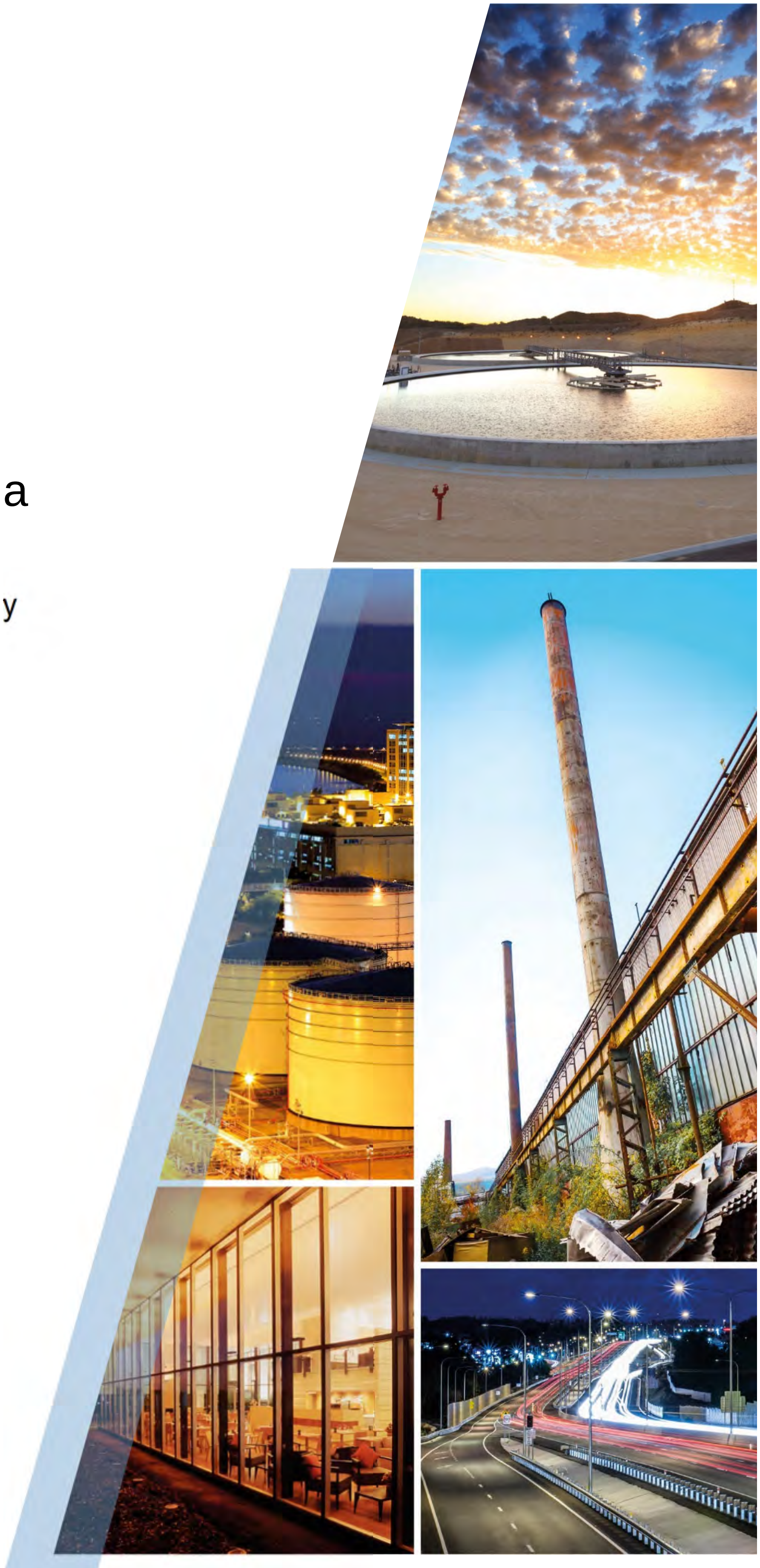
APPENDIX K
TRAFFIC IMPACT STUDY

K-1 Revised Traffic Impact Study (GHD, December 2019)

Fruitland-Winona Secondary Plan

Revised Traffic Impact Study

December 2019



Branthaven Homes

Executive Summary

GHD Limited (GHD) was retained by the Block 3 Landowners Group to prepare a Traffic Impact Study (TIS) for the proposed Fruitland-Winona Secondary Plan, Block 3 Servicing Strategy Area, residential subdivision development located on the north side of Highway 8 and south side of Barton Street, between McNeilly road and Winona Road, in Stoney Creek, City of Hamilton. This report determines the site related traffic and the subsequent traffic-related impacts on the adjacent road network during the weekday AM and PM peak hours from the proposed development. These impacts are based on projected future background traffic and road network conditions derived for 2019 and 2024 planning horizon years.

Proposed Site Characteristics

The proposed Fruitland-Winona Secondary Plan (prepared by Glen Schnarr & Associated Inc., dated July 9, 2019, is expected to consist of a maximum total of 2,403 residential units. The maximum unit count consists of a maximum of 410 “Medium Density Residential Units” and 1993 “Low Density Residential Units”.

New Site Traffic

The total subject development is estimated to generate a total of 1696 two-way trips during the AM peak hour consisting of 425 inbound and 1,271 outbound trips and a total of 2,206 two-way trips during the PM peak hour consisting of 1,419 inbound and 787 outbound trips.

Summary of Findings

Under full build-out, the total subject development is estimated to generate a total of 1,696 two-way trips during the AM peak hour consisting of 425 inbound and 1,271 outbound trips and a total of 2,206 two-way trips during the PM peak hour consisting of 1,419 inbound and 787 outbound trips.

The study intersections are expected to have acceptable future operating characteristics with reserve capacity under 2018 existing, 2019 future background, and 2019 and 2024 future total conditions. Although the operational impact of the added site traffic is likely to be noticeable to the immediate surrounding road network, as expected with a development of this size, it is not expected to contribute to any significant deterioration of overall network’s operational performance.

Under 2024 future total traffic conditions, the existing all-way stop controlled intersections of McNeilly Road and Lewis Road on Barton Street are reported to have increased delays resulting in LOS “F”.

With respect to noted delay concerns at the existing intersections along Highway 8 and Barton Street, future intersections improvements to mitigate any intersections capacity issues along either of these roads will be determined through the ongoing Highway 8 Improvements EA and the Barton Street and Fifty Road Improvements EA studies.

Summary of Recommendations

The Collector Road "D" proposed right-of-way (ROW) width is 26 metres from its western extent at McNeilly Road to its eastern extent at Barton Street; a short segment connecting Collector Road "D" to Highway 8 is proposed with a 20 metre ROW width. The Collector Road "E" proposed right-of-way (ROW) width is 26 metres throughout. The local road proposed right-of-way (ROW) widths are 20 metres throughout.

The following new intersections are proposed:

- Collector Road "D" at Lewis Road
- Collector Road "E" at Highway 8
- Collector Road "D" at Highway 8
- Collector Road "D" at McNeilly Road
- Collector Road "E" at Barton Street
- Collector Road "D" opposite Escarpment Drive at Barton Street
- Two proposed laneway connections on McNeilly Road just north of Highway 8.

As per the results of the all-way stop and traffic signal warrants, and satisfactory operating conditions under two-way stop control as per the results of the capacity analysis, two-way stop control is sufficient at all internal collector road intersections. Future intersection geometry and traffic control at these intersections will be determined through the respective draft plan or site plan applications as they proceed. Should draft plans proceed in advance of City work, they will be required to address temporary intersection improvements with each submission.

We trust that this satisfies your requirements, but do not hesitate to contact the undersigned if you have any questions.

Sincerely,

GHD

LICENSED PROFESSIONAL ENGINEER
December 3 2019
W.C. MARIA
PROVINCE OF ONTARIO

William Maria, P. Eng.
Senior Project Manager

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1. Introduction

1.1 Retainer and Objective

GHD Limited (GHD) was retained by the Block 3 Landowners Group to prepare a Traffic Impact Study (TIS) for full build-out of the proposed Fruitland-Winona Secondary Plan, Block 3 Servicing Strategy Area, residential subdivision development located on the north side of Highway 8 and south side of Barton Street, between McNeilly Road and Winona Road, in Stoney Creek, City of Hamilton, to determine the following:

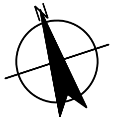
- Establish baseline traffic conditions for the study area and update the existing traffic conditions to derive the future background operating conditions for the study intersections at a future 2019 and 2024 planning horizons.
- Determine the traffic volumes anticipated to be generated by build-out of the proposed Block 3 Servicing Strategy Area during the weekday AM and PM peak hours; to assess the impact of this traffic on the study intersections and if needed, to recommend improvements to accommodate the forecasted traffic volumes.

The proposed site location is shown in **Figure 1**.

1.2 Study Team

The GHD team involved in the preparation of the study are

- William Maria, P. Eng., Senior Project Manager
- Adam Mildenberger, B.A., C.E.T., Transportation Planner



Branthaven Homes
Fruitland-Winona Secondary Plan
Traffic Impact Study
Site Location

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Figure 01

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2. Site Characteristics

2.1 Study Area

The study area includes the following intersections:

- Barton Street at McNeilly Road
- Barton Street at Lewis Road
- Barton Street at Escarpment Drive opposite proposed Collector Road 'D'
- Highway 8 at McNeilly Road
- Highway 8 at Lewis Road
- McNeilly Road at proposed Collector Road 'D'
- Barton Street at proposed Collector Road 'E'
- Highway 8 at proposed Collector Road 'E'
- Highway 8 at proposed Collector Road 'D'
- Proposed Collector Road 'D' at proposed Collector Road 'E'
- Proposed Collector Road 'D' at Lewis Road
- Proposed Collector Road 'D' at proposed Collector Road 'D'

2.2 Secondary Plan

2.2.1 Expected Maximum Unit Count

The proposed Fruitland-Winona Secondary Plan, Block 3 Servicing Strategy Area prepared by Glen Schnarr & Associated Inc., dated July 9, 2019, is expected to consist of a maximum total of 2,403 residential units. The maximum unit count consists of a maximum of 410 "Medium Density Residential Units" and 1,993 "Low Density Residential Units".

2.2.2 Proposed Road Network Layout

The external road network perimeter consists of Barton Street to the north, Highway 8 to the south, McNeilly Road to the west, and Tuscani Drive to the east. The existing alignment of Lewis Road will traverse through the centre of the proposed development, providing site access to Barton Street and Highway 8.

The internal road network provides access to the external road network via the following proposed connections:

- Collector Road 'D' at Lewis Road
- Collector Road 'E' at Highway 8
- Collector Road 'D' at Highway 8
- Collector Road 'D' at McNeilly Road

- Collector Road 'E' at Barton Street
- Collector Road 'D' opposite Escarpment Drive at Barton Street
- Two proposed laneway connections on McNeilly Road just north of Highway 8

In addition to proposed local roads, the internal road network will consist of two new proposed collector roads to be referred to as Collector Road "D" and Collector Road "E". Collector Road "D" will be oriented east-west from McNeilly Road, intersecting Collector Road "E" and Lewis Road, to just east of Lewis Road where it transitions to a north-south orientation and intersects Highway 8 to the south and Barton Street to the north. Collector Road "E" will be oriented north-south through the site from Highway 8 in the south to Barton Street in the north, intersecting Collector Road "D".

The proposed site plan is shown in **Figure 2**.

2.2.3 Proposed Right-of-Way Widths

The Collector Road "D" proposed right-of-way (ROW) width is 26 metres (m) from its western extent at McNeilly Road to its eastern extent at Barton Street. This will include a pavement width of at least 12.7 m, consisting of 3.5 m travel lanes, 1.5 m bikes lane, and 2.7 m on one side devoted to on-street parking. A short segment connecting Collector Road "D" to Highway 8 is proposed with a 20 m ROW width, which is proposed to include an 8 m pavement width (4 m travel lanes) with no on-street parking or bike lanes.

The Collector Road "E" proposed right-of-way (ROW) width is 26 m throughout, which will have a cross-section generally consistent with Collector Road "D".

The local road proposed right-of-way (ROW) widths are 20 m throughout and consistent with Hamilton Standard No. RD-113.01 (see Appendix H). This will include sidewalks on both sides of the road, a pavement width of 8 m and on-street parking.

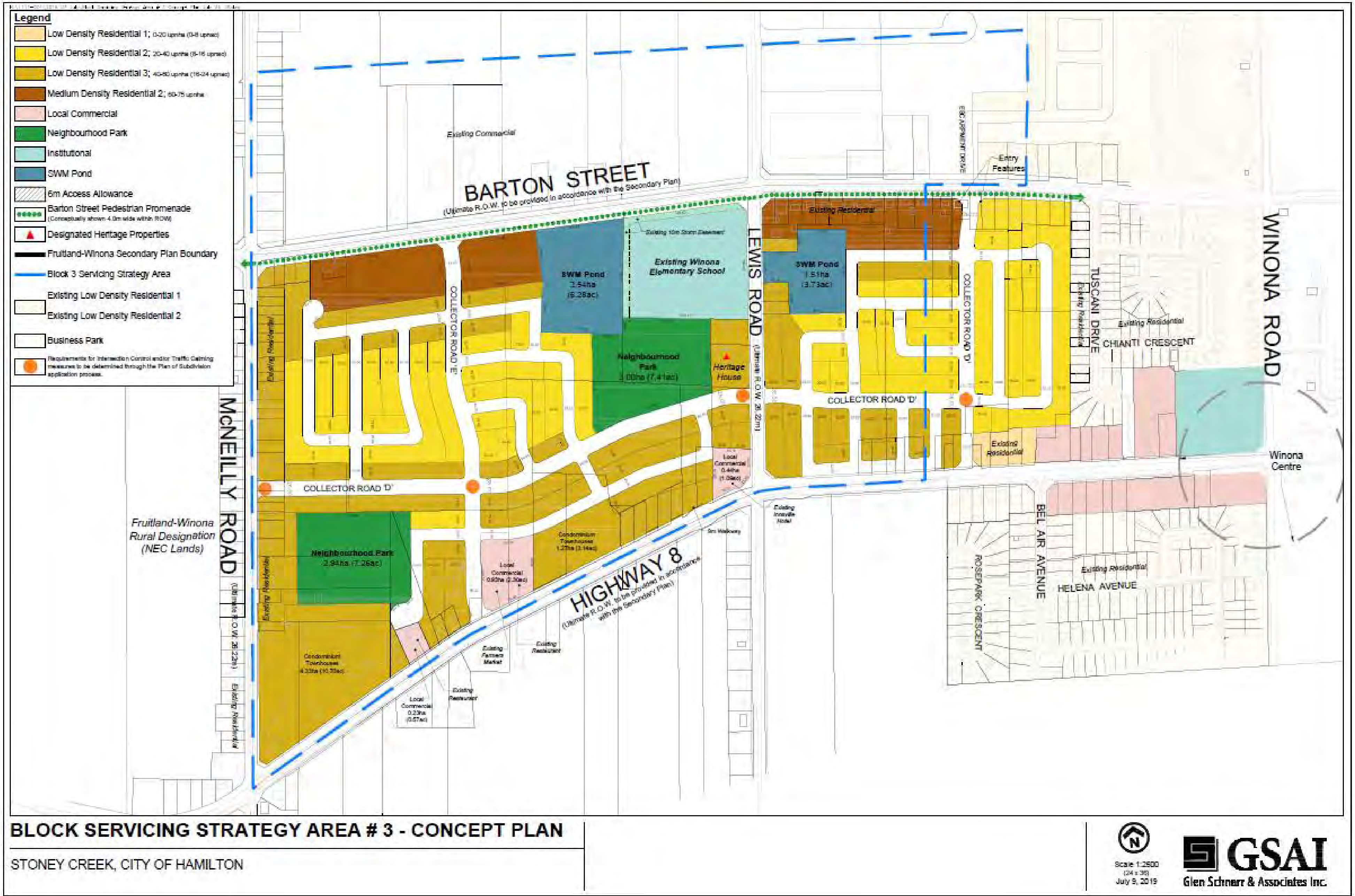
All collector and local roads throughout the Secondary Plan will include sidewalks on both sides of the roadway.

2.2.4 Other Planned Right-of-Way Widths

Highway 8 and Barton Street ultimate right-of-ways are to be determined through their respective EA process. The existing cross-sections are described in Section 3.1 of this report, and the specific future cross-sections will be determined through the EA process. T

he ongoing Barton Street and Fifty Road Improvement EA is expected to conclude that a four lane cross-section (two travel lanes per direction) is the preferred design option along Barton Street, which is described in the Barton Street Pedestrian Promenade concept illustrated in the Fruitland-Winona Urban Design Principles and Guidelines.

McNeilly Road and Lewis Road will have ultimate right-of-ways of 26.22 m, and are expected to maintain existing cross-sections; specific cross-section features in approach to the Barton Street and Highway 8 intersections are expected to be determined upon completion of the EA process.



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Fruitland-Winona Secondary Plan
Traffic Impact Study
Secondary Plan

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Figure 02

3. Existing Conditions

3.1 Existing road Network

Barton Street is a two-lane arterial road with a posted speed limit of 60 km/h and a rural cross-section (gravel shoulders) through the study area. The road is oriented east-west and intersects McNeilly Road (all-way stop control), Lewis Road (all-way stop control) and Escarpment Drive (two-way stop control for Escarpment Drive). There are no significant horizontal or vertical curves in the roadway within the study area.

Highway 8 is a two-lane arterial road with a posted speed limit of 60 km/h and a rural cross-section (gravel shoulders) through the study area. The road is oriented east-west and intersects McNeilly Road (traffic signal) and Lewis Road (two-way stop control for Lewis Road). There is a noticeable horizontal curve in the road’s alignment just west of McNeilly Road with an estimated radius of approximately 200 m; there are no significant vertical curves within the study area.

McNeilly Road is a two-lane collector road with a posted speed limit of 50 km/h and a rural cross-section (gravel shoulders) through the study area. The road is oriented north-south and intersects Highway 8 (traffic signal) and Barton Street (all-way stop control). There are no significant horizontal or vertical curves in the roadway within the study area.

Lewis Road is a two-lane collector road with a posted speed limit of 50 km/h and a rural cross-section (gravel shoulders) through the study area. The road is oriented north-south and intersects Highway 8 (two-way stop control for Lewis Road) and Barton Street (all-way stop control). There are no significant horizontal or vertical curves in the roadway within the study area.

Escarpment Drive is a two-lane collector road with a posted speed limit of 50 km/h and an urban cross-section (curb and gutters) through the study area. The road is oriented north-south and T-intersects Barton Street (two-way stop control for Escarpment Drive). There is horizontal curve in the road’s alignment with an estimated radius of approximately 15 m approximately 100 m north of Barton Street; there are no significant vertical curves in the roadway within the study area.

3.2 Pedestrian Routes

Sidewalks are currently provided on the south side of Barton Street west of McNeilly Road and the north side of Barton Street east of McNeilly Road, the east side of Escarpment Drive, the west side of McNeilly Road between Barton Street and Highway 8, on the south side of Highway 8, and fronting Winona Elementary Public School on Lewis Road and Barton Street.

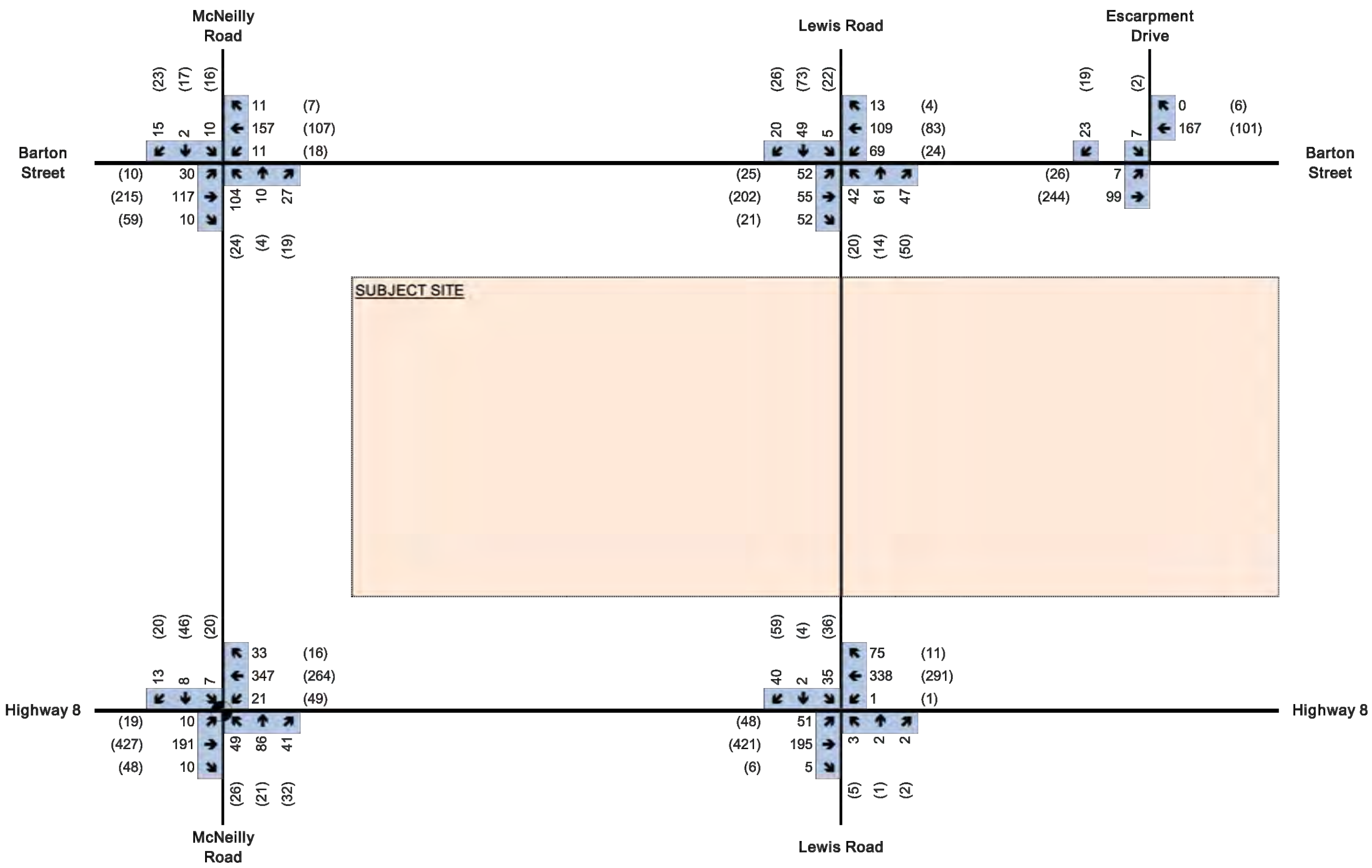
3.3 Transit Services

Transit service is currently not provided on the surrounding road network.

3.4 Existing Traffic Data

GHD collected AM and PM peak hour turning movement counts in May 2016 at the study area intersections. The turning movement counts are included in **Appendix A**.

Figure 3 summarizes the adopted existing traffic volumes during the weekday AM and PM peak hours.



Legend
XX AM Peak Hour Volumes
(XX) PM Peak Hour Volumes
Signalized Intersection

Branthaven Homes
Fruitland-Winona Secondary Plan
Traffic Impact Study
Existing Volumes

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Figure 03

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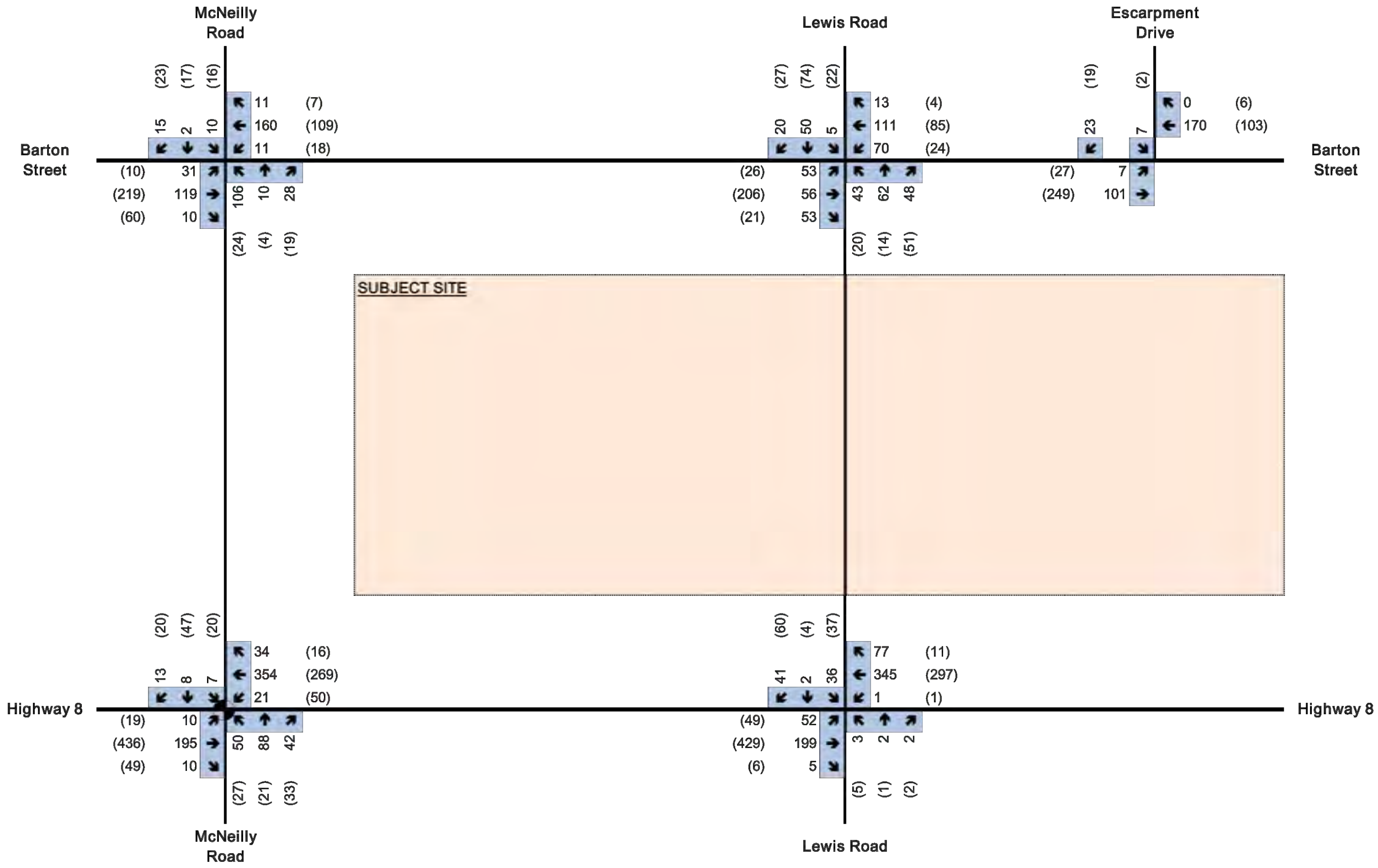
4. Future Background Traffic

4.1 Background Growth

Future background growth was conservatively applied to all existing study area roads for the horizon years of 2019 (build-out) and 2024 (5-years post build-out). A conservative growth rate of 2 percent per annum was applied to account for regional traffic growth in the area.

Traffic generated by both Block 1 and 2 traffic or other future developments were not included in the development of future background traffic volumes. Traffic generated by external development blocks will not contribute additional traffic along Highway 8 and Barton Street and not through the internal road network within the Block 3 Servicing Strategy Area. Consequently, any future road or intersection improvements along these roads will be confirmed when the ongoing EA's for these roads is completed.

The 2019 and 2024 background growth traffic volumes are presented in **Figure 4** and **Figure 5**, respectively.



Legend
XX AM Peak Hour Volumes
(XX) PM Peak Hour Volumes
Signalized Intersection

Branthaven Homes
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Traffic Impact Study
2019 Future Background Volumes

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Figure 04

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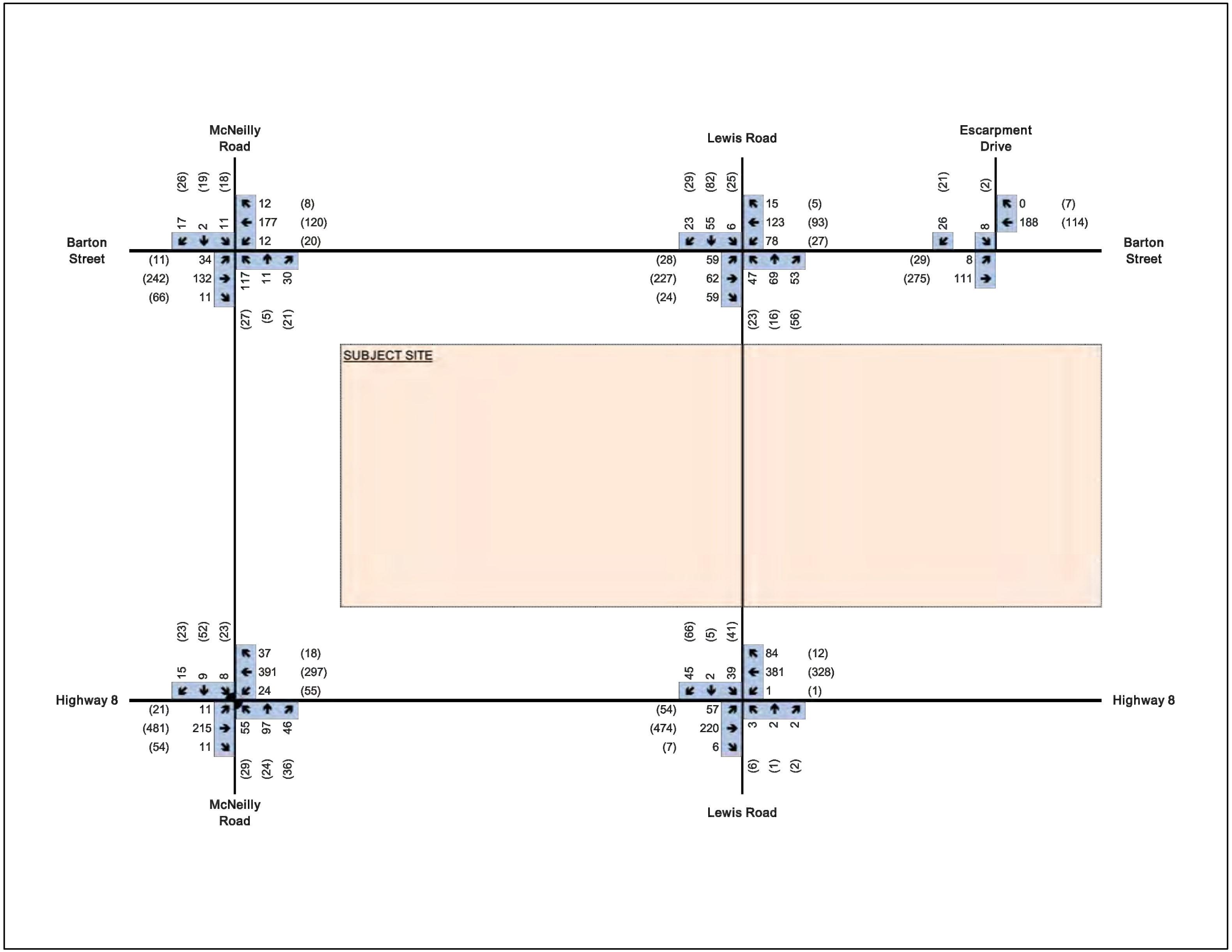

Legend
XX AM Peak Hour Volumes
(XX) PM Peak Hour Volumes
Signalized Intersection

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Traffic Impact Study
2024 Future Background Volumes

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Figure 05

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5. Site Generated Traffic

5.1 Modal Split

As a conservative measure no transit reduction was applied to the estimated site trips in the study analysis.

5.2 Site Trip Generation

Trip generation during the weekday peak hours for full build-out of the Block 3 Servicing Strategy Area was estimated using the Institute of Transportation Engineer's (ITE) 10th Edition Land Use Code (LUC) #210 for single family detached dwellings and #230 for residential condominium/townhouses, as presented in **Table 1**. A comparison of the trip generation between the trip generation rate method and the fitted curve equation method resulted in greater trips for trip generation rate method, thus these results were adopted accordingly as a conservative measure.

Table 1 Site Trip Generation

Land Use Code	Units	Parameters	Peak Hour Trip Generation					
			Weekday AM			Weekday PM		
			In	Out	Total	In	Out	Total
Single Family Detached (LUC 210)	1,993	Trip Rate	0.20	0.56	0.76	0.64	0.36	1.00
		Trip Ratio	26%	74%	-	64%	36%	-
		Gross Trips	**394**	**1121**	**1515**	**1276**	**717**	**1993**
Condominium Townhouse (LUC 230)	410	Trip Rate	0.08	0.37	0.44	0.35	0.17	0.52
		Trip Ratio	17%	83%	-	67%	33%	-
		Gross Trips	**31**	**150**	**180**	**143**	**70**	**213**
Total Trips			**425**	**1,271**	**1,696**	**1,419**	**787**	**2,206**

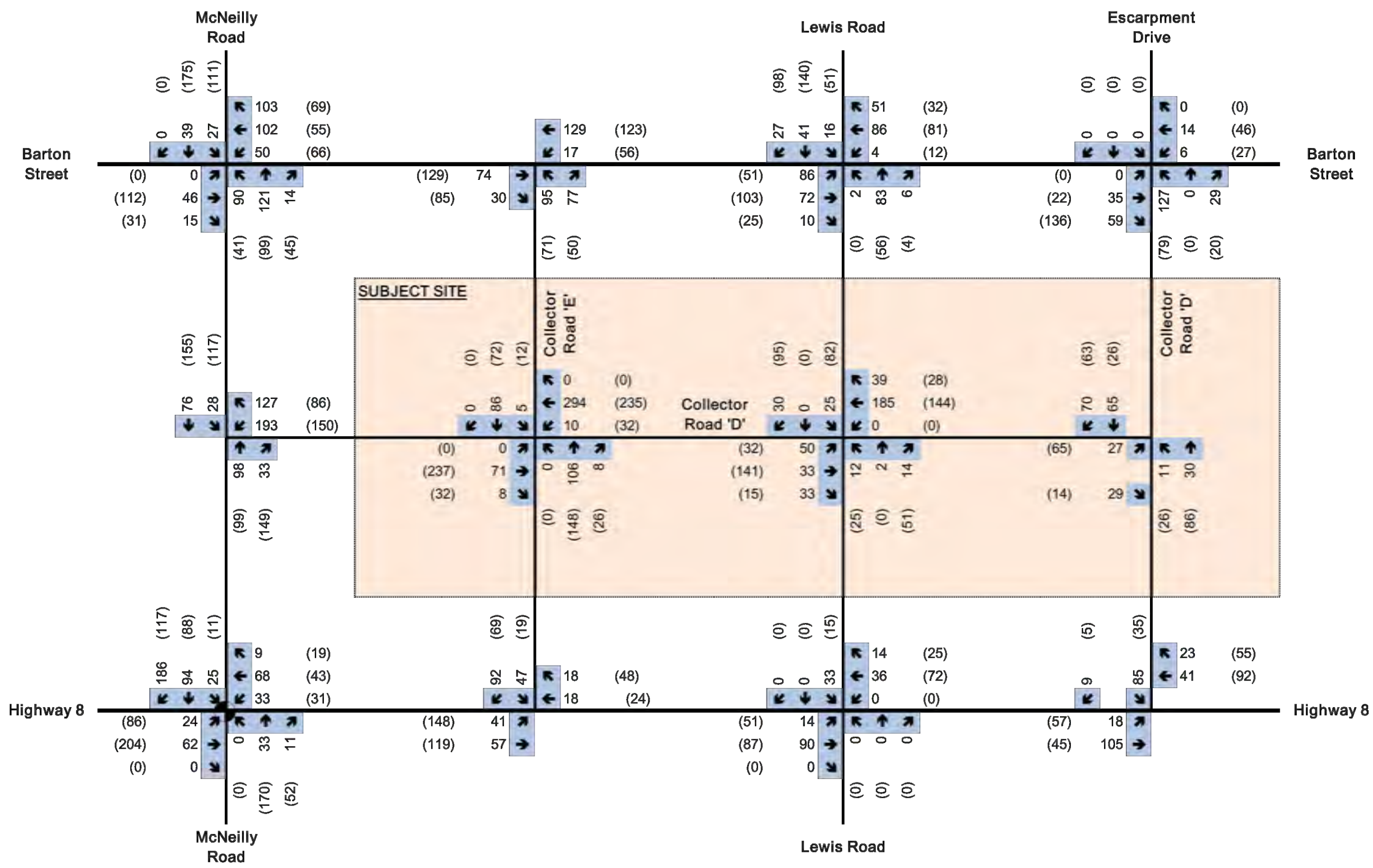
The Block 3 Servicing Strategy Area development is estimated to generate a total of 1,696 two-way trips during the AM peak hour consisting of 425 inbound and 1,271 outbound trips and a total of 2,206 two-way trips during the PM peak hour consisting of 1,419 inbound and 787 outbound trips.

5.3 Site Trip Distribution and Assignment

The distribution of site traffic between the subject site and the limits of the study area was based on 2016 Transportation Tomorrow Survey (TTS) data, which is provided in **Appendix B**.

Upon determining origin and destination points throughout the study area for all inbound and outbound trips, trips were assigned to individual turning movements at study area intersections based on route choice assignment with consideration for anticipated travel times. Turning Movement Diagrams (TMDs) illustrating site trips assigned to turning movements are provided in **Appendix C**.

The estimated site trips generated by the proposed development as assigned to the nearby road network for the weekday AM and PM peak hours are shown in **Figure 6**.



Legend

XX	AM Peak Hour Volumes
(XX)	PM Peak Hour Volumes
◕	Signalized Intersection

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Traffic Impact Study
Site Trips

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Figure 06

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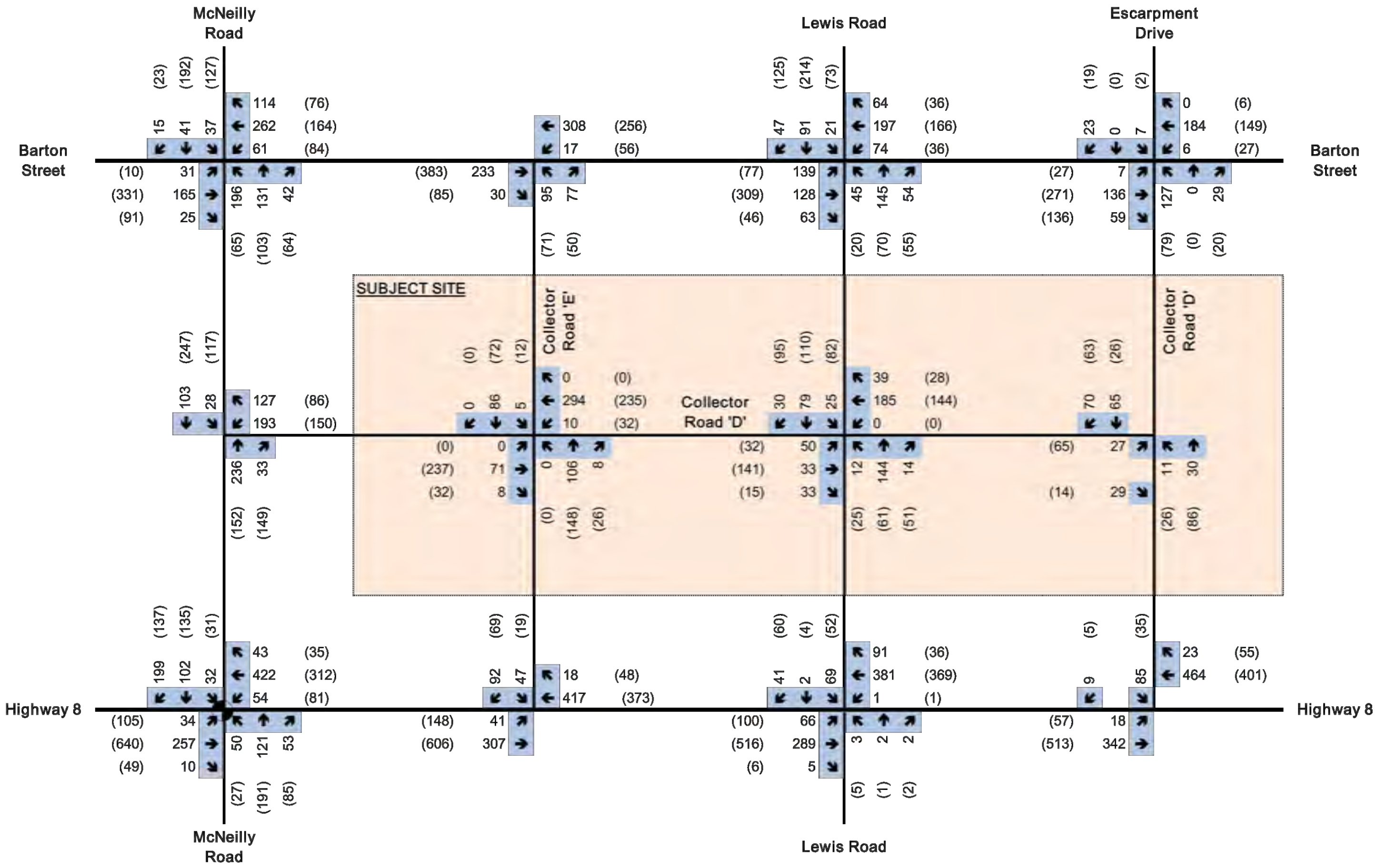
6. Future total traffic

6.1 Future Total Traffic

The future total traffic conditions for the peak study hours in the 2019 and 2024 planning horizons were derived by combining the projected future background traffic with the corresponding estimate of the total site generated traffic.

Figure 7 and **Figure 8** summarize the future total traffic volumes for the 2019 and 2024 planning horizons, respectively; during the weekday AM and PM peak hours.



Legend
XX AM Peak Hour Volumes
(XX) PM Peak Hour Volumes
Signalized Intersection

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2019 Future Total Volumes

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Figure 07

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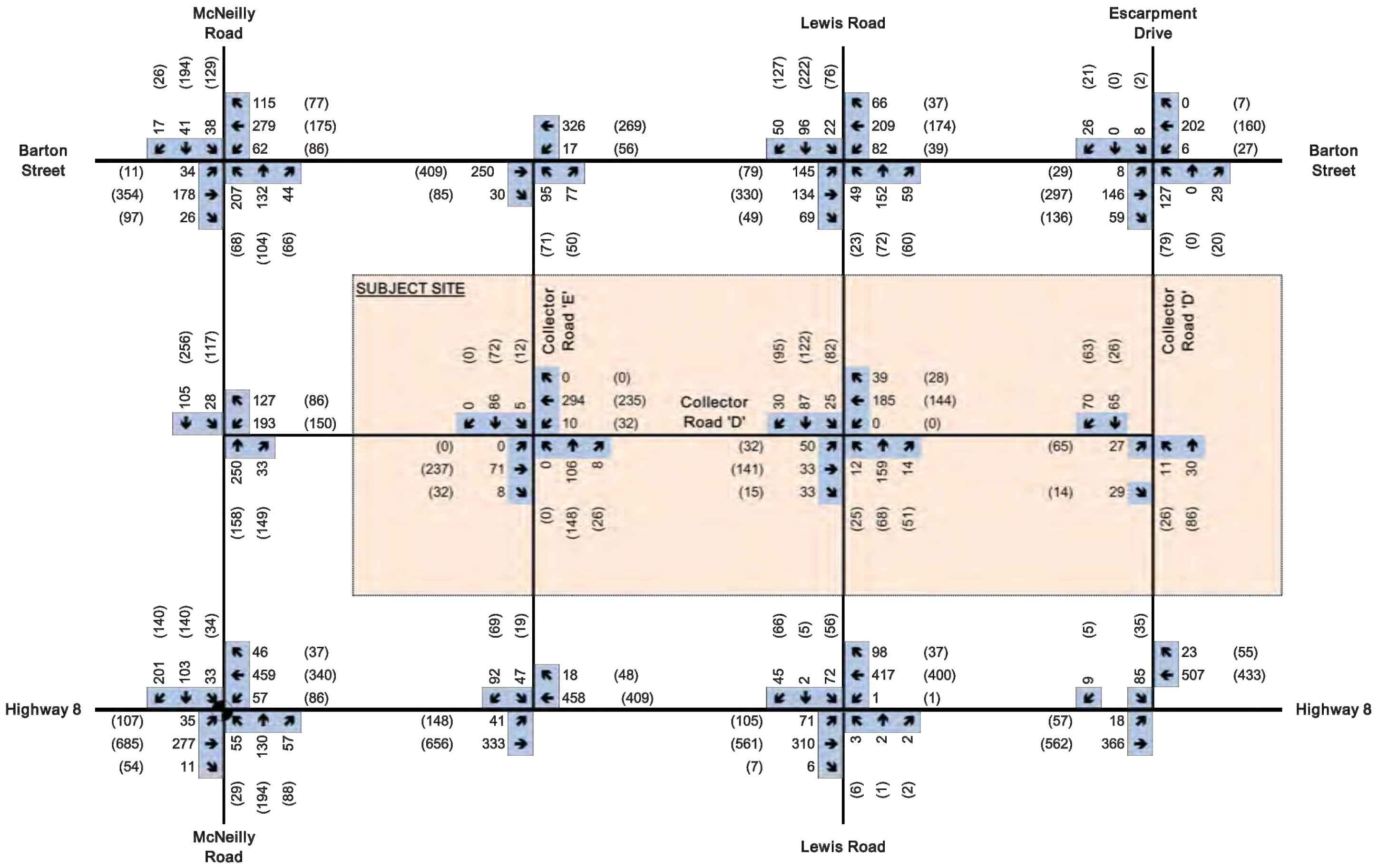

Legend

XX AM Peak Hour Volumes

(XX) PM Peak Hour Volumes

Signalized Intersection

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Fruitland-Winona Secondary Plan
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2024 Future Total Volumes

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Figure 08

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7. Intersection Capacity Analysis

The capacity analysis identifies how well the intersections and driveways are operating. The analysis contained within this report utilized the Highway Capacity Manual (HCM) 2000 procedure within the Synchro Version 9 Software package. The reported intersection volume-to-capacity ratios (v/c) are a measure of the saturation volume for each turning movement, while the levels-of-service (LOS) are a measure of the average delay for each turning movement. Queuing characteristics are reported as the predicted 95th percentile queue for each turning movement.

Further discussion on completed warrants for the proposed method of intersection control for all study area intersections is provided in Section 8.

In accordance with the City of Hamilton's Traffic Impact Study Guidelines, the analysis includes identification of conditions at signalized intersections where:

- Volume/capacity (v/c) ratios for through movements or shared through/turning movements increased to 0.85 or above.
- V/c ratios for exclusive movements increased to 0.90 or above.
- 95th percentile queues for an individual movement are projected to exceed available turning lane storage.

The analysis includes identification of conditions at unsignalized intersections where:

- Level of service if LOS "D" or greater.
- 95th percentile queues for an individual movement are projected to exceed available turning lane storage.

The following tables summarize the HCM capacity results for the study intersections during the weekday AM and PM hours under existing 2018, future background 2019, future total 2019 and 2024 traffic conditions. The detailed calculation sheets are provided in **Appendix D**.

All proposed intersections were modelled as unsignalized, two-way stop controlled intersections. Further discussion on proposed intersection controls are provided later in this report.

The only signalized intersection within the study area, being Highway 8 at McNeilly Road, was modelled utilizing the existing signal timing plan, which is provided in **Appendix E**.

7.1.1 McNeilly Road at Barton Street

Unsignalized capacity analyses during the weekday AM and PM peak hours are summarized in **Table 2** from detailed Synchro reports attached in the Appendix.

Table 2 Capacity Analyses of McNeilly Road at Barton Street

Traffic Condition	Movement v/c (LOS) 95th Percentile Queue	
	AM Peak Hour	PM Peak Hour
Existing 2018	Overall 0.38 (A) NBLTR: 0.22 (A) <1 veh EBLTR: 0.24 (A) <1 veh WBLTR: 0.26 (A) <1 veh SBLTR: 0.04 (A) <1 veh	Overall 0.28 (A) NBLTR: 0.07 (A) <1 veh EBLTR: 0.36 (A) <1 veh WBLTR: 0.18 (A) <1 veh SBLTR: 0.08 (A) <1 veh
Future Background 2019	Overall 0.39 (A) NBLTR: 0.22 (A) <1 veh EBLTR: 0.24 (A) <1 veh WBLTR: 0.27 (A) <1 veh SBLTR: 0.04 (A) <1 veh	Overall 0.28 (A) NBLTR: 0.07 (A) <1 veh EBLTR: 0.36 (A) <1 veh WBLTR: 0.18 (A) <1 veh SBLTR: 0.08 (A) <1 veh
Future Background 2019	Overall 0.66 (**C**) NBLTR: 0.77 (**D**) <1 veh EBLTR: 0.49 (C) <1 veh WBLTR: 0.87 (**E**) 10 m SBLTR: 0.25 (B) <1 veh	Overall 0.79 (**D**) NBLTR: 0.60 (C) <1 veh EBLTR: 1.00 (**F**) 13 m WBLTR: 0.78 (**E**) <1 veh SBLTR: 0.84 (**E**) 1 veh
Future Total 2024	Overall 0.68 (**C**) NBLTR: 0.83 (**E**) 1 veh EBLTR: 0.55 (C) <1 veh WBLTR: 0.95 (**F**) 12 m SBLTR: 0.25 (B) <1 veh	Overall 0.82 (**D**) NBLTR: 0.63 (**D**) <1 veh EBLTR: 1.08 (**F**) 13 m WBLTR: 0.82 (**E**) 1 veh SBLTR: 0.86 (**E**) 1 veh

Under existing and 2019 future background conditions, which includes corridor growth, this intersection is expected to operate satisfactorily with substantial reserve capacity, low levels of delay and negligible queuing. Under 2019 future total traffic conditions the operational impact of the site traffic is noticeable, with increased delays during the PM peak hour. Under 2024 future total traffic conditions with the additional corridor growth, increased delays are now expected during the AM peak hour as well.

Despite the capacity and delay concerns for the westbound approach during the AM peak hour and eastbound approach during the PM peak hour, reported 95th percentile queue lengths generally do not exceed two vehicles.

This intersection is currently an all-way stop controlled intersection, does not warrant signalization due to insufficient overall volumes.

This intersection will be assessed further as part of the ongoing Municipal EA Study on Barton Street to address any future capacity constraints.

It is important to note that the ongoing EA is expected to conclude that a four lane cross-section (two travel lanes per direction) is the preferred design option, which will provide a capacity improvement to intersections along the Barton Street corridor. This is consistent with the Barton

Street Pedestrian Promenade concept illustrated in the Fruitland-Winona Urban Design Principles and Guidelines.

Therefore, GHD does not recommend any improvements to this intersection, at this time.

7.1.1 Collector Road "E" at Barton Street

Unsignalized capacity analyses during the weekday AM and PM peak hours are summarized in **Table 3** from detailed Synchro reports attached in the Appendix.

Table 3 Capacity Analyses of Collector Road "E" at Barton Street

Traffic Condition	Movement v/c (LOS) 95th Percentile Queue	
	AM Peak Hour	PM Peak Hour
Future Total 2019	Overall 0.47 (A) WBLT: 0.01 (A) <1 veh NBLR: 0.35 (C) 11 m	Overall 0.59 (B) WBLT: 0.06 (A) <1 veh NBLR: 0.34 (C) 11 m
Future Total 2024	Overall 0.48 (A) WBLT: 0.01 (A) <1 veh NBLR: 0.36 (C) 12 m	Overall 0.61 (B) WBLT: 0.06 (A) <1 veh NBLR: 0.36 (C) 12 m

Under future total traffic conditions this intersection is expected to operate satisfactorily with substantial reserve capacity, acceptable levels of delay and minimal queuing.

7.1.2 Lewis Road at Barton Street

Unsignalized capacity analyses during the weekday AM and PM peak hours are summarized in **Table 4** from detailed Synchro reports attached in the Appendix.

Table 4 Capacity Analyses of Lewis Road at Barton Street

Traffic Condition	Movement v/c (LOS) 95th Percentile Queue	
	AM Peak Hour	PM Peak Hour
Existing 2018	Overall 0.36 (A) NBLTR: 0.28 (B) <1 veh EBLTR: 0.28 (A) <1 veh WBLTR: 0.35 (B) <1 veh SBLTR: 0.14 (A) <1 veh	Overall 0.30 (A) NBLTR: 0.12 (A) <1 veh EBLTR: 0.36 (B) <1 veh WBLTR: 0.17 (A) <1 veh SBLTR: 0.18 (A) <1 veh
Future Background 2019	Overall 0.36 (A) NBLTR: 0.28 (B) <1 veh EBLTR: 0.29 (A) <1 veh WBLTR: 0.36 (B) <1 veh SBLTR: 0.14 (A) <1 veh	Overall 0.30 (A) NBLTR: 0.12 (A) <1 veh EBLTR: 0.37 (B) <1 veh WBLTR: 0.17 (A) <1 veh SBLTR: 0.19 (A) <1 veh
Future Total 2019	Overall 0.60 (B) NBLTR: 0.67 (**D**) <1 veh EBLTR: 0.85 (**E**) 1 veh WBLTR: 0.87 (**E**) 9 m SBLTR: 0.46 (C) <1 veh	Overall 0.73 (C) NBLTR: 0.35 (C) <1 veh EBLTR: 0.94 (**F**) 11 m WBLTR: 0.55 (C) <1 veh SBLTR: 0.87 (**E**) 9 m
Future Total 2024	Overall 0.62 (B) NBLTR: 0.76 (**E**) <1 veh EBLTR: 0.96 (**F**) 12 m	Overall 0.75 (D) NBLTR: 0.38 (C) <1 veh EBLTR: 1.02 (**F**) 13m

Table 4 Capacity Analyses of Lewis Road at Barton Street

Traffic Condition	Movement v/c (LOS) 95th Percentile Queue	
	AM Peak Hour	PM Peak Hour
	WBLTR: 1.01 (**F**) 13 m SBLTR: 0.52 (C) <1 veh	WBLTR: 0.59 (C) <1 veh SBLTR: 0.92 (**E**) 11m

Under existing and 2019 future background conditions, which includes corridor growth, this intersection is expected to operate satisfactorily with substantial reserve capacity, low levels of delay and negligible queuing. Under 2019 future total traffic conditions the operational impact of the site traffic is noticeable, although generally acceptable. The intersection is still expected to operate satisfactorily with reserve capacity, generally acceptable levels of delay and minimal queuing; however, the eastbound approach is expected to be nearing capacity with increase delays during the PM peak hour. Under 2024 future total traffic conditions with the additional corridor growth, increased delays are now expected during the AM peak hour as well.

The findings for this intersection, being increased delays for Barton Street during peak hours, are similar to the intersection of Barton Street at McNeilly Road; therefore the recommendations for future considerations are also consistent.

This intersection is currently an all-way stop controlled intersection, does not warrant signalization due to insufficient overall volumes.

This intersection will be assessed further as part of the ongoing Municipal EA Study on Barton Street to address any future capacity constraints.

It is important to note that the ongoing EA is expected to conclude that a four lane cross-section (two travel lanes per direction) is the preferred design option, which will provide a capacity improvement to intersections along the Barton Street corridor. This is consistent with the Barton Street Pedestrian Promenade concept illustrated in the Fruitland-Winona Urban Design Principles and Guidelines.

Therefore, GHD does not recommend any improvements to this intersection, at this time.

7.1.3 Escarpment Drive/Collector Road “D” at Barton Street

Unsignalized capacity analyses during the weekday AM and PM peak hours are summarized in **Table 5** from detailed Synchro reports attached in the Appendix.

Table 5 Capacity Analyses of Escarpment Drive/Collector Road “D” at Barton Street

Traffic Condition	Movement v/c (LOS) 95th Percentile Queue	
	AM Peak Hour	PM Peak Hour
Existing 2018	Overall 0.21 (A) EBLT: 0.01 (A) <1 veh SBLR: 0.06 (B) <1 veh	Overall 0.31 (A) EBLT: 0.02 (A) <1 veh SBLR: 0.02 (A) <1 veh
Future Background 2019	Overall 0.21 (A) EBLT: 0.01 (A) <1 veh SBLR: 0.06 (B) <1 veh	Overall 0.31 (A) EBLT: 0.02 (A) <1 veh SBLR: 0.02 (A) <1 veh

Table 5 Capacity Analyses of Escarpment Drive/Collector Road “D” at Barton Street

Traffic Condition	Movement v/c (LOS) 95th Percentile Queue	
	AM Peak Hour	PM Peak Hour
Future Total 2019	Overall 0.36 (B) EBLTR: 0.01 (A) <1 veh WBLTR: 0.01 (A) <1 veh NBLTR: 0.48 (C) 20 m SBLTR: 0.07 (B) <1 veh	Overall 0.46 (A) EBLTR: 0.02 (A) <1 veh WBLTR: 0.02 (A) <1 veh NBLTR: 0.24 (C) <1 veh SBLTR: 0.03 (A) <1 veh
Future Total 2024	Overall 0.37 (A) EBLTR: 0.01 (A) <1 veh WBLTR: 0.01 (A) <1 veh NBLTR: 0.51 (C) 22 m SBLTR: 0.08 (B) <1 veh	Overall 0.48 (A) EBLTR: 0.02 (A) <1 veh WBLTR: 0.02 (A) <1 veh NBLTR: 0.26 (C) 1 veh SBLTR: 0.03 (A) <1 veh

Under existing and all future conditions this intersection is expected to operate satisfactorily with substantial reserve capacity, acceptable levels of delay and minimal queuing.

7.1.4 McNeilly Road at Collector Road “D”

Unsignalized capacity analyses during the weekday AM and PM peak hours are summarized in **Table 6** from detailed Synchro reports attached in the Appendix.

Table 6 Capacity Analyses of McNeilly Road at Collector Road “D”

Traffic Condition	Movement v/c (LOS) 95th Percentile Queue	
	AM Peak Hour	PM Peak Hour
Future Total 2019	Overall 0.50 (A) WBLR: 0.55 (B) 26 m SBLT: 0.02 (A) <1 veh	Overall 0.60 (B) WBLR: 0.61 (**D**) 30 m SBLT: 0.10 (A) <1 veh
Future Total 2024	Overall 0.51 (A) WBLR: 0.57 (C) 27 m SBLT: 0.02 (A) <1 veh	Overall 0.61 (B) WBLR: 0.62 (**D**) 31 m SBLT: 0.10 (A) <1 veh

Under future total traffic conditions this intersection is expected to operate satisfactorily with substantial reserve capacity, acceptable levels of delay and minimal queuing.

7.1.5 Collector Road “D” at Collector Road “E”

Unsignalized capacity analyses during the weekday AM and PM peak hours are summarized in **Table 7** from detailed Synchro reports attached in the Appendix.

Table 7 Capacity Analyses of Collector Road "D" at Collector Road "E"

Traffic Condition	Movement v/c (LOS) 95th Percentile Queue	
	AM Peak Hour	PM Peak Hour
Future Total 2019	Overall 0.38 (A) WBLTR: 0.01 (A) <1 veh NBLTR: 0.23 (B) <1 veh SBLTR: 0.19 (B) <1 veh	Overall 0.53 (A) WBLTR: 0.03 (A) <1 veh NBLTR: 0.43 (C) 16 m SBLTR: 0.25 (C) 1 veh
Future Total 2024	Overall 0.38 (A) WBLTR: 0.01 (A) <1 veh NBLTR: 0.23 (B) <1 veh SBLTR: 0.19 (B) <1 veh	Overall `0.53 (A) WBLTR: 0.03 (A) <1 veh NBLTR: 0.43 (C) 16 m SBLTR: 0.25 (C) 1 veh

Under future total traffic conditions this intersection is expected to operate satisfactorily with substantial reserve capacity, acceptable levels of delay and minimal queuing.

7.1.6 Lewis Road at Collector Road "D"

Unsignalized capacity analyses during the weekday AM and PM peak hours are summarized in **Table 8** from detailed Synchro reports attached in the Appendix.

Table 8 Capacity Analyses of Lewis Road at Collector Road "D"

Traffic Condition	Movement v/c (LOS) 95th Percentile Queue	
	AM Peak Hour	PM Peak Hour
Future Total 2019	Overall 0.43 (A) EBLTR: 0.27 (C) 1 veh WBLTR: 0.41 (C) 8 m NBLTR: 0.01 (A) <1 veh SBLTR: 0.02 (A) <1 veh	Overall 0.52 (A) NBLTR: 0.51 (C) 21 m EBLTR: 0.41 (C) 15 m WBLTR: 0.02 (A) <1 veh SBLTR: 0.06 (A) <1 veh
Future Total 2024	Overall 0.43 (A) EBLTR: 0.28 (C) 8 m WBLTR: 0.43 (C) 16 m NBLTR: 0.01 `(A) <1 veh SBLTR: 0.02 (A) <1 veh	Overall 0.53 (A) NBLTR: 0.53 (C) 23 m EBLTR: 0.42 (C) 16 m WBLTR: 0.02 (A) <1 veh SBLTR: 0.06 (A) <1 veh

Under future total traffic conditions this intersection is expected to operate satisfactorily with substantial reserve capacity, acceptable levels of delay and minimal queuing.

7.1.7 Collector Road "D" at Collector Road "D"

Unsignalized capacity analyses during the weekday AM and PM peak hours are summarized in **Table 9** from detailed Synchro reports attached in the Appendix.

Table 9 Capacity Analyses of Collector Road "D" at Collector Road D

Traffic Condition	Movement v/c (LOS) 95th Percentile Queue	
	AM Peak Hour	PM Peak Hour
Future Total 2019	Overall 0.21 (A) EBLR: 0.07 (A) <1 veh NBT: 0.01 (A) <1 veh	Overall 0.24 (A) EBLR: 0.11 (B) <1 veh NBT: 0.02 (A) <1 veh
Future Total 2024	Overall 0.21 (A) EBLR: 0.07 (A) <1 veh NBT: 0.01 (A) <1 veh	Overall 0.24 (A) EBLR: 0.11 (B) <1 veh NBT: 0.02 (A) <1 veh

Under future total traffic conditions this intersection is expected to operate satisfactorily with substantial reserve capacity, acceptable levels of delay and minimal queuing.

7.1.8 McNeilly Road at Highway 8

Signalized capacity analyses during the weekday AM. and PM peak hours are summarized in **Table 10** from detailed Synchro reports attached in the Appendix.

Table 10 Capacity Analyses of McNeilly Road at Highway 8

Traffic Condition	Movement v/c (LOS) 95th Percentile Queue	
	AM Peak Hour	PM Peak Hour
Existing 2018	Overall 0.46 (A) EBL: 0.03 (A) <1 veh EBTR: 0.25 (A) 21 m WBL: 0.05 (A) <1 veh WBTR: 0.45 (A) 40 m NBLTR: 0.47 (B) 28 m SBLTR: 0.06 (B) <1 veh	Overall 0.46 (A) EBL: 0.04 (A) <1 veh EBTR: 0.51 (A) 46 m WBL: 0.12 (A) <1 veh WBTR: 0.30 (A) 24 m NBLTR: 0.23 (B) 15 m SBLTR: 0.29 (B) 17 m
Future Background 2019	Overall 0.47 (A) EBL: 0.03 (A) <1 veh EBTR: 0.26 (A) 22 m WBL: 0.05 (A) <1 veh WBTR: 0.47 (A) 42 m NBLTR: 0.48 (B) 29 m SBLTR: 0.06 (B) <1 veh	Overall 0.46 (A) EBL: 0.04 (A) <1 veh EBTR: 0.52 (A) 47 m WBL: 0.13 (A) <1 veh WBTR: 0.31 (A) 25 m NBLTR: 0.24 (B) 15 m SBLTR: 0.30 (B) 18 m
Future Total 2019	Overall 0.63 (B) EBL: 0.12 (A) <1 veh EBTR: 0.36 (A) 31 m WBL: 0.13 (A) 1 veh WBTR: 0.59 (B) 58 m NBLTR: 0.54 (B) 44 m SBLTR: 0.70 (C) 70 m	Overall 0.92 (**F**) EBL: 0.27 (A) 16 m EBTR: 0.77 (B) 110 m WBL: 0.42 (B) 17 m WBTR: 0.39 (A) 41 m NBLTR: 0.77 (C) 82 m SBLTR: 0.74 (C) 78 m
Future Total 2024	Overall 0.83 (**E**) EBL: 0.13 (A) <1 veh EBTR: 0.37 (A) 30 m WBL: 0.14 (A) 1 veh WBTR: 0.62 (B) 64 m NBLTR: 0.62 (B) 60 m SBLTR: 0.72 (C) 77 m	Overall 0.96 (**F**) EBL: 0.28 (A) 16 m EBTR: 0.81 (B) 127 m WBL: 0.53 (B) 23 m WBTR: 0.42 (A) 45 m NBLTR: 0.81 (C) 87 m SBLTR: 0.80 (C) 84 m

Under existing and all future conditions this intersection is expected to operate satisfactorily with reserve capacity, acceptable levels of delay and no critical queueing concerns. Under 2024 future total traffic conditions, no individual movements are considered critical, with v/c ratios not exceeding 0.81, delays not exceeding LOS "C", and the highest reported 95th percentile queue length being the eastbound shared through/right-turn movement during the PM peak hour at 127 m, or approximately 18 vehicles. With a low delay representing LOS "B", this 95th percentile queue length is not concerning.

This intersection will be assessed further as part of the ongoing Municipal EA Study on Highway 8 to address any future capacity constraints.

Therefore, GHD does not recommend any improvements to this intersection, at this time.

7.1.9 Highway 8 at Collector Road "E"

Unsignalized capacity analyses during the weekday AM and PM peak hours are summarized in **Table 11** from detailed Synchro reports attached in the Appendix.

Table 11 Capacity Analyses of Highway 8 at Collector Road "E"

Traffic Condition	Movement v/c (LOS) 95th Percentile Queue	
	AM Peak Hour	PM Peak Hour
Future Total 2019	Overall 0.60 (B) EBLT: 0.04 (A) <1 veh SBLR: 0.33 (C) 11 m	Overall 0.78 (**D**) EBLT: 0.14 (A) <1 veh SBLR: 0.28 (C) 1 veh
Future Total 2024	Overall 0.63 (B) EBLT: 0.04 (A) <1 veh SBLR: 0.36 (C) 12 m	Overall 0.83 (**E**) EBLT: 0.15 (A) <1 veh SBLR: 0.31 (C) 1 veh

Under future total traffic conditions this intersection is expected to operate satisfactorily with substantial reserve capacity, acceptable levels of delay and minimal queuing.

7.1.10 Lewis Road at Highway 8

Unsignalized capacity analyses during the weekday AM and PM peak hours are summarized in **Table 12** from detailed Synchro reports attached in the Appendix.

Table 12 Capacity Analyses of Lewis Road at Highway 8

Traffic Condition	Movement v/c (LOS) 95th Percentile Queue	
	AM Peak Hour	PM Peak Hour
Existing 2018	Overall 0.37 (A) EBL: 0.05 (A) <1 veh NBLTR: 0.02 (B) <1 veh SBLTR: 0.18 (B) <1 veh	Overall 0.42 (A) EBL: 0.04 (A) <1 veh NBLTR: 0.03 (C) <1 veh SBLTR: 0.24 (C) <1 veh
Future Background 2019	Overall 0.38 (A) EBL: 0.05 (A) <1 veh NBLTR: 0.02 (C) <1 veh SBLTR: 0.19 (B) <1 veh	Overall 0.43 (A) EBL: 0.04 (A) <1 veh NBLTR: 0.03 (C) <1 veh SBLTR: 0.25 (C) <1 veh
Future Total 2019	Overall 0.43 (A) EBL: 0.07 (A) <1 veh NBLTR: 0.03 (C) <1 veh SBLTR: 0.37 (C) 12m	Overall 0.48 (A) EBL: 0.09 (A) <1 veh NBLTR: 0.05 (**D**) <1 veh SBLTR: 0.45 (**D**) 17m

Table 12 Capacity Analyses of Lewis Road at Highway 8

Traffic Condition	Movement v/c (LOS) 95th Percentile Queue	
	AM Peak Hour	PM Peak Hour
Future Total 2024	Overall 0.46 (A) EBL: 0.08 (A) <1 veh NBLTR: 0.03 (C) <1 veh SBLTR: 0.44 (**D**) 16m	Overall 0.51 (A) EBL: 0.10 (A) <1 veh NBLTR: 0.07 (**D**) <1 veh SBLTR: 0.56 (**E**) 23m

Under existing and all future conditions this intersection is expected to operate satisfactorily with substantial reserve capacity, acceptable levels of delay and minimal queuing.

This intersection will be assessed further as part of the ongoing Municipal EA Study on Highway 8 to address any future capacity constraints.

Therefore, GHD does not recommend any improvements to this intersection, at this time.

7.1.11 Highway 8 at Collector Road "D"

Unsignalized capacity analyses during the weekday AM and PM peak hours are summarized in **Table 13** from detailed Synchro reports attached in the Appendix.

Table 13 Capacity Analyses of Highway 8 at Collector Road "D"

Traffic Condition	Movement v/c (LOS) 95th Percentile Queue	
	AM Peak Hour	PM Peak Hour
Future Total 2019	Overall 0.60 (B) EBLR: 0.04 (A) <1 veh NBT: 0.33 (C) 11 m	Overall 0.78 (**D**) EBLR: 0.14 (A) <1 veh NBT: 0.28 (C) 1 veh
Future Total 2024	Overall 0.63 (B) EBLR: 0.04 (A) <1 veh NBT: 0.36 (C) 12 m	Overall 0.83 (**E**) EBLR: 0.15 (A) <1 veh NBT: 0.31 (C) 10 m

Under future total traffic conditions this intersection is expected to operate satisfactorily with substantial reserve capacity, acceptable levels of delay and minimal queuing.

This intersection will be assessed further as part of the ongoing Municipal EA Study on Highway 8 to address any future capacity constraints.

Therefore, GHD does not recommend any future improvements to this intersection, at this time.

8. Intersection Control

8.1 All-Way Stop Warrants

GHD undertook all-way stop control warrants for all proposed unsignalized intersections. As per the Ontario Traffic Manual (OTM) Book 5 for Regulatory Signs, unsignalized intersections should have at least 350 vehicles per hour for all approaches for minor intersections, and 500 vehicles per hour for all approaches for major intersections, during the peak hour, for an all-way stop to be warranted.

As per the forecasted 2024 future total traffic volumes presented in this report, none of the proposed unsignalized intersections meet the minimum volume threshold as per OTM.

8.2 External Intersection Traffic Signal Warrants

GHD undertook traffic signal warrants as per OTM Book 12 methodology for the following intersections:

- Barton Street at McNeilly Road
- Barton Street at Lewis Road
- Highway 8 at Lewis Road

As per the results of the traffic signal warrants, which are provided in **Appendix F**, none of these intersections warrant signalization under 2024 future total traffic conditions.

8.3 Internal Intersection Control

8.3.1 Roundabout Warrant

GHD has considered the feasibility of roundabouts internal to the subject subdivision, specifically at the future collector road intersections of:

- Collector Road “D” at McNeilly Road
- Collector Road “D” at Collector Road “E”
- Collector Road “D” at Lewis Road
- Collector Road “D” at Collector Road “D”

The City’s Development Engineering Guidelines states, in referencing Hamilton’s Installation of Modern Roundabouts Policy (2008), “if new signals are being considered for an intersection, the potential for a roundabout must also be examined.”

Signals are not being considered at the proposed collector road intersections, and therefore the potential for roundabouts need not be examined based on this criterion.

The City’s Development Engineering Guidelines further states that:

Modern roundabouts will be installed wherever possible, where a study confirms they are feasible, appropriate and advantageous in terms of traffic flow, traffic safety, community design functions or environmental considerations, under the following conditions:

1. Capacity or safety problems have been identified at existing intersections necessitating substantial improvements.
2. Traffic signals or all-way stops are warranted or expected to be warranted in the near future at existing or proposed intersections.
3. As part of a larger capital project, suitable intersections are identified as potential sites.
4. When, through planning approvals, new intersections are to be created.

As per the results of the capacity analysis, operational and safety problems at the aforementioned collector road intersections are not expected under future conditions.

Traffic signals and all-way stop controls are also not warranted at these internal intersections due to insufficient volumes.

8.3.2 Roundabout Analysis

Despite not being warranted, as requested by City staff, GHD has undertaken roundabout analysis at the proposed collector road intersections utilizing the industry-standard Arcady software. A capacity adjustment of 15 percent to the Y-intercept of the capacity equation was applied to approximate driver unfamiliarity with roundabout operations. The results of the analysis under 2024 Future Total traffic conditions are show in **Table 14**. The raw Arcady data sheets are provided in **Appendix G**.

Table 14 Roundabout Analysis Results

Traffic Condition	Movement v/c (LOS) 95th Percentile Queue	
	AM Peak Hour	PM Peak Hour
Collector Road “D” at McNeilly Road	SB: 0.12 (A) <25 m NB: 0.25 (A) <25 m WB: 0.32 (A) <25 m	SB: 0.36 (A) <25 m NB: 0.26 (A) <25 m WB: 0.23 (A) <25 m
Collector Road “D” at Collector Road “E”	WB: 0.28 (A) <25 m SB: 0.09 (A) <25 m EB: 0.07 (A) <25 m NB: 0.10 (A) <25 m	WB: 0.25 (A) <25 m SB: 0.08 (A) <25 m EB: 0.25 (A) <25 m NB: 0.17 (A) <25 m
Collector Road “D” at Lewis Road	WB: 0.22 (A) <25 m SB: 0.13 (A) <25 m EB: 0.11 (A) <25 m NB: 0.17 (A) <25 m	WB: 0.16 (A) <25 m SB: 0.27 (A) <25 m EB: 0.19 (A) <25 m NB: 0.15 (A) <25 m
Collector Road “D” at Collector Road “D”	SB: 0.13 (A) <25 m EB: 0.05 (A) <25 m NB: 0.04 (A) <25 m	SB: 0.09 (A) <25 m EB: 0.07 (A) <25 m NB: 0.10 (A) <25 m

The results of the roundabout analysis indicate that all intersections configured as roundabouts would operate satisfactorily with reserve capacity, low levels of delay, and nominal queueing.

8.4 Proposed Internal Intersection Control

Within the Block 3 Servicing Strategy Area, the interim or ultimate intersection design and traffic control at internal intersections will be confirmed at the Draft Plan stage with submission of the corresponding Draft Plans of subdivision as development proceeds. In addition to stop control and traffic signals, mini roundabouts and traffic circles should be considered during the draft plan stage as a traffic control and calming measure to address capacity, safety and speeding issues.

8.5 Auxiliary Turning Lanes

As per the satisfactory results of the capacity analysis, which analyzed all existing intersections under their current configuration and all proposed intersections without auxiliary turning lanes, no new auxiliary turning lanes are recommended.

9. Conclusions

9.1 Summary of Findings

Full build-out of the Block 3 Servicing Strategy Area lands is estimated to generate a total of 1,696 two-way trips during the AM peak hour consisting of 425 inbound and 1,271 outbound trips and a total of 2,206 two-way trips during the PM peak hour consisting of 1,419 inbound and 787 outbound trips.

The study intersections are expected to have acceptable future operating characteristics with reserve capacity under 2018 existing, 2019 future background, and 2019 and 2024 future total conditions. Although the operational impact of the added site traffic is likely to be noticeable to the immediate surrounding road network, as expected with a development of this size, it is not expected to contribute to any significant deterioration of overall network's operational performance.

Under 2024 future total traffic conditions, the existing all-way stop controlled intersections of McNeilly Road and Lewis Road on Barton Street are reported to have increased delays resulting in LOS “F”.

With respect to noted delay concerns at the existing intersections along Highway 8 and Barton Street, future intersections improvements to mitigate any intersections capacity issues along either of these roads will be determined through the ongoing Highway 8 Improvements EA and the Barton Street and Fifty Road Improvements EA studies.

9.2 Summary of Recommendations

The Collector Road “D” proposed right-of-way (ROW) width is 26 m from its western extent at McNeilly Road to its eastern extent at Barton Street; a short segment connecting Collector Road “D” to Highway 8 is proposed with a 20 m ROW width. The Collector Road “E” proposed right-of-way (ROW) width is 26 m throughout. The local road proposed right-of-way (ROW) widths are 20 m throughout.

The following new intersections are proposed:

- Collector Road “D” at Lewis Road
- Collector Road “E” at Highway 8
- Collector Road “D” at Highway 8
- Collector Road “D” at McNeilly Road
- Collector Road “E” at Barton Street
- Collector Road “D” opposite Escarpment Drive at Barton Street
- Two proposed laneway connections on McNeilly Road just north of Highway 8.

As per the results of the all-way stop and traffic signal warrants, and satisfactory operating conditions under two-way stop control as per the results of the capacity analysis, two-way stop control is sufficient at all internal collector road intersections. Future intersection geometry and traffic control at these intersections will be determined through the respective draft plan or site plan applications as they proceed. In addition to stop control and traffic signals, mini roundabouts and traffic circles should be considered during the draft plan stage as a traffic control and calming measure to address capacity, safety and speeding issues.

Therefore, GHD is not recommending improvements at these intersections.

about GHD

GHD is one of the world's leading professional services companies operating in the global markets of water, energy and resources, environment, property and buildings, and transportation. We provide engineering, environmental, and construction services to private and public sector clients.

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Appendices

Appendix A
Turning Movement Counts

Accu-Traffic Inc.

Morning Peak Diagram

Specified Period
From: 7:00:00
To: 9:00:00

One Hour Peak
From: 7:45:00
To: 8:45:00

Municipality: Hamilton
Site #: 1608500001
Intersection: Barton St & Escarpment Dr
TFR File #: 1
Count date: 25-May-16

Weather conditions:

Person counted:
Person prepared:
Person checked:

**** Non-Signalized Intersection ****

Major Road: Barton St runs W/E

North Leg Total: 37
North Entering: 30
North Peds: 1
Peds Cross: ⋈

Heavys	1	0	1
Trucks	0	0	0
Cars	22	7	29
Totals	23	7	

Heavys	0
Trucks	1
Cars	6
Totals	7

East Leg Total: 273
East Entering: 167
East Peds: 25
Peds Cross: ⧗

Escarpment Dr

Heavys	Trucks	Cars	Totals
12	0	178	190

Barton St

Cars	Trucks	Heavys	Totals
0	0	0	0
156	0	11	167
156	0	11	

N
W E
S

Heavys	Trucks	Cars	Totals
0	1	6	7
9	2	88	99
9	3	94	

Barton St

Cars	Trucks	Heavys	Totals
95	2	9	106

Peds Cross: ⧗
West Peds: 0
West Entering: 106
West Leg Total: 296

Comments

Accu-Traffic Inc.
Traffic Monitoring & Data Analysis

Accu-Traffic Inc.

Afternoon Peak Diagram

Specified Period
From: 16:00:00
To: 18:00:00

One Hour Peak
From: 16:00:00
To: 17:00:00

Municipality: Hamilton
Site #: 1608500001
Intersection: Barton St & Escarpment Dr
TFR File #: 1
Count date: 25-May-16

Weather conditions:

Person counted:
Person prepared:
Person checked:

**** Non-Signalized Intersection ****

Major Road: Barton St runs W/E

North Leg Total: 53
North Entering: 21
North Peds: 4
Peds Cross: ⋈

Heavys	0	1	1
Trucks	0	0	0
Cars	19	1	20
Totals	19	2	

Heavys	0
Trucks	0
Cars	32
Totals	32

East Leg Total: 353
East Entering: 107
East Peds: 5
Peds Cross: ⧗

Escarpment Dr

Heavys	Trucks	Cars	Totals
5	2	113	120

Cars	Trucks	Heavys	Totals
6	0	0	6
94	2	5	101
100	2	5	

Barton St

N
W E
S

Heavys	Trucks	Cars	Totals
0	0	26	26
4	0	240	244
4	0	266	

Barton St

Cars	Trucks	Heavys	Totals
241	0	5	246

Peds Cross: ⧗
West Peds: 0
West Entering: 270
West Leg Total: 390

Comments

Accu-Traffic Inc.

Total Count Diagram

Municipality: Hamilton
Site #: 1608500001
Intersection: Barton St & Escarpment Dr
TFR File #: 1
Count date: 25-May-16

Weather conditions:

Person counted:
Person prepared:
Person checked:

**** Non-Signalized Intersection ****

Major Road: Barton St runs W/E

North Leg Total: 195
North Entering: 106
North Peds: 9
Peds Cross: ⋈

Heavys	1	1	2
Trucks	0	1	1
Cars	83	20	103
Totals	84	22	

Heavys	1
Trucks	1
Cars	87
Totals	89

East Leg Total: 1110
East Entering: 474
East Peds: 39
Peds Cross: ⧖

Escarpment Dr

Heavys	Trucks	Cars	Totals
24	5	513	542

Cars	Trucks	Heavys	Totals
15	0	1	16
430	5	23	458
445	5	24	

Barton St

N
W E
S

Heavys	Trucks	Cars	Totals
0	1	72	73
22	5	587	614
22	6	659	

Barton St

Cars	Trucks	Heavys	Totals
607	6	23	636

Peds Cross: ⧖
West Peds: 0
West Entering: 687
West Leg Total: 1229

Comments

Accu-Traffic Inc.
Traffic Count Summary

Intersection: Barton St & Escarpment Dr	Count Date: 25-May-16	Municipality: Hamilton

North Approach Totals						North/South Total Approaches	South Approach Totals					
Hour Ending	Includes Cars, Trucks, & Heavys				Total Peds		Hour Ending	Includes Cars, Trucks, & Heavys				Total Peds
	Left	Thru	Right	Grand Total				Left	Thru	Right	Grand Total	
7:00:00	0	0	0	0	0	0	7:00:00	0	0	0	0	0
8:00:00	7	0	25	32	3	32	8:00:00	0	0	0	0	0
9:00:00	8	0	28	36	1	36	9:00:00	0	0	0	0	0
16:00:00	0	0	0	0	0	0	16:00:00	0	0	0	0	0
17:00:00	2	0	19	21	4	21	17:00:00	0	0	0	0	0
18:00:00	5	0	12	17	1	17	18:00:00	0	0	0	0	0
Totals:	22	0	84	106	9	106	S Totals:	0	0	0	0	0

East Approach Totals						East/West Total Approaches	West Approach Totals					
Hour Ending	Includes Cars, Trucks, & Heavys				Total Peds		Hour Ending	Includes Cars, Trucks, & Heavys				Total Peds
	Left	Thru	Right	Grand Total				Left	Thru	Right	Grand Total	
7:00:00	0	0	0	0	0	0	7:00:00	0	0	0	0	0
8:00:00	0	122	2	124	3	185	8:00:00	6	55	0	61	0
9:00:00	0	154	1	155	27	256	9:00:00	6	95	0	101	0
16:00:00	0	0	0	0	0	0	16:00:00	0	0	0	0	0
17:00:00	0	101	6	107	5	377	17:00:00	26	244	0	270	0
18:00:00	0	81	7	88	4	343	18:00:00	35	220	0	255	0
Totals:	0	458	16	474	39	1161	W Totals:	73	614	0	687	0

Calculated Values for Traffic Crossing Major Street

Hours Ending:	7:00	8:00	9:00	16:00	17:00	18:00	0:00	0:00
Crossing Values:	0	10	35	0	7	9	0	0

Accu-Traffic Inc.

Count Date: 25-May-16 **Site #: 1608500001**

Interval Time	Passenger Cars - North Approach						Trucks - North Approach						Heavys - North Approach						Pedestrians	
	Left		Thru		Right		Left		Thru		Right		Left		Thru		Right		North Cross	
	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr
7:00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15:00	3	3	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:30:00	4	1	0	0	10	6	0	0	0	0	0	0	0	0	0	0	0	0	3	3
7:45:00	6	2	0	0	22	12	0	0	0	0	0	0	0	0	0	0	0	0	3	0
8:00:00	7	1	0	0	25	3	0	0	0	0	0	0	0	0	0	0	0	0	3	0
8:15:00	9	2	0	0	28	3	0	0	0	0	0	0	0	0	0	0	0	0	3	0
8:30:00	12	3	0	0	36	8	0	0	0	0	0	0	0	0	0	0	1	1	3	0
8:45:00	13	1	0	0	44	8	0	0	0	0	0	0	0	0	0	0	1	0	4	1
9:00:00	15	2	0	0	52	8	0	0	0	0	0	0	0	0	0	0	1	0	4	0
9:15:00	15	0	0	0	52	0	0	0	0	0	0	0	0	0	0	0	1	0	4	0
16:00:00	15	0	0	0	52	0	0	0	0	0	0	0	0	0	0	0	1	0	4	0
16:15:00	15	0	0	0	54	2	0	0	0	0	0	0	0	0	0	0	1	0	8	4
16:30:00	16	1	0	0	61	7	0	0	0	0	0	0	0	0	0	0	1	0	8	0
16:45:00	16	0	0	0	66	5	0	0	0	0	0	0	1	1	0	0	1	0	8	0
17:00:00	16	0	0	0	71	5	0	0	0	0	0	0	1	0	0	0	1	0	8	0
17:15:00	17	1	0	0	72	1	0	0	0	0	0	0	1	0	0	0	1	0	9	1
17:30:00	17	0	0	0	75	3	0	0	0	0	0	0	1	0	0	0	1	0	9	0
17:45:00	20	3	0	0	79	4	0	0	0	0	0	0	1	0	0	0	1	0	9	0
18:00:00	20	0	0	0	83	4	1	1	0	0	0	0	1	0	0	0	1	0	9	0
18:15:00	20	0	0	0	83	0	1	0	0	0	0	0	1	0	0	0	1	0	9	0
18:15:15	20	0	0	0	83	0	1	0	0	0	0	0	1	0	0	0	1	0	9	0

Accu-Traffic Inc.

Count Date: 25-May-16 Site #: 1608500001

Interval Time	Passenger Cars - East Approach						Trucks - East Approach						Heavys - East Approach						Pedestrians	
	Left		Thru		Right		Left		Thru		Right		Left		Thru		Right		East Cross	
	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr
7:00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15:00	0	0	19	19	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:30:00	0	0	36	17	1	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
7:45:00	0	0	78	42	2	1	0	0	1	1	0	0	0	0	2	1	0	0	3	2
8:00:00	0	0	118	40	2	0	0	0	1	0	0	0	0	0	3	1	0	0	3	0
8:15:00	0	0	150	32	2	0	0	0	1	0	0	0	0	0	6	3	0	0	14	11
8:30:00	0	0	207	57	2	0	0	0	1	0	0	0	0	0	13	7	0	0	28	14
8:45:00	0	0	234	27	2	0	0	0	1	0	0	0	0	0	13	0	0	0	28	0
9:00:00	0	0	259	25	2	0	0	0	1	0	0	0	0	0	16	3	1	1	30	2
9:15:00	0	0	259	0	2	0	0	0	1	0	0	0	0	0	16	0	1	0	30	0
16:00:00	0	0	259	0	2	0	0	0	1	0	0	0	0	0	16	0	1	0	30	0
16:15:00	0	0	285	26	2	0	0	0	2	1	0	0	0	0	19	3	1	0	33	3
16:30:00	0	0	311	26	5	3	0	0	2	0	0	0	0	0	21	2	1	0	33	0
16:45:00	0	0	331	20	7	2	0	0	3	1	0	0	0	0	21	0	1	0	35	2
17:00:00	0	0	353	22	8	1	0	0	3	0	0	0	0	0	21	0	1	0	35	0
17:15:00	0	0	371	18	9	1	0	0	5	2	0	0	0	0	21	0	1	0	35	0
17:30:00	0	0	391	20	10	1	0	0	5	0	0	0	0	0	22	1	1	0	37	2
17:45:00	0	0	412	21	11	1	0	0	5	0	0	0	0	0	23	1	1	0	39	2
18:00:00	0	0	430	18	15	4	0	0	5	0	0	0	0	0	23	0	1	0	39	0
18:15:00	0	0	430	0	15	0	0	0	5	0	0	0	0	0	23	0	1	0	39	0
18:15:15	0	0	430	0	15	0	0	0	5	0	0	0	0	0	23	0	1	0	39	0

Accu-Traffic Inc.

Count Date: 25-May-16   Site #: 1608500001

Interval Time	Passenger Cars - South Approach						Trucks - South Approach						Heavys - South Approach						Pedestrians	
	Left		Thru		Right		Left		Thru		Right		Left		Thru		Right		South Cross	
	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr
7:00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:30:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:45:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:15:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:30:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:45:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9:00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9:15:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:15:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:30:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16:45:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17:00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17:15:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17:30:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17:45:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18:00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18:15:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18:15:15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Accu-Traffic Inc.
Traffic Monitoring & Data Analysis

Accu-Traffic Inc.

Count Date: 25-May-16 Site #: 1608500001

Interval Time	Passenger Cars - West Approach						Trucks - West Approach						Heavys - West Approach						Pedestrians	
	Left		Thru		Right		Left		Thru		Right		Left		Thru		Right		West Cross	
	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr
7:00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15:00	1	1	10	10	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
7:30:00	3	2	19	9	0	0	0	0	1	1	0	0	0	0	4	3	0	0	0	0
7:45:00	4	1	27	8	0	0	0	0	2	1	0	0	0	0	5	1	0	0	0	0
8:00:00	6	2	44	17	0	0	0	0	4	2	0	0	0	0	7	2	0	0	0	0
8:15:00	8	2	59	15	0	0	0	0	4	0	0	0	0	0	7	0	0	0	0	0
8:30:00	8	0	84	25	0	0	1	1	4	0	0	0	0	0	11	4	0	0	0	0
8:45:00	10	2	115	31	0	0	1	0	4	0	0	0	0	0	14	3	0	0	0	0
9:00:00	11	1	129	14	0	0	1	0	5	1	0	0	0	0	16	2	0	0	0	0
9:15:00	11	0	129	0	0	0	1	0	5	0	0	0	0	0	16	0	0	0	0	0
16:00:00	11	0	129	0	0	0	1	0	5	0	0	0	0	0	16	0	0	0	0	0
16:15:00	18	7	192	63	0	0	1	0	5	0	0	0	0	0	16	0	0	0	0	0
16:30:00	23	5	243	51	0	0	1	0	5	0	0	0	0	0	16	0	0	0	0	0
16:45:00	31	8	303	60	0	0	1	0	5	0	0	0	0	0	20	4	0	0	0	0
17:00:00	37	6	369	66	0	0	1	0	5	0	0	0	0	0	20	0	0	0	0	0
17:15:00	47	10	437	68	0	0	1	0	5	0	0	0	0	0	21	1	0	0	0	0
17:30:00	55	8	489	52	0	0	1	0	5	0	0	0	0	0	21	0	0	0	0	0
17:45:00	66	11	537	48	0	0	1	0	5	0	0	0	0	0	22	1	0	0	0	0
18:00:00	72	6	587	50	0	0	1	0	5	0	0	0	0	0	22	0	0	0	0	0
18:15:00	72	0	587	0	0	0	1	0	5	0	0	0	0	0	22	0	0	0	0	0
18:15:15	72	0	587	0	0	0	1	0	5	0	0	0	0	0	22	0	0	0	0	0

Accu-Traffic Inc.
Traffic Monitoring & Data Analysis

Accu-Traffic Inc.

Morning Peak Diagram

Specified Period
From: 7:00:00
To: 9:00:00

One Hour Peak
From: 7:45:00
To: 8:45:00

Municipality: Hamilton
Site #: 1608500002
Intersection: Barton St & Lewis Rd
TFR File #: 1
Count date: 25-May-16

Weather conditions:

Person counted:
Person prepared:
Person checked:

**** Non-Signalized Intersection ****

Major Road: Barton St runs W/E

North Leg Total: 200
North Entering: 74
North Peds: 0
Peds Cross: ⋈

Heavys	1	0	0	1
Trucks	2	0	0	2
Cars	17	49	5	71
Totals	20	49	5	

Heavys	2
Trucks	1
Cars	123
Totals	126

East Leg Total: 298
East Entering: 191
East Peds: 0
Peds Cross: ⧖

Lewis Rd

Heavys	Trucks	Cars	Totals
10	2	159	171

Barton St

Cars	Trucks	Heavys	Totals
13	0	0	13
103	0	6	109
63	0	6	69
179	0	12	

N
W E
S

Heavys	Trucks	Cars	Totals
0	1	51	52
3	3	49	55
7	1	44	52
10	5	144	

Barton St

Cars	Trucks	Heavys	Totals
95	3	9	107

Lewis Rd

Peds Cross: ⧖
West Peds: 2
West Entering: 159
West Leg Total: 330

Cars	156
Trucks	1
Heavys	13
Totals	170

Cars	39	59	41	139
Trucks	0	0	0	0
Heavys	3	2	6	11
Totals	42	61	47	

Peds Cross: ⋈
South Peds: 43
South Entering: 150
South Leg Total: 320

Comments

Accu-Traffic Inc.

Afternoon Peak Diagram

Specified Period		One Hour Peak	
From:	16:00:00	**From:**	16:15:00
To:	18:00:00	**To:**	17:15:00

Municipality: Hamilton
Site #: 1608500002
Intersection: Barton St & Lewis Rd
TFR File #: 1
Count date: 25-May-16

Weather conditions:

Person counted:
Person prepared:
Person checked:

**** Non-Signalized Intersection ****

Major Road: Barton St runs W/E

North Leg Total: 164
North Entering: 121
North Peds: 0
Peds Cross: ⋈

Heavys	2	0	0	2
Trucks	1	0	0	1
Cars	23	73	22	118
Totals	26	73	22	

Heavys	1
Trucks	3
Cars	39
Totals	43

East Leg Total: 385
East Entering: 111
East Peds: 0
Peds Cross: ⧗

Lewis Rd

Heavys	Trucks	Cars	Totals
3	5	121	129

Barton St

Cars	Trucks	Heavys	Totals
4	0	0	4
78	4	1	83
23	0	1	24
105	4	2	

N
W E
S

Heavys	Trucks	Cars	Totals
1	2	22	25
4	1	197	202
0	0	21	21
5	3	240	

Barton St

Cars	Trucks	Heavys	Totals
269	1	4	274

Lewis Rd

Peds Cross: ⧗
West Peds: 4
West Entering: 248
West Leg Total: 377

Cars	117
Trucks	0
Heavys	1
Totals	118

Cars	20	13	50	83
Trucks	0	1	0	1
Heavys	0	0	0	0
Totals	20	14	50	

Peds Cross: ⋈
South Peds: 4
South Entering: 84
South Leg Total: 202

Comments

Accu-Traffic Inc.

Total Count Diagram

Municipality: Hamilton
Site #: 1608500002
Intersection: Barton St & Lewis Rd
TFR File #: 1
Count date: 25-May-16

Weather conditions:

Person counted:
Person prepared:
Person checked:

**** Non-Signalized Intersection ****

Major Road: Barton St runs W/E

North Leg Total: 660
North Entering: 351
North Peds: 0
Peds Cross: ⋈

North approach (Lewis Rd, southbound entering)

Heavys	10	2	1	13
Trucks	7	0	0	7
Cars	78	190	63	331
Totals	95	192	64	

North leg (northbound exiting)

Heavys	9
Trucks	6
Cars	294
Totals	309

East Leg Total: 1239
East Entering: 548
East Peds: 1
Peds Cross: ⧗

Lewis Rd

West leg (westbound exiting)

Heavys	Trucks	Cars	Totals
28	13	516	557

Barton St

East approach (westbound entering)

Cars	Trucks	Heavys	Totals
45	0	3	48
347	5	14	366
127	0	7	134
519	5	24	

N
W
E
S

West approach (eastbound entering)

Heavys	Trucks	Cars	Totals
3	5	125	133
14	7	448	469
8	1	93	102
25	13	666	

Barton St

East leg (eastbound exiting)

Cars	Trucks	Heavys	Totals
662	7	22	691

Lewis Rd

Peds Cross: ⧗
West Peds: 10
West Entering: 704
West Leg Total: 1261

South leg (southbound exiting)

Cars	410
Trucks	1
Heavys	17
Totals	428

South approach (northbound entering)

Cars	91	124	151	366
Trucks	1	1	0	2
Heavys	4	3	7	14
Totals	96	128	158	

Peds Cross: ⋈
South Peds: 56
South Entering: 382
South Leg Total: 810

Comments

Accu-Traffic Inc.

Traffic Count Summary

Intersection: Barton St & Lewis Rd	Count Date: 25-May-16	Municipality: Hamilton

North Approach Totals / South Approach Totals

North Hour Ending	North Left	North Thru	North Right	North Grand Total	North Total Peds	North/South Total Approaches	South Hour Ending	South Left	South Thru	South Right	South Grand Total	South Total Peds
7:00:00	0	0	0	0	0	0	7:00:00	0	0	0	0	0
8:00:00	5	23	19	47	0	118	8:00:00	18	43	10	71	3
9:00:00	8	49	21	78	0	227	9:00:00	43	57	49	149	44
16:00:00	0	0	0	0	0	0	16:00:00	0	0	0	0	0
17:00:00	20	61	30	111	0	197	17:00:00	20	13	53	86	5
18:00:00	31	59	25	115	0	191	18:00:00	15	15	46	76	4
Totals:	64	192	95	351	0	733	S Totals:	96	128	158	382	56

(Left, Thru, Right and Grand Total columns: Includes Cars, Trucks, & Heavys)

East Approach Totals / West Approach Totals

East Hour Ending	East Left	East Thru	East Right	East Grand Total	East Total Peds	East/West Total Approaches	West Hour Ending	West Left	West Thru	West Right	West Grand Total	West Total Peds
7:00:00	0	0	0	0	0	0	7:00:00	0	0	0	0	0
8:00:00	18	111	16	145	1	244	8:00:00	26	55	18	99	2
9:00:00	69	104	13	186	0	346	9:00:00	68	45	47	160	2
16:00:00	0	0	0	0	0	0	16:00:00	0	0	0	0	0
17:00:00	27	89	7	123	0	354	17:00:00	21	191	19	231	4
18:00:00	20	62	12	94	0	308	18:00:00	18	178	18	214	2
Totals:	134	366	48	548	1	1252	W Totals:	133	469	102	704	10

(Left, Thru, Right and Grand Total columns: Includes Cars, Trucks, & Heavys)

Calculated Values for Traffic Crossing Major Street

Hours Ending:	7:00	8:00	9:00	16:00	17:00	18:00	0:00	0:00
Crossing Values:	0	69	110	0	105	107	0	0

Accu-Traffic Inc.

Count Date: 25-May-16 Site #: 1608500002

Interval Time	Passenger Cars - North Approach						Trucks - North Approach						Heavys - North Approach						Pedestrians	
	Left		Thru		Right		Left		Thru		Right		Left		Thru		Right		North Cross	
	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr
7:00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15:00	3	3	4	4	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:30:00	3	0	10	6	7	3	0	0	0	0	0	0	0	0	0	0	1	1	0	0
7:45:00	4	1	17	7	13	6	0	0	0	0	1	1	0	0	0	0	1	0	0	0
8:00:00	5	1	23	6	17	4	0	0	0	0	1	0	0	0	0	0	1	0	0	0
8:15:00	6	1	40	17	22	5	0	0	0	0	1	0	0	0	0	0	1	0	0	0
8:30:00	6	0	57	17	25	3	0	0	0	0	3	2	0	0	0	0	2	1	0	0
8:45:00	9	3	66	9	30	5	0	0	0	0	3	0	0	0	0	0	2	0	0	0
9:00:00	12	3	70	4	34	4	0	0	0	0	3	0	1	1	2	2	3	1	0	0
9:15:00	12	0	70	0	34	0	0	0	0	0	3	0	1	0	2	0	3	0	0	0
16:00:00	12	0	70	0	34	0	0	0	0	0	3	0	1	0	2	0	3	0	0	0
16:15:00	22	10	81	11	43	9	0	0	0	0	5	2	1	0	2	0	4	1	0	0
16:30:00	26	4	93	12	46	3	0	0	0	0	6	1	1	0	2	0	5	1	0	0
16:45:00	29	3	113	20	55	9	0	0	0	0	6	0	1	0	2	0	5	0	0	0
17:00:00	32	3	131	18	59	4	0	0	0	0	6	0	1	0	2	0	5	0	0	0
17:15:00	44	12	154	23	66	7	0	0	0	0	6	0	1	0	2	0	6	1	0	0
17:30:00	50	6	169	15	70	4	0	0	0	0	6	0	1	0	2	0	8	2	0	0
17:45:00	56	6	182	13	74	4	0	0	0	0	7	1	1	0	2	0	9	1	0	0
18:00:00	63	7	190	8	78	4	0	0	0	0	7	0	1	0	2	0	10	1	0	0
18:15:00	63	0	190	0	78	0	0	0	0	0	7	0	1	0	2	0	10	0	0	0
18:15:15	63	0	190	0	78	0	0	0	0	0	7	0	1	0	2	0	10	0	0	0

Accu-Traffic Inc.

Count Date: 25-May-16 Site #: 1608500002

Interval Time	Passenger Cars - East Approach						Trucks - East Approach						Heavys - East Approach						Pedestrians	
	Left		Thru		Right		Left		Thru		Right		Left		Thru		Right		East Cross	
	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr
7:00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15:00	3	3	18	18	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:30:00	6	3	36	18	5	3	0	0	0	0	0	0	0	0	1	1	0	0	1	1
7:45:00	12	6	75	39	12	7	0	0	1	1	0	0	0	0	2	1	0	0	1	0
8:00:00	18	6	107	32	16	4	0	0	1	0	0	0	0	0	3	1	0	0	1	0
8:15:00	26	8	134	27	17	1	0	0	1	0	0	0	0	0	6	3	0	0	1	0
8:30:00	60	34	159	25	22	5	0	0	1	0	0	0	6	6	8	2	0	0	1	0
8:45:00	75	15	178	19	25	3	0	0	1	0	0	0	6	0	8	0	0	0	1	0
9:00:00	81	6	204	26	28	3	0	0	1	0	0	0	6	0	10	2	1	1	1	0
9:15:00	81	0	204	0	28	0	0	0	1	0	0	0	6	0	10	0	1	0	1	0
16:00:00	81	0	204	0	28	0	0	0	1	0	0	0	6	0	10	0	1	0	1	0
16:15:00	87	6	225	21	31	3	0	0	1	0	0	0	6	0	13	3	1	0	1	0
16:30:00	94	7	248	23	32	1	0	0	2	1	0	0	7	1	14	1	1	0	1	0
16:45:00	103	9	265	17	34	2	0	0	3	1	0	0	7	0	14	0	1	0	1	0
17:00:00	107	4	287	22	35	1	0	0	3	0	0	0	7	0	14	0	1	0	1	0
17:15:00	110	3	303	16	35	0	0	0	5	2	0	0	7	0	14	0	1	0	1	0
17:30:00	114	4	319	16	38	3	0	0	5	0	0	0	7	0	14	0	1	0	1	0
17:45:00	122	8	331	12	44	6	0	0	5	0	0	0	7	0	14	0	3	2	1	0
18:00:00	127	5	347	16	45	1	0	0	5	0	0	0	7	0	14	0	3	0	1	0
18:15:00	127	0	347	0	45	0	0	0	5	0	0	0	7	0	14	0	3	0	1	0
18:15:15	127	0	347	0	45	0	0	0	5	0	0	0	7	0	14	0	3	0	1	0

Accu-Traffic Inc.

Count Date: 25-May-16 Site #: 1608500002

Interval Time	Passenger Cars - South Approach						Trucks - South Approach						Heavys - South Approach						Pedestrians	
	Left		Thru		Right		Left		Thru		Right		Left		Thru		Right		South Cross	
	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr
7:00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15:00	3	3	13	13	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:30:00	8	5	19	6	5	2	1	1	0	0	0	0	0	0	1	1	0	0	1	1
7:45:00	13	5	31	12	7	2	1	0	0	0	0	0	0	0	1	0	1	1	3	2
8:00:00	17	4	42	11	9	2	1	0	0	0	0	0	0	0	1	0	1	0	3	0
8:15:00	22	5	52	10	13	4	1	0	0	0	0	0	0	0	2	1	1	0	8	5
8:30:00	30	8	73	21	27	14	1	0	0	0	0	0	1	1	3	1	4	3	33	25
8:45:00	52	22	90	17	48	21	1	0	0	0	0	0	3	2	3	0	7	3	46	13
9:00:00	56	4	97	7	52	4	1	0	0	0	0	0	4	1	3	0	7	0	47	1
9:15:00	56	0	97	0	52	0	1	0	0	0	0	0	4	0	3	0	7	0	47	0
16:00:00	56	0	97	0	52	0	1	0	0	0	0	0	4	0	3	0	7	0	47	0
16:15:00	61	5	101	4	70	18	1	0	0	0	0	0	4	0	3	0	7	0	48	1
16:30:00	66	5	105	4	86	16	1	0	0	0	0	0	4	0	3	0	7	0	51	3
16:45:00	71	5	108	3	101	15	1	0	1	1	0	0	4	0	3	0	7	0	51	0
17:00:00	76	5	109	1	105	4	1	0	1	0	0	0	4	0	3	0	7	0	52	1
17:15:00	81	5	114	5	120	15	1	0	1	0	0	0	4	0	3	0	7	0	52	0
17:30:00	83	2	117	3	134	14	1	0	1	0	0	0	4	0	3	0	7	0	53	1
17:45:00	89	6	119	2	145	11	1	0	1	0	0	0	4	0	3	0	7	0	55	2
18:00:00	91	2	124	5	151	6	1	0	1	0	0	0	4	0	3	0	7	0	56	1
18:15:00	91	0	124	0	151	0	1	0	1	0	0	0	4	0	3	0	7	0	56	0
18:15:15	91	0	124	0	151	0	1	0	1	0	0	0	4	0	3	0	7	0	56	0

Accu-Traffic Inc.

Count Date: 25-May-16 Site #: 1608500002

Interval Time	Passenger Cars - West Approach						Trucks - West Approach						Heavys - West Approach						Pedestrians	
	Left		Thru		Right		Left		Thru		Right		Left		Thru		Right		West Cross	
	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr
7:00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15:00	6	6	9	9	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0
7:30:00	10	4	17	8	4	3	0	0	1	1	0	0	0	0	5	4	0	0	0	0
7:45:00	17	7	26	9	12	8	1	1	2	1	0	0	0	0	5	0	0	0	2	2
8:00:00	25	8	44	18	17	5	1	0	4	2	0	0	0	0	7	2	1	1	2	0
8:15:00	39	14	56	12	30	13	2	1	4	0	0	0	0	0	7	0	2	1	2	0
8:30:00	51	12	66	10	44	14	2	0	5	1	0	0	0	0	8	1	6	4	3	1
8:45:00	68	17	75	9	56	12	2	0	5	0	1	1	0	0	8	0	7	1	4	1
9:00:00	90	22	85	10	56	0	3	1	6	1	1	0	1	1	9	1	8	1	4	0
9:15:00	90	0	85	0	56	0	3	0	6	0	1	0	1	0	9	0	8	0	4	0
16:00:00	90	0	85	0	56	0	3	0	6	0	1	0	1	0	9	0	8	0	4	0
16:15:00	93	3	127	42	60	4	3	0	6	0	1	0	1	0	9	0	8	0	4	0
16:30:00	95	2	163	36	66	6	4	1	6	0	1	0	1	0	9	0	8	0	7	3
16:45:00	103	8	211	48	69	3	4	0	7	1	1	0	2	1	12	3	8	0	7	0
17:00:00	109	6	272	61	75	6	4	0	7	0	1	0	2	0	12	0	8	0	8	1
17:15:00	115	6	324	52	81	6	5	1	7	0	1	0	2	0	13	1	8	0	8	0
17:30:00	117	2	363	39	85	4	5	0	7	0	1	0	2	0	13	0	8	0	8	0
17:45:00	120	3	405	42	91	6	5	0	7	0	1	0	3	1	14	1	8	0	10	2
18:00:00	125	5	448	43	93	2	5	0	7	0	1	0	3	0	14	0	8	0	10	0
18:15:00	125	0	448	0	93	0	5	0	7	0	1	0	3	0	14	0	8	0	10	0
18:15:15	125	0	448	0	93	0	5	0	7	0	1	0	3	0	14	0	8	0	10	0

Accu-Traffic Inc.
Traffic Monitoring & Data Analysis

Accu-Traffic Inc.

Morning Peak Diagram

Specified Period
From: 7:00:00
To: 9:00:00

One Hour Peak
From: 7:30:00
To: 8:30:00

Municipality: Hamilton
Site #: 1608500003
Intersection: Barton St & McNeilly Rd
TFR File #: 1
Count date: 25-May-16

Weather conditions:

Person counted:
Person prepared:
Person checked:

**** Non-Signalized Intersection ****

Major Road: Barton St runs W/E

North Leg Total: 78
North Entering: 27
North Peds: 0
Peds Cross: ⋈

Heavys	0	0	0	0
Trucks	1	0	1	2
Cars	14	2	9	25
Totals	15	2	10	

Heavys	2
Trucks	3
Cars	46
Totals	51

East Leg Total: 333
East Entering: 179
East Peds: 1
Peds Cross: ⧗

McNeilly Rd

Heavys	Trucks	Cars	Totals
8	6	262	276

Barton St

Cars	Trucks	Heavys	Totals
10	0	1	11
146	4	7	157
10	0	1	11
166	4	9	

N
W E
S

Heavys	Trucks	Cars	Totals
1	3	26	30
7	4	106	117
2	0	8	10
10	7	140	

Barton St

Cars	Trucks	Heavys	Totals
140	6	8	154

McNeilly Rd

Peds Cross: ⧗
West Peds: 0
West Entering: 157
West Leg Total: 433

Cars	20
Trucks	0
Heavys	3
Totals	23

Cars	102	10	25	137
Trucks	1	0	1	2
Heavys	1	0	1	2
Totals	104	10	27	

Peds Cross: ⋈
South Peds: 0
South Entering: 141
South Leg Total: 164

Comments

Accu-Traffic Inc.
Traffic Monitoring & Data Analysis

Accu-Traffic Inc.

Afternoon Peak Diagram

Specified Period		One Hour Peak	
From:	16:00:00	**From:**	16:15:00
To:	18:00:00	**To:**	17:15:00

Municipality: Hamilton
Site #: 1608500003
Intersection: Barton St & McNeilly Rd
TFR File #: 1
Count date: 25-May-16

Weather conditions:

Person counted:
Person prepared:
Person checked:

**** Non-Signalized Intersection ****

Major Road: Barton St runs W/E

North Leg Total: 77
North Entering: 56
North Peds: 0
Peds Cross: ⋈

Heavys	2	0	0	2
Trucks	1	1	1	3
Cars	20	16	15	51
Totals	23	17	16	

Heavys	0
Trucks	1
Cars	20
Totals	21

East Leg Total: 382
East Entering: 132
East Peds: 2
Peds Cross: ⧗

McNeilly Rd

Heavys	Trucks	Cars	Totals
6	6	142	154

Barton St

Cars	Trucks	Heavys	Totals
6	1	0	7
100	4	3	107
18	0	0	18
124	5	3	

N
W E
S

Heavys	Trucks	Cars	Totals
0	0	10	10
6	3	206	215
0	0	59	59
6	3	275	

Barton St

Cars	Trucks	Heavys	Totals
240	4	6	250

McNeilly Rd

Peds Cross: ⧗
West Peds: 3
West Entering: 284
West Leg Total: 438

Cars	93
Trucks	1
Heavys	0
Totals	94

Cars	22	4	19	45
Trucks	1	0	0	1
Heavys	1	0	0	1
Totals	24	4	19	

Peds Cross: ⋈
South Peds: 0
South Entering: 47
South Leg Total: 141

Comments

Accu-Traffic Inc.
Traffic Monitoring & Data Analysis

Accu-Traffic Inc.

Total Count Diagram

Municipality: Hamilton
Site #: 1608500003
Intersection: Barton St & McNeilly Rd
TFR File #: 1
Count date: 25-May-16

Weather conditions:

Person counted:
Person prepared:
Person checked:

**** Non-Signalized Intersection ****

Major Road: Barton St runs W/E

North Leg Total: 306
North Entering: 167
North Peds: 0
Peds Cross: ⋈

North approach (McNeilly Rd, southbound):

Heavys	6	1	0	7
Trucks	6	1	2	9
Cars	69	34	48	151
Totals	81	36	50	

North exiting (northbound):

Heavys	4
Trucks	7
Cars	128
Totals	139

East Leg Total: 1294
East Entering: 575
East Peds: 7
Peds Cross: ⧗

McNeilly Rd

West exiting (westbound, Barton St):

Heavys	Trucks	Cars	Totals
32	21	735	788

East approach (Barton St, westbound):

Cars	Trucks	Heavys	Totals
27	3	2	32
454	12	23	489
51	0	3	54
532	15	28	

Barton St

N
W E
S

West approach (Barton St, eastbound):

Heavys	Trucks	Cars	Totals
1	3	65	69
26	10	546	582
3	0	111	114
30	13	722	

Barton St

East exiting (eastbound):

Cars	Trucks	Heavys	Totals
678	13	28	719

McNeilly Rd

Peds Cross: ⧗
West Peds: 11
West Entering: 765
West Leg Total: 1553

South exiting (southbound):

Cars	196
Trucks	1
Heavys	7
Totals	204

South approach (McNeilly Rd, northbound):

Cars	212	36	84	332
Trucks	3	1	1	5
Heavys	3	1	2	6
Totals	218	38	87	

Peds Cross: ⋈
South Peds: 2
South Entering: 343
South Leg Total: 547

Comments

Accu-Traffic Inc.

Traffic Count Summary

Intersection: Barton St & McNeilly Rd | **Count Date:** 25-May-16 | **Municipality:** Hamilton

North Approach Totals / South Approach Totals

Hour Ending	North Left	North Thru	North Right	North Grand Total	North Total Peds	North/South Total Approaches	Hour Ending	South Left	South Thru	South Right	South Grand Total	South Total Peds
7:00:00	0	0	0	0	0	0	7:00:00	0	0	0	0	0
8:00:00	7	3	14	24	0	132	8:00:00	79	11	18	108	0
9:00:00	17	4	21	42	0	185	9:00:00	90	18	35	143	0
16:00:00	0	0	0	0	0	0	16:00:00	0	0	0	0	0
17:00:00	15	11	29	55	0	106	17:00:00	29	6	16	51	0
18:00:00	11	18	17	46	0	87	18:00:00	20	3	18	41	2
Totals:	50	36	81	167	0	510	S Totals:	218	38	87	343	2

Includes Cars, Trucks, & Heavys

East Approach Totals / West Approach Totals

Hour Ending	East Left	East Thru	East Right	East Grand Total	East Total Peds	East/West Total Approaches	Hour Ending	West Left	West Thru	West Right	West Grand Total	West Total Peds
7:00:00	0	0	0	0	0	0	7:00:00	0	0	0	0	0
8:00:00	9	138	9	156	3	268	8:00:00	18	84	10	112	0
9:00:00	11	145	11	167	1	318	9:00:00	32	108	11	151	3
16:00:00	0	0	0	0	0	0	16:00:00	0	0	0	0	0
17:00:00	23	114	7	144	2	411	17:00:00	10	208	49	267	5
18:00:00	11	92	5	108	1	343	18:00:00	9	182	44	235	3
Totals:	54	489	32	575	7	1340	W Totals:	69	582	114	765	11

Includes Cars, Trucks, & Heavys

Calculated Values for Traffic Crossing Major Street

Hours Ending:	7:00	8:00	9:00	16:00	17:00	18:00	0:00	0:00
Crossing Values:	0	100	129	0	62	53	0	0

Accu-Traffic Inc.

Count Date: 25-May-16 Site #: 1608500003

Interval Time	Passenger Cars - North Approach						Trucks - North Approach						Heavys - North Approach						Pedestrians	
	Left		Thru		Right		Left		Thru		Right		Left		Thru		Right		North Cross	
	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr
7:00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15:00	2	2	2	2	3	3	0	0	0	0	0	0	0	0	0	0	1	1	0	0
7:30:00	4	2	2	0	6	3	0	0	0	0	2	2	0	0	0	0	1	0	0	0
7:45:00	5	1	2	0	9	3	0	0	0	0	2	0	0	0	0	0	1	0	0	0
8:00:00	6	1	3	1	11	2	1	1	0	0	2	0	0	0	0	0	1	0	0	0
8:15:00	10	4	3	0	16	5	1	0	0	0	2	0	0	0	0	0	1	0	0	0
8:30:00	13	3	4	1	20	4	1	0	0	0	3	1	0	0	0	0	1	0	0	0
8:45:00	17	4	4	0	20	0	1	0	0	0	3	0	0	0	0	0	3	2	0	0
9:00:00	23	6	6	2	28	8	1	0	0	0	4	1	0	0	1	1	3	0	0	0
9:15:00	23	0	6	0	28	0	1	0	0	0	4	0	0	0	1	0	3	0	0	0
16:00:00	23	0	6	0	28	0	1	0	0	0	4	0	0	0	1	0	3	0	0	0
16:15:00	27	4	11	5	40	12	1	0	0	0	4	0	0	0	1	0	4	1	0	0
16:30:00	32	5	13	2	43	3	1	0	0	0	5	1	0	0	1	0	6	2	0	0
16:45:00	35	3	14	1	46	3	2	1	0	0	5	0	0	0	1	0	6	0	0	0
17:00:00	37	2	17	3	53	7	2	0	0	0	5	0	0	0	1	0	6	0	0	0
17:15:00	42	5	27	10	60	7	2	0	1	1	5	0	0	0	1	0	6	0	0	0
17:30:00	43	1	30	3	63	3	2	0	1	0	5	0	0	0	1	0	6	0	0	0
17:45:00	46	3	33	3	66	3	2	0	1	0	5	0	0	0	1	0	6	0	0	0
18:00:00	48	2	34	1	69	3	2	0	1	0	6	1	0	0	1	0	6	0	0	0
18:15:00	48	0	34	0	69	0	2	0	1	0	6	0	0	0	1	0	6	0	0	0
18:15:15	48	0	34	0	69	0	2	0	1	0	6	0	0	0	1	0	6	0	0	0

Accu-Traffic Inc.

Count Date: 25-May-16 Site #: 1608500003

Interval Time	Passenger Cars - East Approach						Trucks - East Approach						Heavys - East Approach						Pedestrians	
	Left		Thru		Right		Left		Thru		Right		Left		Thru		Right		East Cross	
	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr
7:00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15:00	3	3	19	19	4	4	0	0	0	0	1	1	0	0	1	1	0	0	0	0
7:30:00	5	2	44	25	5	1	0	0	1	1	1	0	0	0	4	3	0	0	2	2
7:45:00	7	2	90	46	7	2	0	0	2	1	1	0	1	1	5	1	0	0	3	1
8:00:00	8	1	129	39	8	1	0	0	3	1	1	0	1	0	6	1	0	0	3	0
8:15:00	12	4	159	30	9	1	0	0	4	1	1	0	1	0	9	3	0	0	3	0
8:30:00	15	3	190	31	15	6	0	0	5	1	1	0	1	0	11	2	1	1	3	0
8:45:00	16	1	231	41	15	0	0	0	6	1	1	0	1	0	13	2	1	0	4	1
9:00:00	18	2	262	31	17	2	0	0	6	0	1	0	2	1	15	2	2	1	4	0
9:15:00	18	0	262	0	17	0	0	0	6	0	1	0	2	0	15	0	2	0	4	0
16:00:00	18	0	262	0	17	0	0	0	6	0	1	0	2	0	15	0	2	0	4	0
16:15:00	27	9	291	29	18	1	0	0	7	1	2	1	2	0	19	4	2	0	4	0
16:30:00	31	4	314	23	19	1	0	0	8	1	2	0	2	0	21	2	2	0	6	2
16:45:00	35	4	341	27	21	2	0	0	9	1	2	0	2	0	21	0	2	0	6	0
17:00:00	41	6	366	25	23	2	0	0	10	1	2	0	2	0	21	0	2	0	6	0
17:15:00	45	4	391	25	24	1	0	0	11	1	3	1	2	0	22	1	2	0	6	0
17:30:00	49	4	408	17	24	0	0	0	11	0	3	0	3	1	22	0	2	0	7	1
17:45:00	51	2	430	22	24	0	0	0	12	1	3	0	3	0	23	1	2	0	7	0
18:00:00	51	0	454	24	27	3	0	0	12	0	3	0	3	0	23	0	2	0	7	0
18:15:00	51	0	454	0	27	0	0	0	12	0	3	0	3	0	23	0	2	0	7	0
18:15:15	51	0	454	0	27	0	0	0	12	0	3	0	3	0	23	0	2	0	7	0

Accu-Traffic Inc.

Count Date: 25-May-16 Site #: 1608500003

Interval Time	Passenger Cars - South Approach						Trucks - South Approach						Heavys - South Approach						Pedestrians	
	Left		Thru		Right		Left		Thru		Right		Left		Thru		Right		South Cross	
	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr
7:00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15:00	13	13	4	4	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:30:00	26	13	8	4	7	2	0	0	0	0	0	0	1	1	0	0	0	0	0	0
7:45:00	51	25	11	3	11	4	0	0	0	0	0	0	2	1	0	0	0	0	0	0
8:00:00	77	26	11	0	17	6	0	0	0	0	1	1	2	0	0	0	0	0	0	0
8:15:00	104	27	12	1	24	7	0	0	0	0	1	0	2	0	0	0	0	0	0	0
8:30:00	128	24	18	6	32	8	1	1	0	0	1	0	2	0	0	0	1	1	0	0
8:45:00	143	15	21	3	40	8	1	0	0	0	1	0	2	0	0	0	1	0	0	0
9:00:00	166	23	27	6	51	11	1	0	1	1	1	0	2	0	1	1	1	0	0	0
9:15:00	166	0	27	0	51	0	1	0	1	0	1	0	2	0	1	0	1	0	0	0
16:00:00	166	0	27	0	51	0	1	0	1	0	1	0	2	0	1	0	1	0	0	0
16:15:00	175	9	29	2	55	4	1	0	1	0	1	0	2	0	1	0	1	0	0	0
16:30:00	180	5	29	0	58	3	1	0	1	0	1	0	2	0	1	0	1	0	0	0
16:45:00	186	6	29	0	64	6	1	0	1	0	1	0	3	1	1	0	1	0	0	0
17:00:00	193	7	33	4	67	3	2	1	1	0	1	0	3	0	1	0	1	0	0	0
17:15:00	197	4	33	0	74	7	2	0	1	0	1	0	3	0	1	0	1	0	0	0
17:30:00	204	7	33	0	78	4	3	1	1	0	1	0	3	0	1	0	1	0	2	2
17:45:00	209	5	35	2	82	4	3	0	1	0	1	0	3	0	1	0	2	1	2	0
18:00:00	212	3	36	1	84	2	3	0	1	0	1	0	3	0	1	0	2	0	2	0
18:15:00	212	0	36	0	84	0	3	0	1	0	1	0	3	0	1	0	2	0	2	0
18:15:15	212	0	36	0	84	0	3	0	1	0	1	0	3	0	1	0	2	0	2	0

Accu-Traffic Inc.

Traffic Monitoring & Data Analysis

Accu-Traffic Inc.

Count Date: 25-May-16 Site #: 1608500003

Interval Time	Passenger Cars - West Approach						Trucks - West Approach						Heavys - West Approach						Pedestrians	
	Left		Thru		Right		Left		Thru		Right		Left		Thru		Right		West Cross	
	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr
7:00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15:00	7	7	11	11	3	3	0	0	0	0	0	0	0	0	2	2	1	1	0	0
7:30:00	8	1	21	10	3	0	0	0	0	0	0	0	0	0	5	3	1	0	0	0
7:45:00	13	5	44	23	5	2	0	0	1	1	0	0	0	0	5	0	3	2	0	0
8:00:00	16	3	74	30	7	2	2	2	2	1	0	0	0	0	8	3	3	0	0	0
8:15:00	22	6	102	28	8	1	2	0	2	0	0	0	0	0	8	0	3	0	0	0
8:30:00	34	12	127	25	11	3	3	1	4	2	0	0	1	1	12	4	3	0	0	0
8:45:00	39	5	151	24	17	6	3	0	5	1	0	0	1	0	15	3	3	0	3	3
9:00:00	46	7	168	17	18	1	3	0	6	1	0	0	1	0	18	3	3	0	3	0
9:15:00	46	0	168	0	18	0	3	0	6	0	0	0	1	0	18	0	3	0	3	0
16:00:00	46	0	168	0	18	0	3	0	6	0	0	0	1	0	18	0	3	0	3	0
16:15:00	47	1	213	45	25	7	3	0	6	0	0	0	1	0	18	0	3	0	5	2
16:30:00	51	4	246	33	38	13	3	0	8	2	0	0	1	0	20	2	3	0	7	2
16:45:00	52	1	304	58	62	24	3	0	8	0	0	0	1	0	22	2	3	0	7	0
17:00:00	56	4	368	64	67	5	3	0	9	1	0	0	1	0	23	1	3	0	8	1
17:15:00	57	1	419	51	84	17	3	0	9	0	0	0	1	0	24	1	3	0	8	0
17:30:00	58	1	460	41	94	10	3	0	10	1	0	0	1	0	25	1	3	0	11	3
17:45:00	62	4	502	42	104	10	3	0	10	0	0	0	1	0	26	1	3	0	11	0
18:00:00	65	3	546	44	111	7	3	0	10	0	0	0	1	0	26	0	3	0	11	0
18:15:00	65	0	546	0	111	0	3	0	10	0	0	0	1	0	26	0	3	0	11	0
18:15:15	65	0	546	0	111	0	3	0	10	0	0	0	1	0	26	0	3	0	11	0

Accu-Traffic Inc.

Morning Peak Diagram

Specified Period		One Hour Peak	
From:	7:00:00	**From:**	7:30:00
To:	9:00:00	**To:**	8:30:00

Municipality: Hamilton
Site #: 1608500004
Intersection: HWY 8 & McNeilly Rd
TFR File #: 1
Count date: 25-May-16

Weather conditions:

Person counted:
Person prepared:
Person checked:

**** Signalized Intersection ****

Major Road: HWY 8 runs W/E

North Leg Total: 157
North Entering: 28
North Peds: 1
Peds Cross: ⋈

Heavys	2	0	1	3
Trucks	0	1	0	1
Cars	11	7	6	24
Totals	13	8	7	

Heavys	2
Trucks	4
Cars	123
Totals	129

East Leg Total: 640
East Entering: 401
East Peds: 1
Peds Cross: ⧗

McNeilly Rd

Heavys	Trucks	Cars	Totals
9	2	398	409

HWY 8

Cars	Trucks	Heavys	Totals
32	0	1	33
340	1	6	347
17	3	1	21
389	4	8	

N W E S

Heavys	Trucks	Cars	Totals
1	0	9	10
12	3	176	191
2	0	8	10
15	3	193	

HWY 8

Cars	Trucks	Heavys	Totals
220	5	14	239

McNeilly Rd

Peds Cross: ⧗
West Peds: 5
West Entering: 211
West Leg Total: 620

Cars	32
Trucks	4
Heavys	3
Totals	39

Cars	47	82	38	167
Trucks	1	4	2	7
Heavys	1	0	1	2
Totals	49	86	41	

Peds Cross: ⋈
South Peds: 0
South Entering: 176
South Leg Total: 215

Comments

Accu-Traffic Inc.

Afternoon Peak Diagram

Specified Period		One Hour Peak	
From:	16:00:00	From:	16:30:00
To:	18:00:00	To:	17:30:00

Municipality: Hamilton
Site #: 1608500004
Intersection: HWY 8 & McNeilly Rd
TFR File #: 1
Count date: 25-May-16

Weather conditions:

Person counted:
Person prepared:
Person checked:

**** Signalized Intersection ****

Major Road: HWY 8 runs W/E

North Leg (McNeilly Rd)

North Leg Total: 142
North Entering: 86
North Peds: 0
Peds Cross: ⋈

Heavys	0	0	0	0
Trucks	1	0	0	1
Cars	19	46	20	85
Totals	20	46	20	

North exiting:

Heavys	1
Trucks	4
Cars	51
Totals	56

East Leg (HWY 8)

East Leg Total: 828
East Entering: 349
East Peds: 0
Peds Cross: ⧗

Cars	Trucks	Heavys	Totals
15	1	0	16
280	2	2	284
49	0	0	49
344	3	2	

East exiting:

Cars	Trucks	Heavys	Totals
475	2	2	479

West Leg (HWY 8)

West exiting:

Heavys	Trucks	Cars	Totals
3	3	324	330

West entering:

Heavys	Trucks	Cars	Totals
1	2	16	19
2	2	423	427
0	0	48	48
3	4	487	

Peds Cross: ⧗
West Peds: 1
West Entering: 494
West Leg Total: 824

South Leg (McNeilly Rd)

South exiting:

Cars	143
Trucks	0
Heavys	0
Totals	143

South entering:

Cars	25	20	32	77
Trucks	0	1	0	1
Heavys	1	0	0	1
Totals	26	21	32	

Peds Cross: ⋈
South Peds: 1
South Entering: 79
South Leg Total: 222

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Comments

Accu-Traffic Inc.

Total Count Diagram

Municipality: Hamilton
Site #: 1608500004
Intersection: HWY 8 & McNeilly Rd
TFR File #: 1
Count date: 25-May-16

Weather conditions:

Person counted:
Person prepared:
Person checked:

**** Signalized Intersection ****

Major Road: HWY 8 runs W/E

North (McNeilly Rd)

North Leg Total: 534
North Entering: 196
North Peds: 3
Peds Cross: ⋈

Heavys	3	2	1	6
Trucks	1	1	0	2
Cars	47	90	51	188
Totals	51	93	52	

Heavys	6
Trucks	10
Cars	322
Totals	338

East (HWY 8)

East Leg Total: 2676
East Entering: 1356
East Peds: 5
Peds Cross: ⧗

Cars	Trucks	Heavys	Totals
78	1	2	81
1127	7	18	1152
117	3	3	123
1322	11	23	

HWY 8

Cars	Trucks	Heavys	Totals
1274	14	32	1320

West (HWY 8)

Heavys	Trucks	Cars	Totals
25	9	1322	1356

HWY 8

Heavys	Trucks	Cars	Totals
3	3	51	57
29	12	1114	1155
2	1	90	93
34	16	1255	

Peds Cross: ⧗
West Peds: 7
West Entering: 1305
West Leg Total: 2661

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South (McNeilly Rd)

Cars	297
Trucks	5
Heavys	7
Totals	309

Cars	148	193	109	450
Trucks	1	6	2	9
Heavys	4	1	2	7
Totals	153	200	113	

Peds Cross: ⋈
South Peds: 4
South Entering: 466
South Leg Total: 775

Comments

Accu-Traffic Inc.
Traffic Monitoring & Data Analysis

Accu-Traffic Inc.
Traffic Count Summary

Intersection: HWY 8 & McNeilly Rd	Count Date: 25-May-16	Municipality: Hamilton

North Approach Totals						North/South Total Approaches	South Approach Totals					
Hour Ending	Includes Cars, Trucks, & Heavys				Total Peds		Hour Ending	Includes Cars, Trucks, & Heavys				Total Peds
	Left	Thru	Right	Grand Total				Left	Thru	Right	Grand Total	
7:00:00	0	0	0	0	0	0	7:00:00	0	0	0	0	0
8:00:00	8	9	7	24	3	182	8:00:00	54	69	35	158	2
9:00:00	10	8	13	31	0	175	9:00:00	31	83	30	144	0
16:00:00	0	0	0	0	0	0	16:00:00	0	0	0	0	0
17:00:00	13	45	14	72	0	163	17:00:00	39	30	22	91	0
18:00:00	21	31	17	69	0	142	18:00:00	29	18	26	73	2
Totals:	52	93	51	196	3	662	S Totals:	153	200	113	466	4

East Approach Totals						East/West Total Approaches	West Approach Totals					
Hour Ending	Includes Cars, Trucks, & Heavys				Total Peds		Hour Ending	Includes Cars, Trucks, & Heavys				Total Peds
	Left	Thru	Right	Grand Total				Left	Thru	Right	Grand Total	
7:00:00	0	0	0	0	0	0	7:00:00	0	0	0	0	0
8:00:00	23	285	23	331	5	489	8:00:00	9	141	8	158	2
9:00:00	21	314	36	371	0	591	9:00:00	15	199	6	220	4
16:00:00	0	0	0	0	0	0	16:00:00	0	0	0	0	0
17:00:00	43	268	12	323	0	819	17:00:00	12	439	45	496	1
18:00:00	36	285	10	331	0	762	18:00:00	21	376	34	431	0
Totals:	123	1152	81	1356	5	2661	W Totals:	57	1155	93	1305	7

Calculated Values for Traffic Crossing Major Street

Hours Ending:	7:00	8:00	9:00	16:00	17:00	18:00	0:00	0:00
Crossing Values:	0	138	128	0	98	81	0	0

Accu-Traffic Inc.

Count Date: 25-May-16 Site #: 1608500004

Interval Time	Passenger Cars - North Approach						Trucks - North Approach						Heavys - North Approach						Pedestrians	
	Left		Thru		Right		Left		Thru		Right		Left		Thru		Right		North Cross	
	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr
7:00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15:00	2	2	4	4	1	1	0	0	0	0	0	0	0	0	2	2	0	0	0	0
7:30:00	4	2	4	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	2	2
7:45:00	5	1	7	3	3	2	0	0	0	0	0	0	1	1	2	0	2	2	3	1
8:00:00	7	2	7	0	5	2	0	0	0	0	0	0	1	0	2	0	2	0	3	0
8:15:00	7	0	10	3	9	4	0	0	0	0	0	0	1	0	2	0	2	0	3	0
8:30:00	10	3	11	1	12	3	0	0	1	1	0	0	1	0	2	0	2	0	3	0
8:45:00	16	6	14	3	14	2	0	0	1	0	0	0	1	0	2	0	2	0	3	0
9:00:00	17	1	14	0	17	3	0	0	1	0	0	0	1	0	2	0	3	1	3	0
9:15:00	17	0	14	0	17	0	0	0	1	0	0	0	1	0	2	0	3	0	3	0
16:00:00	17	0	14	0	17	0	0	0	1	0	0	0	1	0	2	0	3	0	3	0
16:15:00	17	0	28	14	19	2	0	0	1	0	0	0	1	0	2	0	3	0	3	0
16:30:00	23	6	33	5	24	5	0	0	1	0	0	0	1	0	2	0	3	0	3	0
16:45:00	29	6	53	20	26	2	0	0	1	0	0	0	1	0	2	0	3	0	3	0
17:00:00	30	1	59	6	31	5	0	0	1	0	0	0	1	0	2	0	3	0	3	0
17:15:00	39	9	71	12	36	5	0	0	1	0	1	1	1	0	2	0	3	0	3	0
17:30:00	43	4	79	8	43	7	0	0	1	0	1	0	1	0	2	0	3	0	3	0
17:45:00	48	5	87	8	45	2	0	0	1	0	1	0	1	0	2	0	3	0	3	0
18:00:00	51	3	90	3	47	2	0	0	1	0	1	0	1	0	2	0	3	0	3	0
18:15:00	51	0	90	0	47	0	0	0	1	0	1	0	1	0	2	0	3	0	3	0
18:15:15	51	0	90	0	47	0	0	0	1	0	1	0	1	0	2	0	3	0	3	0

Accu-Traffic Inc.

Count Date: 25-May-16 Site #: 1608500004

Interval Time	Passenger Cars - East Approach						Trucks - East Approach						Heavys - East Approach						Pedestrians	
	Left		Thru		Right		Left		Thru		Right		Left		Thru		Right		East Cross	
	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr
7:00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15:00	3	3	42	42	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:30:00	11	8	87	45	7	4	0	0	1	1	0	0	1	1	2	2	0	0	4	4
7:45:00	17	6	183	96	18	11	0	0	1	0	0	0	1	0	6	4	1	1	4	0
8:00:00	22	5	278	95	22	4	0	0	1	0	0	0	1	0	6	0	1	0	5	1
8:15:00	25	3	352	74	32	10	2	2	1	0	0	0	2	1	7	1	1	0	5	0
8:30:00	28	3	427	75	39	7	3	1	2	1	0	0	2	0	8	1	1	0	5	0
8:45:00	34	6	514	87	45	6	3	0	3	1	0	0	2	0	9	1	2	1	5	0
9:00:00	38	4	583	69	57	12	3	0	4	1	0	0	3	1	12	3	2	0	5	0
9:15:00	38	0	583	0	57	0	3	0	4	0	0	0	3	0	12	0	2	0	5	0
16:00:00	38	0	583	0	57	0	3	0	4	0	0	0	3	0	12	0	2	0	5	0
16:15:00	43	5	637	54	60	3	3	0	4	0	0	0	3	0	14	2	2	0	5	0
16:30:00	52	9	708	71	61	1	3	0	4	0	0	0	3	0	16	2	2	0	5	0
16:45:00	66	14	786	78	63	2	3	0	5	1	0	0	3	0	17	1	2	0	5	0
17:00:00	81	15	845	59	68	5	3	0	5	0	1	1	3	0	17	0	2	0	5	0
17:15:00	93	12	913	68	72	4	3	0	5	0	1	0	3	0	18	1	2	0	5	0
17:30:00	101	8	988	75	76	4	3	0	6	1	1	0	3	0	18	0	2	0	5	0
17:45:00	110	9	1059	71	76	0	3	0	6	0	1	0	3	0	18	0	2	0	5	0
18:00:00	117	7	1127	68	78	2	3	0	7	1	1	0	3	0	18	0	2	0	5	0
18:15:00	117	0	1127	0	78	0	3	0	7	0	1	0	3	0	18	0	2	0	5	0
18:15:15	117	0	1127	0	78	0	3	0	7	0	1	0	3	0	18	0	2	0	5	0

Accu-Traffic Inc.

Count Date: 25-May-16 **Site #:** 1608500004

Interval Time	Passenger Cars - South Approach						Trucks - South Approach						Heavys - South Approach						Pedestrians	
	Left		Thru		Right		Left		Thru		Right		Left		Thru		Right		South Cross	
	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr
7:00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15:00	6	6	15	15	4	4	0	0	0	0	0	0	0	0	0	0	1	1	0	0
7:30:00	19	13	27	12	11	7	0	0	0	0	0	0	1	1	0	0	1	0	2	2
7:45:00	35	16	46	19	26	15	0	0	0	0	0	0	1	0	0	0	1	0	2	0
8:00:00	52	17	67	21	33	7	0	0	2	2	1	1	2	1	0	0	1	0	2	0
8:15:00	59	7	84	17	44	11	1	1	3	1	2	1	2	0	0	0	1	0	2	0
8:30:00	66	7	109	25	49	5	1	0	4	1	2	0	2	0	0	0	2	1	2	0
8:45:00	78	12	121	12	56	7	1	0	4	0	2	0	2	0	0	0	2	0	2	0
9:00:00	81	3	147	26	61	5	1	0	5	1	2	0	3	1	0	0	2	0	2	0
9:15:00	81	0	147	0	61	0	1	0	5	0	2	0	3	0	0	0	2	0	2	0
16:00:00	81	0	147	0	61	0	1	0	5	0	2	0	3	0	0	0	2	0	2	0
16:15:00	92	11	161	14	65	4	1	0	5	0	2	0	3	0	0	0	2	0	2	0
16:30:00	103	11	165	4	68	3	1	0	5	0	2	0	3	0	1	1	2	0	2	0
16:45:00	115	12	170	5	76	8	1	0	5	0	2	0	4	1	1	0	2	0	2	0
17:00:00	119	4	176	6	83	7	1	0	5	0	2	0	4	0	1	0	2	0	2	0
17:15:00	123	4	178	2	89	6	1	0	5	0	2	0	4	0	1	0	2	0	2	0
17:30:00	128	5	185	7	100	11	1	0	6	1	2	0	4	0	1	0	2	0	3	1
17:45:00	136	8	191	6	104	4	1	0	6	0	2	0	4	0	1	0	2	0	3	0
18:00:00	148	12	193	2	109	5	1	0	6	0	2	0	4	0	1	0	2	0	4	1
18:15:00	148	0	193	0	109	0	1	0	6	0	2	0	4	0	1	0	2	0	4	0
18:15:15	148	0	193	0	109	0	1	0	6	0	2	0	4	0	1	0	2	0	4	0

Accu-Traffic Inc.

Count Date: 25-May-16 Site #: 1608500004

Interval Time	Passenger Cars - West Approach						Trucks - West Approach						Heavys - West Approach						Pedestrians	
	Left		Thru		Right		Left		Thru		Right		Left		Thru		Right		West Cross	
	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr
7:00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15:00	2	2	24	24	1	1	0	0	1	1	0	0	0	0	1	1	0	0	1	1
7:30:00	5	3	56	32	2	1	0	0	1	0	0	0	1	1	3	2	0	0	1	0
7:45:00	7	2	91	35	4	2	0	0	1	0	0	0	1	0	4	1	0	0	2	1
8:00:00	8	1	129	38	6	2	0	0	1	0	0	0	1	0	11	7	2	2	2	0
8:15:00	9	1	182	53	8	2	0	0	2	1	0	0	2	1	12	1	2	0	6	4
8:30:00	14	5	232	50	10	2	0	0	4	2	0	0	2	0	15	3	2	0	6	0
8:45:00	17	3	282	50	10	0	0	0	6	2	0	0	2	0	18	3	2	0	6	0
9:00:00	22	5	314	32	12	2	0	0	7	1	0	0	2	0	19	1	2	0	6	0
9:15:00	22	0	314	0	12	0	0	0	7	0	0	0	2	0	19	0	2	0	6	0
16:00:00	22	0	314	0	12	0	0	0	7	0	0	0	2	0	19	0	2	0	6	0
16:15:00	23	1	415	101	23	11	0	0	7	0	1	1	2	0	22	3	2	0	6	0
16:30:00	26	3	516	101	31	8	0	0	9	2	1	0	2	0	24	2	2	0	6	0
16:45:00	28	2	623	107	48	17	0	0	10	1	1	0	3	1	25	1	2	0	6	0
17:00:00	33	5	743	120	56	8	0	0	11	1	1	0	3	0	25	0	2	0	7	1
17:15:00	38	5	842	99	69	13	2	2	11	0	1	0	3	0	25	0	2	0	7	0
17:30:00	42	4	939	97	79	10	2	0	11	0	1	0	3	0	26	1	2	0	7	0
17:45:00	48	6	1029	90	86	7	2	0	11	0	1	0	3	0	27	1	2	0	7	0
18:00:00	51	3	1114	85	90	4	3	1	12	1	1	0	3	0	29	2	2	0	7	0
18:15:00	51	0	1114	0	90	0	3	0	12	0	1	0	3	0	29	0	2	0	7	0
18:15:15	51	0	1114	0	90	0	3	0	12	0	1	0	3	0	29	0	2	0	7	0

Accu-Traffic Inc.

Morning Peak Diagram

Specified Period		One Hour Peak	
From:	7:00:00	From:	7:45:00
To:	9:00:00	To:	8:45:00

Municipality: Hamilton
Site #: 1608500005
Intersection: HWY 8 & Lewis Rd
TFR File #: 1
Count date: 25-May-16

Weather conditions:

Person counted:
Person prepared:
Person checked:

**** Non-Signalized Intersection ****

Major Road: HWY 8 runs W/E

North Leg Total: 205
North Entering: 77
North Peds: 1
Peds Cross: ⋈

Heavys	1	1	1	3
Trucks	0	0	1	1
Cars	39	1	33	73
Totals	40	2	35	

Heavys	2
Trucks	1
Cars	125
Totals	128

East Leg Total: 646
East Entering: 414
East Peds: 5
Peds Cross: ⧖

Lewis Rd

Heavys	Trucks	Cars	Totals
3	5	373	381

HWY 8

Cars	Trucks	Heavys	Totals
74	0	1	75
331	5	2	338
1	0	0	1
406	5	3	

N
W E
S

Heavys	Trucks	Cars	Totals
1	1	49	51
11	5	179	195
0	0	5	5
12	6	233	

HWY 8

Cars	Trucks	Heavys	Totals
214	6	12	232

Lewis Rd

Peds Cross: ⧖
West Peds: 6
West Entering: 251
West Leg Total: 632

Cars	7
Trucks	0
Heavys	1
Totals	8

Cars	3	2	2	7
Trucks	0	0	0	0
Heavys	0	0	0	0
Totals	3	2	2	

Peds Cross: ⋈
South Peds: 12
South Entering: 7
South Leg Total: 15

Comments

Accu-Traffic Inc.

Afternoon Peak Diagram

Specified Period
From: 16:00:00
To: 18:00:00

One Hour Peak
From: 16:15:00
To: 17:15:00

Municipality: Hamilton
Site #: 1608500005
Intersection: HWY 8 & Lewis Rd
TFR File #: 1
Count date: 25-May-16

Weather conditions:

Person counted:
Person prepared:
Person checked:

**** Non-Signalized Intersection ****

Major Road: HWY 8 runs W/E

North Leg Total: 159
North Entering: 99
North Peds: 0
Peds Cross: ⋈

Heavys	1	0	0	1
Trucks	0	0	0	0
Cars	58	4	36	98
Totals	59	4	36	

Heavys	0
Trucks	1
Cars	59
Totals	60

East Leg Total: 762
East Entering: 303
East Peds: 0
Peds Cross: ⧗

Lewis Rd

Heavys	Trucks	Cars	Totals
5	1	349	355

Cars	Trucks	Heavys	Totals
11	0	0	11
286	1	4	291
1	0	0	1
298	1	4	

HWY 8

N
W E
S

Heavys	Trucks	Cars	Totals
0	1	47	48
2	4	415	421
0	0	6	6
2	5	468	

HWY 8

Cars	Trucks	Heavys	Totals
453	4	2	459

Lewis Rd

Peds Cross: ⧗
West Peds: 0
West Entering: 475
West Leg Total: 830

Cars	11
Trucks	0
Heavys	0
Totals	11

Cars	5	1	2	8
Trucks	0	0	0	0
Heavys	0	0	0	0
Totals	5	1	2	

Peds Cross: ⋈
South Peds: 2
South Entering: 8
South Leg Total: 19

Comments

Accu-Traffic Inc.

Total Count Diagram

Municipality: Hamilton
Site #: 1608500005
Intersection: HWY 8 & Lewis Rd
TFR File #: 1
Count date: 25-May-16

Weather conditions:

Person counted:
Person prepared:
Person checked:

**** Non-Signalized Intersection ****

Major Road: HWY 8 runs W/E

North Leg (Lewis Rd)

North Leg Total: 578
North Entering: 288
North Peds: 3
Peds Cross: ⋈

Heavys	3	2	1	6
Trucks	0	0	1	1
Cars	156	7	118	281
Totals	159	9	120	

Heavys	5
Trucks	3
Cars	282
Totals	290

East Leg (HWY 8)

East Leg Total: 2595
East Entering: 1320
East Peds: 12
Peds Cross: ⧗

Cars	Trucks	Heavys	Totals
128	0	3	131
1158	9	17	1184
5	0	0	5
1291	9	20	

Cars	Trucks	Heavys	Totals
1237	11	27	1275

West Leg (HWY 8)

Heavys	Trucks	Cars	Totals
21	9	1330	1360

Heavys	Trucks	Cars	Totals
2	3	150	155
26	10	1112	1148
0	0	15	15
28	13	1277	

Peds Cross: ⧗
West Peds: 7
West Entering: 1318
West Leg Total: 2678

N / S / E / W

South Leg (Lewis Rd)

Cars	27
Trucks	0
Heavys	2
Totals	29

Cars	16	4	7	27
Trucks	0	0	0	0
Heavys	1	0	0	1
Totals	17	4	7	

Peds Cross: ⋈
South Peds: 18
South Entering: 28
South Leg Total: 57

Comments

Accu-Traffic Inc.

Traffic Count Summary

Intersection: HWY 8 & Lewis Rd	Count Date: 25-May-16	Municipality: Hamilton

North Approach Totals / **South Approach Totals**

Hour Ending	Left	Thru	Right	Grand Total	Total Peds	North/South Total Approaches	Hour Ending	Left	Thru	Right	Grand Total	Total Peds
7:00:00	0	0	0	0	0	0	7:00:00	0	0	0	0	0
8:00:00	11	0	17	28	0	37	8:00:00	7	1	1	9	2
9:00:00	35	3	44	82	3	89	9:00:00	3	2	2	7	12
16:00:00	0	0	0	0	0	0	16:00:00	0	0	0	0	0
17:00:00	42	3	49	94	0	101	17:00:00	4	1	2	7	0
18:00:00	32	3	49	84	0	89	18:00:00	3	0	2	5	4
Totals:	120	9	159	288	3	316	S Totals:	17	4	7	28	18

(Left, Thru, Right and Grand Total columns: Includes Cars, Trucks, & Heavys)

East Approach Totals / **West Approach Totals**

Hour Ending	Left	Thru	Right	Grand Total	Total Peds	East/West Total Approaches	Hour Ending	Left	Thru	Right	Grand Total	Total Peds
7:00:00	0	0	0	0	0	0	7:00:00	0	0	0	0	0
8:00:00	0	305	43	348	2	529	8:00:00	24	153	4	181	1
9:00:00	1	317	65	383	9	621	9:00:00	47	188	3	238	6
16:00:00	0	0	0	0	0	0	16:00:00	0	0	0	0	0
17:00:00	2	273	13	288	0	753	17:00:00	41	419	5	465	0
18:00:00	2	289	10	301	1	735	18:00:00	43	388	3	434	0
Totals:	5	1184	131	1320	12	2638	W Totals:	155	1148	15	1318	7

(Left, Thru, Right and Grand Total columns: Includes Cars, Trucks, & Heavys)

Calculated Values for Traffic Crossing Major Street

Hours Ending:	7:00	8:00	9:00	16:00	17:00	18:00	0:00	0:00
Crossing Values:	0	22	56	0	49	39	0	0

Accu-Traffic Inc.

Count Date: 25-May-16 Site #: 1608500005

Interval Time	Passenger Cars - North Approach						Trucks - North Approach						Heavys - North Approach						Pedestrians	
	Left		Thru		Right		Left		Thru		Right		Left		Thru		Right		North Cross	
	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr
7:00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15:00	3	3	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:30:00	6	3	0	0	8	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:45:00	8	2	0	0	13	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:00:00	11	3	0	0	17	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8:15:00	16	5	0	0	26	9	0	0	0	0	0	0	0	0	1	1	0	0	0	0
8:30:00	30	14	1	1	39	13	0	0	0	0	0	0	1	1	1	0	0	0	0	0
8:45:00	41	11	1	0	52	13	1	1	0	0	0	0	1	0	1	0	1	1	1	1
9:00:00	44	3	1	0	59	7	1	0	0	0	0	0	1	0	2	1	2	1	3	2
9:15:00	44	0	1	0	59	0	1	0	0	0	0	0	1	0	2	0	2	0	3	0
16:00:00	44	0	1	0	59	0	1	0	0	0	0	0	1	0	2	0	2	0	3	0
16:15:00	57	13	1	0	64	5	1	0	0	0	0	0	1	0	2	0	2	0	3	0
16:30:00	63	6	3	2	79	15	1	0	0	0	0	0	1	0	2	0	3	1	3	0
16:45:00	75	12	4	1	95	16	1	0	0	0	0	0	1	0	2	0	3	0	3	0
17:00:00	86	11	4	0	107	12	1	0	0	0	0	0	1	0	2	0	3	0	3	0
17:15:00	93	7	5	1	122	15	1	0	0	0	0	0	1	0	2	0	3	0	3	0
17:30:00	101	8	5	0	135	13	1	0	0	0	0	0	1	0	2	0	3	0	3	0
17:45:00	114	13	6	1	146	11	1	0	0	0	0	0	1	0	2	0	3	0	3	0
18:00:00	118	4	7	1	156	10	1	0	0	0	0	0	1	0	2	0	3	0	3	0
18:15:00	118	0	7	0	156	0	1	0	0	0	0	0	1	0	2	0	3	0	3	0
18:15:15	118	0	7	0	156	0	1	0	0	0	0	0	1	0	2	0	3	0	3	0

Accu-Traffic Inc.

Count Date: 25-May-16 Site #: 1608500005

Interval Time	Passenger Cars - East Approach						Trucks - East Approach						Heavys - East Approach						Pedestrians	
	Left		Thru		Right		Left		Thru		Right		Left		Thru		Right		East Cross	
	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr
7:00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15:00	0	0	43	43	11	11	0	0	0	0	0	0	0	0	0	0	1	1	1	1
7:30:00	0	0	97	54	17	6	0	0	1	1	0	0	0	0	4	4	1	0	2	1
7:45:00	0	0	198	101	27	10	0	0	1	0	0	0	0	0	8	4	1	0	2	0
8:00:00	0	0	296	98	42	15	0	0	1	0	0	0	0	0	8	0	1	0	2	0
8:15:00	0	0	372	76	63	21	0	0	3	2	0	0	0	0	9	1	1	0	2	0
8:30:00	0	0	446	74	83	20	0	0	6	3	0	0	0	0	10	1	2	1	2	0
8:45:00	1	1	529	83	101	18	0	0	6	0	0	0	0	0	10	0	2	0	7	5
9:00:00	1	0	604	75	105	4	0	0	7	1	0	0	0	0	11	1	3	1	11	4
9:15:00	1	0	604	0	105	0	0	0	7	0	0	0	0	0	11	0	3	0	11	0
16:00:00	1	0	604	0	105	0	0	0	7	0	0	0	0	0	11	0	3	0	11	0
16:15:00	2	1	656	52	108	3	0	0	7	0	0	0	0	0	13	2	3	0	11	0
16:30:00	2	0	729	73	114	6	0	0	7	0	0	0	0	0	14	1	3	0	11	0
16:45:00	2	0	805	76	116	2	0	0	7	0	0	0	0	0	16	2	3	0	11	0
17:00:00	3	1	872	67	118	2	0	0	7	0	0	0	0	0	16	0	3	0	11	0
17:15:00	3	0	942	70	119	1	0	0	8	1	0	0	0	0	17	1	3	0	11	0
17:30:00	3	0	1020	78	120	1	0	0	8	0	0	0	0	0	17	0	3	0	11	0
17:45:00	4	1	1087	67	125	5	0	0	9	1	0	0	0	0	17	0	3	0	11	0
18:00:00	5	1	1158	71	128	3	0	0	9	0	0	0	0	0	17	0	3	0	12	1
18:15:00	5	0	1158	0	128	0	0	0	9	0	0	0	0	0	17	0	3	0	12	0
18:15:15	5	0	1158	0	128	0	0	0	9	0	0	0	0	0	17	0	3	0	12	0

Accu-Traffic Inc.
Traffic Monitoring & Data Analysis

Accu-Traffic Inc.

Count Date: 25-May-16 Site #: 1608500005

Interval Time	Passenger Cars - South Approach						Trucks - South Approach						Heavys - South Approach						Pedestrians	
	Left		Thru		Right		Left		Thru		Right		Left		Thru		Right		South Cross	
	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr
7:00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15:00	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
7:30:00	3	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
7:45:00	5	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1
8:00:00	7	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
8:15:00	7	0	2	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	4	2
8:30:00	7	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	11	7
8:45:00	8	1	2	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	14	3
9:00:00	9	1	3	1	3	0	0	0	0	0	0	0	1	1	0	0	0	0	14	0
9:15:00	9	0	3	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	14	0
16:00:00	9	0	3	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	14	0
16:15:00	10	1	3	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	14	0
16:30:00	11	1	4	1	5	2	0	0	0	0	0	0	1	0	0	0	0	0	14	0
16:45:00	13	2	4	0	5	0	0	0	0	0	0	0	1	0	0	0	0	0	14	0
17:00:00	13	0	4	0	5	0	0	0	0	0	0	0	1	0	0	0	0	0	14	0
17:15:00	15	2	4	0	5	0	0	0	0	0	0	0	1	0	0	0	0	0	16	2
17:30:00	15	0	4	0	6	1	0	0	0	0	0	0	1	0	0	0	0	0	17	1
17:45:00	16	1	4	0	7	1	0	0	0	0	0	0	1	0	0	0	0	0	17	0
18:00:00	16	0	4	0	7	0	0	0	0	0	0	0	1	0	0	0	0	0	18	1
18:15:00	16	0	4	0	7	0	0	0	0	0	0	0	1	0	0	0	0	0	18	0
18:15:15	16	0	4	0	7	0	0	0	0	0	0	0	1	0	0	0	0	0	18	0

Accu-Traffic Inc.

Count Date: 25-May-16 Site #: 1608500005

Interval Time	Passenger Cars - West Approach						Trucks - West Approach						Heavys - West Approach						Pedestrians	
	Left		Thru		Right		Left		Thru		Right		Left		Thru		Right		West Cross	
	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr	Cum	Incr
7:00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7:15:00	4	4	28	28	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0
7:30:00	8	4	63	35	2	2	1	0	0	0	0	0	1	1	3	2	0	0	0	0
7:45:00	14	6	104	41	2	0	1	0	0	0	0	0	1	0	4	1	0	0	1	1
8:00:00	22	8	141	37	4	2	1	0	2	2	0	0	1	0	10	6	0	0	1	0
8:15:00	33	11	187	46	4	0	1	0	2	0	0	0	1	0	11	1	0	0	1	0
8:30:00	55	22	234	47	4	0	1	0	3	1	0	0	2	1	13	2	0	0	7	6
8:45:00	63	8	283	49	7	3	2	1	5	2	0	0	2	0	15	2	0	0	7	0
9:00:00	67	4	320	37	7	0	2	0	5	0	0	0	2	0	16	1	0	0	7	0
9:15:00	67	0	320	0	7	0	2	0	5	0	0	0	2	0	16	0	0	0	7	0
16:00:00	67	0	320	0	7	0	2	0	5	0	0	0	2	0	16	0	0	0	7	0
16:15:00	76	9	416	96	7	0	2	0	5	0	0	0	2	0	20	4	0	0	7	0
16:30:00	88	12	516	100	9	2	2	0	5	0	0	0	2	0	22	2	0	0	7	0
16:45:00	98	10	624	108	10	1	3	1	7	2	0	0	2	0	22	0	0	0	7	0
17:00:00	107	9	729	105	12	2	3	0	9	2	0	0	2	0	22	0	0	0	7	0
17:15:00	123	16	831	102	13	1	3	0	9	0	0	0	2	0	22	0	0	0	7	0
17:30:00	139	16	935	104	13	0	3	0	9	0	0	0	2	0	23	1	0	0	7	0
17:45:00	148	9	1026	91	14	1	3	0	9	0	0	0	2	0	24	1	0	0	7	0
18:00:00	150	2	1112	86	15	1	3	0	10	1	0	0	2	0	26	2	0	0	7	0
18:15:00	150	0	1112	0	15	0	3	0	10	0	0	0	2	0	26	0	0	0	7	0
18:15:15	150	0	1112	0	15	0	3	0	10	0	0	0	2	0	26	0	0	0	7	0

Appendix B
2016 Transportation Tomorrow Survey Data

Zone 35
Stoney Creek
2011 Home to Work
6-9 am

1	500	3%	Toronto	QEW
2	0	0%	Toronto	QEW
3	0	0%	Toronto	QEW
4	100	1%	Toronto	QEW
5	100	1%	Toronto	QEW
6	0	0%	Toronto	QEW
7	0	0%	Durham	QEW
8	0	0%	Durham	QEW
9	0	0%	Durham	QEW
10	0	0%	Durham	QEW
11	0	0%	Durham	QEW
12	0	0%	Durham	QEW
13	0	0%	Durham	QEW
14	0	0%	Durham	QEW
15	0	0%	York	QEW
16	0	0%	York	QEW
17	0	0%	York	QEW
18	0	0%	York	QEW
19	0	0%	York	QEW
20	0	0%	York	QEW
21	0	0%	York	QEW
22	0	0%	York	QEW
23	100	1%	York	QEW
24	0	0%	Peel	QEW
25	200	1%	Peel	QEW
26	800	6%	Peel	QEW
27	0	0%	Halton	QEW
28	0	0%	Halton	QEW
29	700	5%	Halton	QEW
30	2600	18%	Halton	QEW
31	100	1%	Flamborough	QEW
32	100	1%	Dundas	QEW
33	400	3%	Ancaster	Hamilton
34	200	1%	Glanbrook	South
35	2300	16%	Stoney Creek	Hamilton
36A	6200	22%	Hamilton (lower)	QEW
36B	n/a	22%	Hamilton (upper)	Hamilton
	14400	**100%**		

Stoney Creek Trips	
QEW	58.31%
Hamilton	40.25%
Glanbrook	1.39%
	100%

		AM OUT	PM IN
		1271	1419
EB	40%	508	568
WB-QEW	35%	445	496
WB-Hamilton	24%	307	343
WB-McNeilly	1%	11	12
	100%	1271	1419

		AM IN	PM OUT
		425	787
EB	60%	255	472
WB-QEW	23%	99	184
WB-Hamilton	16%	68	127
WB-McNeilly	1%	2	4
	100%	424	787

PLANNING DISTRICTS	2006 GTA Traffic Anaylsis Zones
Tue Oct 23 2018 14:02:44 GMT-0400 (Eastern Daylight Time) - Run Time: 2704ms	Tue Oct 23 2018 14:28:27 GMT-0400 (Eastern Daylight Time) - Run Time: 2078ms
Cross Tabulation Query Form - Trip - 2016 v1.1	Cross Tabulation Query Form - Trip - 2016 v1.1
Row: Planning district of destination - pd dest Column: 2006 GTA zone of origin - gta06 orig	Row: 2006 GTA zone of destination - gta06 dest Column: 2006 GTA zone of origin - gta06 orig
RowG: ColG:(5061) TblG:	RowG: ColG:(5061) TblG:
Filters: (Start time of trip - start time In 600-900 and Type of dwelling unit - dwell type In 1,3 and Trip purpose of origin - purp orig In H and Primary travel mode of trip - mode prime In D,N,P,T)	Filters: (Start time of trip - start time In 600-900 and Type of dwelling unit - dwell type In 1,3 and Trip purpose of origin - purp orig In H and Primary travel mode of trip - mode prime In D,N,P,T)
Trip 2016 Table:	Trip 2016 Table:

To/From	To/From	AM IN	AM OUT	PM IN	PM OUT
West (QEW)	via North Lewis Rd	15%	15%	15%	15%
West (QEW)	via North McNeily Rd	15%	15%	15%	15%
North	Lewis Road	5%	5%	5%	5%
North	McNeily Road	0%	0%	5%	5%
South	Lewis Road	0%	0%	0%	0%
South	McNeily Road	10%	10%	15%	15%
East	Barton Street	5%	5%	5%	5%
East	Highway 8	15%	15%	10%	10%
West	Barton Street	15%	15%	10%	10%
West	Highway 8	20%	20%	20%	20%
		100%	100%	100%	100%

			West	West	North	North	South	South	East	East	West	West		West	West	North	North	South	South	East	East	West	West
TAZ	PD	Trips	N Lewis Rd (QEW)	N McNeily Rd (QEW)	Lewis Rd	McNeily Rd	Lewis Rd	McNeily Rd	Barton St	Hwy 8	Barton St	Hwy 8		N Lewis Rd (QEW)	N McNeily Rd (QEW)	Lewis Rd	McNeily Rd	Lewis Rd	McNeily Rd	Barton St	Hwy 8	Barton St	Hwy 8
	PD 8 of Toronto	25	0.5	0.5									1	12.5	12.5	0	0	0	0	0	0	0	0
	Mississauga	25	0.5	0.5									1	12.5	12.5	0	0	0	0	0	0	0	0
	Oakville	58	0.5	0.5									1	29	29	0	0	0	0	0	0	0	0
	Burlington	128	0.5	0.5									1	64	64	0	0	0	0	0	0	0	0
5036	Ancaster	55	0.25	0.25							0.25	0.25	1	13.75	13.75	0	0	0	0	0	0	13.75	13.75
5061	Stoney Creek	144							0.5	0.5			1	0	0	0	0	0	0	72	72	0	0
5088	Stoney Creek	24			0.5	0.5							1	0	0	12	12	0	0	0	0	0	0
5093	Stoney Creek	125						0.5				0.5	1	0	0	0	0	0	62.5	0	0	0	62.5
5106	Stoney Creek	96									0.5	0.5	1	0	0	0	0	0	0	0	0	48	48
5108	Stoney Creek	47			0.2						0.4	0.4	1	0	0	9.4	0	0	0	0	0	18.8	18.8
5136	Stoney Creek	55			0.2						0.4	0.4	1	0	0	11	0	0	0	0	0	22	22
5126	Hamilton	37									0.5	0.5	1	0	0	0	0	0	0	0	0	18.5	18.5
5145	Hamilton	50			0.3						0.4	0.3	1	0	0	15	0	0	0	0	0	20	15
5153	Hamilton	18			0.3						0.4	0.3	1	0	0	5.4	0	0	0	0	0	7.2	5.4
5159	Hamilton	16	0.5	0.5									1	8	8	0	0	0	0	0	0	0	0
5192	Hamilton	45	0.5	0.5									1	22.5	22.5	0	0	0	0	0	0	0	0
5194	Hamilton	21	0.5	0.5									1	10.5	10.5	0	0	0	0	0	0	0	0
5195	Hamilton	21	0.5	0.5									1	10.5	10.5	0	0	0	0	0	0	0	0
5198	Hamilton	19	0.5	0.5									1	9.5	9.5	0	0	0	0	0	0	0	0
6006	Grimsby	22						1		0			1	0	0	0	0	0	22	0	0	0	0
6007	Grimsby	22						1		0			1	0	0	0	0	0	22	0	0	0	0
6009	Grimsby	22						1		0			1	0	0	0	0	0	22	0	0	0	0
	Lincoln	46								1			1	0	0	0	0	0	0	0	46	0	0
	St. Catharines	55								1			1	0	0	0	0	0	0	0	55	0	0
	City of Guelph	14	0.5	0.5									1	7	7	0	0	0	0	0	0	0	0
	Total	1190												199.75	199.75	52.8	12	0	128.5	72	173	148.25	203.95
														200	200	53	12	0	128	72	173	148	204
														16.8%	16.8%	4.5%	1.0%	0.0%	10.8%	6.1%	14.5%	12.4%	17.1%
														15%	15%	5%	0%	0%	10%	5%	15%	15%	20%
														15%	15%	5%	5%	0%	15%	5%	10%	10%	20%

	PD	TAZ
Ancaster	55	55
Stoney Creek	490	491
Hamilton	226	227
Grimsby	67	66

PLANNING DISTRICTS

Tue Oct 23 2018 14:02:44 GMT-0400 (Eastern Daylight Time) - Run Time: 2704ms

Cross Tabulation Query Form - Trip - 2016 v1.1

Row: Planning district of destination - pd_dest
Column: 2006 GTA zone of origin - gta06_orig

RowG:
ColG:(5061)
TblG:

Filters:
(Start time of trip - start_time In 600-900
and
Type of dwelling unit - dwell_type In 1,3
and
Trip purpose of origin - purp_orig In H
and
Primary travel mode of trip - mode_prime In D,N,P,T)

Trip 2016
Table:

			West	West	North
TAZ	PD	Trips	N Lewis Rd (QEW)	N McNeily Rd (QEW)	Lewis Rd
	PD 8 of Toronto	25	0.5	0.5	
	Mississauga	25	0.5	0.5	
	Oakville	58	0.5	0.5	
	Burlington	128	0.5	0.5	
5036	Ancaster	55	0.25	0.25	
5061	Stoney Creek	144			
5088	Stoney Creek	24			0.5
5093	Stoney Creek	125			
5106	Stoney Creek	96			
5108	Stoney Creek	47			0.2
5136	Stoney Creek	55			0.2
5126	Hamilton	37			
5145	Hamilton	50			0.3
5153	Hamilton	18			0.3
5159	Hamilton	16	0.5	0.5	
5192	Hamilton	45	0.5	0.5	
5194	Hamilton	21	0.5	0.5	
5195	Hamilton	21	0.5	0.5	
5198	Hamilton	19	0.5	0.5	
6006	Grimsby	22			
6007	Grimsby	22			
6009	Grimsby	22			
	Lincoln	46			
	St. Catharines	55			
	City of Guelph	14	0.5	0.5	
	Total	1190			

	PD	TAZ
Ancaster	55	55
Stoney Creek	490	491

Hamilton	226	227
Grimsby	67	66

2006 GTA Traffic Anaylsis Zones

Tue Oct 23 2018 14:28:27 GMT-0400 (Eastern Daylight Time) - Run Time: 2078ms

Cross Tabulation Query Form - Trip - 2016 v1.1

Row: 2006 GTA zone of destination - gta06_dest
Column: 2006 GTA zone of origin - gta06_orig

RowG:
ColG:(5061)
TblG:

Filters:
(Start time of trip - start_time In 600-900
and
Type of dwelling unit - dwell_type In 1,3
and
Trip purpose of origin - purp_orig In H
and
Primary travel mode of trip - mode_prime In D,N,P,T)

Trip 2016
Table:

North	South	South	East	East	West	West	
McNeily Rd	Lewis Rd	McNeily Rd	Barton St	Hwy 8	Barton St	Hwy 8	
							1
							1
							1
							1
					0.25	0.25	1
			0.5	0.5			1
0.5							1
		0.5				0.5	1
					0.5	0.5	1
					0.4	0.4	1
					0.4	0.4	1
					0.5	0.5	1
					0.4	0.3	1
					0.4	0.3	1
							1
							1
							1
							1
							1
		1		0			1
		1		0			1
		1		0			1
				1			1
				1			1
							1

To/From	To/From	AM IN	AM OUT	PM IN	PM OUT
West (QEW)	via North Lewis Rd	15%	15%	15%	15%
West (QEW)	via North McNeily Rd	15%	15%	15%	15%
North	Lewis Road	5%	5%	5%	5%
North	McNeily Road	0%	0%	5%	5%
South	Lewis Road	0%	0%	0%	0%
South	McNeily Road	10%	10%	15%	15%
East	Barton Street	5%	5%	5%	5%
East	Highway 8	15%	15%	10%	10%
West	Barton Street	15%	15%	10%	10%
West	Highway 8	20%	20%	20%	20%
		100%	100%	100%	100%

West	West	North	North	South	South	East
N Lewis Rd (QEW)	N McNeily Rd (QEW)	Lewis Rd	McNeily Rd	Lewis Rd	McNeily Rd	Barton St
12.5	12.5	0	0	0	0	0
12.5	12.5	0	0	0	0	0
29	29	0	0	0	0	0
64	64	0	0	0	0	0
13.75	13.75	0	0	0	0	0
0	0	0	0	0	0	72
0	0	12	12	0	0	0
0	0	0	0	0	62.5	0
0	0	0	0	0	0	0
0	0	9.4	0	0	0	0
0	0	11	0	0	0	0
0	0	0	0	0	0	0
0	0	15	0	0	0	0
0	0	5.4	0	0	0	0
8	8	0	0	0	0	0
22.5	22.5	0	0	0	0	0
10.5	10.5	0	0	0	0	0
10.5	10.5	0	0	0	0	0
9.5	9.5	0	0	0	0	0
0	0	0	0	0	22	0
0	0	0	0	0	22	0
0	0	0	0	0	22	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
7	7	0	0	0	0	0
199.75	199.75	52.8	12	0	128.5	72
200	200	53	12	0	128	72
16.8%	16.8%	4.5%	1.0%	0.0%	10.8%	6.1%
15%	15%	5%	0%	0%	10%	5%

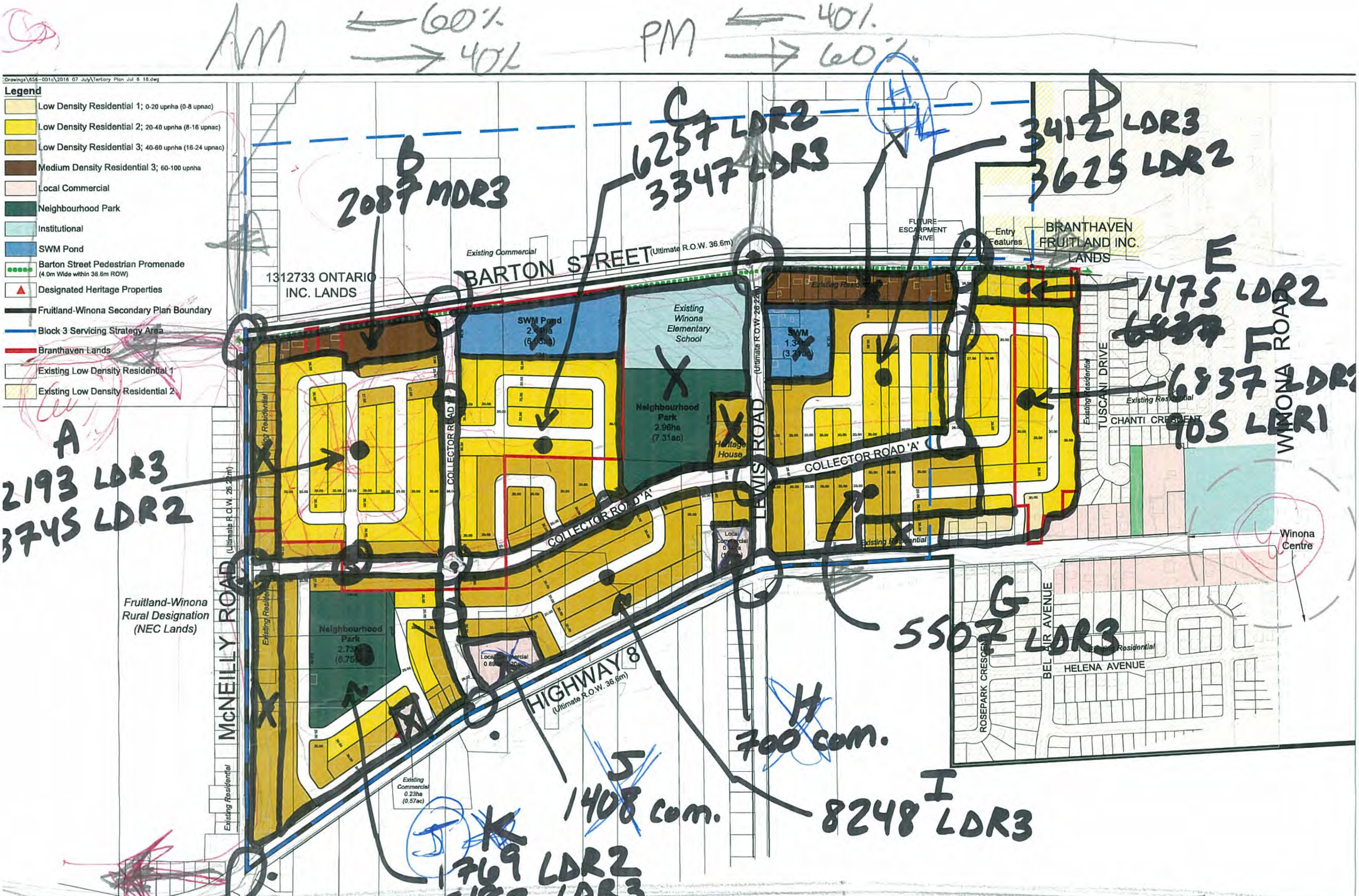
15%	15%	5%	5%	0%	15%	5%

East	West	West
Hwy 8	Barton St	Hwy 8
0	0	0
0	0	0
0	0	0
0	0	0
0	13.75	13.75
72	0	0
0	0	0
0	0	62.5
0	48	48
0	18.8	18.8
0	22	22
0	18.5	18.5
0	20	15
0	7.2	5.4
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
46	0	0
55	0	0
0	0	0
173	148.25	203.95
173	148	204
14.5%	12.4%	17.1%
15%	15%	20%

10%	10%	20%

Appendix C

Turning Movement Diagarams



FRUITLAND-WINONA SECONDARY PLAN - TERTIARY PLAN

STONEY CREEK, CITY OF HAMILTON

Low Density Residential 1; 0-20 upnha (0-8 upnac)
Net Developable Area 0.60ha (1.48ac) x 20 upnha = 12 units

Low Density Residential 2; 20-40 upnha (8-16 upnac)
Net Developable Area 18.2ha (45.0ac) x 20 upnha = 364 units
Net Developable Area 18.2ha (45.0ac) x 40 upnha = 728 units

Low Density Residential 3; 40-60 upnha (16-24 upnac)
Net Developable Area 21.8ha (53.9ac) x 40 upnha = 872 units
Net Developable Area 21.8ha (53.9ac) x 60 upnha = 1,308 units

Medium Density Residential 3; 60-100 upnha
Net Developable Area 3.04ha (7.51ac) x 60 upnha = 182 units
Net Developable Area 3.04ha (7.51ac) x 100 upnha = 304 units

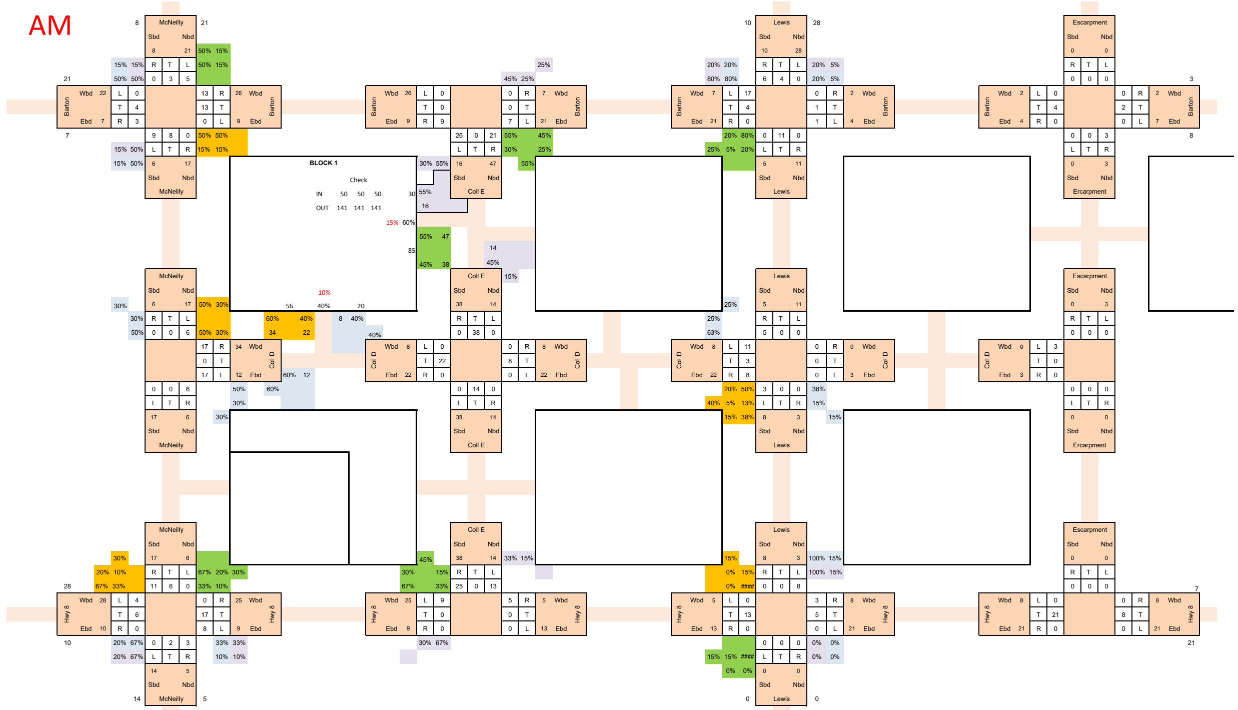
UNIT TOTALS:	
MINIMUM	MAXIMUM
1,430	2,352

Scale 1:2500 (24 x 36)
July 7, 2016

WORKING COPY

Glen Schnarr & Associates Inc.
Urban & Regional Planners, Land Development Consultants

AM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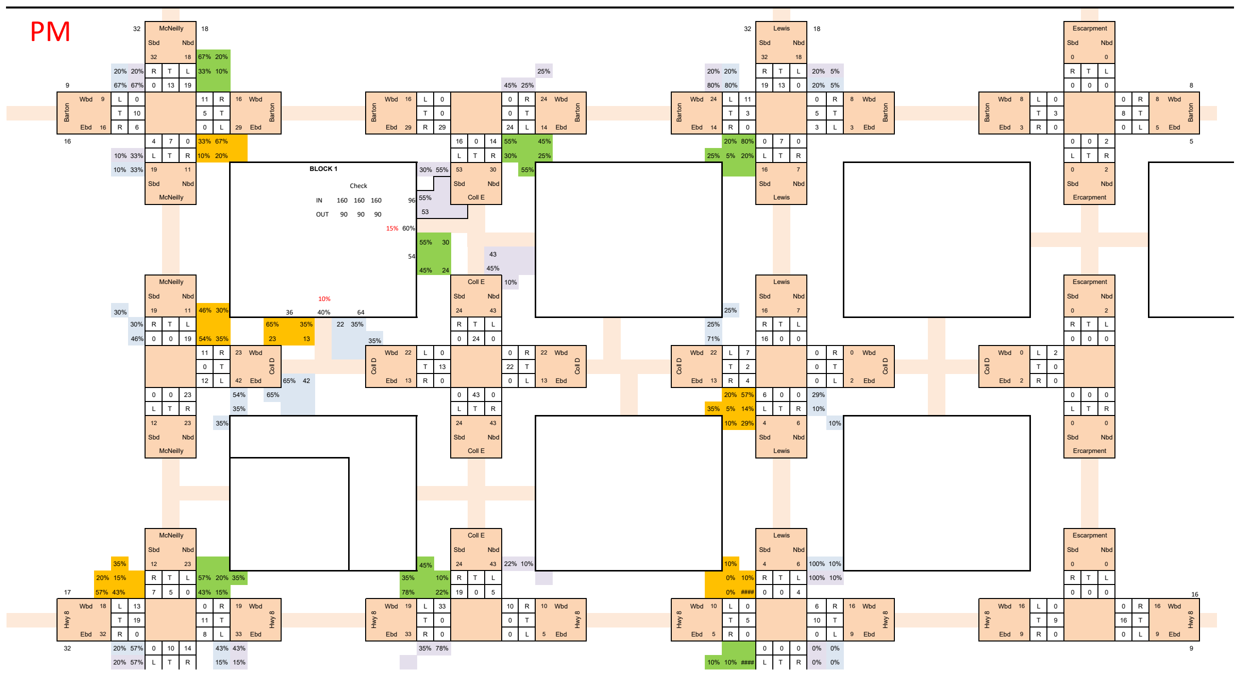
Check
McNeilly
Barton
Coll E
Coll D
Lewis
Escarpment
Hwy 8

PM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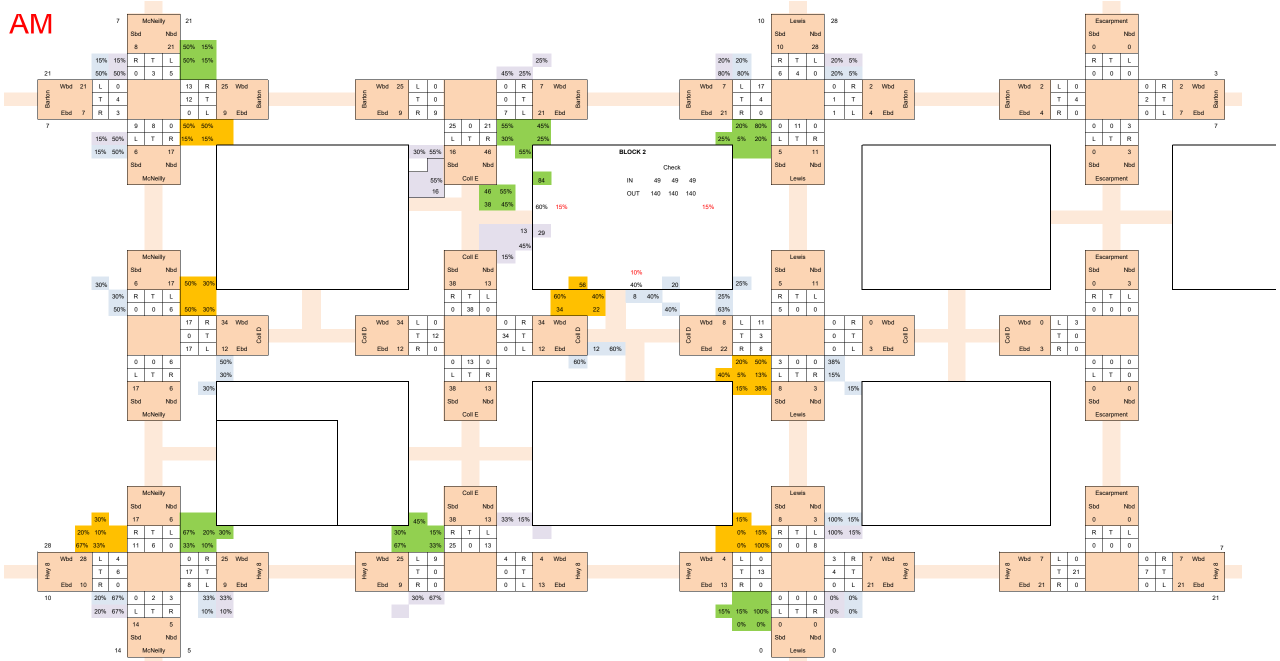
McNeilly
Barton
Coll E
Coll D
Lewis
Escarpment
Hwy 8



AM
McNeilly
Barton
Lewis
Escarpment
Coll E
Coll D
Hwy 8
BLOCK 2
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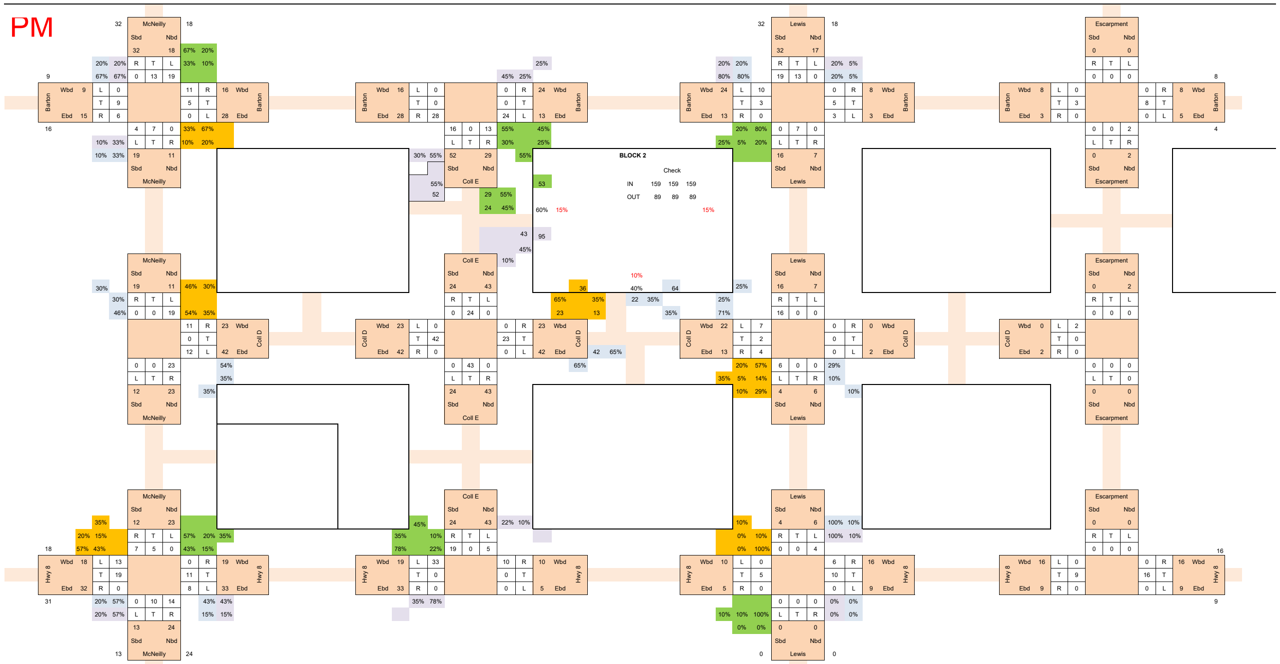
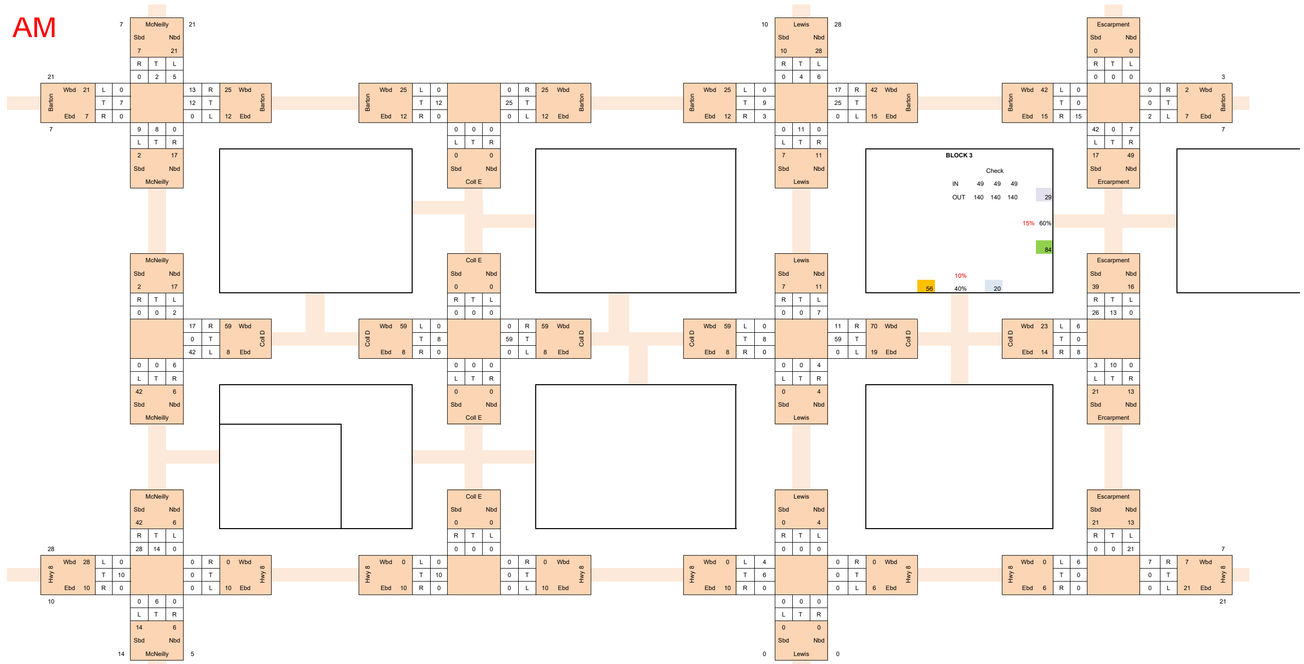


PM
McNeilly
Barton
Lewis
Escarpment
Coll E
Coll D
Hwy 8
BLOCK 2
Check
IN 159 159 159
OUT 89 89 89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McNeilly
Lewis
Escarpment
Barton
Coll E
Coll D
Hwy 8
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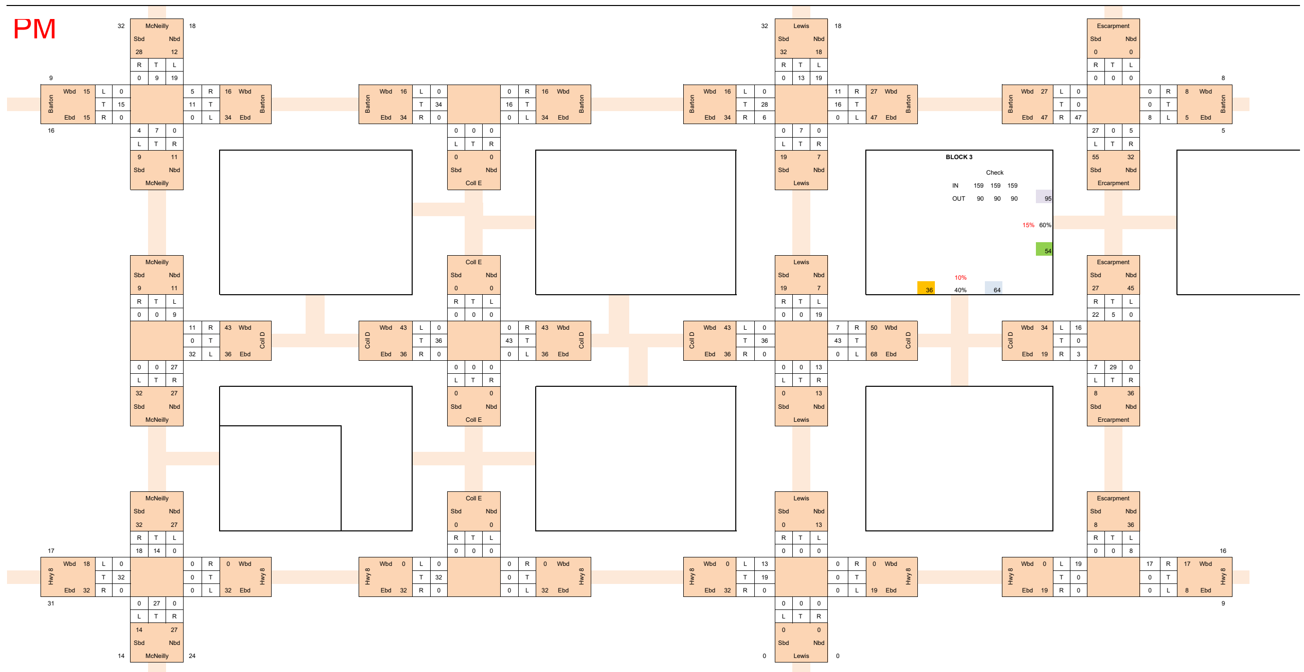
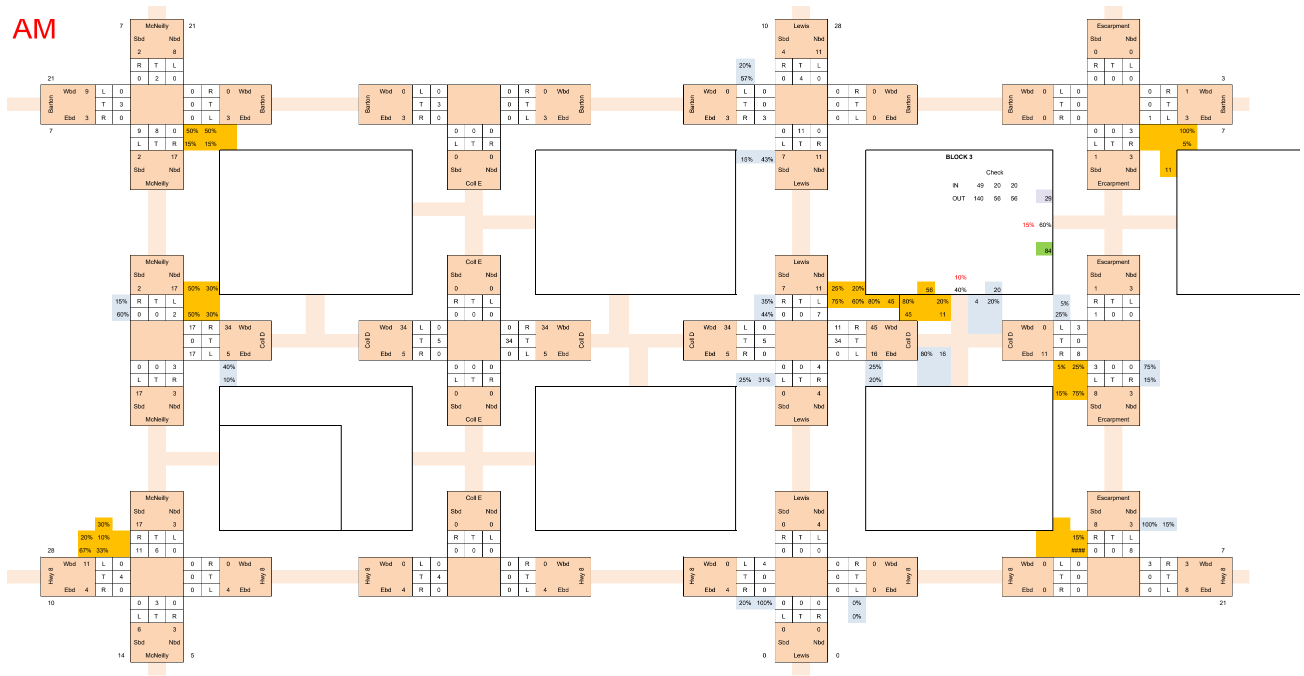
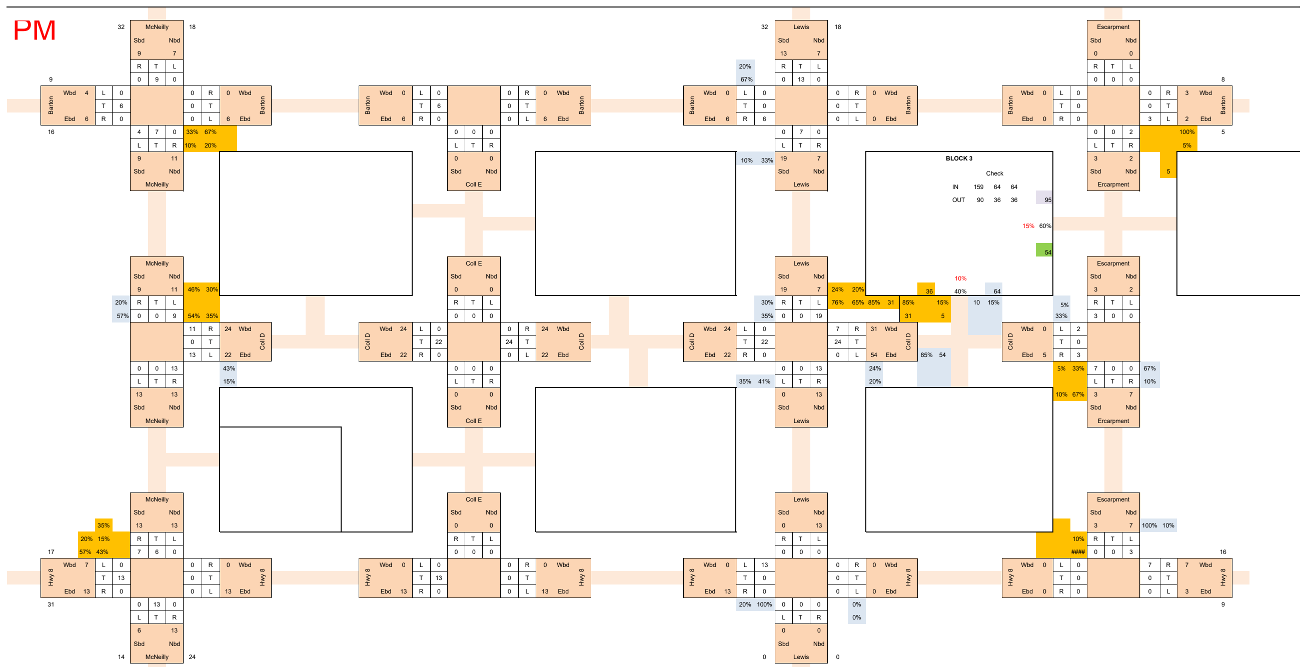

PM
McNeilly
Lewis
Escarpment
Barton
Coll E
Coll D
Hwy 8
BLOCK 3
Check
IN 159 159 159
OUT 90 90 90

AM



McNeilly
Lewis
Escarpment
Barton
Coll E
Coll D
Hwy 8
BLOCK 3

PM



McNeilly
Lewis
Escarpment
Barton
Coll E
Coll D
Hwy 8
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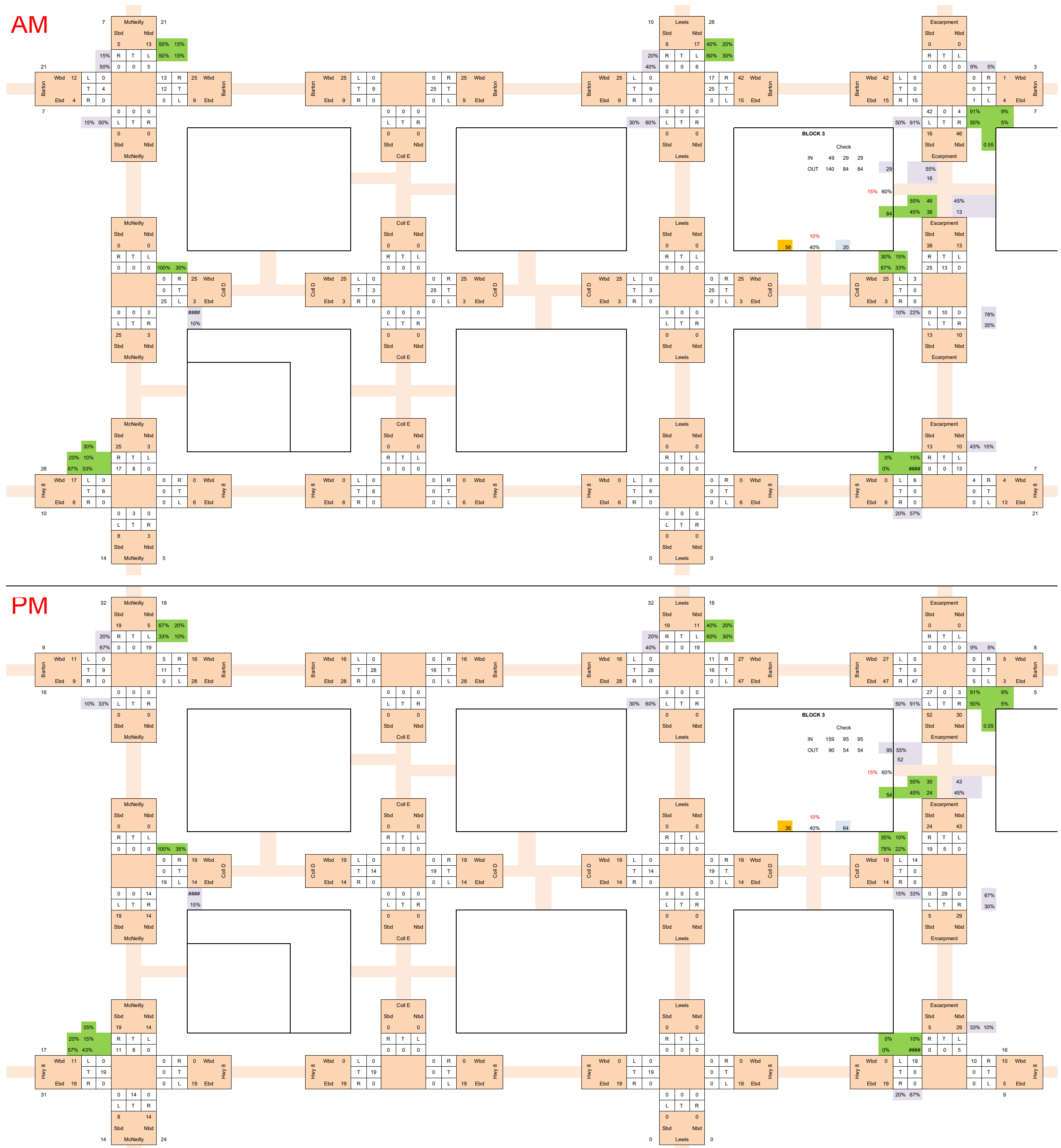
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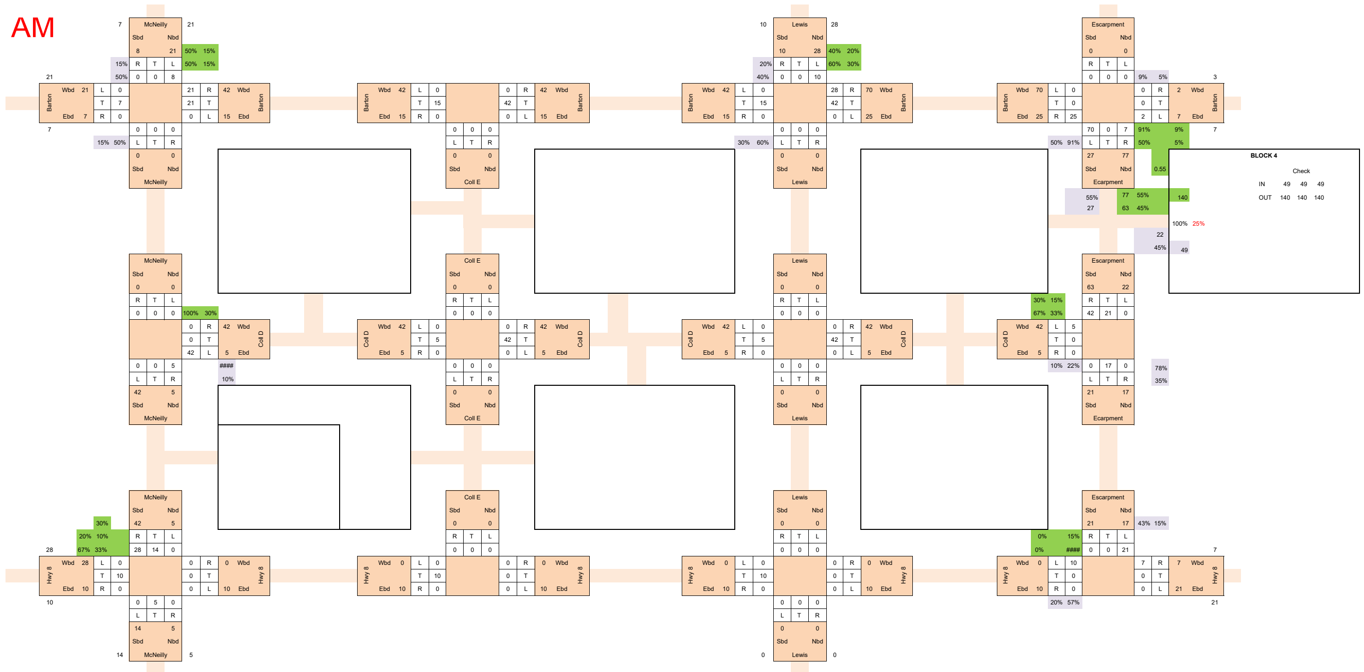
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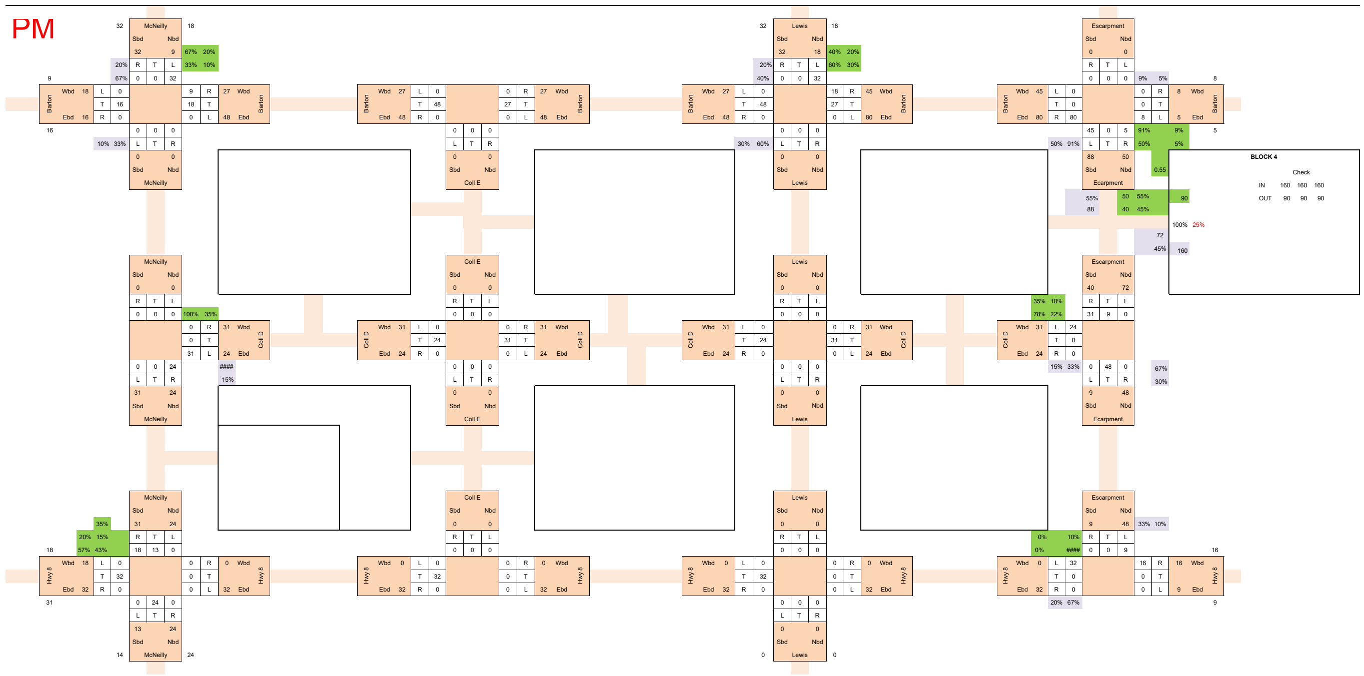
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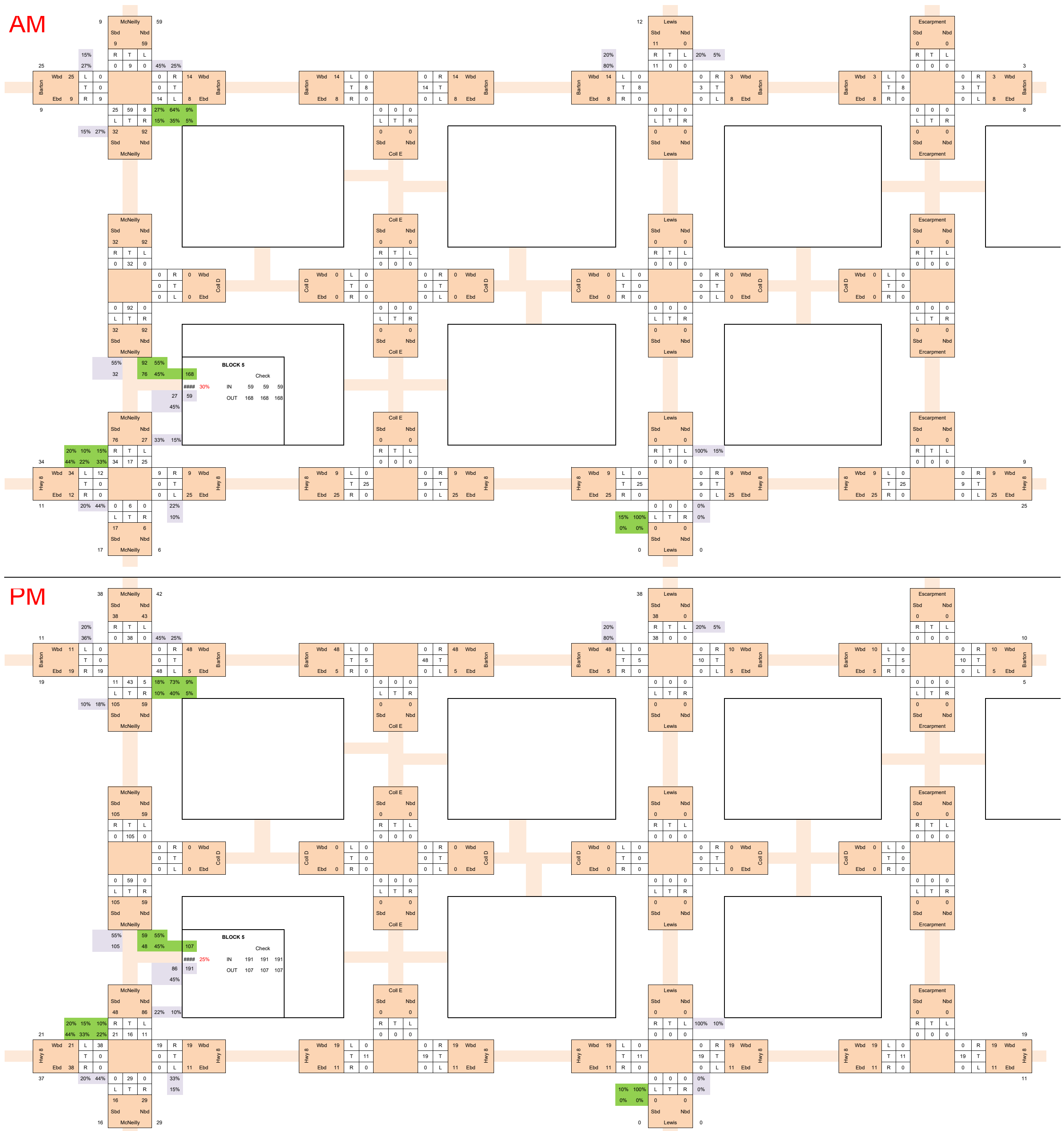

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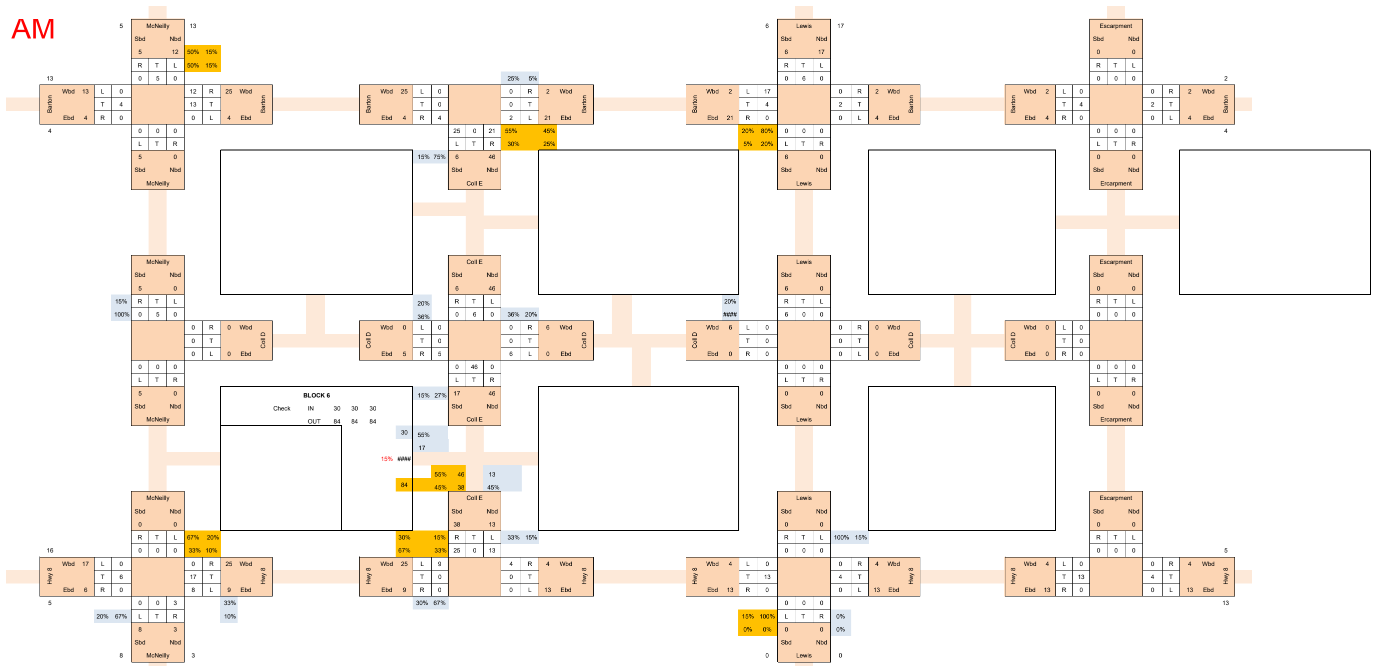
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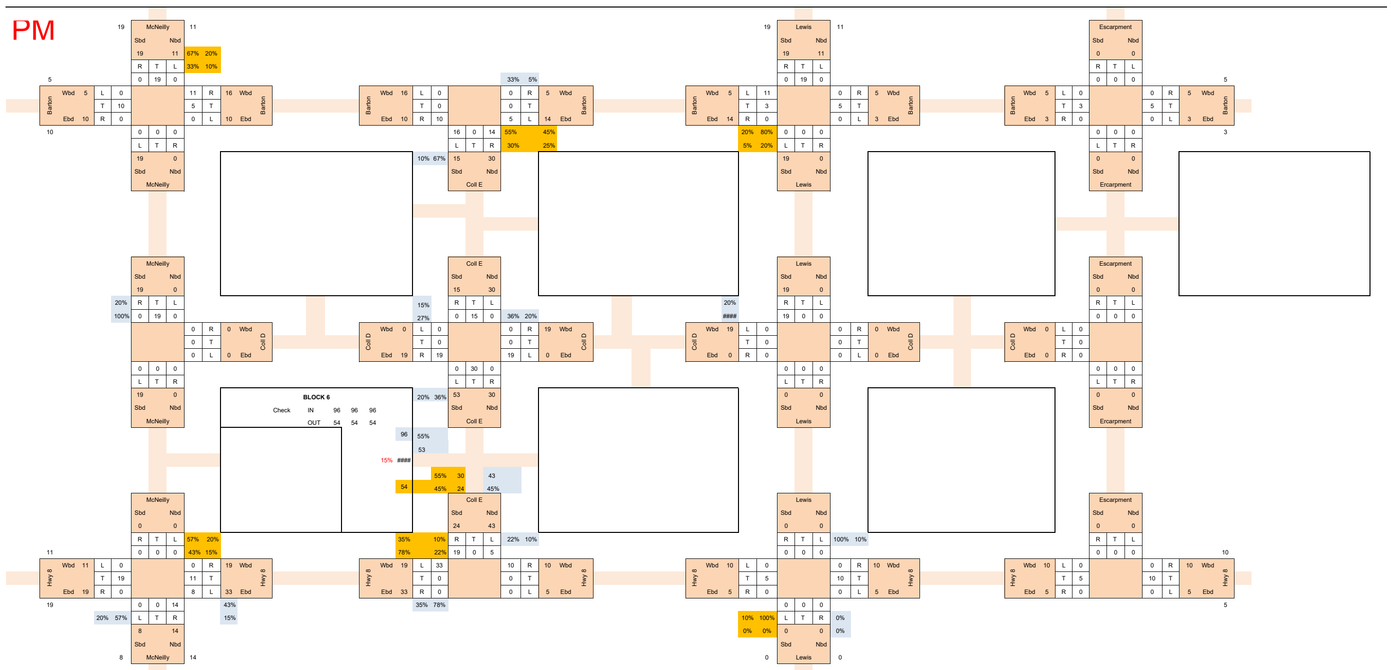
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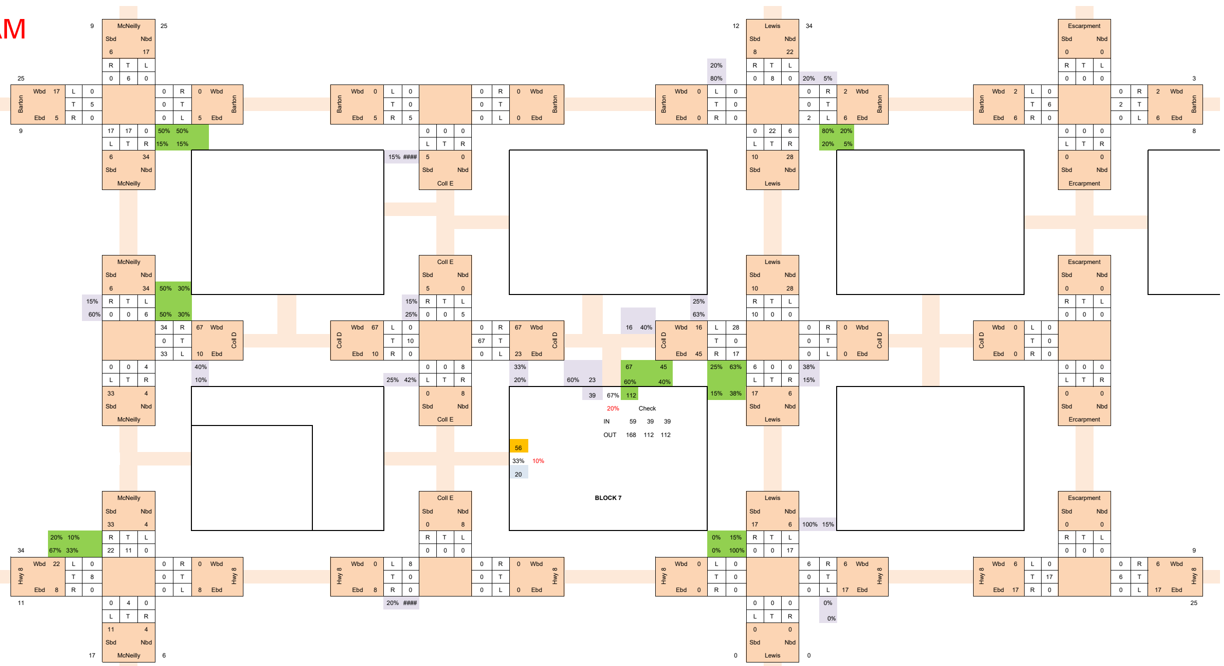

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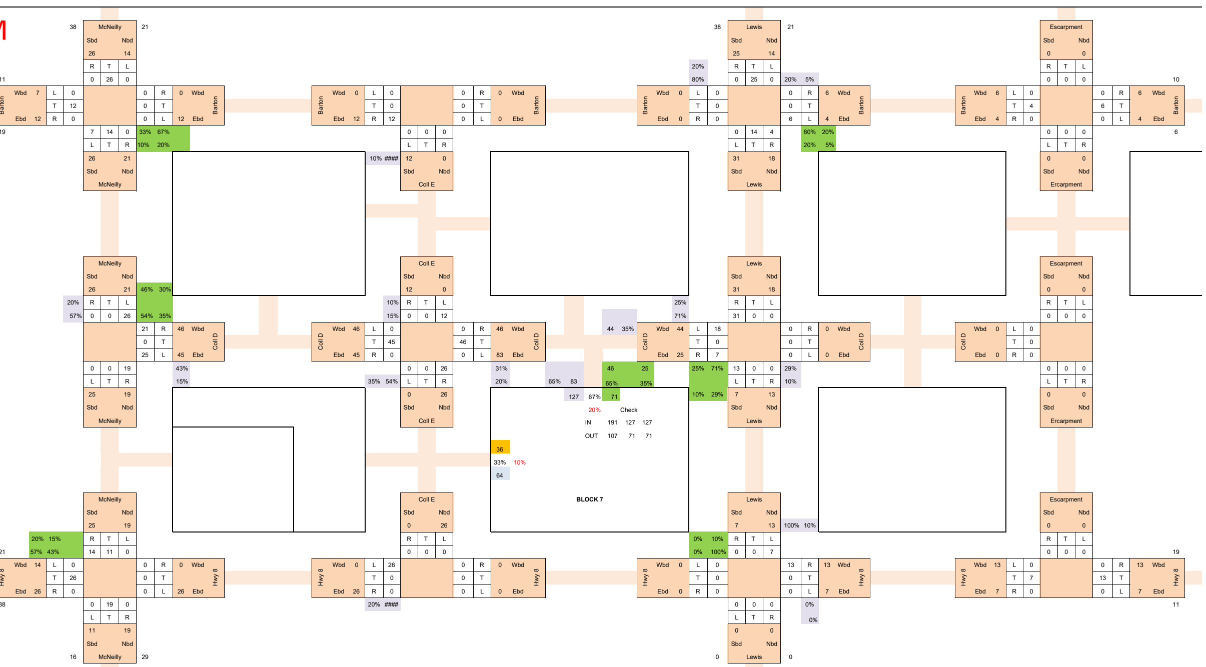

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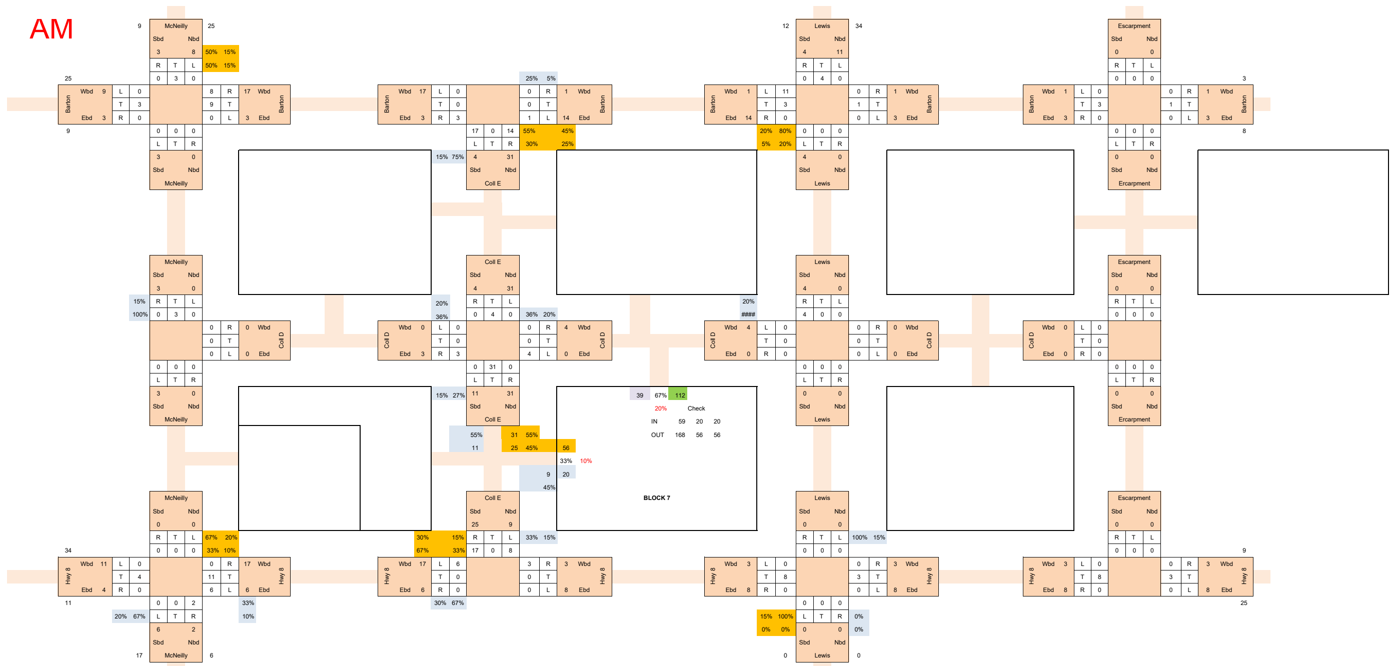
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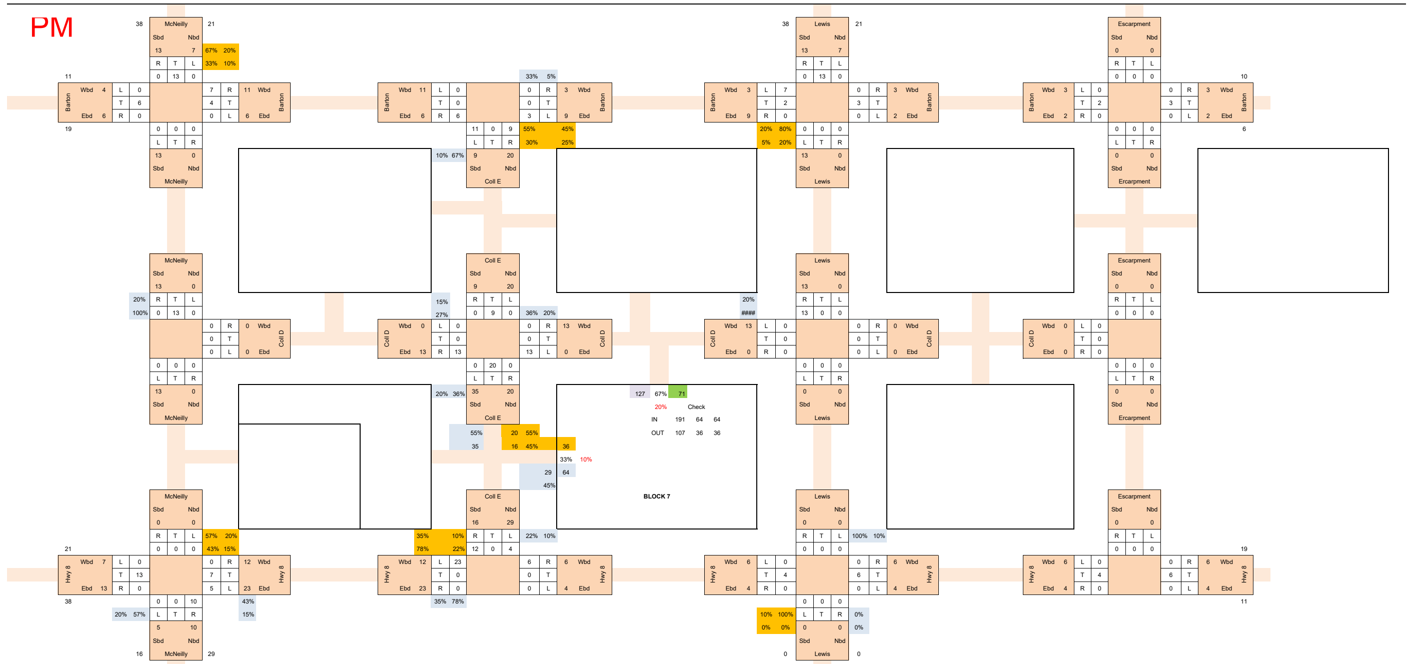
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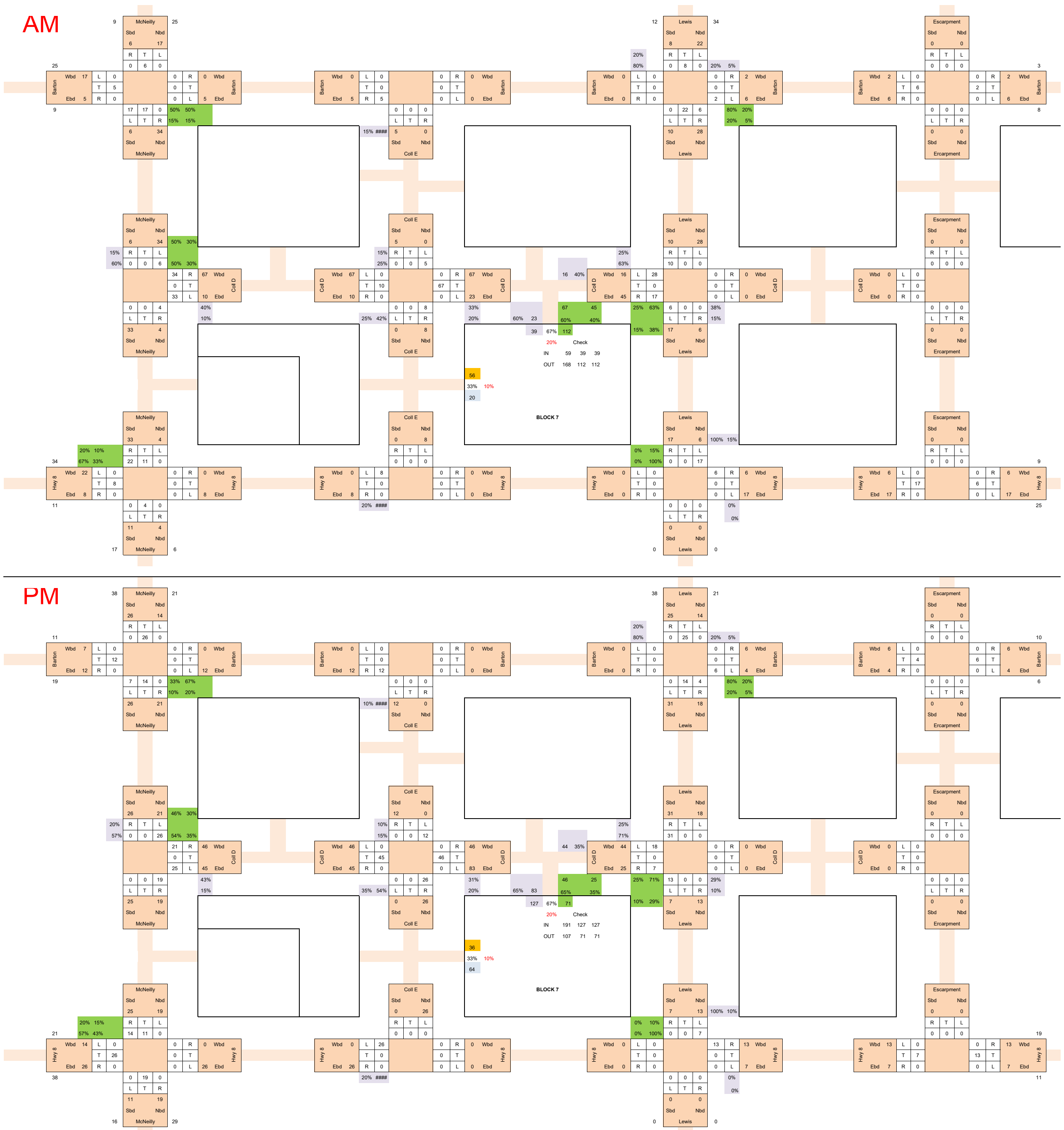

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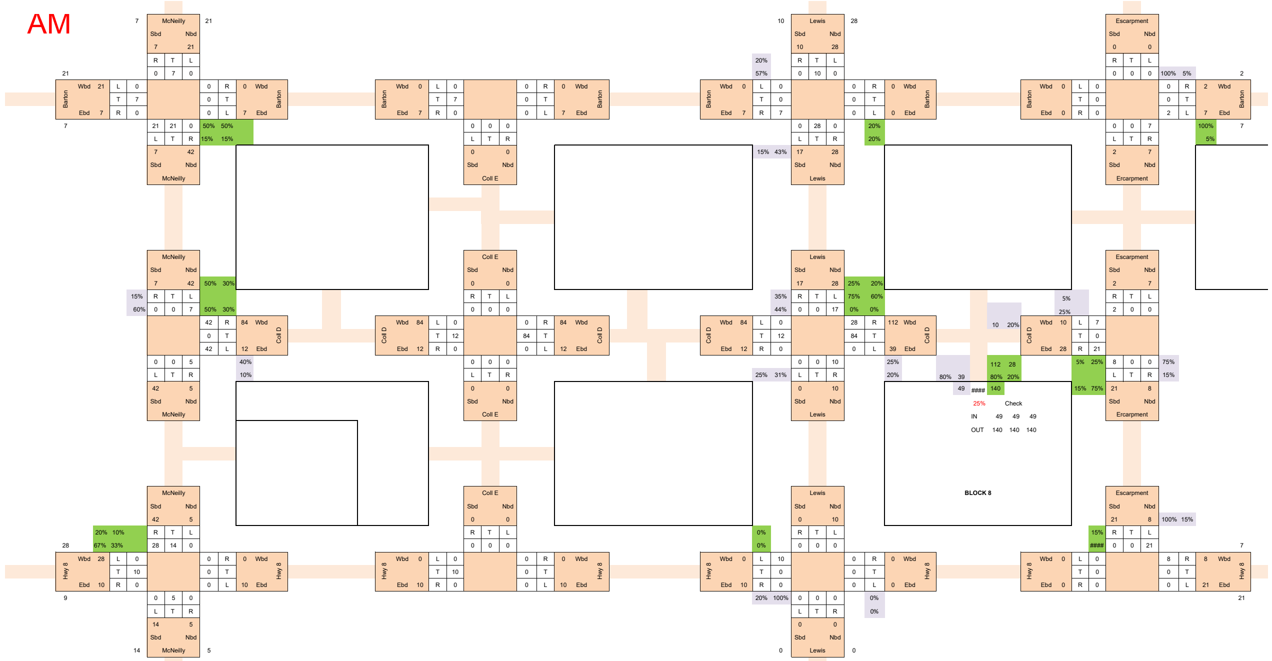

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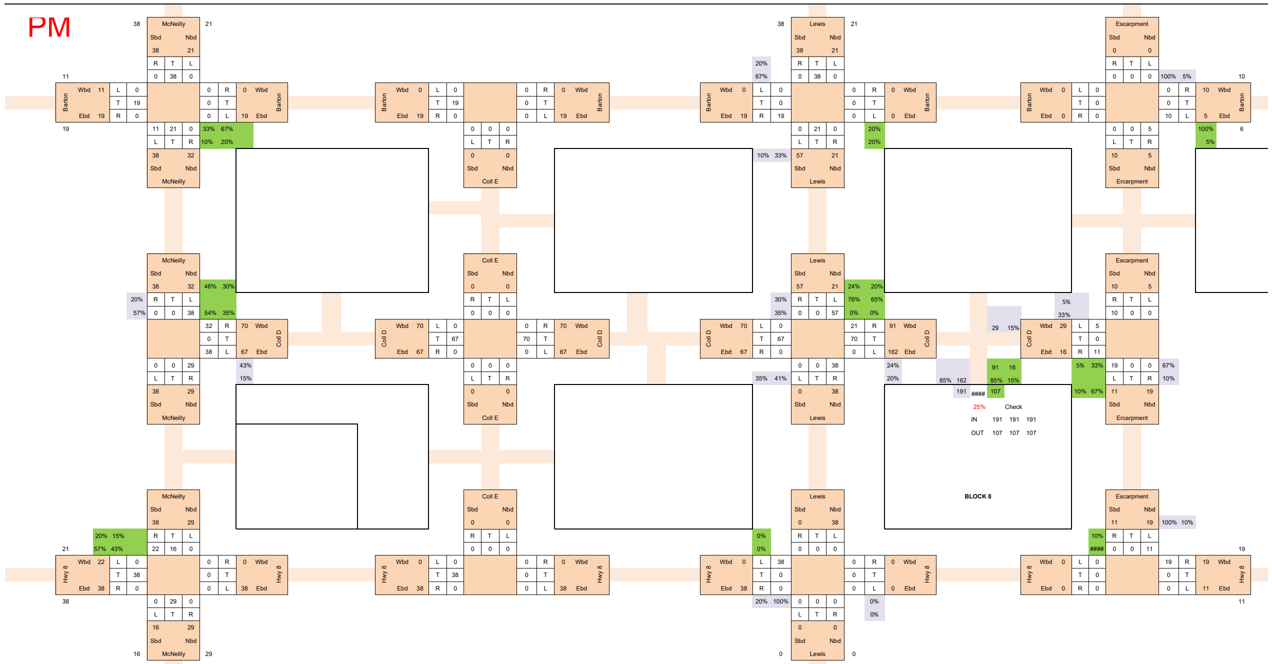

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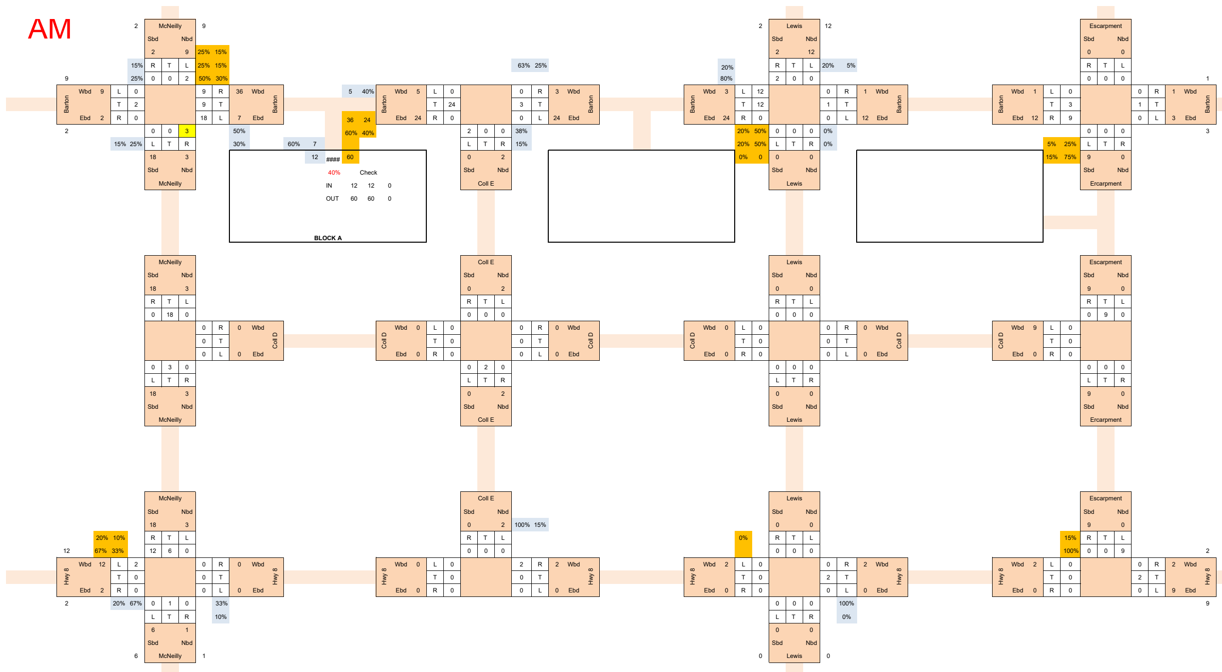
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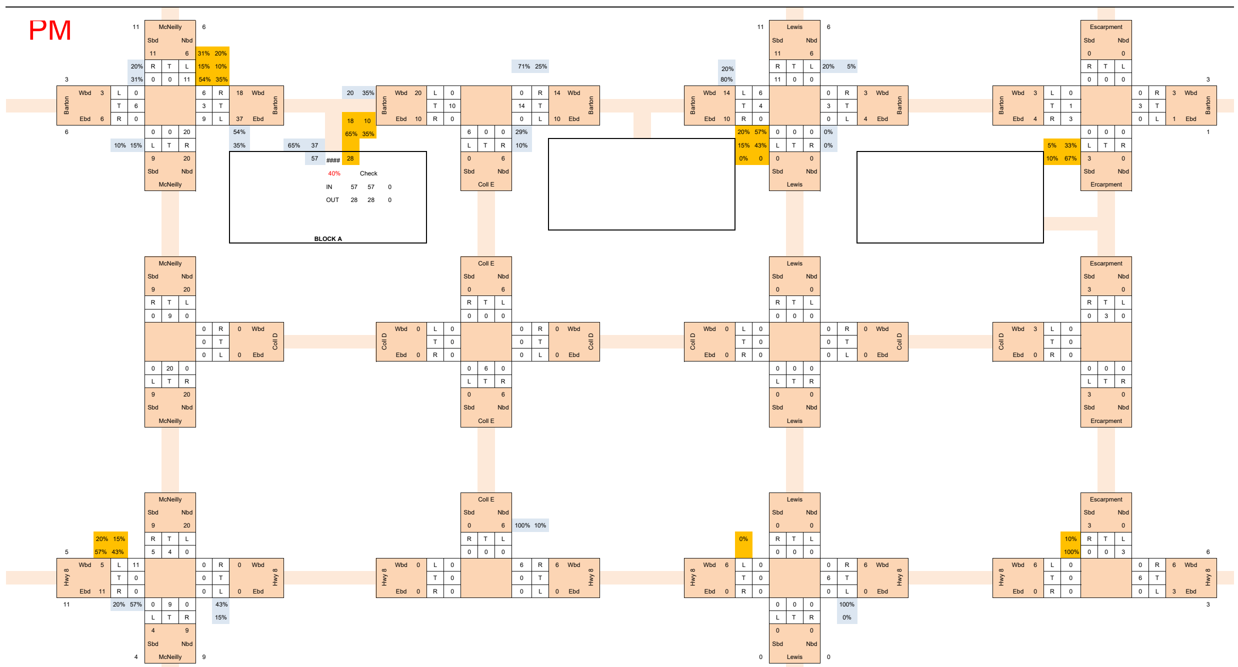
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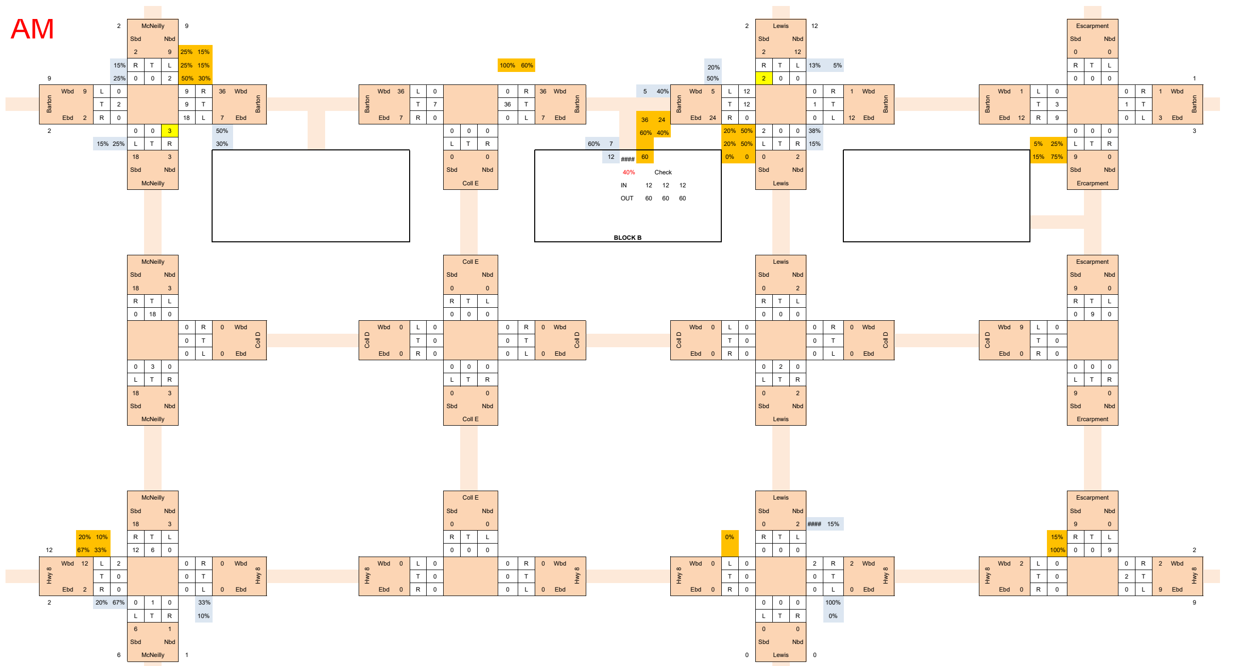
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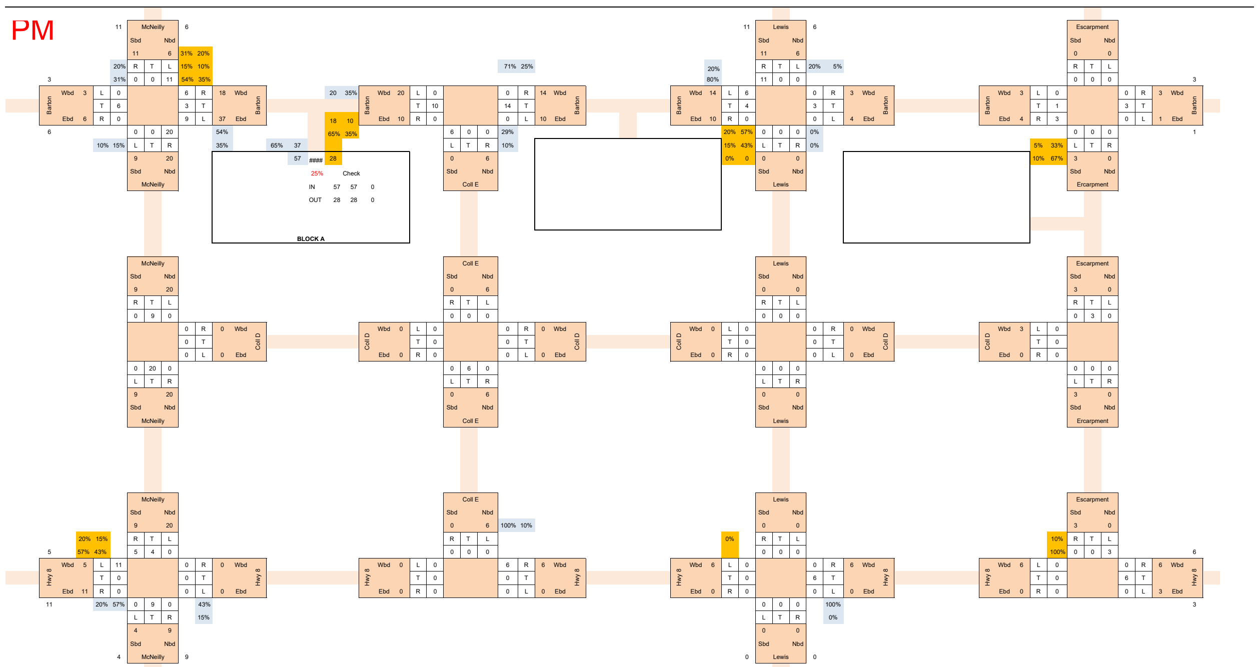
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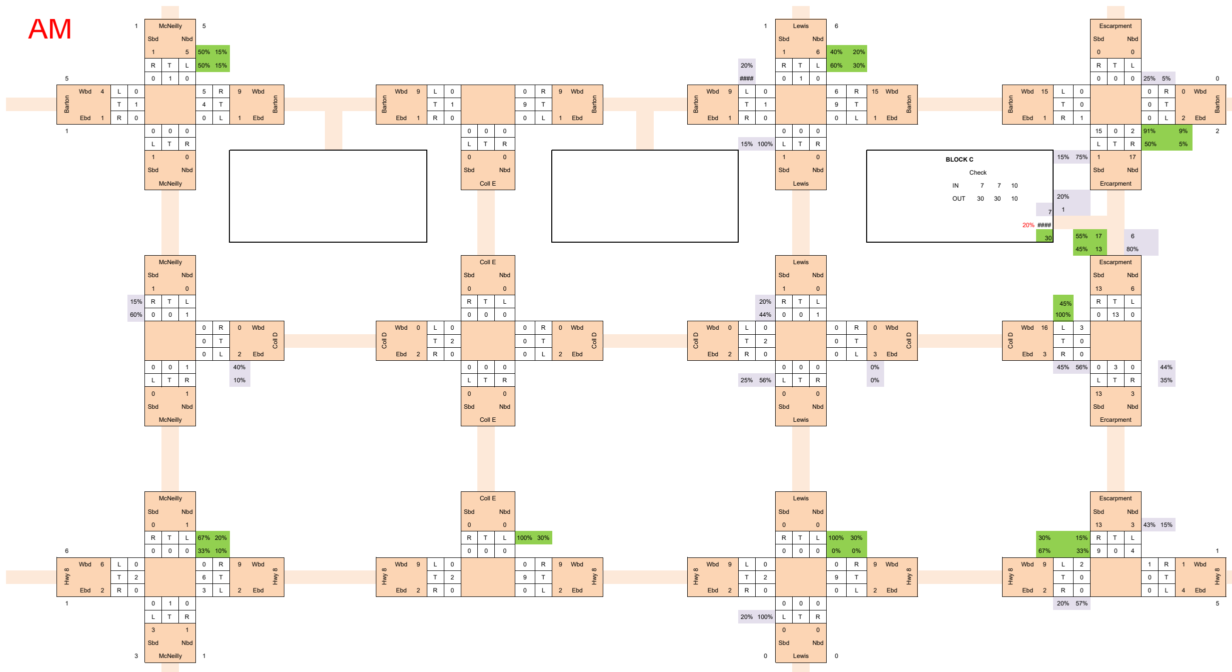
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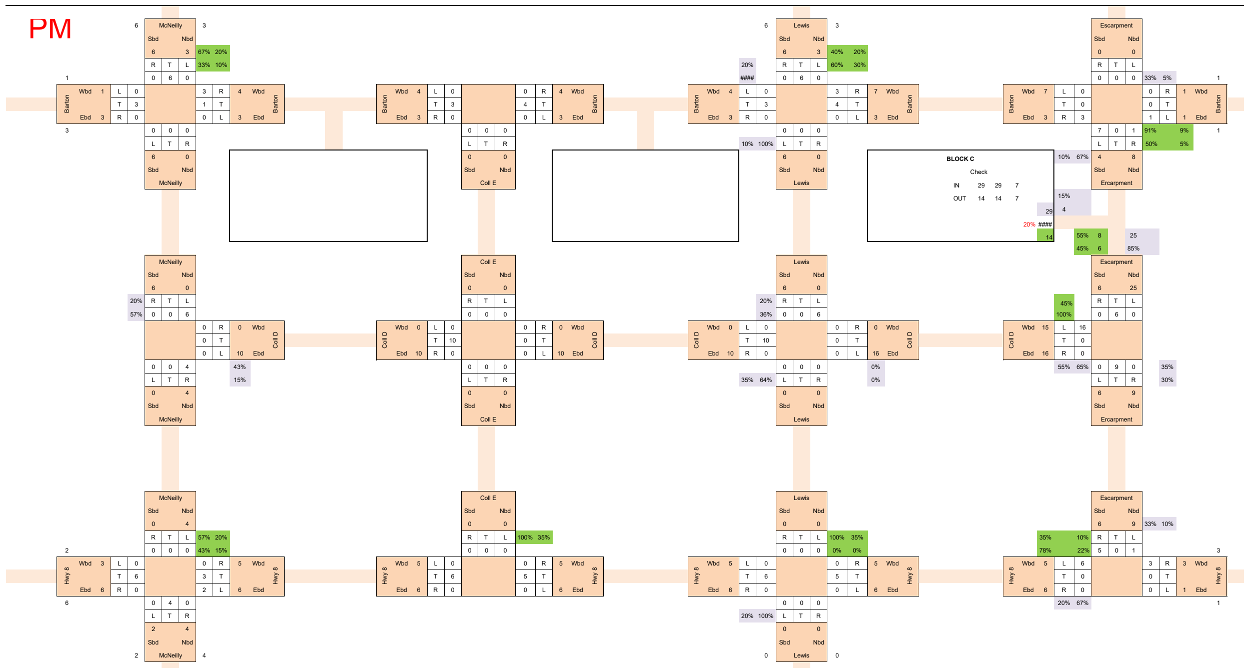
OUT 30 30 10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Nbd
BLOCK C
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OUT 14 14 7

Appendix D

Capacity Analysis Tables

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✣			✣			✣			✣	
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	30	117	10	11	157	11	104	10	27	10	2	15
Peak Hour Factor	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Hourly flow rate (vph)	34	131	11	12	176	12	117	11	30	11	2	17

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	176	201	158	30
Volume Left (vph)	34	12	117	11
Volume Right (vph)	11	12	30	17
Hadj (s)	0.18	0.10	0.08	-0.13
Departure Headway (s)	4.8	4.7	4.9	4.9
Degree Utilization, x	0.24	0.26	0.22	0.04
Capacity (veh/h)	704	725	679	655
Control Delay (s)	9.3	9.4	9.3	8.1
Approach Delay (s)	9.3	9.4	9.3	8.1
Approach LOS	A	A	A	A

Intersection Summary			
Delay	9.3		
Level of Service	A		
Intersection Capacity Utilization	38.3%	ICU Level of Service	A
Analysis Period (min)	15		

Intersection	
Intersection Delay, s/veh	9.3
Intersection LOS	A

Movement	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR
Vol, veh/h	0	30	117	10	0	11	157	11	0	104	10	27
Peak Hour Factor	0.92	0.89	0.89	0.89	0.92	0.89	0.89	0.89	0.92	0.89	0.89	0.89
Heavy Vehicles, %	0	13	9	20	0	9	7	9	0	2	0	7
Mvmt Flow	0	34	131	11	0	12	176	12	0	117	11	30
Number of Lanes	0	0	1	0	0	0	1	0	0	0	1	0

Approach	EB	WB	NB
Opposing Approach	WB	EB	SB
Opposing Lanes	1	1	1
Conflicting Approach Left	SB	NB	EB
Conflicting Lanes Left	1	1	1
Conflicting Approach Right	NB	SB	WB
Conflicting Lanes Right	1	1	1
HCM Control Delay	9.4	9.4	9.3
HCM LOS	A	A	A

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	74%	19%	6%	37%
Vol Thru, %	7%	75%	88%	7%
Vol Right, %	19%	6%	6%	56%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	141	157	179	27
LT Vol	104	30	11	10
Through Vol	10	117	157	2
RT Vol	27	10	11	15
Lane Flow Rate	158	176	201	30
Geometry Grp	1	1	1	1
Degree of Util (X)	0.216	0.237	0.263	0.042
Departure Headway (Hd)	4.906	4.831	4.714	4.929
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	729	741	760	722
Service Time	2.951	2.873	2.755	2.987
HCM Lane V/C Ratio	0.217	0.238	0.264	0.042
HCM Control Delay	9.3	9.4	9.4	8.2
HCM Lane LOS	A	A	A	A
HCM 95th-tile Q	0.8	0.9	1.1	0.1

Intersection	
Intersection Delay, s/veh	
Intersection LOS	

Movement	SBU	SBL	SBT	SBR
Vol, veh/h	0	10	2	15
Peak Hour Factor	0.92	0.89	0.89	0.89
Heavy Vehicles, %	0	10	0	7
Mvmt Flow	0	11	2	17
Number of Lanes	0	0	1	0

Approach	SB
Opposing Approach	NB
Opposing Lanes	1
Conflicting Approach Left	WB
Conflicting Lanes Left	1
Conflicting Approach Right	EB
Conflicting Lanes Right	1
HCM Control Delay	8.2
HCM LOS	A

Lane

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	52	55	52	69	109	13	42	61	47	5	49	20
Peak Hour Factor	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78
Hourly flow rate (vph)	67	71	67	88	140	17	54	78	60	6	63	26

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	204	245	192	95
Volume Left (vph)	67	88	54	6
Volume Right (vph)	67	17	60	26
Hadj (s)	0.03	0.14	-0.01	-0.08
Departure Headway (s)	5.1	5.1	5.2	5.3
Degree Utilization, x	0.29	0.35	0.28	0.14
Capacity (veh/h)	659	660	636	605
Control Delay (s)	10.1	10.9	10.2	9.2
Approach Delay (s)	10.1	10.9	10.2	9.2
Approach LOS	B	B	B	A

Intersection Summary			
Delay	10.3		
Level of Service	B		
Intersection Capacity Utilization	35.9%	ICU Level of Service	A
Analysis Period (min)	15		

Intersection	
Intersection Delay, s/veh	10.1
Intersection LOS	B

Movement	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR
Vol, veh/h	0	52	55	52	0	69	109	13	0	42	61	47
Peak Hour Factor	0.92	0.78	0.78	0.78	0.92	0.78	0.78	0.78	0.92	0.78	0.78	0.78
Heavy Vehicles, %	0	2	11	15	0	9	6	0	0	7	3	13
Mvmt Flow	0	67	71	67	0	88	140	17	0	54	78	60
Number of Lanes	0	0	1	0	0	0	1	0	0	0	1	0

Approach	EB	WB	NB
Opposing Approach	WB	EB	SB
Opposing Lanes	1	1	1
Conflicting Approach Left	SB	NB	EB
Conflicting Lanes Left	1	1	1
Conflicting Approach Right	NB	SB	WB
Conflicting Lanes Right	1	1	1
HCM Control Delay	9.8	10.8	10.1
HCM LOS	A	B	B

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	28%	33%	36%	7%
Vol Thru, %	41%	35%	57%	66%
Vol Right, %	31%	33%	7%	27%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	150	159	191	74
LT Vol	42	52	69	5
Through Vol	61	55	109	49
RT Vol	47	52	13	20
Lane Flow Rate	192	204	245	95
Geometry Grp	1	1	1	1
Degree of Util (X)	0.273	0.275	0.344	0.138
Departure Headway (Hd)	5.106	4.849	5.063	5.223
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	696	732	703	691
Service Time	3.199	2.942	3.154	3.223
HCM Lane V/C Ratio	0.276	0.279	0.349	0.137
HCM Control Delay	10.1	9.8	10.8	9.1
HCM Lane LOS	B	A	B	A
HCM 95th-tile Q	1.1	1.1	1.5	0.5

Intersection				
Intersection Delay, s/veh				
Intersection LOS				

Movement	SBU	SBL	SBT	SBR
Vol, veh/h	0	5	49	20
Peak Hour Factor	0.92	0.78	0.78	0.78
Heavy Vehicles, %	0	0	0	15
Mvmt Flow	0	6	63	26
Number of Lanes	0	0	1	0

Approach	SB
Opposing Approach	NB
Opposing Lanes	1
Conflicting Approach Left	WB
Conflicting Lanes Left	1
Conflicting Approach Right	EB
Conflicting Lanes Right	1
HCM Control Delay	9.1
HCM LOS	A

Lane

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	7	99	167	0	7	23
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.71	0.71	0.71	0.71	0.71	0.71
Hourly flow rate (vph)	10	139	235	0	10	32
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	235				394	235
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	235				394	235
tC, single (s)	4.2				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.3				3.5	3.3
p0 queue free %	99				98	96
cM capacity (veh/h)	1265				609	799

Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	149	235	42
Volume Left	10	0	10
Volume Right	0	0	32
cSH	1265	1700	745
Volume to Capacity	0.01	0.14	0.06
Queue Length 95th (m)	0.2	0.0	1.4
Control Delay (s)	0.6	0.0	10.1
Lane LOS	A		B
Approach Delay (s)	0.6	0.0	10.1
Approach LOS			B

Intersection Summary			
Average Delay	1.2		
Intersection Capacity Utilization	21.0%	ICU Level of Service	A
Analysis Period (min)	15		

Lane Group	EBL	EBT	WBL	WBT	NBT	SBT
Lane Group Flow (vph)	11	214	22	404	187	30
v/c Ratio	0.03	0.26	0.05	0.46	0.50	0.09
Control Delay	6.9	8.0	7.0	9.9	18.5	10.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	6.9	8.0	7.0	9.9	18.5	10.9
Queue Length 50th (m)	0.4	8.2	0.8	17.4	10.4	0.9
Queue Length 95th (m)	2.4	20.7	3.8	40.3	28.0	5.9
Internal Link Dist (m)		209.0		438.7	135.3	482.6
Turn Bay Length (m)	30.0		30.0			
Base Capacity (vph)	792	1563	897	1656	627	560
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.01	0.14	0.02	0.24	0.30	0.05

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	191	10	21	347	33	49	86	41	7	8	13
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.1	6.1		6.1	6.1			6.2			6.2	
Lane Util. Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Frt	1.00	0.99		1.00	0.99			0.97			0.94	
Flt Protected	0.95	1.00		0.95	1.00			0.99			0.99	
Satd. Flow (prot)	1586	1678		1466	1776			1667			1490	
Flt Permitted	0.51	1.00		0.62	1.00			0.90			0.90	
Satd. Flow (perm)	849	1678		963	1776			1514			1358	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	11	203	11	22	369	35	52	91	44	7	9	14
RTOR Reduction (vph)	0	3	0	0	6	0	0	15	0	0	11	0
Lane Group Flow (vph)	11	211	0	22	398	0	0	172	0	0	19	0
Heavy Vehicles (%)	10%	8%	20%	19%	2%	3%	4%	5%	7%	14%	13%	15%
Turn Type	Perm	NA		Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2			2			4			4	
Permitted Phases	2			2			4			4		
Actuated Green, G (s)	23.1	23.1		23.1	23.1			11.2			11.2	
Effective Green, g (s)	23.1	23.1		23.1	23.1			11.2			11.2	
Actuated g/C Ratio	0.50	0.50		0.50	0.50			0.24			0.24	
Clearance Time (s)	6.1	6.1		6.1	6.1			6.2			6.2	
Vehicle Extension (s)	3.5	3.5		3.5	3.5			2.5			2.5	
Lane Grp Cap (vph)	420	831		477	880			363			326	
v/s Ratio Prot		0.13			c0.22							
v/s Ratio Perm	0.01			0.02				c0.11			0.01	
v/c Ratio	0.03	0.25		0.05	0.45			0.47			0.06	
Uniform Delay, d1	6.0	6.8		6.1	7.6			15.2			13.6	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	0.0	0.2		0.0	0.4			0.7			0.1	
Delay (s)	6.0	7.0		6.1	8.1			15.9			13.7	
Level of Service	A	A		A	A			B			B	
Approach Delay (s)		6.9			8.0			15.9			13.7	
Approach LOS		A			A			B			B	

Intersection Summary			
HCM 2000 Control Delay	9.6	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.46		
Actuated Cycle Length (s)	46.6	Sum of lost time (s)	12.3
Intersection Capacity Utilization	44.0%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	51	195	5	1	338	75	3	2	2	35	2	40
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Hourly flow rate (vph)	55	210	5	1	363	81	3	2	2	38	2	43
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	444			215			732	768	212	688	690	363
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	444			215			732	768	212	688	690	363
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.2	7.0	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.6	4.5	3.3
p0 queue free %	95			100			99	99	100	89	99	94
cM capacity (veh/h)	1105			1367			304	317	833	339	298	679

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	WB 3	NB 1	SB 1
Volume Total	55	215	1	363	81	8	83
Volume Left	55	0	1	0	0	3	38
Volume Right	0	5	0	0	81	2	43
cSH	1105	1700	1367	1700	1700	377	456
Volume to Capacity	0.05	0.13	0.00	0.21	0.05	0.02	0.18
Queue Length 95th (m)	1.2	0.0	0.0	0.0	0.0	0.5	5.0
Control Delay (s)	8.4	0.0	7.6	0.0	0.0	14.7	14.6
Lane LOS	A		A			B	B
Approach Delay (s)	1.7		0.0			14.7	14.6
Approach LOS						B	B

Intersection Summary			
Average Delay	2.2		
Intersection Capacity Utilization	37.0%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	10	215	59	18	107	7	24	4	19	16	17	23
Peak Hour Factor	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Hourly flow rate (vph)	11	231	63	19	115	8	26	4	20	17	18	25

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	305	142	51	60
Volume Left (vph)	11	19	26	17
Volume Right (vph)	63	8	20	25
Hadj (s)	-0.07	0.10	-0.07	-0.04
Departure Headway (s)	4.3	4.6	4.9	4.9
Degree Utilization, x	0.36	0.18	0.07	0.08
Capacity (veh/h)	817	743	661	656
Control Delay (s)	9.7	8.6	8.3	8.4
Approach Delay (s)	9.7	8.6	8.3	8.4
Approach LOS	A	A	A	A

Intersection Summary			
Delay	9.2		
Level of Service	A		
Intersection Capacity Utilization	28.0%	ICU Level of Service	A
Analysis Period (min)	15		

Intersection	
Intersection Delay, s/veh	9.1
Intersection LOS	A

Movement	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR
Vol, veh/h	0	10	215	59	0	18	107	7	0	24	4	19
Peak Hour Factor	0.92	0.93	0.93	0.93	0.92	0.93	0.93	0.93	0.92	0.93	0.93	0.93
Heavy Vehicles, %	0	0	4	0	0	0	7	14	0	8	0	0
Mvmt Flow	0	11	231	63	0	19	115	8	0	26	4	20
Number of Lanes	0	0	1	0	0	0	1	0	0	0	1	0

Approach	EB	WB	NB
Opposing Approach	WB	EB	SB
Opposing Lanes	1	1	1
Conflicting Approach Left	SB	NB	EB
Conflicting Lanes Left	1	1	1
Conflicting Approach Right	NB	SB	WB
Conflicting Lanes Right	1	1	1
HCM Control Delay	9.6	8.5	8.4
HCM LOS	A	A	A

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	51%	4%	14%	29%
Vol Thru, %	9%	76%	81%	30%
Vol Right, %	40%	21%	5%	41%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	47	284	132	56
LT Vol	24	10	18	16
Through Vol	4	215	107	17
RT Vol	19	59	7	23
Lane Flow Rate	51	305	142	60
Geometry Grp	1	1	1	1
Degree of Util (X)	0.07	0.357	0.177	0.081
Departure Headway (Hd)	4.956	4.213	4.484	4.86
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	722	855	801	736
Service Time	2.99	2.234	2.51	2.894
HCM Lane V/C Ratio	0.071	0.357	0.177	0.082
HCM Control Delay	8.4	9.6	8.5	8.3
HCM Lane LOS	A	A	A	A
HCM 95th-tile Q	0.2	1.6	0.6	0.3

Intersection				
Intersection Delay, s/veh				
Intersection LOS				

Movement	SBU	SBL	SBT	SBR
Vol, veh/h	0	16	17	23
Peak Hour Factor	0.92	0.93	0.93	0.93
Heavy Vehicles, %	0	6	6	13
Mvmt Flow	0	17	18	25
Number of Lanes	0	0	1	0

Approach	SB
Opposing Approach	NB
Opposing Lanes	1
Conflicting Approach Left	WB
Conflicting Lanes Left	1
Conflicting Approach Right	EB
Conflicting Lanes Right	1
HCM Control Delay	8.3
HCM LOS	A

Lane

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✣			✣			✣			✣	
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	25	202	21	24	83	4	20	14	50	22	73	26
Peak Hour Factor	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
Hourly flow rate (vph)	27	222	23	26	91	4	22	15	55	24	80	29

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	273	122	92	133
Volume Left (vph)	27	26	22	24
Volume Right (vph)	23	4	55	29
Hadj (s)	0.02	0.11	-0.29	-0.05
Departure Headway (s)	4.6	4.9	4.8	4.9
Degree Utilization, x	0.35	0.17	0.12	0.18
Capacity (veh/h)	733	682	685	666
Control Delay (s)	10.2	8.9	8.4	9.0
Approach Delay (s)	10.2	8.9	8.4	9.0
Approach LOS	B	A	A	A

Intersection Summary			
Delay	9.4		
Level of Service	A		
Intersection Capacity Utilization	29.9%	ICU Level of Service	A
Analysis Period (min)	15		

Intersection	
Intersection Delay, s/veh	9.6
Intersection LOS	A

Movement	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR
Vol, veh/h	0	25	202	21	0	24	83	4	0	20	14	50
Peak Hour Factor	0.92	0.91	0.91	0.91	0.92	0.91	0.91	0.91	0.92	0.91	0.91	0.91
Heavy Vehicles, %	0	12	2	0	0	4	6	0	0	0	7	0
Mvmt Flow	0	27	222	23	0	26	91	4	0	22	15	55
Number of Lanes	0	0	1	0	0	0	1	0	0	0	1	0

Approach	EB	WB	NB
Opposing Approach	WB	EB	SB
Opposing Lanes	1	1	1
Conflicting Approach Left	SB	NB	EB
Conflicting Lanes Left	1	1	1
Conflicting Approach Right	NB	SB	WB
Conflicting Lanes Right	1	1	1
HCM Control Delay	10.5	8.9	8.4
HCM LOS	B	A	A

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	24%	10%	22%	18%
Vol Thru, %	17%	81%	75%	60%
Vol Right, %	60%	8%	4%	21%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	84	248	111	121
LT Vol	20	25	24	22
Through Vol	14	202	83	73
RT Vol	50	21	4	26
Lane Flow Rate	92	273	122	133
Geometry Grp	1	1	1	1
Degree of Util (X)	0.121	0.36	0.165	0.18
Departure Headway (Hd)	4.717	4.762	4.862	4.875
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	755	752	733	733
Service Time	2.776	2.812	2.92	2.93
HCM Lane V/C Ratio	0.122	0.363	0.166	0.181
HCM Control Delay	8.4	10.5	8.9	9
HCM Lane LOS	A	B	A	A
HCM 95th-tile Q	0.4	1.6	0.6	0.7

Intersection				
Intersection Delay, s/veh				
Intersection LOS				

Movement	SBU	SBL	SBT	SBR
Vol, veh/h	0	22	73	26
Peak Hour Factor	0.92	0.91	0.91	0.91
Heavy Vehicles, %	0	0	0	12
Mvmt Flow	0	24	80	29
Number of Lanes	0	0	1	0

Approach	SB
Opposing Approach	NB
Opposing Lanes	1
Conflicting Approach Left	WB
Conflicting Lanes Left	1
Conflicting Approach Right	EB
Conflicting Lanes Right	1
HCM Control Delay	9
HCM LOS	A

Lane

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	26	244	101	6	2	19
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98
Hourly flow rate (vph)	27	249	103	6	2	19
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	109				408	106
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	109				408	106
tC, single (s)	4.1				6.7	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.8	3.3
p0 queue free %	98				100	98
cM capacity (veh/h)	1494				534	954

Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	276	109	21
Volume Left	27	0	2
Volume Right	0	6	19
cSH	1494	1700	887
Volume to Capacity	0.02	0.06	0.02
Queue Length 95th (m)	0.4	0.0	0.6
Control Delay (s)	0.9	0.0	9.2
Lane LOS	A		A
Approach Delay (s)	0.9	0.0	9.2
Approach LOS			A

Intersection Summary			
Average Delay	1.1		
Intersection Capacity Utilization	30.9%	ICU Level of Service	A
Analysis Period (min)	15		

Lane Group	EBL	EBT	WBL	WBT	NBT	SBT
Lane Group Flow (vph)	21	527	54	311	88	95
v/c Ratio	0.04	0.48	0.11	0.28	0.25	0.26
Control Delay	5.5	8.6	6.4	6.8	13.6	16.2
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	5.5	8.6	6.4	6.8	13.6	16.2
Queue Length 50th (m)	0.8	24.8	2.0	12.6	3.0	4.4
Queue Length 95th (m)	2.9	45.5	6.0	24.0	14.6	17.3
Internal Link Dist (m)		209.0		438.7	135.3	482.6
Turn Bay Length (m)	30.0		30.0			
Base Capacity (vph)	851	1688	738	1692	620	664
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.02	0.31	0.07	0.18	0.14	0.14

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	19	427	48	49	264	16	26	21	32	20	46	20
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.1	6.1		6.1	6.1			6.2			6.2	
Lane Util. Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Frt	1.00	0.98		1.00	0.99			0.94			0.97	
Flt Protected	0.95	1.00		0.95	1.00			0.98			0.99	
Satd. Flow (prot)	1504	1793		1745	1798			1663			1739	
Flt Permitted	0.57	1.00		0.43	1.00			0.85			0.89	
Satd. Flow (perm)	904	1793		785	1798			1443			1573	
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Adj. Flow (vph)	21	474	53	54	293	18	29	23	36	22	51	22
RTOR Reduction (vph)	0	6	0	0	3	0	0	30	0	0	16	0
Lane Group Flow (vph)	21	521	0	54	308	0	0	58	0	0	79	0
Heavy Vehicles (%)	16%	1%	0%	0%	1%	6%	4%	5%	0%	0%	0%	5%
Turn Type	Perm	NA		Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2			2			4			4	
Permitted Phases	2			2			4			4		
Actuated Green, G (s)	26.7	26.7		26.7	26.7			8.1			8.1	
Effective Green, g (s)	26.7	26.7		26.7	26.7			8.1			8.1	
Actuated g/C Ratio	0.57	0.57		0.57	0.57			0.17			0.17	
Clearance Time (s)	6.1	6.1		6.1	6.1			6.2			6.2	
Vehicle Extension (s)	3.5	3.5		3.5	3.5			2.5			2.5	
Lane Grp Cap (vph)	512	1016		445	1019			248			270	
v/s Ratio Prot		c0.29			0.17							
v/s Ratio Perm	0.02			0.07				0.04			c0.05	
v/c Ratio	0.04	0.51		0.12	0.30			0.23			0.29	
Uniform Delay, d1	4.5	6.2		4.7	5.3			16.8			17.0	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	0.0	0.5		0.1	0.2			0.4			0.4	
Delay (s)	4.6	6.7		4.9	5.5			17.2			17.4	
Level of Service	A	A		A	A			B			B	
Approach Delay (s)		6.7			5.4			17.2			17.4	
Approach LOS		A			A			B			B	

Intersection Summary			
HCM 2000 Control Delay	8.0	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.46		
Actuated Cycle Length (s)	47.1	Sum of lost time (s)	12.3
Intersection Capacity Utilization	59.3%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	48	421	6	1	291	11	5	1	2	36	4	59
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	51	443	6	1	306	12	5	1	2	38	4	62
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	318			449			920	867	446	855	859	306
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	318			449			920	867	446	855	859	306
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	96			100			98	100	100	86	99	92
cM capacity (veh/h)	1242			1122			222	281	616	270	284	734

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	WB 3	NB 1	SB 1
Volume Total	51	449	1	306	12	8	104
Volume Left	51	0	1	0	0	5	38
Volume Right	0	6	0	0	12	2	62
cSH	1242	1700	1122	1700	1700	273	434
Volume to Capacity	0.04	0.26	0.00	0.18	0.01	0.03	0.24
Queue Length 95th (m)	1.0	0.0	0.0	0.0	0.0	0.7	7.0
Control Delay (s)	8.0	0.0	8.2	0.0	0.0	18.6	15.9
Lane LOS	A		A			C	C
Approach Delay (s)	0.8		0.0			18.6	15.9
Approach LOS						C	C

Intersection Summary			
Average Delay	2.4		
Intersection Capacity Utilization	41.9%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	31	119	10	11	160	11	106	10	28	10	2	15
Peak Hour Factor	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Hourly flow rate (vph)	35	134	11	12	180	12	119	11	31	11	2	17

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	180	204	162	30
Volume Left (vph)	35	12	119	11
Volume Right (vph)	11	12	31	17
Hadj (s)	0.18	0.10	0.08	-0.13
Departure Headway (s)	4.8	4.7	5.0	5.0
Degree Utilization, x	0.24	0.27	0.22	0.04
Capacity (veh/h)	701	722	677	650
Control Delay (s)	9.4	9.5	9.4	8.2
Approach Delay (s)	9.4	9.5	9.4	8.2
Approach LOS	A	A	A	A

Intersection Summary			
Delay	9.3		
Level of Service	A		
Intersection Capacity Utilization	39.0%	ICU Level of Service	A
Analysis Period (min)	15		

Intersection	
Intersection Delay, s/veh	9.4
Intersection LOS	A

Movement	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR
Vol, veh/h	0	31	119	10	0	11	160	11	0	106	10	28
Peak Hour Factor	0.92	0.89	0.89	0.89	0.92	0.89	0.89	0.89	0.92	0.89	0.89	0.89
Heavy Vehicles, %	0	13	9	20	0	9	7	9	0	2	0	7
Mvmt Flow	0	35	134	11	0	12	180	12	0	119	11	31
Number of Lanes	0	0	1	0	0	0	1	0	0	0	1	0

Approach	EB	WB	NB
Opposing Approach	WB	EB	SB
Opposing Lanes	1	1	1
Conflicting Approach Left	SB	NB	EB
Conflicting Lanes Left	1	1	1
Conflicting Approach Right	NB	SB	WB
Conflicting Lanes Right	1	1	1
HCM Control Delay	9.4	9.5	9.4
HCM LOS	A	A	A

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	74%	19%	6%	37%
Vol Thru, %	7%	74%	88%	7%
Vol Right, %	19%	6%	6%	56%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	144	160	182	27
LT Vol	106	31	11	10
Through Vol	10	119	160	2
RT Vol	28	10	11	15
Lane Flow Rate	162	180	204	30
Geometry Grp	1	1	1	1
Degree of Util (X)	0.221	0.242	0.269	0.042
Departure Headway (Hd)	4.922	4.847	4.729	4.954
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	726	739	759	719
Service Time	2.969	2.89	2.77	3.013
HCM Lane V/C Ratio	0.223	0.244	0.269	0.042
HCM Control Delay	9.4	9.4	9.5	8.2
HCM Lane LOS	A	A	A	A
HCM 95th-tile Q	0.8	0.9	1.1	0.1

Intersection	
Intersection Delay, s/veh	
Intersection LOS	

Movement	SBU	SBL	SBT	SBR
Vol, veh/h	0	10	2	15
Peak Hour Factor	0.92	0.89	0.89	0.89
Heavy Vehicles, %	0	10	0	7
Mvmt Flow	0	11	2	17
Number of Lanes	0	0	1	0

Approach	SB
Opposing Approach	NB
Opposing Lanes	1
Conflicting Approach Left	WB
Conflicting Lanes Left	1
Conflicting Approach Right	EB
Conflicting Lanes Right	1
HCM Control Delay	8.2
HCM LOS	A

Lane

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	53	56	53	70	111	13	43	62	48	5	50	20
Peak Hour Factor	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78
Hourly flow rate (vph)	68	72	68	90	142	17	55	79	62	6	64	26

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	208	249	196	96
Volume Left (vph)	68	90	55	6
Volume Right (vph)	68	17	62	26
Hadj (s)	0.03	0.15	-0.01	-0.08
Departure Headway (s)	5.1	5.2	5.3	5.4
Degree Utilization, x	0.29	0.36	0.29	0.14
Capacity (veh/h)	655	656	623	600
Control Delay (s)	10.2	11.0	10.3	9.2
Approach Delay (s)	10.2	11.0	10.3	9.2
Approach LOS	B	B	B	A

Intersection Summary			
Delay	10.4		
Level of Service	B		
Intersection Capacity Utilization	36.2%	ICU Level of Service	A
Analysis Period (min)	15		

Intersection	
Intersection Delay, s/veh	10.2
Intersection LOS	B

Movement	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR
Vol, veh/h	0	53	56	53	0	70	111	13	0	43	62	48
Peak Hour Factor	0.92	0.78	0.78	0.78	0.92	0.78	0.78	0.78	0.92	0.78	0.78	0.78
Heavy Vehicles, %	0	2	11	15	0	9	6	0	0	7	3	13
Mvmt Flow	0	68	72	68	0	90	142	17	0	55	79	62
Number of Lanes	0	0	1	0	0	0	1	0	0	0	1	0

Approach	EB	WB	NB
Opposing Approach	WB	EB	SB
Opposing Lanes	1	1	1
Conflicting Approach Left	SB	NB	EB
Conflicting Lanes Left	1	1	1
Conflicting Approach Right	NB	SB	WB
Conflicting Lanes Right	1	1	1
HCM Control Delay	9.9	11	10.2
HCM LOS	A	B	B

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	28%	33%	36%	7%
Vol Thru, %	41%	35%	57%	67%
Vol Right, %	31%	33%	7%	27%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	153	162	194	75
LT Vol	43	53	70	5
Through Vol	62	56	111	50
RT Vol	48	53	13	20
Lane Flow Rate	196	208	249	96
Geometry Grp	1	1	1	1
Degree of Util (X)	0.28	0.281	0.351	0.14
Departure Headway (Hd)	5.13	4.872	5.085	5.259
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	692	727	699	686
Service Time	3.226	2.968	3.179	3.259
HCM Lane V/C Ratio	0.283	0.286	0.356	0.14
HCM Control Delay	10.2	9.9	11	9.1
HCM Lane LOS	B	A	B	A
HCM 95th-tile Q	1.1	1.2	1.6	0.5

Intersection	
Intersection Delay, s/veh	
Intersection LOS	

Movement	SBU	SBL	SBT	SBR
Vol, veh/h	0	5	50	20
Peak Hour Factor	0.92	0.78	0.78	0.78
Heavy Vehicles, %	0	0	0	15
Mvmt Flow	0	6	64	26
Number of Lanes	0	0	1	0

Approach	SB
Opposing Approach	NB
Opposing Lanes	1
Conflicting Approach Left	WB
Conflicting Lanes Left	1
Conflicting Approach Right	EB
Conflicting Lanes Right	1
HCM Control Delay	9.1
HCM LOS	A

Lane

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	7	101	170	0	7	23
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.71	0.71	0.71	0.71	0.71	0.71
Hourly flow rate (vph)	10	142	239	0	10	32
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	239				401	239
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	239				401	239
tC, single (s)	4.2				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.3				3.5	3.3
p0 queue free %	99				98	96
cM capacity (veh/h)	1260				604	795

Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	152	239	42
Volume Left	10	0	10
Volume Right	0	0	32
cSH	1260	1700	740
Volume to Capacity	0.01	0.14	0.06
Queue Length 95th (m)	0.2	0.0	1.4
Control Delay (s)	0.6	0.0	10.2
Lane LOS	A		B
Approach Delay (s)	0.6	0.0	10.2
Approach LOS			B

Intersection Summary			
Average Delay	1.2		
Intersection Capacity Utilization	21.1%	ICU Level of Service	A
Analysis Period (min)	15		

Lane Group	EBL	EBT	WBL	WBT	NBT	SBT
Lane Group Flow (vph)	11	218	22	413	192	30
v/c Ratio	0.03	0.26	0.05	0.47	0.50	0.09
Control Delay	7.0	8.1	7.1	10.1	18.7	10.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	7.0	8.1	7.1	10.1	18.7	10.9
Queue Length 50th (m)	0.4	8.3	0.8	17.9	10.8	0.9
Queue Length 95th (m)	2.4	21.4	3.8	42.0	28.9	6.0
Internal Link Dist (m)		209.0		438.7	135.3	482.6
Turn Bay Length (m)	30.0		30.0			
Base Capacity (vph)	779	1570	898	1662	629	562
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.01	0.14	0.02	0.25	0.31	0.05

Intersection Summary

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	195	10	21	354	34	50	88	42	7	8	13
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.1	6.1		6.1	6.1			6.2			6.2	
Lane Util. Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Frt	1.00	0.99		1.00	0.99			0.97			0.94	
Flt Protected	0.95	1.00		0.95	1.00			0.99			0.99	
Satd. Flow (prot)	1586	1678		1466	1776			1668			1490	
Flt Permitted	0.50	1.00		0.62	1.00			0.90			0.90	
Satd. Flow (perm)	833	1678		960	1776			1515			1358	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	11	207	11	22	377	36	53	94	45	7	9	14
RTOR Reduction (vph)	0	3	0	0	6	0	0	15	0	0	11	0
Lane Group Flow (vph)	11	215	0	22	407	0	0	177	0	0	19	0
Heavy Vehicles (%)	10%	8%	20%	19%	2%	3%	4%	5%	7%	14%	13%	15%
Turn Type	Perm	NA		Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2			2			4			4	
Permitted Phases	2			2			4			4		
Actuated Green, G (s)	22.9	22.9		22.9	22.9			11.3			11.3	
Effective Green, g (s)	22.9	22.9		22.9	22.9			11.3			11.3	
Actuated g/C Ratio	0.49	0.49		0.49	0.49			0.24			0.24	
Clearance Time (s)	6.1	6.1		6.1	6.1			6.2			6.2	
Vehicle Extension (s)	3.5	3.5		3.5	3.5			2.5			2.5	
Lane Grp Cap (vph)	410	826		472	874			368			330	
v/s Ratio Prot		0.13			c0.23							
v/s Ratio Perm	0.01			0.02				c0.12			0.01	
v/c Ratio	0.03	0.26		0.05	0.47			0.48			0.06	
Uniform Delay, d1	6.1	6.9		6.1	7.8			15.1			13.5	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	0.0	0.2		0.0	0.5			0.7			0.1	
Delay (s)	6.1	7.1		6.2	8.2			15.8			13.6	
Level of Service	A	A		A	A			B			B	
Approach Delay (s)		7.0			8.1			15.8			13.6	
Approach LOS		A			A			B			B	

Intersection Summary			
HCM 2000 Control Delay	9.7	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.47		
Actuated Cycle Length (s)	46.5	Sum of lost time (s)	12.3
Intersection Capacity Utilization	44.7%	ICU Level of Service	A
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	52	199	5	1	345	77	3	2	2	36	2	41
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Hourly flow rate (vph)	56	214	5	1	371	83	3	2	2	39	2	44
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	454			219			747	784	217	702	704	371
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	454			219			747	784	217	702	704	371
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.2	7.0	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.6	4.5	3.3
p0 queue free %	95			100			99	99	100	88	99	93
cM capacity (veh/h)	1096			1362			296	310	828	331	292	673

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	WB 3	NB 1	SB 1
Volume Total	56	219	1	371	83	8	85
Volume Left	56	0	1	0	0	3	39
Volume Right	0	5	0	0	83	2	44
cSH	1096	1700	1362	1700	1700	369	448
Volume to Capacity	0.05	0.13	0.00	0.22	0.05	0.02	0.19
Queue Length 95th (m)	1.2	0.0	0.0	0.0	0.0	0.5	5.3
Control Delay (s)	8.5	0.0	7.6	0.0	0.0	15.0	14.9
Lane LOS	A		A			B	B
Approach Delay (s)	1.7		0.0			15.0	14.9
Approach LOS						B	B

Intersection Summary			
Average Delay	2.3		
Intersection Capacity Utilization	37.5%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	10	219	60	18	109	7	24	4	19	16	17	23
Peak Hour Factor	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Hourly flow rate (vph)	11	235	65	19	117	8	26	4	20	17	18	25

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	311	144	51	60
Volume Left (vph)	11	19	26	17
Volume Right (vph)	65	8	20	25
Hadj (s)	-0.07	0.10	-0.07	-0.04
Departure Headway (s)	4.3	4.6	4.9	5.0
Degree Utilization, x	0.37	0.19	0.07	0.08
Capacity (veh/h)	817	741	658	653
Control Delay (s)	9.8	8.7	8.3	8.4
Approach Delay (s)	9.8	8.7	8.3	8.4
Approach LOS	A	A	A	A

Intersection Summary			
Delay	9.2		
Level of Service	A		
Intersection Capacity Utilization	28.3%	ICU Level of Service	A
Analysis Period (min)	15		

Intersection	
Intersection Delay, s/veh	9.1
Intersection LOS	A

Movement	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR
Vol, veh/h	0	10	219	60	0	18	109	7	0	24	4	19
Peak Hour Factor	0.92	0.93	0.93	0.93	0.92	0.93	0.93	0.93	0.92	0.93	0.93	0.93
Heavy Vehicles, %	0	0	4	0	0	0	7	14	0	8	0	0
Mvmt Flow	0	11	235	65	0	19	117	8	0	26	4	20
Number of Lanes	0	0	1	0	0	0	1	0	0	0	1	0

Approach	EB	WB	NB
Opposing Approach	WB	EB	SB
Opposing Lanes	1	1	1
Conflicting Approach Left	SB	NB	EB
Conflicting Lanes Left	1	1	1
Conflicting Approach Right	NB	SB	WB
Conflicting Lanes Right	1	1	1
HCM Control Delay	9.6	8.5	8.4
HCM LOS	A	A	A

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	51%	3%	13%	29%
Vol Thru, %	9%	76%	81%	30%
Vol Right, %	40%	21%	5%	41%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	47	289	134	56
LT Vol	24	10	18	16
Through Vol	4	219	109	17
RT Vol	19	60	7	23
Lane Flow Rate	51	311	144	60
Geometry Grp	1	1	1	1
Degree of Util (X)	0.07	0.364	0.18	0.082
Departure Headway (Hd)	4.971	4.214	4.49	4.875
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	720	855	798	734
Service Time	3.009	2.239	2.519	2.912
HCM Lane V/C Ratio	0.071	0.364	0.18	0.082
HCM Control Delay	8.4	9.6	8.5	8.4
HCM Lane LOS	A	A	A	A
HCM 95th-tile Q	0.2	1.7	0.7	0.3

Intersection				
Intersection Delay, s/veh				
Intersection LOS				

Movement	SBU	SBL	SBT	SBR
Vol, veh/h	0	16	17	23
Peak Hour Factor	0.92	0.93	0.93	0.93
Heavy Vehicles, %	0	6	6	13
Mvmt Flow	0	17	18	25
Number of Lanes	0	0	1	0

Approach	SB
Opposing Approach	NB
Opposing Lanes	1
Conflicting Approach Left	WB
Conflicting Lanes Left	1
Conflicting Approach Right	EB
Conflicting Lanes Right	1
HCM Control Delay	8.4
HCM LOS	A

Lane

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✣			✣			✣			✣	
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	26	206	21	24	85	4	20	14	51	22	74	27
Peak Hour Factor	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
Hourly flow rate (vph)	29	226	23	26	93	4	22	15	56	24	81	30

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	278	124	93	135
Volume Left (vph)	29	26	22	24
Volume Right (vph)	23	4	56	30
Hadj (s)	0.02	0.11	-0.29	-0.05
Departure Headway (s)	4.7	4.9	4.8	5.0
Degree Utilization, x	0.36	0.17	0.12	0.19
Capacity (veh/h)	731	679	680	662
Control Delay (s)	10.3	9.0	8.5	9.1
Approach Delay (s)	10.3	9.0	8.5	9.1
Approach LOS	B	A	A	A

Intersection Summary			
Delay	9.5		
Level of Service	A		
Intersection Capacity Utilization	30.4%	ICU Level of Service	A
Analysis Period (min)	15		

Intersection	
Intersection Delay, s/veh	9.6
Intersection LOS	A

Movement	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR
Vol, veh/h	0	26	206	21	0	24	85	4	0	20	14	51
Peak Hour Factor	0.92	0.91	0.91	0.91	0.92	0.91	0.91	0.91	0.92	0.91	0.91	0.91
Heavy Vehicles, %	0	12	2	0	0	4	6	0	0	0	7	0
Mvmt Flow	0	29	226	23	0	26	93	4	0	22	15	56
Number of Lanes	0	0	1	0	0	0	1	0	0	0	1	0

Approach	EB	WB	NB
Opposing Approach	WB	EB	SB
Opposing Lanes	1	1	1
Conflicting Approach Left	SB	NB	EB
Conflicting Lanes Left	1	1	1
Conflicting Approach Right	NB	SB	WB
Conflicting Lanes Right	1	1	1
HCM Control Delay	10.6	8.9	8.5
HCM LOS	B	A	A

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	24%	10%	21%	18%
Vol Thru, %	16%	81%	75%	60%
Vol Right, %	60%	8%	4%	22%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	85	253	113	123
LT Vol	20	26	24	22
Through Vol	14	206	85	74
RT Vol	51	21	4	27
Lane Flow Rate	93	278	124	135
Geometry Grp	1	1	1	1
Degree of Util (X)	0.123	0.369	0.168	0.184
Departure Headway (Hd)	4.739	4.778	4.882	4.894
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	751	751	730	729
Service Time	2.8	2.828	2.941	2.951
HCM Lane V/C Ratio	0.124	0.37	0.17	0.185
HCM Control Delay	8.5	10.6	8.9	9.1
HCM Lane LOS	A	B	A	A
HCM 95th-tile Q	0.4	1.7	0.6	0.7

Intersection	
Intersection Delay, s/veh	
Intersection LOS	

Movement	SBU	SBL	SBT	SBR
Vol, veh/h	0	22	74	27
Peak Hour Factor	0.92	0.91	0.91	0.91
Heavy Vehicles, %	0	0	0	12
Mvmt Flow	0	24	81	30
Number of Lanes	0	0	1	0

Approach	SB
Opposing Approach	NB
Opposing Lanes	1
Conflicting Approach Left	WB
Conflicting Lanes Left	1
Conflicting Approach Right	EB
Conflicting Lanes Right	1
HCM Control Delay	9.1
HCM LOS	A

Lane

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	27	249	103	6	2	19
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98
Hourly flow rate (vph)	28	254	105	6	2	19
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	111				417	108
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	111				417	108
tC, single (s)	4.1				6.7	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.8	3.3
p0 queue free %	98				100	98
cM capacity (veh/h)	1491				527	951

Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	282	111	21
Volume Left	28	0	2
Volume Right	0	6	19
cSH	1491	1700	883
Volume to Capacity	0.02	0.07	0.02
Queue Length 95th (m)	0.4	0.0	0.6
Control Delay (s)	0.9	0.0	9.2
Lane LOS	A		A
Approach Delay (s)	0.9	0.0	9.2
Approach LOS			A

Intersection Summary			
Average Delay	1.1		
Intersection Capacity Utilization	31.3%	ICU Level of Service	A
Analysis Period (min)	15		

Lane Group	EBL	EBT	WBL	WBT	NBT	SBT
Lane Group Flow (vph)	21	538	56	317	90	96
v/c Ratio	0.04	0.49	0.12	0.29	0.26	0.26
Control Delay	5.5	8.7	6.4	6.8	13.7	16.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	5.5	8.7	6.4	6.8	13.7	16.4
Queue Length 50th (m)	0.8	25.7	2.1	12.9	3.1	4.5
Queue Length 95th (m)	2.9	47.0	6.2	24.6	14.9	17.7
Internal Link Dist (m)		209.0		438.7	135.3	482.6
Turn Bay Length (m)	30.0		30.0			
Base Capacity (vph)	843	1684	722	1687	616	662
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.02	0.32	0.08	0.19	0.15	0.15

Intersection Summary

HCM Signalized Intersection Capacity Analysis | 2019 Future Background Conditions
9: McNeilly Road & Highway 8 | PM Peak Hour

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	19	436	49	50	269	16	27	21	33	20	47	20
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.1	6.1		6.1	6.1			6.2			6.2	
Lane Util. Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Frt	1.00	0.98		1.00	0.99			0.94			0.97	
Flt Protected	0.95	1.00		0.95	1.00			0.98			0.99	
Satd. Flow (prot)	1504	1793		1745	1798			1663			1740	
Flt Permitted	0.57	1.00		0.42	1.00			0.85			0.89	
Satd. Flow (perm)	900	1793		770	1798			1439			1574	
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Adj. Flow (vph)	21	484	54	56	299	18	30	23	37	22	52	22
RTOR Reduction (vph)	0	6	0	0	3	0	0	31	0	0	16	0
Lane Group Flow (vph)	21	532	0	56	314	0	0	59	0	0	80	0
Heavy Vehicles (%)	16%	1%	0%	0%	1%	6%	4%	5%	0%	0%	0%	5%
Turn Type	Perm	NA		Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2			2			4			4	
Permitted Phases	2			2			4			4		
Actuated Green, G (s)	27.0	27.0		27.0	27.0			8.1			8.1	
Effective Green, g (s)	27.0	27.0		27.0	27.0			8.1			8.1	
Actuated g/C Ratio	0.57	0.57		0.57	0.57			0.17			0.17	
Clearance Time (s)	6.1	6.1		6.1	6.1			6.2			6.2	
Vehicle Extension (s)	3.5	3.5		3.5	3.5			2.5			2.5	
Lane Grp Cap (vph)	512	1021		438	1024			245			268	
v/s Ratio Prot		c0.30			0.17							
v/s Ratio Perm	0.02			0.07				0.04			c0.05	
v/c Ratio	0.04	0.52		0.13	0.31			0.24			0.30	
Uniform Delay, d1	4.5	6.2		4.7	5.3			17.0			17.2	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	0.0	0.6		0.2	0.2			0.4			0.5	
Delay (s)	4.5	6.8		4.9	5.5			17.4			17.6	
Level of Service	A	A		A	A			B			B	
Approach Delay (s)		6.7			5.4			17.4			17.6	
Approach LOS		A			A			B			B	

Intersection Summary			
HCM 2000 Control Delay	8.1	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.47		
Actuated Cycle Length (s)	47.4	Sum of lost time (s)	12.3
Intersection Capacity Utilization	60.1%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	49	429	6	1	297	11	5	1	2	37	4	60
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	52	452	6	1	313	12	5	1	2	39	4	63
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	324			458			938	884	455	872	876	313
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	324			458			938	884	455	872	876	313
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	96			100			98	100	100	85	98	91
cM capacity (veh/h)	1236			1114			215	274	610	263	277	728

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	WB 3	NB 1	SB 1
Volume Total	52	458	1	313	12	8	106
Volume Left	52	0	1	0	0	5	39
Volume Right	0	6	0	0	12	2	63
cSH	1236	1700	1114	1700	1700	265	425
Volume to Capacity	0.04	0.27	0.00	0.18	0.01	0.03	0.25
Queue Length 95th (m)	1.0	0.0	0.0	0.0	0.0	0.7	7.4
Control Delay (s)	8.0	0.0	8.2	0.0	0.0	19.0	16.3
Lane LOS	A		A			C	C
Approach Delay (s)	0.8		0.0			19.0	16.3
Approach LOS						C	C

Intersection Summary			
Average Delay	2.4		
Intersection Capacity Utilization	42.5%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✣			✣			✣			✣	
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	31	165	25	61	262	114	196	131	42	37	41	15
Peak Hour Factor	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Hourly flow rate (vph)	35	185	28	69	294	128	220	147	47	42	46	17

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	248	491	415	104
Volume Left (vph)	35	69	220	42
Volume Right (vph)	28	128	47	17
Hadj (s)	0.14	0.00	0.07	0.07
Departure Headway (s)	7.1	6.4	6.7	7.8
Degree Utilization, x	0.49	0.88	0.78	0.23
Capacity (veh/h)	469	491	504	401
Control Delay (s)	16.8	39.1	29.3	13.0
Approach Delay (s)	16.8	39.1	29.3	13.0
Approach LOS	C	E	D	B

Intersection Summary			
Delay	29.3		
Level of Service	D		
Intersection Capacity Utilization	65.8%	ICU Level of Service	C
Analysis Period (min)	15		

Intersection	
Intersection Delay, s/veh	28.8
Intersection LOS	D

Movement	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR
Vol, veh/h	0	31	165	25	0	61	262	114	0	196	131	42
Peak Hour Factor	0.92	0.89	0.89	0.89	0.92	0.89	0.89	0.89	0.92	0.89	0.89	0.89
Heavy Vehicles, %	0	13	9	20	0	9	7	9	0	2	0	7
Mvmt Flow	0	35	185	28	0	69	294	128	0	220	147	47
Number of Lanes	0	0	1	0	0	0	1	0	0	0	1	0

Approach	EB	WB	NB
Opposing Approach	WB	EB	SB
Opposing Lanes	1	1	1
Conflicting Approach Left	SB	NB	EB
Conflicting Lanes Left	1	1	1
Conflicting Approach Right	NB	SB	WB
Conflicting Lanes Right	1	1	1
HCM Control Delay	16.8	38.2	28.7
HCM LOS	C	E	D

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	53%	14%	14%	40%
Vol Thru, %	36%	75%	60%	44%
Vol Right, %	11%	11%	26%	16%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	369	221	437	93
LT Vol	196	31	61	37
Through Vol	131	165	262	41
RT Vol	42	25	114	15
Lane Flow Rate	415	248	491	104
Geometry Grp	1	1	1	1
Degree of Util (X)	0.768	0.487	0.869	0.227
Departure Headway (Hd)	6.672	7.163	6.371	7.829
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	539	507	565	462
Service Time	4.755	5.163	4.453	5.829
HCM Lane V/C Ratio	0.77	0.489	0.869	0.225
HCM Control Delay	28.7	16.8	38.2	13.1
HCM Lane LOS	D	C	E	B
HCM 95th-tile Q	6.9	2.6	9.7	0.9

Intersection				
Intersection Delay, s/veh				
Intersection LOS				

Movement	SBU	SBL	SBT	SBR
Vol, veh/h	0	37	41	15
Peak Hour Factor	0.92	0.89	0.89	0.89
Heavy Vehicles, %	0	10	0	7
Mvmt Flow	0	42	46	17
Number of Lanes	0	0	1	0

Approach	SB
Opposing Approach	NB
Opposing Lanes	1
Conflicting Approach Left	WB
Conflicting Lanes Left	1
Conflicting Approach Right	EB
Conflicting Lanes Right	1
HCM Control Delay	13.1
HCM LOS	B

Lane

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	233	30	17	308	95	77
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	253	33	18	335	103	84
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume			286		641	270
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			286		641	270
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			99		76	89
cM capacity (veh/h)			1288		436	774

Direction, Lane #	EB 1	WB 1	NB 1
Volume Total	286	353	187
Volume Left	0	18	103
Volume Right	33	0	84
cSH	1700	1288	542
Volume to Capacity	0.17	0.01	0.35
Queue Length 95th (m)	0.0	0.3	11.6
Control Delay (s)	0.0	0.5	15.1
Lane LOS		A	C
Approach Delay (s)	0.0	0.5	15.1
Approach LOS			C

Intersection Summary			
Average Delay	3.7		
Intersection Capacity Utilization	46.7%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	139	128	63	74	197	64	45	145	54	21	91	47
Peak Hour Factor	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78
Hourly flow rate (vph)	178	164	81	95	253	82	58	186	69	27	117	60

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	423	429	313	204
Volume Left (vph)	178	95	58	27
Volume Right (vph)	81	82	69	60
Hadj (s)	0.11	0.02	0.01	-0.08
Departure Headway (s)	7.5	7.4	7.9	8.3
Degree Utilization, x	0.88	0.88	0.68	0.47
Capacity (veh/h)	423	429	421	385
Control Delay (s)	43.5	43.6	26.2	18.4
Approach Delay (s)	43.5	43.6	26.2	18.4
Approach LOS	E	E	D	C

Intersection Summary			
Delay	35.8		
Level of Service	E		
Intersection Capacity Utilization	59.8%	ICU Level of Service	B
Analysis Period (min)	15		

Intersection	
Intersection Delay, s/veh	33.4
Intersection LOS	D

Movement	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR
Vol, veh/h	0	139	128	63	0	74	197	64	0	45	145	54
Peak Hour Factor	0.92	0.78	0.78	0.78	0.92	0.78	0.78	0.78	0.92	0.78	0.78	0.78
Heavy Vehicles, %	0	2	11	15	0	9	6	0	0	7	3	13
Mvmt Flow	0	178	164	81	0	95	253	82	0	58	186	69
Number of Lanes	0	0	1	0	0	0	1	0	0	0	1	0

Approach	EB	WB	NB
Opposing Approach	WB	EB	SB
Opposing Lanes	1	1	1
Conflicting Approach Left	SB	NB	EB
Conflicting Lanes Left	1	1	1
Conflicting Approach Right	NB	SB	WB
Conflicting Lanes Right	1	1	1
HCM Control Delay	38.6	41.3	25.7
HCM LOS	E	E	D

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	18%	42%	22%	13%
Vol Thru, %	59%	39%	59%	57%
Vol Right, %	22%	19%	19%	30%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	244	330	335	159
LT Vol	45	139	74	21
Through Vol	145	128	197	91
RT Vol	54	63	64	47
Lane Flow Rate	313	423	429	204
Geometry Grp	1	1	1	1
Degree of Util (X)	0.677	0.844	0.863	0.459
Departure Headway (Hd)	7.795	7.319	7.37	8.106
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	466	499	494	446
Service Time	5.811	5.319	5.37	6.126
HCM Lane V/C Ratio	0.672	0.848	0.868	0.457
HCM Control Delay	25.7	38.6	41.3	17.8
HCM Lane LOS	D	E	E	C
HCM 95th-tile Q	5	8.6	9.1	2.4

Intersection				
Intersection Delay, s/veh				
Intersection LOS				

Movement	SBU	SBL	SBT	SBR
Vol, veh/h	0	21	91	47
Peak Hour Factor	0.92	0.78	0.78	0.78
Heavy Vehicles, %	0	0	0	15
Mvmt Flow	0	27	117	60
Number of Lanes	0	0	1	0

Approach	SB
Opposing Approach	NB
Opposing Lanes	1
Conflicting Approach Left	WB
Conflicting Lanes Left	1
Conflicting Approach Right	EB
Conflicting Lanes Right	1
HCM Control Delay	17.8
HCM LOS	C

Lane

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	7	136	59	6	184	0	127	0	29	7	0	23
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
Hourly flow rate (vph)	10	192	83	8	259	0	179	0	41	10	0	32
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	259			275			561	529	233	570	570	259
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	259			275			561	529	233	570	570	259
tC, single (s)	4.2			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.3			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	99			99			57	100	95	98	100	96
cM capacity (veh/h)	1239			1300			418	451	811	409	428	775

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	285	268	220	42
Volume Left	10	8	179	10
Volume Right	83	0	41	32
cSH	1239	1300	459	641
Volume to Capacity	0.01	0.01	0.48	0.07
Queue Length 95th (m)	0.2	0.1	19.3	1.6
Control Delay (s)	0.3	0.3	19.8	11.0
Lane LOS	A	A	C	B
Approach Delay (s)	0.3	0.3	19.8	11.0
Approach LOS			C	B

Intersection Summary			
Average Delay	6.1		
Intersection Capacity Utilization	36.0%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (veh/h)	193	127	236	33	28	103
Sign Control	Stop		Free			Free
Grade	0%		0%			0%
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	210	138	257	36	30	112
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type			None			None
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	447	274			292	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	447	274			292	
tC, single (s)	6.4	6.2			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	62	82			98	
cM capacity (veh/h)	559	769			1281	

Direction, Lane #	WB 1	NB 1	SB 1
Volume Total	348	292	142
Volume Left	210	0	30
Volume Right	138	36	0
cSH	627	1700	1281
Volume to Capacity	0.55	0.17	0.02
Queue Length 95th (m)	25.9	0.0	0.6
Control Delay (s)	17.7	0.0	1.8
Lane LOS	C		A
Approach Delay (s)	17.7	0.0	1.8
Approach LOS	C		

Intersection Summary			
Average Delay	8.2		
Intersection Capacity Utilization	49.9%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	71	8	10	294	0	0	106	8	5	86	0
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	77	9	11	320	0	0	115	9	5	93	0
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	320			86			470	423	82	489	427	320
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	320			86			470	423	82	489	427	320
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	100			99			100	78	99	99	82	100
cM capacity (veh/h)	1252			1523			435	522	984	403	519	726

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	86	330	124	99
Volume Left	0	11	0	5
Volume Right	9	0	9	0
cSH	1252	1523	540	511
Volume to Capacity	0.00	0.01	0.23	0.19
Queue Length 95th (m)	0.0	0.2	6.7	5.4
Control Delay (s)	0.0	0.3	13.6	13.7
Lane LOS		A	B	B
Approach Delay (s)	0.0	0.3	13.6	13.7
Approach LOS			B	B

Intersection Summary			
Average Delay	4.9		
Intersection Capacity Utilization	38.0%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	50	33	33	0	185	39	12	144	14	25	79	30
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	54	36	36	0	201	42	13	157	15	27	86	33
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	490	354	102	401	363	164	118			172		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	490	354	102	401	363	164	118			172		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	83	94	96	100	64	95	99			98		
cM capacity (veh/h)	329	558	958	505	552	886	1482			1418		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	126	243	185	146
Volume Left	54	0	13	27
Volume Right	36	42	15	33
cSH	473	591	1482	1418
Volume to Capacity	0.27	0.41	0.01	0.02
Queue Length 95th (m)	8.1	15.3	0.2	0.4
Control Delay (s)	15.4	15.3	0.6	1.5
Lane LOS	C	C	A	A
Approach Delay (s)	15.4	15.3	0.6	1.5
Approach LOS	C	C		

Intersection Summary			
Average Delay	8.6		
Intersection Capacity Utilization	42.6%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (veh/h)	27	29	11	30	65	70
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	29	32	12	33	71	76
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				None	None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	165	109	147			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	165	109	147			
tC, single (s)	6.4	6.2	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	96	97	99			
cM capacity (veh/h)	823	950	1448			

Direction, Lane #	EB 1	NB 1	SB 1
Volume Total	61	45	147
Volume Left	29	12	0
Volume Right	32	0	76
cSH	885	1448	1700
Volume to Capacity	0.07	0.01	0.09
Queue Length 95th (m)	1.7	0.2	0.0
Control Delay (s)	9.4	2.1	0.0
Lane LOS	A	A	
Approach Delay (s)	9.4	2.1	0.0
Approach LOS	A		

Intersection Summary			
Average Delay	2.6		
Intersection Capacity Utilization	21.2%	ICU Level of Service	A
Analysis Period (min)	15		

Lane Group	EBL	EBT	WBL	WBT	NBT	SBT
Lane Group Flow (vph)	36	284	57	495	238	355
v/c Ratio	0.12	0.36	0.14	0.59	0.56	0.75
Control Delay	9.5	10.7	9.4	13.9	21.4	25.1
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	9.5	10.7	9.4	13.9	21.4	25.1
Queue Length 50th (m)	1.9	16.8	3.0	33.4	15.2	18.9
Queue Length 95th (m)	6.0	31.0	8.3	58.3	44.3	#69.6
Internal Link Dist (m)		209.0		440.9	135.3	482.6
Turn Bay Length (m)	30.0		30.0			
Base Capacity (vph)	559	1425	765	1503	524	570
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.06	0.20	0.07	0.33	0.45	0.62

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	34	257	10	54	422	43	50	121	53	32	102	199
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.1	6.1		6.1	6.1			6.2			6.2	
Lane Util. Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Frt	1.00	0.99		1.00	0.99			0.97			0.92	
Flt Protected	0.95	1.00		0.95	1.00			0.99			1.00	
Satd. Flow (prot)	1586	1683		1466	1774			1671			1470	
Flt Permitted	0.40	1.00		0.59	1.00			0.83			0.94	
Satd. Flow (perm)	661	1683		904	1774			1401			1394	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	36	273	11	57	449	46	53	129	56	34	109	212
RTOR Reduction (vph)	0	3	0	0	6	0	0	14	0	0	67	0
Lane Group Flow (vph)	36	281	0	57	489	0	0	224	0	0	288	0
Heavy Vehicles (%)	10%	8%	20%	19%	2%	3%	4%	5%	7%	14%	13%	15%
Turn Type	Perm	NA		Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2			2			4			4	
Permitted Phases	2			2			4			4		
Actuated Green, G (s)	24.7	24.7		24.7	24.7			15.5			15.5	
Effective Green, g (s)	24.7	24.7		24.7	24.7			15.5			15.5	
Actuated g/C Ratio	0.47	0.47		0.47	0.47			0.30			0.30	
Clearance Time (s)	6.1	6.1		6.1	6.1			6.2			6.2	
Vehicle Extension (s)	3.5	3.5		3.5	3.5			2.5			2.5	
Lane Grp Cap (vph)	310	791		425	834			413			411	
v/s Ratio Prot		0.17			c0.28							
v/s Ratio Perm	0.05			0.06				0.16			c0.21	
v/c Ratio	0.12	0.36		0.13	0.59			0.54			0.70	
Uniform Delay, d1	7.8	8.8		7.9	10.2			15.5			16.4	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	0.2	0.3		0.2	1.1			1.1			4.9	
Delay (s)	8.0	9.2		8.0	11.3			16.7			21.4	
Level of Service	A	A		A	B			B			C	
Approach Delay (s)		9.0			11.0			16.7			21.4	
Approach LOS		A			B			B			C	

Intersection Summary			
HCM 2000 Control Delay	14.0	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.63		
Actuated Cycle Length (s)	52.5	Sum of lost time (s)	12.3
Intersection Capacity Utilization	78.1%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	41	307	417	18	47	92
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	45	334	453	20	51	100
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	473				886	463
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	473				886	463
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	96				83	83
cM capacity (veh/h)	1100				305	603

Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	378	473	151
Volume Left	45	0	51
Volume Right	0	20	100
cSH	1100	1700	453
Volume to Capacity	0.04	0.28	0.33
Queue Length 95th (m)	1.0	0.0	11.0
Control Delay (s)	1.4	0.0	16.9
Lane LOS	A		C
Approach Delay (s)	1.4	0.0	16.9
Approach LOS			C

Intersection Summary			
Average Delay	3.1		
Intersection Capacity Utilization	59.7%	ICU Level of Service	B
Analysis Period (min)	15		

11: Lewis Road & Highway 8

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	66	289	5	1	381	91	3	2	2	69	2	41
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Hourly flow rate (vph)	71	311	5	1	410	98	3	2	2	74	2	44
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	508			316			912	965	313	868	870	410
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	508			316			912	965	313	868	870	410
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.2	7.0	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.6	4.5	3.3
p0 queue free %	93			100			99	99	100	71	99	93
cM capacity (veh/h)	1047			1255			225	239	732	252	227	640

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	WB 3	NB 1	SB 1
Volume Total	71	316	1	410	98	8	120
Volume Left	71	0	1	0	0	3	74
Volume Right	0	5	0	0	98	2	44
cSH	1047	1700	1255	1700	1700	286	323
Volume to Capacity	0.07	0.19	0.00	0.24	0.06	0.03	0.37
Queue Length 95th (m)	1.7	0.0	0.0	0.0	0.0	0.6	12.7
Control Delay (s)	8.7	0.0	7.9	0.0	0.0	17.9	22.6
Lane LOS	A		A			C	C
Approach Delay (s)	1.6		0.0			17.9	22.6
Approach LOS						C	C

Intersection Summary			
Average Delay	3.4		
Intersection Capacity Utilization	43.4%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	18	342	464	23	85	9
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	20	372	504	25	92	10
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	529				928	517
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	529				928	517
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	98				69	98
cM capacity (veh/h)	1048				294	562

Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	391	529	102
Volume Left	20	0	92
Volume Right	0	25	10
cSH	1048	1700	309
Volume to Capacity	0.02	0.31	0.33
Queue Length 95th (m)	0.4	0.0	10.7
Control Delay (s)	0.6	0.0	22.3
Lane LOS	A		C
Approach Delay (s)	0.6	0.0	22.3
Approach LOS			C

Intersection Summary			
Average Delay	2.5		
Intersection Capacity Utilization	44.6%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	10	331	91	84	164	76	65	103	64	127	192	23
Peak Hour Factor	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Hourly flow rate (vph)	11	356	98	90	176	82	70	111	69	137	206	25

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	465	348	249	368
Volume Left (vph)	11	90	70	137
Volume Right (vph)	98	82	69	25
Hadj (s)	-0.07	0.03	-0.07	0.14
Departure Headway (s)	7.9	8.2	8.6	8.3
Degree Utilization, x	1.00	0.80	0.60	0.85
Capacity (veh/h)	465	420	389	368
Control Delay (s)	70.4	36.3	23.7	42.5
Approach Delay (s)	70.4	36.3	23.7	42.5
Approach LOS	F	E	C	E

Intersection Summary			
Delay	46.8		
Level of Service	E		
Intersection Capacity Utilization	79.0%	ICU Level of Service	D
Analysis Period (min)	15		

Intersection	
Intersection Delay, s/veh	47.2
Intersection LOS	E

Movement	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR
Vol, veh/h	0	10	331	91	0	84	164	76	0	65	103	64
Peak Hour Factor	0.92	0.93	0.93	0.93	0.92	0.93	0.93	0.93	0.92	0.93	0.93	0.93
Heavy Vehicles, %	0	0	4	0	0	0	7	14	0	8	0	0
Mvmt Flow	0	11	356	98	0	90	176	82	0	70	111	69
Number of Lanes	0	0	1	0	0	0	1	0	0	0	1	0

Approach	EB	WB	NB
Opposing Approach	WB	EB	SB
Opposing Lanes	1	1	1
Conflicting Approach Left	SB	NB	EB
Conflicting Lanes Left	1	1	1
Conflicting Approach Right	NB	SB	WB
Conflicting Lanes Right	1	1	1
HCM Control Delay	70.3	36.4	24.8
HCM LOS	F	E	C

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	28%	2%	26%	37%
Vol Thru, %	44%	77%	51%	56%
Vol Right, %	28%	21%	23%	7%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	232	432	324	342
LT Vol	65	10	84	127
Through Vol	103	331	164	192
RT Vol	64	91	76	23
Lane Flow Rate	249	465	348	368
Geometry Grp	1	1	1	1
Degree of Util (X)	0.615	1	0.798	0.85
Departure Headway (Hd)	8.757	7.811	8.25	8.32
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	414	465	446	438
Service Time	6.757	5.858	6.15	6.32
HCM Lane V/C Ratio	0.601	1	0.78	0.84
HCM Control Delay	24.8	70.3	36.4	43.3
HCM Lane LOS	C	F	E	E
HCM 95th-tile Q	4	13.1	7.2	8.4

Intersection	
Intersection Delay, s/veh	
Intersection LOS	

Movement	SBU	SBL	SBT	SBR
Vol, veh/h	0	127	192	23
Peak Hour Factor	0.92	0.93	0.93	0.93
Heavy Vehicles, %	0	6	6	13
Mvmt Flow	0	137	206	25
Number of Lanes	0	0	1	0

Approach	SB
Opposing Approach	NB
Opposing Lanes	1
Conflicting Approach Left	WB
Conflicting Lanes Left	1
Conflicting Approach Right	EB
Conflicting Lanes Right	1
HCM Control Delay	43.3
HCM LOS	E

Lane

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	383	85	56	256	71	50
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	416	92	61	278	77	54
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume			509		862	462
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			509		862	462
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			94		75	91
cM capacity (veh/h)			1067		309	603

Direction, Lane #	EB 1	WB 1	NB 1
Volume Total	509	339	132
Volume Left	0	61	77
Volume Right	92	0	54
cSH	1700	1067	387
Volume to Capacity	0.30	0.06	0.34
Queue Length 95th (m)	0.0	1.4	11.2
Control Delay (s)	0.0	2.0	19.0
Lane LOS		A	C
Approach Delay (s)	0.0	2.0	19.0
Approach LOS			C

Intersection Summary			
Average Delay	3.3		
Intersection Capacity Utilization	58.9%	ICU Level of Service	B
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✥			✥			✥			✥	
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	77	309	46	36	166	36	20	70	55	73	214	125
Peak Hour Factor	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
Hourly flow rate (vph)	85	340	51	40	182	40	22	77	60	80	235	137

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	475	262	159	453
Volume Left (vph)	85	40	22	80
Volume Right (vph)	51	40	60	137
Hadj (s)	0.03	0.02	-0.14	-0.08
Departure Headway (s)	7.1	7.7	8.0	7.0
Degree Utilization, x	0.93	0.56	0.36	0.89
Capacity (veh/h)	475	442	409	453
Control Delay (s)	50.9	19.9	15.4	43.3
Approach Delay (s)	50.9	19.9	15.4	43.3
Approach LOS	F	C	C	E

Intersection Summary			
Delay	38.1		
Level of Service	E		
Intersection Capacity Utilization	73.0%	ICU Level of Service	C
Analysis Period (min)	15		

Intersection	
Intersection Delay, s/veh	37.7
Intersection LOS	E

Movement	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR
Vol, veh/h	0	77	309	46	0	36	166	36	0	20	70	55
Peak Hour Factor	0.92	0.91	0.91	0.91	0.92	0.91	0.91	0.91	0.92	0.91	0.91	0.91
Heavy Vehicles, %	0	12	2	0	0	4	6	0	0	0	7	0
Mvmt Flow	0	85	340	51	0	40	182	40	0	22	77	60
Number of Lanes	0	0	1	0	0	0	1	0	0	0	1	0

Approach	EB	WB	NB
Opposing Approach	WB	EB	SB
Opposing Lanes	1	1	1
Conflicting Approach Left	SB	NB	EB
Conflicting Lanes Left	1	1	1
Conflicting Approach Right	NB	SB	WB
Conflicting Lanes Right	1	1	1
HCM Control Delay	52.4	19.5	15.2
HCM LOS	F	C	C

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	14%	18%	15%	18%
Vol Thru, %	48%	72%	70%	52%
Vol Right, %	38%	11%	15%	30%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	145	432	238	412
LT Vol	20	77	36	73
Through Vol	70	309	166	214
RT Vol	55	46	36	125
Lane Flow Rate	159	475	262	453
Geometry Grp	1	1	1	1
Degree of Util (X)	0.352	0.935	0.548	0.87
Departure Headway (Hd)	7.96	7.093	7.543	6.916
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	454	508	476	521
Service Time	5.96	5.174	5.643	4.996
HCM Lane V/C Ratio	0.35	0.935	0.55	0.869
HCM Control Delay	15.2	52.4	19.5	40.7
HCM Lane LOS	C	F	C	E
HCM 95th-tile Q	1.6	11.4	3.2	9.4

Intersection				
Intersection Delay, s/veh				
Intersection LOS				

Movement	SBU	SBL	SBT	SBR
Vol, veh/h	0	73	214	125
Peak Hour Factor	0.92	0.91	0.91	0.91
Heavy Vehicles, %	0	0	0	12
Mvmt Flow	0	80	235	137
Number of Lanes	0	0	1	0

Approach	SB
Opposing Approach	NB
Opposing Lanes	1
Conflicting Approach Left	WB
Conflicting Lanes Left	1
Conflicting Approach Right	EB
Conflicting Lanes Right	1
HCM Control Delay	40.7
HCM LOS	E

Lane

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	27	271	136	27	149	6	79	0	20	2	0	19
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Hourly flow rate (vph)	28	277	139	28	152	6	81	0	20	2	0	19
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	158			415			631	614	346	632	681	155
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	158			415			631	614	346	632	681	155
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.4	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.8	4.0	3.3
p0 queue free %	98			98			79	100	97	99	100	98
cM capacity (veh/h)	1434			1155			375	392	702	331	359	896

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	443	186	101	21
Volume Left	28	28	81	2
Volume Right	139	6	20	19
cSH	1434	1155	414	771
Volume to Capacity	0.02	0.02	0.24	0.03
Queue Length 95th (m)	0.4	0.6	7.2	0.7
Control Delay (s)	0.7	1.4	16.5	9.8
Lane LOS	A	A	C	A
Approach Delay (s)	0.7	1.4	16.5	9.8
Approach LOS			C	A

Intersection Summary			
Average Delay	3.2		
Intersection Capacity Utilization	45.9%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (veh/h)	150	86	152	149	117	247
Sign Control	Stop		Free			Free
Grade	0%		0%			0%
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	163	93	165	162	127	268
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type			None			None
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	769	246			327	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	769	246			327	
tC, single (s)	6.4	6.2			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	51	88			90	
cM capacity (veh/h)	334	797			1244	

Direction, Lane #	WB 1	NB 1	SB 1
Volume Total	257	327	396
Volume Left	163	0	127
Volume Right	93	162	0
cSH	424	1700	1244
Volume to Capacity	0.61	0.19	0.10
Queue Length 95th (m)	29.5	0.0	2.6
Control Delay (s)	25.7	0.0	3.3
Lane LOS	D		A
Approach Delay (s)	25.7	0.0	3.3
Approach LOS	D		

Intersection Summary			
Average Delay	8.1		
Intersection Capacity Utilization	60.2%	ICU Level of Service	B
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✣			✣			✣			✣	
Volume (veh/h)	0	237	32	32	235	0	0	148	26	12	72	0
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	258	35	35	255	0	0	161	28	13	78	0
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	255			292			639	600	275	709	617	255
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	255			292			639	600	275	709	617	255
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	100			97			100	60	96	94	80	100
cM capacity (veh/h)	1321			1281			325	406	769	230	397	788

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	292	290	189	91
Volume Left	0	35	0	13
Volume Right	35	0	28	0
cSH	1321	1281	437	359
Volume to Capacity	0.00	0.03	0.43	0.25
Queue Length 95th (m)	0.0	0.6	16.3	7.5
Control Delay (s)	0.0	1.2	19.4	18.4
Lane LOS		A	C	C
Approach Delay (s)	0.0	1.2	19.4	18.4
Approach LOS			C	C

Intersection Summary			
Average Delay	6.6		
Intersection Capacity Utilization	52.5%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	32	141	15	0	144	28	25	61	51	82	110	95
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	35	153	16	0	157	30	27	66	55	89	120	103
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	607	526	171	591	549	94	223			122		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	607	526	171	591	549	94	223			122		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	87	64	98	100	62	97	98			94		
cM capacity (veh/h)	265	424	878	281	411	968	1358			1478		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	204	187	149	312
Volume Left	35	0	27	89
Volume Right	16	30	55	103
cSH	399	453	1358	1478
Volume to Capacity	0.51	0.41	0.02	0.06
Queue Length 95th (m)	21.4	15.1	0.5	1.5
Control Delay (s)	23.1	18.4	1.5	2.5
Lane LOS	C	C	A	A
Approach Delay (s)	23.1	18.4	1.5	2.5
Approach LOS	C	C		

Intersection Summary			
Average Delay	10.8		
Intersection Capacity Utilization	52.2%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (veh/h)	65	14	26	86	26	63
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	71	15	28	93	28	68
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				None	None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	212	62	97			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	212	62	97			
tC, single (s)	6.4	6.2	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	91	98	98			
cM capacity (veh/h)	766	1008	1509			

Direction, Lane #	EB 1	NB 1	SB 1
Volume Total	86	122	97
Volume Left	71	28	0
Volume Right	15	0	68
cSH	800	1509	1700
Volume to Capacity	0.11	0.02	0.06
Queue Length 95th (m)	2.7	0.4	0.0
Control Delay (s)	10.0	1.8	0.0
Lane LOS	B	A	
Approach Delay (s)	10.0	1.8	0.0
Approach LOS	B		

Intersection Summary			
Average Delay	3.6		
Intersection Capacity Utilization	23.8%	ICU Level of Service	A
Analysis Period (min)	15		

Lane Group	EBL	EBT	WBL	WBT	NBT	SBT
Lane Group Flow (vph)	117	765	90	386	336	336
v/c Ratio	0.27	0.78	0.42	0.40	0.79	0.77
Control Delay	9.7	17.9	16.1	9.5	38.2	34.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	9.7	17.9	16.1	9.5	38.2	34.7
Queue Length 50th (m)	7.3	69.6	6.2	25.0	37.7	34.2
Queue Length 95th (m)	15.7	110.9	17.3	40.9	#82.4	#77.6
Internal Link Dist (m)		209.0		438.7	135.3	482.6
Turn Bay Length (m)	30.0		30.0			
Base Capacity (vph)	564	1271	275	1260	501	506
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.21	0.60	0.33	0.31	0.67	0.66

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	105	640	49	81	312	35	27	191	85	31	135	137
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.1	6.1		6.1	6.1			6.2			6.2	
Lane Util. Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Frt	1.00	0.99		1.00	0.98			0.96			0.94	
Flt Protected	0.95	1.00		0.95	1.00			1.00			0.99	
Satd. Flow (prot)	1504	1800		1745	1782			1700			1678	
Flt Permitted	0.51	1.00		0.21	1.00			0.93			0.91	
Satd. Flow (perm)	801	1800		391	1782			1589			1542	
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Adj. Flow (vph)	117	711	54	90	347	39	30	212	94	34	150	152
RTOR Reduction (vph)	0	4	0	0	6	0	0	19	0	0	39	0
Lane Group Flow (vph)	117	761	0	90	380	0	0	317	0	0	297	0
Heavy Vehicles (%)	16%	1%	0%	0%	1%	6%	4%	5%	0%	0%	0%	5%
Turn Type	Perm	NA		Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2			2			4			4	
Permitted Phases	2			2			4			4		
Actuated Green, G (s)	35.2	35.2		35.2	35.2			16.6			16.6	
Effective Green, g (s)	35.2	35.2		35.2	35.2			16.6			16.6	
Actuated g/C Ratio	0.55	0.55		0.55	0.55			0.26			0.26	
Clearance Time (s)	6.1	6.1		6.1	6.1			6.2			6.2	
Vehicle Extension (s)	3.5	3.5		3.5	3.5			2.5			2.5	
Lane Grp Cap (vph)	439	988		214	978			411			399	
v/s Ratio Prot		c0.42			0.21							
v/s Ratio Perm	0.15			0.23				c0.20			0.19	
v/c Ratio	0.27	0.77		0.42	0.39			0.77			0.74	
Uniform Delay, d1	7.6	11.3		8.5	8.3			22.0			21.8	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	0.4	3.9		1.6	0.3			8.4			7.0	
Delay (s)	8.0	15.2		10.0	8.6			30.4			28.8	
Level of Service	A	B		B	A			C			C	
Approach Delay (s)		14.2			8.9			30.4			28.8	
Approach LOS		B			A			C			C	

Intersection Summary			
HCM 2000 Control Delay	18.0	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.77		
Actuated Cycle Length (s)	64.1	Sum of lost time (s)	12.3
Intersection Capacity Utilization	92.2%	ICU Level of Service	F
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	148	606	373	48	19	69
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	161	659	405	52	21	75
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	458				1412	432
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	458				1412	432
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	86				84	88
cM capacity (veh/h)	1114				131	628

Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	820	458	96
Volume Left	161	0	21
Volume Right	0	52	75
cSH	1114	1700	346
Volume to Capacity	0.14	0.27	0.28
Queue Length 95th (m)	3.8	0.0	8.4
Control Delay (s)	3.4	0.0	19.3
Lane LOS	A		C
Approach Delay (s)	3.4	0.0	19.3
Approach LOS			C

Intersection Summary			
Average Delay	3.4		
Intersection Capacity Utilization	77.9%	ICU Level of Service	D
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	100	516	6	1	369	36	5	1	2	52	4	60
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	105	543	6	1	388	38	5	1	2	55	4	63
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	426			549			1213	1185	546	1147	1151	388
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	426			549			1213	1185	546	1147	1151	388
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	91			100			96	99	100	67	98	90
cM capacity (veh/h)	1133			1030			132	173	541	164	181	660

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	WB 3	NB 1	SB 1
Volume Total	105	549	1	388	38	8	122
Volume Left	105	0	1	0	0	5	55
Volume Right	0	6	0	0	38	2	63
cSH	1133	1700	1030	1700	1700	169	269
Volume to Capacity	0.09	0.32	0.00	0.23	0.02	0.05	0.45
Queue Length 95th (m)	2.3	0.0	0.0	0.0	0.0	1.2	16.9
Control Delay (s)	8.5	0.0	8.5	0.0	0.0	27.4	29.0
Lane LOS	A		A			D	D
Approach Delay (s)	1.4		0.0			27.4	29.0
Approach LOS						D	D

Intersection Summary			
Average Delay	3.9		
Intersection Capacity Utilization	48.2%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	57	513	401	55	35	5
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	62	558	436	60	38	5
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	496				1147	466
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	496				1147	466
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	94				82	99
cM capacity (veh/h)	1079				209	601

Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	620	496	43
Volume Left	62	0	38
Volume Right	0	60	5
cSH	1079	1700	228
Volume to Capacity	0.06	0.29	0.19
Queue Length 95th (m)	1.4	0.0	5.2
Control Delay (s)	1.5	0.0	24.5
Lane LOS	A		C
Approach Delay (s)	1.5	0.0	24.5
Approach LOS			C

Intersection Summary			
Average Delay	1.7		
Intersection Capacity Utilization	67.9%	ICU Level of Service	C
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	34	178	26	62	279	115	207	132	44	38	41	17
Peak Hour Factor	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Hourly flow rate (vph)	38	200	29	70	313	129	233	148	49	43	46	19

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	267	512	430	108
Volume Left (vph)	38	70	233	43
Volume Right (vph)	29	129	49	19
Hadj (s)	0.15	0.01	0.07	0.06
Departure Headway (s)	7.4	6.7	7.0	8.2
Degree Utilization, x	0.55	0.95	0.84	0.25
Capacity (veh/h)	462	512	506	402
Control Delay (s)	19.2	53.3	36.6	13.8
Approach Delay (s)	19.2	53.3	36.6	13.8
Approach LOS	C	F	E	B

Intersection Summary			
Delay	37.7		
Level of Service	E		
Intersection Capacity Utilization	67.5%	ICU Level of Service	C
Analysis Period (min)	15		

Intersection	
Intersection Delay, s/veh	36.3
Intersection LOS	E

Movement	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR
Vol, veh/h	0	34	178	26	0	62	279	115	0	207	132	44
Peak Hour Factor	0.92	0.89	0.89	0.89	0.92	0.89	0.89	0.89	0.92	0.89	0.89	0.89
Heavy Vehicles, %	0	13	9	20	0	9	7	9	0	2	0	7
Mvmt Flow	0	38	200	29	0	70	313	129	0	233	148	49
Number of Lanes	0	0	1	0	0	0	1	0	0	0	1	0

Approach	EB	WB	NB
Opposing Approach	WB	EB	SB
Opposing Lanes	1	1	1
Conflicting Approach Left	SB	NB	EB
Conflicting Lanes Left	1	1	1
Conflicting Approach Right	NB	SB	WB
Conflicting Lanes Right	1	1	1
HCM Control Delay	19.3	50.8	35.1
HCM LOS	C	F	E

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	54%	14%	14%	40%
Vol Thru, %	34%	75%	61%	43%
Vol Right, %	11%	11%	25%	18%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	383	238	456	96
LT Vol	207	34	62	38
Through Vol	132	178	279	41
RT Vol	44	26	115	17
Lane Flow Rate	430	267	512	108
Geometry Grp	1	1	1	1
Degree of Util (X)	0.825	0.553	0.938	0.246
Departure Headway (Hd)	7.027	7.441	6.715	8.222
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	521	487	543	438
Service Time	5.027	5.451	4.715	6.246
HCM Lane V/C Ratio	0.825	0.548	0.943	0.247
HCM Control Delay	35.1	19.3	50.8	13.9
HCM Lane LOS	E	C	F	B
HCM 95th-tile Q	8.2	3.3	11.8	1

Intersection	
Intersection Delay, s/veh	
Intersection LOS	

Movement	SBU	SBL	SBT	SBR
Vol, veh/h	0	38	41	17
Peak Hour Factor	0.92	0.89	0.89	0.89
Heavy Vehicles, %	0	10	0	7
Mvmt Flow	0	43	46	19
Number of Lanes	0	0	1	0

Approach	SB
Opposing Approach	NB
Opposing Lanes	1
Conflicting Approach Left	WB
Conflicting Lanes Left	1
Conflicting Approach Right	EB
Conflicting Lanes Right	1
HCM Control Delay	13.9
HCM LOS	B

Lane

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	250	30	17	326	95	77
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	272	33	18	354	103	84
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume			304		679	288
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			304		679	288
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			99		75	89
cM capacity (veh/h)			1268		414	756

Direction, Lane #	EB 1	WB 1	NB 1
Volume Total	304	373	187
Volume Left	0	18	103
Volume Right	33	0	84
cSH	1700	1268	519
Volume to Capacity	0.18	0.01	0.36
Queue Length 95th (m)	0.0	0.3	12.4
Control Delay (s)	0.0	0.5	15.8
Lane LOS		A	C
Approach Delay (s)	0.0	0.5	15.8
Approach LOS			C

Intersection Summary			
Average Delay	3.6		
Intersection Capacity Utilization	47.7%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✣			✣			✣			✣	
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	145	134	69	82	209	66	49	152	59	22	96	50
Peak Hour Factor	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78
Hourly flow rate (vph)	186	172	88	105	268	85	63	195	76	28	123	64

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	446	458	333	215
Volume Left (vph)	186	105	63	28
Volume Right (vph)	88	85	76	64
Hadj (s)	0.10	0.03	0.00	-0.08
Departure Headway (s)	7.9	8.0	8.4	8.9
Degree Utilization, x	0.98	1.00	0.77	0.53
Capacity (veh/h)	446	458	422	382
Control Delay (s)	66.8	71.0	34.6	21.6
Approach Delay (s)	66.8	71.0	34.6	21.6
Approach LOS	F	F	D	C

Intersection Summary			
Delay	54.0		
Level of Service	F		
Intersection Capacity Utilization	62.3%	ICU Level of Service	B
Analysis Period (min)	15		

Intersection	
Intersection Delay, s/veh	53.4
Intersection LOS	F

Movement	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR
Vol, veh/h	0	145	134	69	0	82	209	66	0	49	152	59
Peak Hour Factor	0.92	0.78	0.78	0.78	0.92	0.78	0.78	0.78	0.92	0.78	0.78	0.78
Heavy Vehicles, %	0	2	11	15	0	9	6	0	0	7	3	13
Mvmt Flow	0	186	172	88	0	105	268	85	0	63	195	76
Number of Lanes	0	0	1	0	0	0	1	0	0	0	1	0

Approach	EB	WB	NB
Opposing Approach	WB	EB	SB
Opposing Lanes	1	1	1
Conflicting Approach Left	SB	NB	EB
Conflicting Lanes Left	1	1	1
Conflicting Approach Right	NB	SB	WB
Conflicting Lanes Right	1	1	1
HCM Control Delay	64.4	71.1	35.1
HCM LOS	F	F	E

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	19%	42%	23%	13%
Vol Thru, %	58%	39%	59%	57%
Vol Right, %	23%	20%	18%	30%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	260	348	357	168
LT Vol	49	145	82	22
Through Vol	152	134	209	96
RT Vol	59	69	66	50
Lane Flow Rate	333	446	458	215
Geometry Grp	1	1	1	1
Degree of Util (X)	0.779	0.976	1	0.53
Departure Headway (Hd)	8.408	7.875	8.028	8.859
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	437	464	453	411
Service Time	6.354	5.844	6.028	6.822
HCM Lane V/C Ratio	0.762	0.961	1.011	0.523
HCM Control Delay	35.1	64.4	71.1	21.3
HCM Lane LOS	E	F	F	C
HCM 95th-tile Q	6.7	12.3	13	3

Intersection	
Intersection Delay, s/veh	
Intersection LOS	

Movement	SBU	SBL	SBT	SBR
Vol, veh/h	0	22	96	50
Peak Hour Factor	0.92	0.78	0.78	0.78
Heavy Vehicles, %	0	0	0	15
Mvmt Flow	0	28	123	64
Number of Lanes	0	0	1	0

Approach	SB
Opposing Approach	NB
Opposing Lanes	1
Conflicting Approach Left	WB
Conflicting Lanes Left	1
Conflicting Approach Right	EB
Conflicting Lanes Right	1
HCM Control Delay	21.3
HCM LOS	C

Lane

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	8	146	59	6	202	0	127	0	29	8	0	26
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
Hourly flow rate (vph)	11	206	83	8	285	0	179	0	41	11	0	37
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	285			289			608	571	247	612	613	285
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	285			289			608	571	247	612	613	285
tC, single (s)	4.2			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.3			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	99			99			54	100	95	97	100	95
cM capacity (veh/h)	1212			1285			386	427	796	383	404	750

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	300	293	220	48
Volume Left	11	8	179	11
Volume Right	83	0	41	37
cSH	1212	1285	427	612
Volume to Capacity	0.01	0.01	0.51	0.08
Queue Length 95th (m)	0.2	0.2	21.8	1.9
Control Delay (s)	0.4	0.3	22.0	11.4
Lane LOS	A	A	C	B
Approach Delay (s)	0.4	0.3	22.0	11.4
Approach LOS			C	B

Intersection Summary			
Average Delay	6.5		
Intersection Capacity Utilization	37.1%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (veh/h)	193	127	250	33	28	105
Sign Control	Stop		Free			Free
Grade	0%		0%			0%
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	210	138	272	36	30	114
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type			None			None
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	465	290			308	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	465	290			308	
tC, single (s)	6.4	6.2			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	62	82			98	
cM capacity (veh/h)	546	754			1264	

Direction, Lane #	WB 1	NB 1	SB 1
Volume Total	348	308	145
Volume Left	210	0	30
Volume Right	138	36	0
cSH	613	1700	1264
Volume to Capacity	0.57	0.18	0.02
Queue Length 95th (m)	27.0	0.0	0.6
Control Delay (s)	18.3	0.0	1.8
Lane LOS	C		A
Approach Delay (s)	18.3	0.0	1.8
Approach LOS	C		

Intersection Summary			
Average Delay	8.3		
Intersection Capacity Utilization	50.7%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	71	8	10	294	0	0	106	8	5	86	0
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	77	9	11	320	0	0	115	9	5	93	0
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	320			86			470	423	82	489	427	320
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	320			86			470	423	82	489	427	320
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	100			99			100	78	99	99	82	100
cM capacity (veh/h)	1252			1523			435	522	984	403	519	726

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	86	330	124	99
Volume Left	0	11	0	5
Volume Right	9	0	9	0
cSH	1252	1523	540	511
Volume to Capacity	0.00	0.01	0.23	0.19
Queue Length 95th (m)	0.0	0.2	6.7	5.4
Control Delay (s)	0.0	0.3	13.6	13.7
Lane LOS		A	B	B
Approach Delay (s)	0.0	0.3	13.6	13.7
Approach LOS			B	B

Intersection Summary			
Average Delay	4.9		
Intersection Capacity Utilization	38.0%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	50	33	33	0	185	39	12	159	14	25	87	30
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	54	36	36	0	201	42	13	173	15	27	95	33
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	515	379	111	426	388	180	127			188		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	515	379	111	426	388	180	127			188		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	83	93	96	100	62	95	99			98		
cM capacity (veh/h)	312	540	948	485	534	867	1471			1398		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	126	243	201	154
Volume Left	54	0	13	27
Volume Right	36	42	15	33
cSH	453	573	1471	1398
Volume to Capacity	0.28	0.43	0.01	0.02
Queue Length 95th (m)	8.6	16.0	0.2	0.5
Control Delay (s)	16.0	15.9	0.6	1.5
Lane LOS	C	C	A	A
Approach Delay (s)	16.0	15.9	0.6	1.5
Approach LOS	C	C		

Intersection Summary			
Average Delay	8.6		
Intersection Capacity Utilization	43.4%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (veh/h)	27	29	11	30	65	70
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	29	32	12	33	71	76
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				None	None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	165	109	147			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	165	109	147			
tC, single (s)	6.4	6.2	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	96	97	99			
cM capacity (veh/h)	823	950	1448			

Direction, Lane #	EB 1	NB 1	SB 1
Volume Total	61	45	147
Volume Left	29	12	0
Volume Right	32	0	76
cSH	885	1448	1700
Volume to Capacity	0.07	0.01	0.09
Queue Length 95th (m)	1.7	0.2	0.0
Control Delay (s)	9.4	2.1	0.0
Lane LOS	A	A	
Approach Delay (s)	9.4	2.1	0.0
Approach LOS	A		

Intersection Summary			
Average Delay	2.6		
Intersection Capacity Utilization	21.2%	ICU Level of Service	A
Analysis Period (min)	15		

Lane Group	EBL	EBT	WBL	WBT	NBT	SBT
Lane Group Flow (vph)	37	307	61	537	258	359
v/c Ratio	0.13	0.38	0.14	0.63	0.63	0.76
Control Delay	9.4	10.7	9.2	14.3	26.1	27.2
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	9.4	10.7	9.2	14.3	26.1	27.2
Queue Length 50th (m)	2.1	19.5	3.5	39.6	18.6	21.3
Queue Length 95th (m)	6.1	33.1	8.6	63.8	#60.0	#77.3
Internal Link Dist (m)		209.0		440.9	135.3	482.6
Turn Bay Length (m)	30.0		30.0			
Base Capacity (vph)	490	1373	721	1449	490	554
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.08	0.22	0.08	0.37	0.53	0.65

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	35	277	11	57	459	46	55	130	57	33	103	201
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.1	6.1		6.1	6.1			6.2			6.2	
Lane Util. Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Frt	1.00	0.99		1.00	0.99			0.97			0.92	
Flt Protected	0.95	1.00		0.95	1.00			0.99			1.00	
Satd. Flow (prot)	1586	1683		1466	1774			1670			1471	
Flt Permitted	0.36	1.00		0.57	1.00			0.80			0.95	
Satd. Flow (perm)	601	1683		885	1774			1358			1398	
Peak-hour factor, PHF	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Adj. Flow (vph)	37	295	12	61	488	49	59	138	61	35	110	214
RTOR Reduction (vph)	0	3	0	0	6	0	0	14	0	0	67	0
Lane Group Flow (vph)	37	304	0	61	531	0	0	244	0	0	292	0
Heavy Vehicles (%)	10%	8%	20%	19%	2%	3%	4%	5%	7%	14%	13%	15%
Turn Type	Perm	NA		Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2			2			4			4	
Permitted Phases	2			2			4			4		
Actuated Green, G (s)	26.5	26.5		26.5	26.5			16.0			16.0	
Effective Green, g (s)	26.5	26.5		26.5	26.5			16.0			16.0	
Actuated g/C Ratio	0.48	0.48		0.48	0.48			0.29			0.29	
Clearance Time (s)	6.1	6.1		6.1	6.1			6.2			6.2	
Vehicle Extension (s)	3.5	3.5		3.5	3.5			2.5			2.5	
Lane Grp Cap (vph)	290	813		427	857			396			408	
v/s Ratio Prot		0.18			c0.30							
v/s Ratio Perm	0.06			0.07				0.18			c0.21	
v/c Ratio	0.13	0.37		0.14	0.62			0.62			0.72	
Uniform Delay, d1	7.8	8.9		7.8	10.4			16.7			17.4	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	0.2	0.3		0.2	1.4			2.4			5.5	
Delay (s)	8.0	9.3		8.0	11.8			19.2			22.8	
Level of Service	A	A		A	B			B			C	
Approach Delay (s)		9.1			11.5			19.2			22.8	
Approach LOS		A			B			B			C	

Intersection Summary			
HCM 2000 Control Delay	14.8	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.65		
Actuated Cycle Length (s)	54.8	Sum of lost time (s)	12.3
Intersection Capacity Utilization	82.5%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	41	333	458	18	47	92
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	45	362	498	20	51	100
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	517				959	508
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	517				959	508
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	96				81	82
cM capacity (veh/h)	1059				276	569

Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	407	517	151
Volume Left	45	0	51
Volume Right	0	20	100
cSH	1059	1700	418
Volume to Capacity	0.04	0.30	0.36
Queue Length 95th (m)	1.0	0.0	12.3
Control Delay (s)	1.3	0.0	18.4
Lane LOS	A		C
Approach Delay (s)	1.3	0.0	18.4
Approach LOS			C

Intersection Summary			
Average Delay	3.1		
Intersection Capacity Utilization	63.3%	ICU Level of Service	B
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	71	310	6	1	417	98	3	2	2	72	2	45
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Hourly flow rate (vph)	76	333	6	1	448	105	3	2	2	77	2	48
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	554			340			989	1045	337	940	943	448
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	554			340			989	1045	337	940	943	448
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.2	7.0	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.6	4.5	3.3
p0 queue free %	92			100			98	99	100	65	99	92
cM capacity (veh/h)	1006			1231			196	213	710	223	202	608

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	WB 3	NB 1	SB 1
Volume Total	76	340	1	448	105	8	128
Volume Left	76	0	1	0	0	3	77
Volume Right	0	6	0	0	105	2	48
cSH	1006	1700	1231	1700	1700	254	293
Volume to Capacity	0.08	0.20	0.00	0.26	0.06	0.03	0.44
Queue Length 95th (m)	1.9	0.0	0.0	0.0	0.0	0.7	16.0
Control Delay (s)	8.9	0.0	7.9	0.0	0.0	19.6	26.5
Lane LOS	A		A			C	D
Approach Delay (s)	1.6		0.0			19.6	26.5
Approach LOS						C	D

Intersection Summary			
Average Delay	3.8		
Intersection Capacity Utilization	46.1%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	18	366	507	23	85	9
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	20	398	551	25	92	10
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	576				1001	564
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	576				1001	564
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	98				65	98
cM capacity (veh/h)	1007				266	529

Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	417	576	102
Volume Left	20	0	92
Volume Right	0	25	10
cSH	1007	1700	280
Volume to Capacity	0.02	0.34	0.37
Queue Length 95th (m)	0.5	0.0	12.2
Control Delay (s)	0.6	0.0	25.1
Lane LOS	A		D
Approach Delay (s)	0.6	0.0	25.1
Approach LOS			D

Intersection Summary			
Average Delay	2.6		
Intersection Capacity Utilization	45.8%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	11	354	97	86	175	77	68	104	66	129	194	26
Peak Hour Factor	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Hourly flow rate (vph)	12	381	104	92	188	83	73	112	71	139	209	28

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	497	363	256	375
Volume Left (vph)	12	92	73	139
Volume Right (vph)	104	83	71	28
Hadj (s)	-0.07	0.03	-0.07	0.14
Departure Headway (s)	8.1	8.3	8.8	8.4
Degree Utilization, x	1.00	0.84	0.62	0.88
Capacity (veh/h)	497	416	371	375
Control Delay (s)	71.3	42.2	25.3	47.5
Approach Delay (s)	71.3	42.2	25.3	47.5
Approach LOS	F	E	D	E

Intersection Summary			
Delay	50.3		
Level of Service	F		
Intersection Capacity Utilization	81.7%	ICU Level of Service	D
Analysis Period (min)	15		

Intersection	
Intersection Delay, s/veh	49
Intersection LOS	E

Movement	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR
Vol, veh/h	0	11	354	97	0	86	175	77	0	68	104	66
Peak Hour Factor	0.92	0.93	0.93	0.93	0.92	0.93	0.93	0.93	0.92	0.93	0.93	0.93
Heavy Vehicles, %	0	0	4	0	0	0	7	14	0	8	0	0
Mvmt Flow	0	12	381	104	0	92	188	83	0	73	112	71
Number of Lanes	0	0	1	0	0	0	1	0	0	0	1	0

Approach	EB	WB	NB
Opposing Approach	WB	EB	SB
Opposing Lanes	1	1	1
Conflicting Approach Left	SB	NB	EB
Conflicting Lanes Left	1	1	1
Conflicting Approach Right	NB	SB	WB
Conflicting Lanes Right	1	1	1
HCM Control Delay	70.8	39.8	25.6
HCM LOS	F	E	D

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	29%	2%	25%	37%
Vol Thru, %	44%	77%	52%	56%
Vol Right, %	28%	21%	23%	7%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	238	462	338	349
LT Vol	68	11	86	129
Through Vol	104	354	175	194
RT Vol	66	97	77	26
Lane Flow Rate	256	497	363	375
Geometry Grp	1	1	1	1
Degree of Util (X)	0.627	1	0.826	0.86
Departure Headway (Hd)	8.815	7.915	8.183	8.402
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	409	457	443	435
Service Time	6.848	5.967	6.208	6.402
HCM Lane V/C Ratio	0.626	1.088	0.819	0.862
HCM Control Delay	25.6	70.8	39.8	45
HCM Lane LOS	D	F	E	E
HCM 95th-tile Q	4.1	13	7.8	8.6

Intersection				
Intersection Delay, s/veh				
Intersection LOS				

Movement	SBU	SBL	SBT	SBR
Vol, veh/h	0	129	194	26
Peak Hour Factor	0.92	0.93	0.93	0.93
Heavy Vehicles, %	0	6	6	13
Mvmt Flow	0	139	209	28
Number of Lanes	0	0	1	0

Approach	SB
Opposing Approach	NB
Opposing Lanes	1
Conflicting Approach Left	WB
Conflicting Lanes Left	1
Conflicting Approach Right	EB
Conflicting Lanes Right	1
HCM Control Delay	45
HCM LOS	E

Lane

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	409	85	56	269	71	50
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	445	92	61	292	77	54
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume			537		905	491
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			537		905	491
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			94		74	91
cM capacity (veh/h)			1041		291	582

Direction, Lane #	EB 1	WB 1	NB 1
Volume Total	537	353	132
Volume Left	0	61	77
Volume Right	92	0	54
cSH	1700	1041	367
Volume to Capacity	0.32	0.06	0.36
Queue Length 95th (m)	0.0	1.4	12.1
Control Delay (s)	0.0	2.0	20.2
Lane LOS		A	C
Approach Delay (s)	0.0	2.0	20.2
Approach LOS			C

Intersection Summary			
Average Delay	3.3		
Intersection Capacity Utilization	60.9%	ICU Level of Service	B
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✥			✥			✥			✥	
Sign Control		Stop			Stop			Stop			Stop	
Volume (vph)	79	330	49	39	174	37	23	72	60	76	222	127
Peak Hour Factor	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
Hourly flow rate (vph)	87	363	54	43	191	41	25	79	66	84	244	140

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total (vph)	503	275	170	467
Volume Left (vph)	87	43	25	84
Volume Right (vph)	54	41	66	140
Hadj (s)	0.03	0.02	-0.15	-0.08
Departure Headway (s)	7.4	7.9	8.3	7.2
Degree Utilization, x	1.00	0.60	0.39	0.94
Capacity (veh/h)	503	437	404	467
Control Delay (s)	67.9	22.2	16.5	53.2
Approach Delay (s)	67.9	22.2	16.5	53.2
Approach LOS	F	C	C	F

Intersection Summary			
Delay	48.0		
Level of Service	E		
Intersection Capacity Utilization	74.5%	ICU Level of Service	D
Analysis Period (min)	15		

Intersection	
Intersection Delay, s/veh	46.9
Intersection LOS	E

Movement	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR
Vol, veh/h	0	79	330	49	0	39	174	37	0	23	72	60
Peak Hour Factor	0.92	0.91	0.91	0.91	0.92	0.91	0.91	0.91	0.92	0.91	0.91	0.91
Heavy Vehicles, %	0	12	2	0	0	4	6	0	0	0	7	0
Mvmt Flow	0	87	363	54	0	43	191	41	0	25	79	66
Number of Lanes	0	0	1	0	0	0	1	0	0	0	1	0

Approach	EB	WB	NB
Opposing Approach	WB	EB	SB
Opposing Lanes	1	1	1
Conflicting Approach Left	SB	NB	EB
Conflicting Lanes Left	1	1	1
Conflicting Approach Right	NB	SB	WB
Conflicting Lanes Right	1	1	1
HCM Control Delay	68.2	21.6	16.2
HCM LOS	F	C	C

Lane	NBLn1	EBLn1	WBLn1	SBLn1
Vol Left, %	15%	17%	16%	18%
Vol Thru, %	46%	72%	70%	52%
Vol Right, %	39%	11%	15%	30%
Sign Control	Stop	Stop	Stop	Stop
Traffic Vol by Lane	155	458	250	425
LT Vol	23	79	39	76
Through Vol	72	330	174	222
RT Vol	60	49	37	127
Lane Flow Rate	170	503	275	467
Geometry Grp	1	1	1	1
Degree of Util (X)	0.383	1	0.592	0.923
Departure Headway (Hd)	8.105	7.426	7.762	7.113
Convergence, Y/N	Yes	Yes	Yes	Yes
Cap	443	493	464	509
Service Time	6.183	5.426	5.831	5.141
HCM Lane V/C Ratio	0.384	1.02	0.593	0.917
HCM Control Delay	16.2	68.2	21.6	50
HCM Lane LOS	C	F	C	E
HCM 95th-tile Q	1.8	13.5	3.8	11

Intersection	
Intersection Delay, s/veh	
Intersection LOS	

Movement	SBU	SBL	SBT	SBR
Vol, veh/h	0	76	222	127
Peak Hour Factor	0.92	0.91	0.91	0.91
Heavy Vehicles, %	0	0	0	12
Mvmt Flow	0	84	244	140
Number of Lanes	0	0	1	0

Approach	SB
Opposing Approach	NB
Opposing Lanes	1
Conflicting Approach Left	WB
Conflicting Lanes Left	1
Conflicting Approach Right	EB
Conflicting Lanes Right	1
HCM Control Delay	50
HCM LOS	E

Lane

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	29	297	136	27	160	7	79	0	20	2	0	21
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Hourly flow rate (vph)	30	303	139	28	163	7	81	0	20	2	0	21
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	170			442			675	657	372	674	723	167
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	170			442			675	657	372	674	723	167
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.4	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.8	4.0	3.3
p0 queue free %	98			98			77	100	97	99	100	98
cM capacity (veh/h)	1419			1129			349	370	678	309	339	883

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	471	198	101	23
Volume Left	30	28	81	2
Volume Right	139	7	20	21
cSH	1419	1129	387	760
Volume to Capacity	0.02	0.02	0.26	0.03
Queue Length 95th (m)	0.5	0.6	7.8	0.7
Control Delay (s)	0.7	1.3	17.6	9.9
Lane LOS	A	A	C	A
Approach Delay (s)	0.7	1.3	17.6	9.9
Approach LOS			C	A

Intersection Summary			
Average Delay	3.3		
Intersection Capacity Utilization	47.9%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (veh/h)	150	86	158	149	117	256
Sign Control	Stop		Free			Free
Grade	0%		0%			0%
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	163	93	172	162	127	278
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type			None			None
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	785	253			334	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	785	253			334	
tC, single (s)	6.4	6.2			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	50	88			90	
cM capacity (veh/h)	327	791			1237	

Direction, Lane #	WB 1	NB 1	SB 1
Volume Total	257	334	405
Volume Left	163	0	127
Volume Right	93	162	0
cSH	416	1700	1237
Volume to Capacity	0.62	0.20	0.10
Queue Length 95th (m)	30.6	0.0	2.6
Control Delay (s)	26.7	0.0	3.3
Lane LOS	D		A
Approach Delay (s)	26.7	0.0	3.3
Approach LOS	D		

Intersection Summary			
Average Delay	8.2		
Intersection Capacity Utilization	60.9%	ICU Level of Service	B
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✣			✣			✣			✣	
Volume (veh/h)	0	237	32	32	235	0	0	148	26	12	72	0
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	258	35	35	255	0	0	161	28	13	78	0
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	255			292			639	600	275	709	617	255
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	255			292			639	600	275	709	617	255
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	100			97			100	60	96	94	80	100
cM capacity (veh/h)	1321			1281			325	406	769	230	397	788

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	292	290	189	91
Volume Left	0	35	0	13
Volume Right	35	0	28	0
cSH	1321	1281	437	359
Volume to Capacity	0.00	0.03	0.43	0.25
Queue Length 95th (m)	0.0	0.6	16.3	7.5
Control Delay (s)	0.0	1.2	19.4	18.4
Lane LOS		A	C	C
Approach Delay (s)	0.0	1.2	19.4	18.4
Approach LOS			C	C

Intersection Summary			
Average Delay	6.6		
Intersection Capacity Utilization	52.5%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	32	141	15	0	144	28	25	68	51	82	122	95
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	35	153	16	0	157	30	27	74	55	89	133	103
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	627	546	184	611	570	102	236			129		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	627	546	184	611	570	102	236			129		
tC, single (s)	7.1	6.5	6.2	7.1	6.5	6.2	4.1			4.1		
tC, 2 stage (s)												
tF (s)	3.5	4.0	3.3	3.5	4.0	3.3	2.2			2.2		
p0 queue free %	86	63	98	100	61	97	98			94		
cM capacity (veh/h)	253	412	863	269	399	959	1343			1469		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	204	187	157	325
Volume Left	35	0	27	89
Volume Right	16	30	55	103
cSH	387	441	1343	1469
Volume to Capacity	0.53	0.42	0.02	0.06
Queue Length 95th (m)	22.6	15.7	0.5	1.5
Control Delay (s)	24.3	19.0	1.5	2.5
Lane LOS	C	C	A	A
Approach Delay (s)	24.3	19.0	1.5	2.5
Approach LOS	C	C		

Intersection Summary			
Average Delay	10.9		
Intersection Capacity Utilization	52.8%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Volume (veh/h)	65	14	26	86	26	63
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	71	15	28	93	28	68
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				None	None	
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	212	62	97			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	212	62	97			
tC, single (s)	6.4	6.2	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	91	98	98			
cM capacity (veh/h)	766	1008	1509			

Direction, Lane #	EB 1	NB 1	SB 1
Volume Total	86	122	97
Volume Left	71	28	0
Volume Right	15	0	68
cSH	800	1509	1700
Volume to Capacity	0.11	0.02	0.06
Queue Length 95th (m)	2.7	0.4	0.0
Control Delay (s)	10.0	1.8	0.0
Lane LOS	B	A	
Approach Delay (s)	10.0	1.8	0.0
Approach LOS	B		

Intersection Summary			
Average Delay	3.6		
Intersection Capacity Utilization	23.8%	ICU Level of Service	A
Analysis Period (min)	15		

Lane Group	EBL	EBT	WBL	WBT	NBT	SBT
Lane Group Flow (vph)	119	821	96	419	346	350
v/c Ratio	0.28	0.82	0.53	0.42	0.83	0.83
Control Delay	10.0	20.2	22.4	9.8	42.4	40.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	10.0	20.2	22.4	9.8	42.4	40.3
Queue Length 50th (m)	7.5	78.9	7.2	28.0	43.2	40.3
Queue Length 95th (m)	16.4	127.3	23.2	45.2	#86.7	#84.1
Internal Link Dist (m)		209.0		438.7	135.3	482.6
Turn Bay Length (m)	30.0		30.0			
Base Capacity (vph)	512	1219	221	1209	471	473
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.23	0.67	0.43	0.35	0.73	0.74

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	107	685	54	86	340	37	29	194	88	34	140	140
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	6.1	6.1		6.1	6.1			6.2			6.2	
Lane Util. Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Frt	1.00	0.99		1.00	0.99			0.96			0.94	
Flt Protected	0.95	1.00		0.95	1.00			1.00			0.99	
Satd. Flow (prot)	1504	1800		1745	1783			1699			1679	
Flt Permitted	0.48	1.00		0.18	1.00			0.92			0.89	
Satd. Flow (perm)	757	1800		327	1783			1565			1507	
Peak-hour factor, PHF	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Adj. Flow (vph)	119	761	60	96	378	41	32	216	98	38	156	156
RTOR Reduction (vph)	0	4	0	0	6	0	0	19	0	0	39	0
Lane Group Flow (vph)	119	817	0	96	413	0	0	327	0	0	311	0
Heavy Vehicles (%)	16%	1%	0%	0%	1%	6%	4%	5%	0%	0%	0%	5%
Turn Type	Perm	NA		Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2			2			4			4	
Permitted Phases	2			2			4			4		
Actuated Green, G (s)	37.3	37.3		37.3	37.3			17.2			17.2	
Effective Green, g (s)	37.3	37.3		37.3	37.3			17.2			17.2	
Actuated g/C Ratio	0.56	0.56		0.56	0.56			0.26			0.26	
Clearance Time (s)	6.1	6.1		6.1	6.1			6.2			6.2	
Vehicle Extension (s)	3.5	3.5		3.5	3.5			2.5			2.5	
Lane Grp Cap (vph)	422	1005		182	995			402			388	
v/s Ratio Prot		c0.45			0.23							
v/s Ratio Perm	0.16			0.29				c0.21			0.21	
v/c Ratio	0.28	0.81		0.53	0.42			0.81			0.80	
Uniform Delay, d1	7.7	11.9		9.2	8.5			23.3			23.2	
Progression Factor	1.00	1.00		1.00	1.00			1.00			1.00	
Incremental Delay, d2	0.4	5.2		3.1	0.3			11.7			11.1	
Delay (s)	8.2	17.2		12.4	8.8			35.0			34.3	
Level of Service	A	B		B	A			C			C	
Approach Delay (s)		16.0			9.5			35.0			34.3	
Approach LOS		B			A			C			C	

Intersection Summary			
HCM 2000 Control Delay	20.5	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.81		
Actuated Cycle Length (s)	66.8	Sum of lost time (s)	12.3
Intersection Capacity Utilization	95.8%	ICU Level of Service	F
Analysis Period (min)	15		

c Critical Lane Group

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	148	656	409	48	19	69
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	161	713	445	52	21	75
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	497				1505	471
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	497				1505	471
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	85				82	87
cM capacity (veh/h)	1078				115	597

Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	874	497	96
Volume Left	161	0	21
Volume Right	0	52	75
cSH	1078	1700	313
Volume to Capacity	0.15	0.29	0.31
Queue Length 95th (m)	4.0	0.0	9.6
Control Delay (s)	3.5	0.0	21.5
Lane LOS	A		C
Approach Delay (s)	3.5	0.0	21.5
Approach LOS			C

Intersection Summary			
Average Delay	3.5		
Intersection Capacity Utilization	82.5%	ICU Level of Service	E
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	105	561	7	1	400	37	6	1	2	56	5	66
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Hourly flow rate (vph)	111	591	7	1	421	39	6	1	2	59	5	69
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	460			598			1311	1277	594	1237	1242	421
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	460			598			1311	1277	594	1237	1242	421
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	90			100			94	99	100	58	97	89
cM capacity (veh/h)	1101			989			110	151	508	141	158	632

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	WB 3	NB 1	SB 1
Volume Total	111	598	1	421	39	9	134
Volume Left	111	0	1	0	0	6	59
Volume Right	0	7	0	0	39	2	69
cSH	1101	1700	989	1700	1700	138	238
Volume to Capacity	0.10	0.35	0.00	0.25	0.02	0.07	0.56
Queue Length 95th (m)	2.5	0.0	0.0	0.0	0.0	1.7	23.6
Control Delay (s)	8.6	0.0	8.6	0.0	0.0	33.0	37.9
Lane LOS	A		A			D	E
Approach Delay (s)	1.3		0.0			33.0	37.9
Approach LOS						D	E

Intersection Summary			
Average Delay	4.8		
Intersection Capacity Utilization	51.1%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	57	562	433	55	35	5
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	62	611	471	60	38	5
Pedestrians						
Lane Width (m)						
Walking Speed (m/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (m)						
pX, platoon unblocked						
vC, conflicting volume	530				1235	501
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	530				1235	501
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	94				79	99
cM capacity (veh/h)	1047				185	574

Direction, Lane #	EB 1	WB 1	SB 1
Volume Total	673	530	43
Volume Left	62	0	38
Volume Right	0	60	5
cSH	1047	1700	202
Volume to Capacity	0.06	0.31	0.22
Queue Length 95th (m)	1.4	0.0	6.0
Control Delay (s)	1.5	0.0	27.6
Lane LOS	A		D
Approach Delay (s)	1.5	0.0	27.6
Approach LOS			D

Intersection Summary			
Average Delay	1.8		
Intersection Capacity Utilization	72.2%	ICU Level of Service	C
Analysis Period (min)	15		

Appendix E
Signal Timing Plan

WORK ORDER
PUBLIC WORKS
TRAFFIC SECTION

CITY OF HAMILTON

Priority
1= Emergency
2= Priority(date)
3= Regular

ISSUE DATE: 15 (DD) 02 (MM) 2010 (YY)

SIGNS R : SIGNALS S : PAINTING P :

HANSEN CUSTOMER SERVICE NUMBER ______

LOCATION: MC NEILLY & QUEENSTON

DISTRICT: ______

WORK TO BE DONE: REPLACE CABINET + TIMER WITH ITS CABINET + 3000 E TIMER TIMINGS ATTACHED

ACTIVITY ______

SPECIAL PROJECT WORK ORDER NO: TSR 10 - 443

OPERATIONS CENTER: TO INIT.

- [ ] ______ SUPT
- [ ] SIGNS FOREMEN
- [ ] SIGNAL FOREMEN
- [ ] MARKING FOREMEN
- [ ] ______ UPDATE INVENTORY
- [x] TO LOCATION FILE (OPERATIONS CENTRE)

ISSUED BY: Rob (Crew initials)

AUTHORIZED BY: ______

DATE REQ'D: ______

- [ ] FROM ENGINEERING SECTION ______
- [ ] MAINTENANCE/OTHER ORIGIN: ______

- [ ] TROUBLE CALL
  RECEIVED BY: ______
  TIME (24 HR): ______
  DISPATCHED (24 HR): ______

- [ ] BY-LAW
  NUMBER: ______
  DATE: ______ 20
  APP'D

NORTH

CALL ROB (4585) When Ready at TOC

UNDERGROUND UTILITIES

NOTE: NO POUNDING, DIGGING OR EXCAVATING UNTIL ALL UTILITIES HAVE BEEN CHECKED.

NOTE: ______

Hydro: ______

Bell Tell: ______

Union Gas: ______

CATV: ______

Other: ______

FIELD REMARKS (CONDITION FOUND & ACTION TAKEN FOR TROUBLE CALL)

- [ ] TRAFFIC ENGINEERING
- [ ] PARKING OPERATIONS
- [ ] HSR

ATTENTION: ______

COMMENTS: ______

- [ ] TO LOCATION FILE

ARRIVAL (TROUBLE CALL)
DATE: ______ DD MM YY
TIME: ______ 24 HR CLOCK

WORK COMPLETE
BY: ______
DATE: ______ 20 DD MM YY
TIME: ______ 24 HOUR CLOCK

YELLOW COPY - Operations Centre Location File **WHITE COPY** - Traffic Operations Engineer **PINK COPY** - Author Revised Mar 2009

/

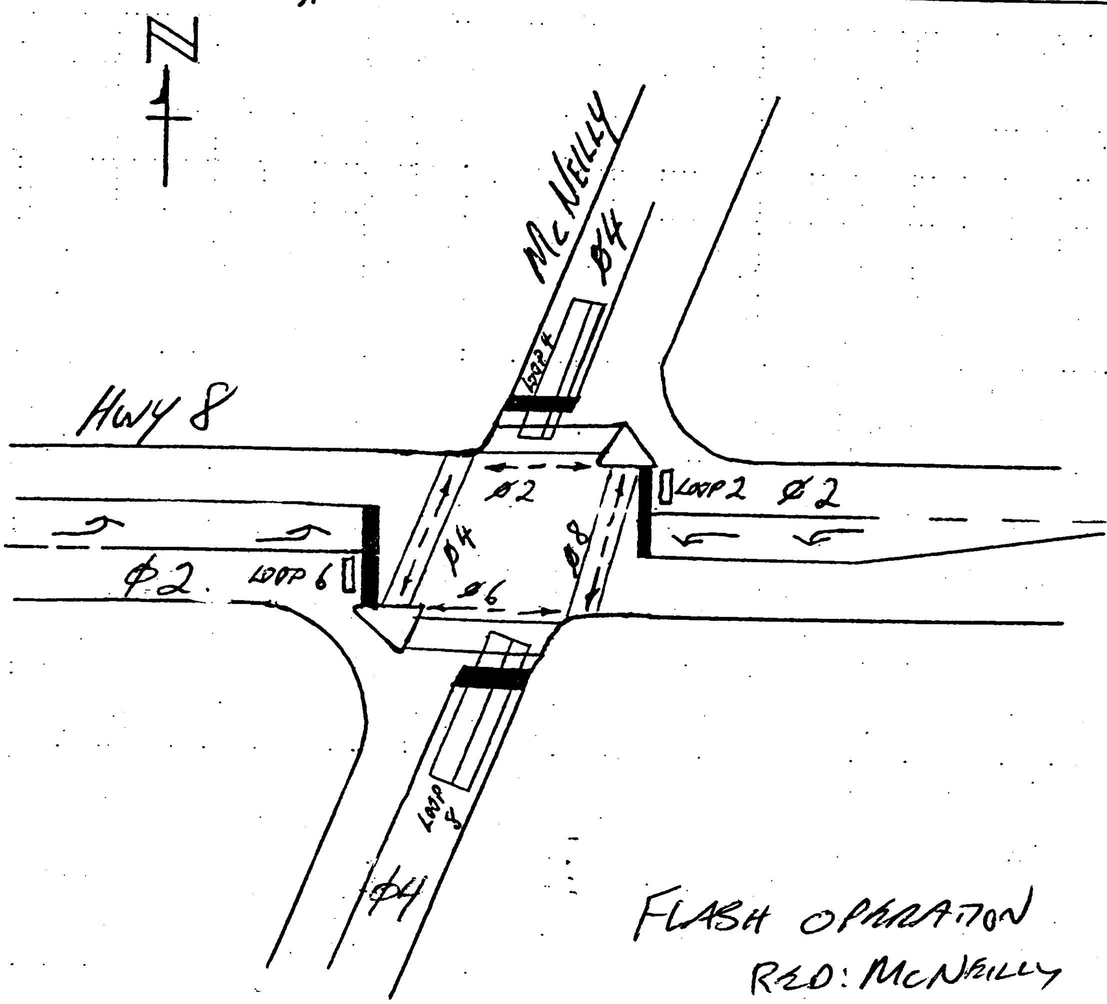
CITY OF HAMILTON TRAFFIC DIVISION
TRAFFIC SIGNAL CONTROLLER TIMING DATA

INTERSECTION Hwy 8 & McNeilly

CONTROLLER TYPE 3000 E PAGE 1 OF 6

PROGRAMMED BY RDG INSTALLED BY

DATE MAR 15/10 DATE



FLASH OPERATION
RED: McNEILLY
AMBER: HWY 8

- FULLY ACTUATED
- FREE OPERATION
- REST IN GREEN ON HWY 8

Ø2 - EB/WB HWY 8, NORTH-SOUTH PEDS, LOOPS.
Ø4 - NB/SB McNEILLY, EAST-WEST PEDS, LOOPS.

SEQUENCE/START-UP (MM-3-1-1)

START-UP PHASES/INTERVAL/SEQUENCE

(X = Enable for start-up phases. Must be compatible if more than one)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
START-UP	Phases		X														
	Interval	0	(0=Red, 1=Yel, 2= Grn, determines color of selected phases above on start-up)														
	Flash	10	(0-255 seconds start-up flash time)														
	Red	0	(0-25.5 secs = length of first red after start-up if start-up in yellow or red)														
	Sequence	2	(2=single ring, 3=dual ring, 4=123/567+48, 5=12/56+3478, 6=1234/56+78, 7=1234/5678, 8=dual quad, 9=12ph														

PHASE RING ASSIGNMENTS

X = Phase assigned to ring (if used). Phases in different rings but same co-phase group can time together.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
RING	Ring 1		X		X												
	Ring 2																
	Ring 3																
	Ring 4																

CO-PHASE GRP 1-4 ASSIGNMENTS

X = phase assigned to co-phase group. All ph's assigned to rings must be assigned to co-phase group.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CO-PHASE	CO PH 1		X														
	CO PH 2				X												
	CO PH 3																
	CO PH 4																

CONTROLLER DATA

PHASE RECALLS/MODES; MIN, MAX, etc. (MM-3-1-2-1-PGDN, etc.) USE 1 TO ALL 4 TIMING PLANS

(X = ENABLE) **TP1 PHASE RECALLS**

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PHASE RECALLS	MIN RCL		X														
	MAX RCL																
	PED RCL																
	SOFT REC																
	NON-LOCK		X		X												
	VEH OMIT																
	PED OMIT																
	WLK REST																
	MAX II																
	RED REST																
	NO SKIP																

PHASE RECALLS/MODES; CNA, INH MAX, PED OPTIONS, etc. (MM-3-1-2-2) ONLY 1 PLAN PER UNIT

(X = ENABLE)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PHASE RECALLS	CNA 1																
	CNA 2																
	CNA 3																
	CNA 4																
	WRM																
	INH MAX																
	PED RECY																
	FL WALK																
	FDW->YEL																
	FDW->RED																
	COND PED																

HWY 8 / McNeilly

PHASE TIMES (MM-3-1-3-PGDN, etc.)

CONTROLLER DATA
USE 1 TO ALL 4 TIMING PLANS

2010.03.15

		TP1															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PHASE TIMES	Initial		20		10												
	Passage		3.5		2.5												
	Yellow		4.2		3.3												
	Red		1.9		2.9												
	Walk		12		7												
	Ped Clr		5		9												
	Max 1		50		25												
	Max 2																
	Mx 3 Lim																
	Mx 3 Adh																
	TBR																
	TTR																
	Min Gap																
	Al/Act																
	Max In																

VEHICLE DETECTOR ASSIGNMENTS (MM-3-1-4-1, PGDN etc.)

(X = ASSIGN VEH DETECTOR TO THAT PHASE)

	DET/PH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
VEH DET ASSIGN-MENTS	1																
	2		X														
	3																
	4				X												
	5																
	6		X														
	7																
	8				X												

PED DETECTOR ASSIGNMENTS (MM-3-1-4-2)

(X = ASSIGN PED DETECTOR TO THAT PHASE)

	DET/PH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PED	1																
DET	2		X														
ASSIGN-	3																
MENTS	4				X												
	5																
	6																
	7																
	8																

DETECTOR MODES (MM-3-1-4-3)

	DET	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
VEH DET	Mode	0	0	0	2	0	0	0	2								
MODES																	

DETECTOR TIMES (MM-3-1-4-4)

USE 1 TO ALL 3 DETECTOR TIMING PLANS

	TP1								
	DET	1	2	3	4	5	6	7	8
DET	Delay		0		2		0		2
TIMES	Str/Stp								

Detector Plans selected by TOD or cycle/split association. Plan 1 = default

DELAY = Amount of time during phase red that phase call is delayed before it is registered.

STR/STP = If DET mode = 2, this value is stretch time. If DET mode = 4, this is stop bar disconnect time (I.e. passage for stop bar)

DUAL ENTRY (MM-3-1-6)

CONTROLLER DATA

DUAL ENTRY ENABLE:	N	Y/N: Y=Enable Dual Entry. Note this is only one setting even though it appears on each controller screen.

PG1	PH/CALLS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
DUAL	1																
ENTRY	2																
ASSIGN-	3																
MENTS	4																
	5																
	6																
	7																
	8																

Dual Entry = Left column phase automatically places call on selected phase(s) if no other real calls within selected phases ring and co-phase group

Appendix F
Traffic Signal Warrant

TRAFFIC SIGNAL WARRANT DATA INPUT

PROJECTED VOLUMES FOR JUSTIFICATION 7

Study Period: Future Total 2024

East/West Street Name	: Barton Street	Major Street [x]	Minor Street [ ]
North/South Street Name	: McNeilley Street	Major Street [ ]	Minor Street [x]

	PEAK HOUR	Major Street Barton Street Eastbound RIGHT	THRU	LEFT	Minor Street McNeilley Street Northbound RIGHT	THRU	LEFT	Major Street Barton Street Westbound RIGHT	THRU	LEFT	Minor Street McNeilley Street Southbound RIGHT	THRU	LEFT	Pedestrians Crossing Major Street	Totals	Splits E-W	N-S
1	AM	26	178	34	44	132	207	115	279	62	17	41	38	0	1173	59%	41%
2	PM	97	354	11	66	104	68	77	175	86	26	194	129	0	1387	58%	42%
	PHV (AM+PM)	***123***	***532***	***45***	***110***	***236***	***275***	***192***	***454***	***148***	***43***	***235***	***167***	***0***			
	Average Hourly Volume (PHV/4)	31	133	11	28	59	69	48	114	37	11	59	42	0			

The crossing volume is defined as the sum of:

(1) Left turns from both minor street apporaches		111
(2) The heaviest through volume from the minor street		59
(3) 50% of the heavier left turn movement from major street when both of the following criteria are met:		
(a) The left turn volume > 120 vph	T=TRUE	F
(b) The left turn volume plus the opposing volume > 720 vph	F=FALSE	F
heavier left turn= 37 oppposing though= 133		0
(4) Pedestrians crossing the major street		0
	sum:	170

AWS Warrant

Major

Total peak hourly exceeds 500 vph? TRUE WARRANTED
Volumes Split does not exceed 70/30? TRUE WARRANTED

Minor

Total peak hourly exceeds 500 vph? FALSE NOT WARRANTED
Volumes Split does not exceed 70/30? TRUE WARRANTED

TRAFFIC SIGNAL WARRANT ANLYSIS FORM FOR INTERSECTION CONTROL.

Traffic Signal Justification 7 for Future Development - Traffic Impact Studies (page 88 OTM Book 12) Future Total 2024

Major street : Barton Street No. of lanes : 1
Minor street : McNeilley Street

FREE FLOW CONDITIONS (RURAL) ☐

RESTRICTED FLOW CONDITIONS (URBAN) ☒ x

IS THIS A T - INTERSECTION YES ☐ NO ☒
IS THIS AN EXISTING INTERSECTION YES ☒ NO ☐
IS THIS A NEW INTERSECTION YES ☐ NO ☒

WARRANT 1 - MINIMUM VEHICULAR VOLUME

100 % SATISFIED - YES ☐ NO ☒

80 % SATISFIED - YES ☐ NO ☒

	MINIMUM REQUIREMENTS Justification Increased by 20%				PERCENTAGE WARRANT		
APPROACH LANES	1		2 or MORE				
FLOW CONDITION	FREE FLOW ☐	RESTR. FLOW ☒	FREE FLOW ☐	RESTR. FLOW ☐	AVERAGE HOURLY VOLUME	TOTAL ACROSS	
A. ALL APPROACHES	0	864	0	0	640		
	100% FULFILLED					0	SECTIONAL PERCENT
	80% FULFILLED					0	
	ACTUAL % IF BELOW 80% VALUE				74	74	
					TOTAL DOWN	74 / 1 =	74

Justification Increased by 20%

B. MINOR STREET BOTH APPROACHES*	0	204	0	0	267	TOTAL ACROSS	
	100% FULFILLED				100	100	SECTIONAL PERCENT
	80% FULFILLED					0	
	ACTUAL % IF BELOW 80% VALUE					0	
					TOTAL DOWN	100 / 1 =	100

* FOR 'T' INTERSECTIONS MINOR ROAD THRESHOLDS ARE INCREASED BY AN ADDITIONAL 50%

WARRANT 2 - DELAY TO CROSS TRAFFIC

100 % SATISFIED - YES ☐ NO ☒

80 % SATISFIED - YES ☐ NO ☒

	MINIMUM REQUIREMENTS Justification Increased by 20%				PERCENTAGE WARRANT		
APPROACH LANES	1		2 or MORE				
FLOW CONDITION	FREE FLOW ☐	RESTR. FLOW ☒	FREE FLOW ☐	RESTR. FLOW ☐	AVERAGE HOURLY VOLUME	TOTAL ACROSS	
A. MAJOR STREET BOTH APPROACHES	0	864	0	0	374		
	100% FULFILLED					0	SECTIONAL PERCENT
	80% FULFILLED					0	
	ACTUAL % IF BELOW 80% VALUE				43	43	
					TOTAL DOWN	43 / 1 =	43

Justification Increased by 20%

B. TRAFFIC CROSSING MAJOR STREET	0	90	0	0	118	TOTAL ACROSS	
	100% FULFILLED				100	100	SECTIONAL PERCENT
	80% FULFILLED					0	
	ACTUAL % IF BELOW 80% VALUE					0	
					TOTAL DOWN	100 / 1 =	100

NOTES:
1. The warrant values are based on annual average daily traffic (AADT) which apporximates May and October traffic
2. For warrants 1, 2, 3 and 4, each hourly volume must exceed the minimum requirements for the warrant to be 100% satisfied
3. For warrant 5 the 8 hour average must exceed the minimum requirements for the warrant to be 100% satisfied
4. The crossing volume is defined as the sum of:
   (1) Left turns from both minor street apporaches
   (2) The heaviest through volume from the minor street
   (3) 50% of the heavier left turn movement from major street when both of the following criteria are met:
      (a) The left turn volume > 120 vph
      (b) The left turn volume plus the opposing volume > 720 vph
   (4) Pedestrians crossing the major street

TRAFFIC SIGNAL WARRANT DATA INPUT

PROJECTED VOLUMES FOR JUSTIFICATION 7

Study Period: Future Total 2024

East/West Street Name	: Barton Street	Major Street	x	Minor Street	
North/South Street Name	: Lewis Road	Major Street		Minor Street	x

	PEAK	Major Street Barton Street Eastbound			Minor Street Lewis Road Northbound			Major Street Barton Street Westbound			Minor Street Lewis Road Southbound			Pedestrians Crossing Major Street	Totals	Splits E-W	Splits N-S
	HOUR	RIGHT	THRU	LEFT	RIGHT	THRU	LEFT	RIGHT	THRU	LEFT	RIGHT	THRU	LEFT				
1	AM	69	134	145	59	152	49	66	209	82	50	96	22	0	1133	62%	38%
2	PM	49	330	79	60	72	23	37	174	39	127	222	76	0	1288	55%	45%
	PHV (AM+PM)	***118***	***464***	***224***	***119***	***224***	***72***	***103***	***383***	***121***	***177***	***318***	***98***	***0***			
	Average Hourly Volume (PHV/4)	30	116	56	30	56	18	26	96	30	44	80	25	0			

The crossing volume is defined as the sum of:

(1) Left turns from both minor street apporaches		43
(2) The heaviest through volume from the minor street		80
(3) 50% of the heavier left turn movement from major street when both of the following criteria are met:		
(a) The left turn volume > 120 vph	T=TRUE F	
(b) The left turn volume plus the opposing volume > 720 vph	F=FALSE F	
heavier left turn= 56 oppposing though= 96		0
(4) Pedestrians crossing the major street		0
	sum:	122

AWS Warrant

Major
Total peak hourly exceeds 500 vph? TRUE WARRANTED
Volumes Split does not exceed 70/30? TRUE WARRANTED

Minor
Total peak hourly exceeds 500 vph? FALSE NOT WARRANTED
Volumes Split does not exceed 70/30? TRUE WARRANTED

TRAFFIC SIGNAL WARRANT ANLYSIS FORM FOR INTERSECTION CONTROL.

Traffic Signal Justification 7 for Future Development - Traffic Impact Studies (page 88 OTM Book 12) Future Total 2024

Major street : Barton Street No. of lanes : 1
Minor street : Lewis Road

FREE FLOW CONDITIONS (RURAL) ☐
RESTRICTED FLOW CONDITIONS (URBAN) ☒

IS THIS A T - INTERSECTION YES ☐ NO ☒
IS THIS AN EXISTING INTERSECTION YES ☒ NO ☐
IS THIS A NEW INTERSECTION YES ☐ NO ☒

WARRANT 1 - MINIMUM VEHICULAR VOLUME

100 % SATISFIED - YES ☐ NO ☒
80 % SATISFIED - YES ☐ NO ☒

	MINIMUM REQUIREMENTS Justification Increased by 20%				PERCENTAGE WARRANT		
APPROACH LANES	1		2 or MORE				
FLOW CONDITION	FREE FLOW ☐	RESTR. FLOW ☒	FREE FLOW ☐	RESTR. FLOW ☐	AVERAGE HOURLY VOLUME	TOTAL ACROSS	
A. ALL APPROACHES	0	864	0	0	605		
	100% FULFILLED					0	SECTIONAL PERCENT
	80% FULFILLED					0	
	ACTUAL % IF BELOW 80% VALUE				70	70	
					TOTAL DOWN	70 / 1 =	70

Justification Increased by 20%

B. MINOR STREET BOTH APPROACHES*	0	204	0	0	252	TOTAL ACROSS	
	100% FULFILLED				100	100	SECTIONAL PERCENT
	80% FULFILLED					0	
	ACTUAL % IF BELOW 80% VALUE					0	
					TOTAL DOWN	100 / 1 =	100

* FOR 'T' INTERSECTIONS MINOR ROAD THRESHOLDS ARE INCREASED BY AN ADDITIONAL 50%

WARRANT 2 - DELAY TO CROSS TRAFFIC

100 % SATISFIED - YES ☐ NO ☒
80 % SATISFIED - YES ☐ NO ☒

	MINIMUM REQUIREMENTS Justification Increased by 20%				PERCENTAGE WARRANT		
APPROACH LANES	1		2 or MORE				
FLOW CONDITION	FREE FLOW ☐	RESTR. FLOW ☒	FREE FLOW ☐	RESTR. FLOW ☐	AVERAGE HOURLY VOLUME	TOTAL ACROSS	
A. MAJOR STREET BOTH APPROACHES	0	864	0	0	353		
	100% FULFILLED					0	SECTIONAL PERCENT
	80% FULFILLED					0	
	ACTUAL % IF BELOW 80% VALUE				41	41	
					TOTAL DOWN	41 / 1 =	41

Justification Increased by 20%

B. TRAFFIC CROSSING MAJOR STREET	0	90	0	0	136	TOTAL ACROSS	
	100% FULFILLED				100	100	SECTIONAL PERCENT
	80% FULFILLED					0	
	ACTUAL % IF BELOW 80% VALUE					0	
					TOTAL DOWN	100 / 1 =	100

NOTES:
1. The warrant values are based on annual average daily traffic (AADT) which apporximates May and October traffic
2. For warrants 1, 2, 3 and 4, each hourly volume must exceed the minimum requirements for the warrant to be 100% satisfied
3. For warrant 5 the 8 hour average must exceed the minimum requirements for the warrant to be 100% satisfied
4. The crossing volume is defined as the sum of:
   (1) Left turns from both minor street apporaches
   (2) The heaviest through volume from the minor street
   (3) 50% of the heavier left turn movement from major street when both of the following criteria are met:
      (a) The left turn volume > 120 vph
      (b) The left turn volume plus the opposing volume > 720 vph
   (4) Pedestrians crossing the major street

TRAFFIC SIGNAL WARRANT DATA INPUT

PROJECTED VOLUMES FOR JUSTIFICATION 7

Study Period: Future Total 2024

East/West Street Name : Highway 8 — Major Street [x] Minor Street [ ]
North/South Street Name : Lewis Road — Major Street [ ] Minor Street [x]

	PEAK HOUR	Major Street Highway 8 Eastbound RIGHT	THRU	LEFT	Minor Street Lewis Road Northbound RIGHT	THRU	LEFT	Major Street Highway 8 Westbound RIGHT	THRU	LEFT	Minor Street Lewis Road Southbound RIGHT	THRU	LEFT	Pedestrians Crossing Major Street	Totals	Splits E-W	N-S
1	AM	6	310	71	2	2	3	98	417	1	45	2	72	0	1029	88%	12%
2	PM	7	561	105	2	1	6	37	400	1	66	5	56	0	1247	89%	11%
	PHV (AM+PM)	***13***	***871***	***176***	***4***	***3***	***9***	***135***	***817***	***2***	***111***	***7***	***128***	***0***			
	Average Hourly Volume (PHV/4)	3	218	44	1	1	2	34	204	1	28	2	32	0			

The crossing volume is defined as the sum of:

(1) Left turns from both minor street apporaches		34
(2) The heaviest through volume from the minor street		2
(3) 50% of the heavier left turn movement from major street when both of the following criteria are met:		
(a) The left turn volume > 120 vph	T=TRUE	F
(b) The left turn volume plus the opposing volume > 720 vph	F=FALSE	F
heavier left turn= 44 oppposing though= 204		0
(4) Pedestrians crossing the major street		0
	sum:	36

AWS Warrant

Major
Total peak hourly exceeds 500 vph? TRUE WARRANTED
Volumes Split does not exceed 70/30? FALSE NOT WARRANTED

Minor
Total peak hourly exceeds 500 vph? FALSE NOT WARRANTED
Volumes Split does not exceed 70/30? TRUE WARRANTED

TRAFFIC SIGNAL WARRANT ANLYSIS FORM FOR INTERSECTION CONTROL.

Traffic Signal Justification 7 for Future Development - Traffic Impact Studies (page 88 OTM Book 12) — Future Total 2024

Major street : Highway 8 — No. of lanes : 1
Minor street : Lewis Road

FREE FLOW CONDITIONS (RURAL) [ ]
RESTRICTED FLOW CONDITIONS (URBAN) [x]

IS THIS A T - INTERSECTION — YES [ ] NO [X]
IS THIS AN EXISTING INTERSECTION — YES [X] NO [ ]
IS THIS A NEW INTERSECTION — YES [ ] NO [X]

WARRANT 1 - MINIMUM VEHICULAR VOLUME

100 % SATISFIED - YES [ ] NO [X]
80 % SATISFIED - YES [ ] NO [X]

	MINIMUM REQUIREMENTS Justification Increased by 20%				PERCENTAGE WARRANT		
APPROACH LANES	1		2 or MORE				
FLOW CONDITION	FREE FLOW [ ]	RESTR. FLOW [X]	FREE FLOW [ ]	RESTR. FLOW [ ]	AVERAGE HOURLY VOLUME	TOTAL ACROSS	
A. ALL APPROACHES	0	864	0	0	569		
	100% FULFILLED					0	SECTIONAL PERCENT
	80% FULFILLED					0	
	ACTUAL % IF BELOW 80% VALUE				66	66	
					TOTAL DOWN	66 / 1 =	66

	Justification Increased by 20%						
B. MINOR STREET BOTH APPROACHES*	0	204	0	0	66	TOTAL ACROSS	
	100% FULFILLED					0	SECTIONAL PERCENT
	80% FULFILLED					0	
	ACTUAL % IF BELOW 80% VALUE				32	32	
					TOTAL DOWN	32 / 1 =	32

* FOR 'T' INTERSECTIONS MINOR ROAD THRESHOLDS ARE INCREASED BY AN ADDITIONAL 50%

WARRANT 2 - DELAY TO CROSS TRAFFIC

100 % SATISFIED - YES [ ] NO [X]
80 % SATISFIED - YES [ ] NO [X]

	MINIMUM REQUIREMENTS Justification Increased by 20%				PERCENTAGE WARRANT		
APPROACH LANES	1		2 or MORE				
FLOW CONDITION	FREE FLOW [ ]	RESTR. FLOW [X]	FREE FLOW [ ]	RESTR. FLOW [ ]	AVERAGE HOURLY VOLUME	TOTAL ACROSS	
A. MAJOR STREET BOTH APPROACHES	0	864	0	0	504		
	100% FULFILLED					0	SECTIONAL PERCENT
	80% FULFILLED					0	
	ACTUAL % IF BELOW 80% VALUE				58	58	
					TOTAL DOWN	58 / 1 =	58

	Justification Increased by 20%						
B. TRAFFIC CROSSING MAJOR STREET	0	90	0	0	3	TOTAL ACROSS	
	100% FULFILLED					0	SECTIONAL PERCENT
	80% FULFILLED					0	
	ACTUAL % IF BELOW 80% VALUE				3	3	
					TOTAL DOWN	3 / 1 =	3

NOTES:
1. The warrant values are based on annual average daily traffic (AADT) which apporximates May and October traffic
2. For warrants 1, 2, 3 and 4, each hourly volume must exceed the minimum requirements for the warrant to be 100% satisfied
3. For warrant 5 the 8 hour average must exceed the minimum requirements for the warrant to be 100% satisfied
4. The crossing volume is defined as the sum of:
   (1) Left turns from both minor street apporaches
   (2) The heaviest through volume from the minor street
   (3) 50% of the heavier left turn movement from major street when both of the following criteria are met:
      (a) The left turn volume > 120 vph
      (b) The left turn volume plus the opposing volume > 720 vph
   (4) Pedestrians crossing the major street

Appendix G
Arcady Data Sheets

Junctions 8

ARCADY 8 - Roundabout Module

Version: 8.0.6.541 [19821,26/11/2015]

Filename: CA01 - Coll D at Coll D.arc8
Path: G:\Legacy\SernasTransTech\Projects\2018\Fruitland TIS\Analysis\Arcady
Report generation date: 10/28/2018 10:48:08 PM

Summary of intersection performance

	AM							PM						
	95% Queue (Veh)	Delay (s)	V/C Ratio	LOS	Intersection Delay (s)	Intersection LOS	Network Residual Capacity	95% Queue (Veh)	Delay (s)	V/C Ratio	LOS	Intersection Delay (s)	Intersection LOS	Network Residual Capacity
	C-85 - 2024													
SB Collector D	~1	3.68	0.13	A	3.59	A	574 % [SB Collector D]	~1	3.53	0.09	A	3.57	A	607 % [NB Collector D]
EB Collector D	~1	3.51	0.05	A				~1	3.48	0.07	A			
NB Collector D	~1	3.36	0.04	A				~1	3.67	0.10	A			

Values shown are the maximum values over all time segments. Delay is the maximum value of average delay per arriving vehicle. Intersection LOS and Intersection Delay are demand-weighted averages. Network Residual Capacity indicates the amount by which network flow could be increased before a user-definable threshold (see Analysis Options) is met.

"D1 - 2024, AM " model duration: 7:45 AM - 9:15 AM
"D2 - 2024, PM" model duration: 7:45 AM - 9:15 AM

Run using Junctions 8.0.6.541 at 10/28/2018 10:47:59 PM

File summary

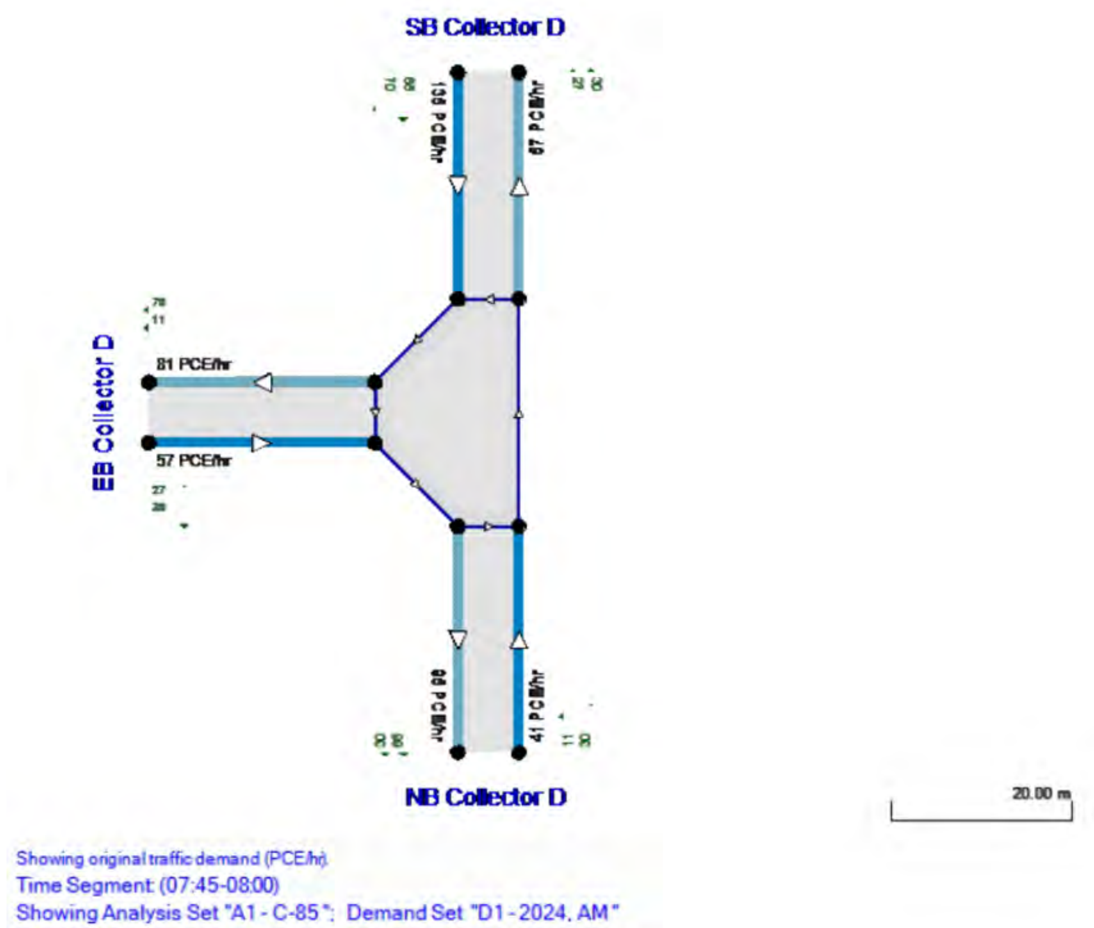
Title	(untitled)
Location	
Site Number	
Date	11/18/2014
Version	
Status	Conceptual
Identifier	
Client	
Jobnumber	
Analyst	
Description	

Analysis Options

Vehicle Length (m)	Do Queue Variations	Calculate Residual Capacity	Residual Capacity Criteria Type	V/C Ratio Threshold	Average Delay Threshold (s)	Queue Threshold (PCE)
7.00	✓	✓	Delay	0.85	36.00	20.00

Units

Distance Units	Speed Units	Traffic Units Input	Traffic Units Results	Flow Units	Average Delay Units	Total Delay Units	Rate Of Delay Units
m	kph	Veh	Veh	perHour	s	-Min	perMin



The intersection diagram reflects the last run of ARCADY.

C-85 - 2024, AM

Data Errors and Warnings

Severity	Area	Item	Description
Warning	DemandSets	D1 - 2024, AM	Time results are shown for central hour only. (Model is run for a 90 minute period.)

Analysis Set Details

Name	Roundabout Capacity Model	Description	Include In Report	Use Specific Demand Set(s)	Specific Demand Set(s)	Locked	Network Flow Scaling Factor (%)	Network Capacity Scaling Factor (%)	Reason For Scaling Factors
C-85	ARCADY		✓				100.000	100.000	

Demand Set Details

Name	Scenario Name	Time Period Name	Description	Traffic Profile Type	Model Start Time (HH:mm)	Model Finish Time (HH:mm)	Model Time Period Length (min)	Time Segment Length (min)	Results For Central Hour Only	Single Time Segment Only	Locked	Run Automatically	Use Relationship	Relationship
2024, AM	2024	AM		ONE HOUR	07:45	09:15	90	15	✓			✓		

Intersection Network

Intersections

Intersection	Name	Intersection Type	Leg Order	Grade Separated	Large Roundabout	Do Geometric Delay	Intersection Delay (s)	Intersection LOS
1	untitled	Roundabout	3,4,1				3.59	A

Intersection Network Options

Driving Side	Lighting	Network Residual Capacity (%)	First Leg Reaching Threshold
Right	Normal/unknown	574	SB Collector D

Legs

Legs

Name	Leg	Name	Description
SB Collector D	3	SB Collector D	
EB Collector D	4	EB Collector D	
NB Collector D	1	NB Collector D	

Capacity Options

Name	Minimum Capacity (PCE/hr)	Maximum Capacity (PCE/hr)	Assume Flat Start Profile	Initial Queue (PCE)
SB Collector D	0.00	99999.00		0.00
EB Collector D	0.00	99999.00		0.00
NB Collector D	0.00	99999.00		0.00

Roundabout Geometry

Name	V - Approach road half-width (m)	E - Entry width (m)	l' - Effective flare length (m)	R - Entry radius (m)	D - Inscribed circle diameter (m)	PHI - Conflict (entry) angle (deg)	Exit Only
SB Collector D	4.25	4.25	0.00	20.00	40.00	20.00	
EB Collector D	4.25	4.25	0.00	20.00	40.00	20.00	
NB Collector D	4.25	4.25	0.00	20.00	40.00	20.00	

Slope / Intercept / Capacity

Leg Intercept Adjustments

Name	Type	Reason	Direct Intercept Adjustment (PCE/hr)	Percentage Intercept Adjustment (%)
SB Collector D	Percentage			85.00
EB Collector D	Percentage			85.00
NB Collector D	Percentage			85.00

Roundabout Slope and Intercept used in model

Name	Enter slope and intercept directly	Entered slope	Entered intercept (PCE/hr)	Final Slope	Final Intercept (PCE/hr)
SB Collector D		(calculated)	(calculated)	0.579	1132.570
EB Collector D		(calculated)	(calculated)	0.579	1132.570
NB Collector D		(calculated)	(calculated)	0.579	1132.570

The slope and intercept shown above include any corrections and adjustments.

Leg Capacity Adjustments

Name	Type	Reason	Direct Capacity Adjustment (PCE/hr)	Percentage Capacity Adjustment (%)
SB Collector D	None			
EB Collector D	Percentage			100.00
NB Collector D	Percentage			100.00

Traffic Flows

Demand Set Data Options

Default Vehicle Mix	Vehicle Mix Varies Over Time	Vehicle Mix Varies Over Turn	Vehicle Mix Varies Over Entry	Vehicle Mix Source	PCE Factor for a Truck (PCE)	Default Turning Proportions	Estimate from entry/exit counts	Turning Proportions Vary Over Time	Turning Proportions Vary Over Turn	Turning Proportions Vary Over Entry
		✓	✓	Truck Percentages	2.00				✓	✓

Entry Flows

General Flows Data

Name	Profile Type	Use Turning Counts	Average Demand Flow (Veh/hr)	Flow Scaling Factor (%)
SB Collector D	ONE HOUR	✓	135.00	100.000
EB Collector D	ONE HOUR	✓	56.00	89.000
NB Collector D	ONE HOUR	✓	41.00	89.000

Direct/Resultant Flows

Direct Flows Data

Time Segment	Name	Direct Demand Entry Flow (Veh/hr)	DirectDemandEntryFlowInPCE (PCE/hr)	Direct Demand Exit Flow (Veh/hr)	Direct Demand Pedestrian Flow (Ped/hr)
08:00-08:15	SB Collector D	121.36	121.36		
08:00-08:15	EB Collector D	50.34	50.86		
08:00-08:15	NB Collector D	36.86	37.06		
08:15-08:30	SB Collector D	148.64	148.64		
08:15-08:30	EB Collector D	61.66	62.30		
08:15-08:30	NB Collector D	45.14	45.38		
08:30-08:45	SB Collector D	148.64	148.64		
08:30-08:45	EB Collector D	61.66	62.30		
08:30-08:45	NB Collector D	45.14	45.38		
08:45-09:00	SB Collector D	121.36	121.36		
08:45-09:00	EB Collector D	50.34	50.86		
08:45-09:00	NB Collector D	36.86	37.06		

Turning Proportions

Turning Counts / Proportions (Veh/hr) - untitled (for whole period)

		To		
		SB Collector D	EB Collector D	NB Collector D
From	SB Collector D	0.000	70.000	65.000
	EB Collector D	27.000	0.000	29.000
	NB Collector D	30.000	11.000	0.000

Turning Proportions (Veh) - untitled (for whole period)

		To		
		SB Collector D	EB Collector D	NB Collector D
From	SB Collector D	0.00	0.52	0.48
	EB Collector D	0.48	0.00	0.52
	NB Collector D	0.73	0.27	0.00

Vehicle Mix

Average PCE Per Vehicle - untitled (for whole period)

		To		
		SB Collector D	EB Collector D	NB Collector D
From	SB Collector D	1.000	1.000	1.000

	EB Collector D	1.000	1.020	1.020
	NB Collector D	1.000	1.020	1.020

Truck Percentages - untitled (for whole period)

		To		
		SB Collector D	EB Collector D	NB Collector D
From	SB Collector D	0.0	0.0	0.0
	EB Collector D	0.0	2.0	2.0
	NB Collector D	0.0	2.0	2.0

Results

Results Summary for whole modelled period

Name	Max V/C Ratio	Max Delay (s)	Max Queue (Veh)	Max 95th percentile Queue (Veh)	Max LOS	Average Demand (Veh/hr)	Total Intersection Arrivals (Veh)	Total Queueing Delay (Veh-min)	Average Queueing Delay (s)	Rate Of Queueing Delay (Veh-min/min)	Inclusive Total Queueing Delay (Veh-min)	Inclusive Average Queueing Delay (s)
SB Collector D	0.13	3.68	0.15	~1	A	135.00	135.00	8.13	3.62	0.09	11.10	3.58
EB Collector D	0.05	3.51	0.05	~1	A	49.84	49.84	2.88	3.47	0.03	3.94	3.45
NB Collector D	0.04	3.36	0.04	~1	A	36.49	36.49	2.03	3.33	0.02	2.78	3.32

Main Results for each time segment

Main results: (08:00-08:15)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
SB Collector D	121.36	30.34	121.28	45.58	8.80	0.00	1127.38	991.36	0.108	0.10	0.12	3.577	A
EB Collector D	44.81	11.20	44.78	71.68	58.39	0.00	1087.49	847.42	0.041	0.04	0.04	3.451	A
NB Collector D	32.80	8.20	32.78	81.58	21.59	0.00	1114.09	891.21	0.029	0.03	0.03	3.328	A

Main results: (08:15-08:30)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
SB Collector D	148.64	37.16	148.51	55.81	10.77	0.00	1126.21	991.36	0.132	0.12	0.15	3.681	A
EB Collector D	54.87	13.72	54.83	87.78	71.51	0.00	1079.98	847.42	0.051	0.04	0.05	3.510	A
NB Collector D	40.18	10.04	40.15	99.90	26.44	0.00	1111.29	891.21	0.036	0.03	0.04	3.360	A

Main results: (08:30-08:45)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
SB Collector D	148.64	37.16	148.64	55.85	10.78	0.00	1126.20	991.36	0.132	0.15	0.15	3.681	A
EB Collector D	54.87	13.72	54.87	87.85	71.57	0.00	1079.94	847.42	0.051	0.05	0.05	3.511	A
NB Collector D	40.18	10.04	40.18	99.98	26.46	0.00	1111.28	891.21	0.036	0.04	0.04	3.360	A

Main results: (08:45-09:00)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
SB Collector D	121.36	30.34	121.48	45.65	8.81	0.00	1127.37	991.36	0.108	0.15	0.12	3.578	A
EB Collector D	44.81	11.20	44.85	71.80	58.49	0.00	1087.44	847.42	0.041	0.05	0.04	3.452	A
NB Collector D	32.80	8.20	32.83	81.72	21.62	0.00	1114.07	891.21	0.029	0.04	0.03	3.331	A

Queueing Delay Results for each time segment

Queueing Delay results: (08:00-08:15)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
SB Collector D	1.78	0.12	3.577	A	A
EB Collector D	0.63	0.04	3.451	A	A
NB Collector D	0.45	0.03	3.328	A	A

Queueing Delay results: (08:15-08:30)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
SB Collector D	2.24	0.15	3.681	A	A
EB Collector D	0.79	0.05	3.510	A	A
NB Collector D	0.55	0.04	3.360	A	A

Queueing Delay results: (08:30-08:45)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
SB Collector D	2.27	0.15	3.681	A	A
EB Collector D	0.80	0.05	3.511	A	A
NB Collector D	0.56	0.04	3.360	A	A

Queueing Delay results: (08:45-09:00)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
SB Collector D	1.84	0.12	3.578	A	A
EB Collector D	0.66	0.04	3.452	A	A
NB Collector D	0.46	0.03	3.331	A	A

Queue Variation Results for each time segment

Queue Variation results: (08:00-08:15)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
SB Collector D	0.12	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
EB Collector D	0.04	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB Collector D	0.03	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

Queue Variation results: (08:15-08:30)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
SB Collector D	0.15	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
EB Collector D	0.05	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

NB Collector D	0.04	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

Queue Variation results: (08:30-08:45)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
SB Collector D	0.15	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
EB Collector D	0.05	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB Collector D	0.04	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

Queue Variation results: (08:45-09:00)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
SB Collector D	0.12	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
EB Collector D	0.04	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB Collector D	0.03	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

C-85 - 2024, PM

Data Errors and Warnings

Severity	Area	Item	Description
Warning	DemandSets	D2 - 2024, PM	Time results are shown for central hour only. (Model is run for a 90 minute period.)

Analysis Set Details

Name	Roundabout Capacity Model	Description	Include In Report	Use Specific Demand Set(s)	Specific Demand Set(s)	Locked	Network Flow Scaling Factor (%)	Network Capacity Scaling Factor (%)	Reason For Scaling Factors
C-85	ARCADY		✓				100.000	100.000	

Demand Set Details

Name	Scenario Name	Time Period Name	Description	Traffic Profile Type	Model Start Time (HH:mm)	Model Finish Time (HH:mm)	Model Time Period Length (min)	Time Segment Length (min)	Results For Central Hour Only	Single Time Segment Only	Locked	Run Automatically	Use Relationship	Relationship
2024, PM	2024	PM		ONE HOUR	07:45	09:15	90	15	✓			✓		

Intersection Network

Intersections

Intersection	Name	Intersection Type	Leg Order	Grade Separated	Large Roundabout	Do Geometric Delay	Intersection Delay (s)	Intersection LOS
1	untitled	Roundabout	3,4,1				3.57	A

Intersection Network Options

Driving Side	Lighting	Network Residual Capacity (%)	First Leg Reaching Threshold
Right	Normal/unknown	607	NB Collector D

Legs

Legs

Name	Leg	Name	Description
SB Collector D	3	SB Collector D	
EB Collector D	4	EB Collector D	
NB Collector D	1	NB Collector D	

Capacity Options

Name	Minimum Capacity (PCE/hr)	Maximum Capacity (PCE/hr)	Assume Flat Start Profile	Initial Queue (PCE)
SB Collector D	0.00	99999.00		0.00
EB Collector D	0.00	99999.00		0.00
NB Collector D	0.00	99999.00		0.00

Roundabout Geometry

Name	V - Approach road half-width (m)	E - Entry width (m)	l' - Effective flare length (m)	R - Entry radius (m)	D - Inscribed circle diameter (m)	PHI - Conflict (entry) angle (deg)	Exit Only
SB Collector D	4.25	4.25	0.00	20.00	40.00	20.00	
EB Collector D	4.25	4.25	0.00	20.00	40.00	20.00	
NB Collector D	4.25	4.25	0.00	20.00	40.00	20.00	

Slope / Intercept / Capacity

Leg Intercept Adjustments

Name	Type	Reason	Direct Intercept Adjustment (PCE/hr)	Percentage Intercept Adjustment (%)
SB Collector D	Percentage			85.00
EB Collector D	Percentage			85.00
NB Collector D	Percentage			85.00

Roundabout Slope and Intercept used in model

Name	Enter slope and intercept directly	Entered slope	Entered intercept (PCE/hr)	Final Slope	Final Intercept (PCE/hr)
SB Collector D		(calculated)	(calculated)	0.579	1132.570
EB Collector D		(calculated)	(calculated)	0.579	1132.570
NB Collector D		(calculated)	(calculated)	0.579	1132.570

The slope and intercept shown above include any corrections and adjustments.

Leg Capacity Adjustments

Name	Type	Reason	Direct Capacity Adjustment (PCE/hr)	Percentage Capacity Adjustment (%)
SB Collector D	None			
EB Collector D	Percentage			100.00
NB Collector D	Percentage			100.00

Traffic Flows

Demand Set Data Options

Default Vehicle Mix	Vehicle Mix Varies Over Time	Vehicle Mix Varies Over Turn	Vehicle Mix Varies Over Entry	Vehicle Mix Source	PCE Factor for a Truck (PCE)	Default Turning Proportions	Estimate from entry/exit counts	Turning Proportions Vary Over Time	Turning Proportions Vary Over Turn	Turning Proportions Vary Over Entry
		✓	✓	Truck Percentages	2.00				✓	✓

Entry Flows

General Flows Data

Name	Profile Type	Use Turning Counts	Average Demand Flow (Veh/hr)	Flow Scaling Factor (%)
SB Collector D	ONE HOUR	✓	89.00	100.000
EB Collector D	ONE HOUR	✓	79.00	89.000
NB Collector D	ONE HOUR	✓	112.00	89.000

Direct/Resultant Flows

Direct Flows Data

Time Segment	Name	Direct Demand Entry Flow (Veh/hr)	DirectDemandEntryFlowInPCE (PCE/hr)	Direct Demand Exit Flow (Veh/hr)	Direct Demand Pedestrian Flow (Ped/hr)

08:00-08:15	SB Collector D	80.01	80.01		
08:00-08:15	EB Collector D	71.02	71.27		
08:00-08:15	NB Collector D	100.69	101.15		
08:15-08:30	SB Collector D	97.99	97.99		
08:15-08:30	EB Collector D	86.98	87.29		
08:15-08:30	NB Collector D	123.31	123.89		
08:30-08:45	SB Collector D	97.99	97.99		
08:30-08:45	EB Collector D	86.98	87.29		
08:30-08:45	NB Collector D	123.31	123.89		
08:45-09:00	SB Collector D	80.01	80.01		
08:45-09:00	EB Collector D	71.02	71.27		
08:45-09:00	NB Collector D	100.69	101.15		

Turning Proportions

Turning Counts / Proportions (Veh/hr) - untitled (for whole period)

		To		
		SB Collector D	EB Collector D	NB Collector D
From	SB Collector D	0.000	63.000	26.000
	EB Collector D	65.000	0.000	14.000
	NB Collector D	86.000	26.000	0.000

Turning Proportions (Veh) - untitled (for whole period)

		To		
		SB Collector D	EB Collector D	NB Collector D
From	SB Collector D	0.00	0.71	0.29
	EB Collector D	0.82	0.00	0.18
	NB Collector D	0.77	0.23	0.00

Vehicle Mix

Average PCE Per Vehicle - untitled (for whole period)

		To		
		SB Collector D	EB Collector D	NB Collector D
From	SB Collector D	1.000	1.000	1.000
	EB Collector D	1.000	1.020	1.020
	NB Collector D	1.000	1.020	1.020

Truck Percentages - untitled (for whole period)

		To		
		SB Collector D	EB Collector D	NB Collector D
From	SB Collector D	0.0	0.0	0.0
	EB Collector D	0.0	2.0	2.0
	NB Collector D	0.0	2.0	2.0

Results

Results Summary for whole modelled period

Name	Max V/C Ratio	Max Delay (s)	Max Queue (Veh)	Max 95th percentile Queue (Veh)	Max LOS	Average Demand (Veh/hr)	Total Intersection Arrivals (Veh)	Total Queueing Delay (Veh-min)	Average Queueing Delay (s)	Rate Of Queueing Delay (Veh-min/min)	Inclusive Total Queueing Delay (Veh-min)	Inclusive Average Queueing Delay (s)

SB Collector D	0.09	3.53	0.10	~1	A	89.00	89.00	5.16	3.48	0.06	7.06	3.46
EB Collector D	0.07	3.48	0.07	~1	A	70.31	70.31	4.03	3.44	0.04	5.51	3.42
NB Collector D	0.10	3.67	0.11	~1	A	99.68	99.68	5.99	3.61	0.07	8.18	3.58

Main Results for each time segment

Main results: (08:00-08:15)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
SB Collector D	80.01	20.00	79.96	120.73	20.79	0.00	1120.29	1039.98	0.071	0.06	0.08	3.459	A
EB Collector D	63.21	15.80	63.17	77.39	23.36	0.00	1115.10	953.28	0.057	0.05	0.06	3.421	A
NB Collector D	89.61	22.40	89.55	34.55	51.97	0.00	1097.39	675.29	0.082	0.07	0.09	3.571	A

Main results: (08:15-08:30)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
SB Collector D	97.99	24.50	97.91	147.85	25.46	0.00	1117.54	1039.98	0.088	0.08	0.10	3.530	A
EB Collector D	77.41	19.35	77.35	94.77	28.60	0.00	1112.07	953.28	0.070	0.06	0.07	3.478	A
NB Collector D	109.75	27.44	109.66	42.31	63.65	0.00	1090.66	675.29	0.101	0.09	0.11	3.669	A

Main results: (08:30-08:45)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
SB Collector D	97.99	24.50	97.99	147.96	25.48	0.00	1117.52	1039.98	0.088	0.10	0.10	3.530	A
EB Collector D	77.41	19.35	77.41	94.84	28.63	0.00	1112.06	953.28	0.070	0.07	0.07	3.478	A
NB Collector D	109.75	27.44	109.75	42.34	63.69	0.00	1090.63	675.29	0.101	0.11	0.11	3.669	A

Main results: (08:45-09:00)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
SB Collector D	80.01	20.00	80.08	120.93	20.82	0.00	1120.27	1039.98	0.071	0.10	0.08	3.463	A
EB Collector D	63.21	15.80	63.26	77.51	23.40	0.00	1115.08	953.28	0.057	0.07	0.06	3.424	A
NB Collector D	89.61	22.40	89.70	34.61	52.05	0.00	1097.34	675.29	0.082	0.11	0.09	3.572	A

Queueing Delay Results for each time segment

Queueing Delay results: (08:00-08:15)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
SB Collector D	1.14	0.08	3.459	A	A

EB Collector D	0.89	0.06	3.421	A	A
NB Collector D	1.31	0.09	3.571	A	A

Queueing Delay results: (08:15-08:30)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
SB Collector D	1.42	0.09	3.530	A	A
EB Collector D	1.10	0.07	3.478	A	A
NB Collector D	1.65	0.11	3.669	A	A

Queueing Delay results: (08:30-08:45)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
SB Collector D	1.44	0.10	3.530	A	A
EB Collector D	1.12	0.07	3.478	A	A
NB Collector D	1.67	0.11	3.669	A	A

Queueing Delay results: (08:45-09:00)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
SB Collector D	1.17	0.08	3.463	A	A
EB Collector D	0.92	0.06	3.424	A	A
NB Collector D	1.36	0.09	3.572	A	A

Queue Variation Results for each time segment

Queue Variation results: (08:00-08:15)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
SB Collector D	0.08	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
EB Collector D	0.06	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB Collector D	0.09	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

Queue Variation results: (08:15-08:30)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
SB Collector D	0.10	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
EB Collector D	0.07	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB Collector D	0.11	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

Queue Variation results: (08:30-08:45)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
SB Collector D	0.10	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
EB Collector D	0.07	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB Collector D	0.11	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

Queue Variation results: (08:45-09:00)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
SB Collector D	0.08	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
EB Collector D	0.06	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

NB Collector D	0.09	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

Junctions 8

ARCADY 8 - Roundabout Module

Filename: CA01 - Coll D at Coll E.arc8
Path: G:\Legacy\SernasTransTech\Projects\2018\Fruitland TIS\Analysis\Arcady
Report generation date: 10/28/2018 10:36:41 PM

Summary of intersection performance

	AM							PM						
	95% Queue (Veh)	Delay (s)	V/C Ratio	LOS	Intersection Delay (s)	Intersection LOS	Network Residual Capacity	95% Queue (Veh)	Delay (s)	V/C Ratio	LOS	Intersection Delay (s)	Intersection LOS	Network Residual Capacity
	C-85 - 2024													
WB Collector D	~1	4.78	0.28	A	4.20	A	186 % [WB Collector D]	~1	4.70	0.25	A	4.46	A	196 % [WB Collector D]
SB Collector E	~1	3.41	0.09	A				~1	3.32	0.08	A			
EB Collector D	~1	3.71	0.07	A				~1	4.64	0.25	A			
NB Collector E	~1	3.69	0.10	A				~1	4.42	0.17	A			

Values shown are the maximum values over all time segments. Delay is the maximum value of average delay per arriving vehicle. Intersection LOS and Intersection Delay are demand-weighted averages. Network Residual Capacity indicates the amount by which network flow could be increased before a user-definable threshold (see Analysis Options) is met.

"D1 - 2024, AM " model duration: 7:45 AM - 9:15 AM
"D2 - 2024, PM" model duration: 7:45 AM - 9:15 AM

Run using Junctions 8.0.6.541 at 10/28/2018 10:36:07 PM

File summary

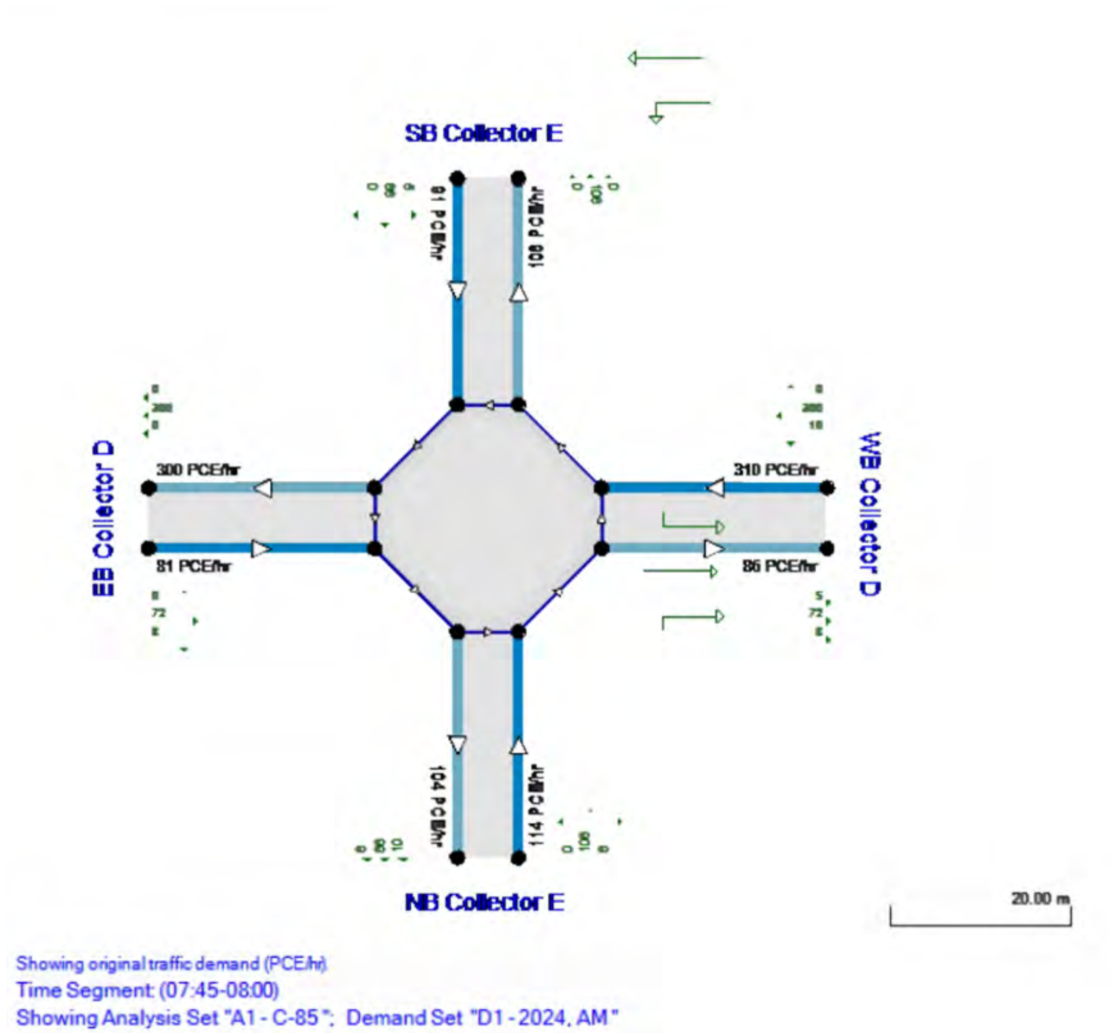
Title	(untitled)
Location	
Site Number	
Date	11/18/2014
Version	
Status	Conceptual
Identifier	
Client	
Jobnumber	
Analyst	
Description	

Analysis Options

Vehicle Length (m)	Do Queue Variations	Calculate Residual Capacity	Residual Capacity Criteria Type	V/C Ratio Threshold	Average Delay Threshold (s)	Queue Threshold (PCE)
7.00	✓	✓	Delay	0.85	36.00	20.00

Units

Distance Units	Speed Units	Traffic Units Input	Traffic Units Results	Flow Units	Average Delay Units	Total Delay Units	Rate Of Delay Units
m	kph	Veh	Veh	perHour	s	-Min	perMin



The intersection diagram reflects the last run of ARCADY.

C-85 - 2024, AM

Data Errors and Warnings

Severity	Area	Item	Description
Warning	DemandSets	D1 - 2024, AM	Time results are shown for central hour only. (Model is run for a 90 minute period.)

Analysis Set Details

Name	Roundabout Capacity Model	Description	Include In Report	Use Specific Demand Set(s)	Specific Demand Set(s)	Locked	Network Flow Scaling Factor (%)	Network Capacity Scaling Factor (%)	Reason For Scaling Factors
C-85	ARCADY		✓				100.000	100.000	

Demand Set Details

Name	Scenario Name	Time Period Name	Description	Traffic Profile Type	Model Start Time (HH:mm)	Model Finish Time (HH:mm)	Model Time Period Length (min)	Time Segment Length (min)	Results For Central Hour Only	Single Time Segment Only	Locked	Run Automatically	Use Relationship	Relationship
2024, AM	2024	AM		ONE HOUR	07:45	09:15	90	15	✓			✓		

Intersection Network

Intersections

Intersection	Name	Intersection Type	Leg Order	Grade Separated	Large Roundabout	Do Geometric Delay	Intersection Delay (s)	Intersection LOS
1	untitled	Roundabout	2,3,4,1				4.20	A

Intersection Network Options

Driving Side	Lighting	Network Residual Capacity (%)	First Leg Reaching Threshold
Right	Normal/unknown	186	WB Collector D

Legs

Legs

Name	Leg	Name	Description
WB Collector D	2	WB Collector D	
SB Collector E	3	SB Collector E	
EB Collector D	4	EB Collector D	
NB Collector E	1	NB Collector E	

Capacity Options

Name	Minimum Capacity (PCE/hr)	Maximum Capacity (PCE/hr)	Assume Flat Start Profile	Initial Queue (PCE)
WB Collector D	0.00	99999.00		0.00
SB Collector E	0.00	99999.00		0.00
EB Collector D	0.00	99999.00		0.00
NB Collector E	0.00	99999.00		0.00

Roundabout Geometry

Name	V - Approach road half-width (m)	E - Entry width (m)	l' - Effective flare length (m)	R - Entry radius (m)	D - Inscribed circle diameter (m)	PHI - Conflict (entry) angle (deg)	Exit Only
WB Collector D	4.25	4.25	0.00	20.00	40.00	20.00	
SB Collector E	4.25	4.25	0.00	20.00	40.00	20.00	
EB Collector D	4.25	4.25	0.00	20.00	40.00	20.00	
NB Collector E	4.25	4.25	0.00	20.00	40.00	20.00	

Slope / Intercept / Capacity

Leg Intercept Adjustments

Name	Type	Reason	Direct Intercept Adjustment (PCE/hr)	Percentage Intercept Adjustment (%)
WB Collector D	Percentage			85.00
SB Collector E	None			
EB Collector D	Percentage			85.00
NB Collector E	Percentage			85.00

Roundabout Slope and Intercept used in model

Name	Enter slope and intercept directly	Entered slope	Entered intercept (PCE/hr)	Final Slope	Final Intercept (PCE/hr)
WB Collector D		(calculated)	(calculated)	0.579	1132.570
SB Collector E		(calculated)	(calculated)	0.579	1332.435
EB Collector D		(calculated)	(calculated)	0.579	1132.570
NB Collector E		(calculated)	(calculated)	0.579	1132.570

The slope and intercept shown above include any corrections and adjustments.

Leg Capacity Adjustments

Name	Type	Reason	Direct Capacity Adjustment (PCE/hr)	Percentage Capacity Adjustment (%)
WB Collector D	Percentage			100.00
SB Collector E	None			
EB Collector D	Percentage			100.00
NB Collector E	Percentage			100.00

Traffic Flows

Demand Set Data Options

Default Vehicle Mix	Vehicle Mix Varies Over Time	Vehicle Mix Varies Over Turn	Vehicle Mix Varies Over Entry	Vehicle Mix Source	PCE Factor for a Truck (PCE)	Default Turning Proportions	Estimate from entry/exit counts	Turning Proportions Vary Over Time	Turning Proportions Vary Over Turn	Turning Proportions Vary Over Entry
		✓	✓	Truck Percentages	2.00				✓	✓

Entry Flows

General Flows Data

Name	Profile Type	Use Turning Counts	Average Demand Flow (Veh/hr)	Flow Scaling Factor (%)
WB Collector D	ONE HOUR	✓	304.00	89.000
SB Collector E	ONE HOUR	✓	91.00	100.000
EB Collector D	ONE HOUR	✓	79.00	89.000
NB Collector E	ONE HOUR	✓	114.00	89.000

Direct/Resultant Flows

Direct Flows Data

Time Segment	Name	Direct Demand Entry Flow (Veh/hr)	DirectDemandEntryFlowInPCE (PCE/hr)	Direct Demand Exit Flow (Veh/hr)	Direct Demand Pedestrian Flow (Ped/hr)
08:00-08:15	WB Collector D	273.29	278.76		
08:00-08:15	SB Collector E	81.81	81.81		
08:00-08:15	EB Collector D	71.02	72.44		
08:00-08:15	NB Collector E	102.48	102.63		
08:15-08:30	WB Collector D	334.71	341.40		
08:15-08:30	SB Collector E	100.19	100.19		
08:15-08:30	EB Collector D	86.98	88.72		
08:15-08:30	NB Collector E	125.52	125.69		
08:30-08:45	WB Collector D	334.71	341.40		
08:30-08:45	SB Collector E	100.19	100.19		
08:30-08:45	EB Collector D	86.98	88.72		
08:30-08:45	NB Collector E	125.52	125.69		
08:45-09:00	WB Collector D	273.29	278.76		
08:45-09:00	SB Collector E	81.81	81.81		
08:45-09:00	EB Collector D	71.02	72.44		
08:45-09:00	NB Collector E	102.48	102.63		

Turning Proportions

Turning Counts / Proportions (Veh/hr) - untitled (for whole period)

		To			
		WB Collector D	SB Collector E	EB Collector D	NB Collector E
From	WB Collector D	0.000	0.000	294.000	10.000
	SB Collector E	5.000	0.000	0.000	86.000
	EB Collector D	71.000	0.000	0.000	8.000
	NB Collector E	8.000	106.000	0.000	0.000

Turning Proportions (Veh) - untitled (for whole period)

		To			
		WB Collector D	SB Collector E	EB Collector D	NB Collector E
From	WB Collector D	0.00	0.00	0.97	0.03
	SB Collector E	0.05	0.00	0.00	0.95
	EB Collector D	0.90	0.00	0.00	0.10
	NB Collector E	0.07	0.93	0.00	0.00

Vehicle Mix

Average PCE Per Vehicle - untitled (for whole period)

		To			
		WB Collector D	SB Collector E	EB Collector D	NB Collector E
From	WB Collector D	1.020	1.000	1.020	1.020
	SB Collector E	1.000	1.000	1.000	1.000
	EB Collector D	1.020	1.000	1.020	1.020
	NB Collector E	1.020	1.000	1.020	1.020

Truck Percentages - untitled (for whole period)

		To			
		WB Collector D	SB Collector E	EB Collector D	NB Collector E
From	WB Collector D	2.0	0.0	2.0	2.0
	SB Collector E	0.0	0.0	0.0	0.0
	EB Collector D	2.0	0.0	2.0	2.0
	NB Collector E	2.0	0.0	2.0	2.0

Results

Results Summary for whole modelled period

Name	Max V/C Ratio	Max Delay (s)	Max Queue (Veh)	Max 95th percentile Queue (Veh)	Max LOS	Average Demand (Veh/hr)	Total Intersection Arrivals (Veh)	Total Queueing Delay (Veh-min)	Average Queueing Delay (s)	Rate Of Queueing Delay (Veh-min/min)	Inclusive Total Queueing Delay (Veh-min)	Inclusive Average Queueing Delay (s)
WB Collector D	0.28	4.78	0.39	~1	A	270.56	270.56	20.59	4.57	0.23	27.63	4.45
SB Collector E	0.09	3.41	0.09	~1	A	91.00	91.00	5.04	3.32	0.06	6.83	3.27
EB Collector D	0.07	3.71	0.08	~1	A	70.31	70.31	4.27	3.65	0.05	5.83	3.62
NB Collector E	0.10	3.69	0.11	~1	A	101.46	101.46	6.13	3.62	0.07	8.36	3.59

Main Results for each time segment

Main results: (08:00-08:15)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
WB Collector D	243.23	60.81	242.98	67.65	84.75	0.00	1062.25	688.92	0.229	0.23	0.30	4.393	A
SB Collector E	81.81	20.45	81.75	84.75	242.98	0.00	1188.93	925.57	0.069	0.06	0.07	3.250	A
EB Collector D	63.21	15.80	63.16	234.99	89.74	0.00	1059.33	571.84	0.060	0.05	0.06	3.613	A
NB Collector E	91.21	22.80	91.15	91.65	61.26	0.00	1094.91	798.48	0.083	0.07	0.09	3.585	A

Main results: (08:15-08:30)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
WB Collector D	297.89	74.47	297.50	82.85	103.78	0.00	1051.45	688.92	0.283	0.30	0.39	4.773	A
SB Collector	100.19	25.05	100.11	103.78	297.50	0.00	1156.73	925.57	0.087	0.07	0.09	3.406	A

E													
EB Collector D	77.41	19.35	77.35	287.72	109.90	0.00	1047.87	571.84	0.074	0.06	0.08	3.708	A
NB Collector E	111.71	27.93	111.62	112.23	75.02	0.00	1086.81	798.48	0.103	0.09	0.11	3.691	A

Main results: (08:30-08:45)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
WB Collector D	297.89	74.47	297.89	82.92	103.87	0.00	1051.40	688.92	0.283	0.39	0.39	4.777	A
SB Collector E	100.19	25.05	100.19	103.87	297.89	0.00	1156.51	925.57	0.087	0.09	0.09	3.407	A
EB Collector D	77.41	19.35	77.41	288.09	109.99	0.00	1047.81	571.84	0.074	0.08	0.08	3.708	A
NB Collector E	111.71	27.93	111.71	112.33	75.08	0.00	1086.77	798.48	0.103	0.11	0.11	3.691	A

Main results: (08:45-09:00)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
WB Collector D	243.23	60.81	243.61	67.77	84.90	0.00	1062.17	688.92	0.229	0.39	0.30	4.401	A
SB Collector E	81.81	20.45	81.89	84.90	243.61	0.00	1188.56	925.57	0.069	0.09	0.07	3.255	A
EB Collector D	63.21	15.80	63.27	235.59	89.90	0.00	1059.24	571.84	0.060	0.08	0.06	3.613	A
NB Collector E	91.21	22.80	91.30	91.81	61.36	0.00	1094.85	798.48	0.083	0.11	0.09	3.586	A

Queueing Delay Results for each time segment

Queueing Delay results: (08:00-08:15)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
WB Collector D	4.35	0.29	4.393	A	A
SB Collector E	1.09	0.07	3.250	A	A
EB Collector D	0.94	0.06	3.613	A	A
NB Collector E	1.34	0.09	3.585	A	A

Queueing Delay results: (08:15-08:30)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
WB Collector D	5.77	0.38	4.773	A	A
SB Collector E	1.40	0.09	3.406	A	A
EB Collector D	1.18	0.08	3.708	A	A
NB Collector E	1.69	0.11	3.691	A	A

Queueing Delay results: (08:30-08:45)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
WB Collector D	5.90	0.39	4.777	A	A
SB Collector E	1.42	0.09	3.407	A	A
EB Collector D	1.19	0.08	3.708	A	A
NB Collector E	1.71	0.11	3.691	A	A

Queueing Delay results: (08:45-09:00)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
WB Collector D	4.57	0.30	4.401	A	A
SB Collector E	1.13	0.08	3.255	A	A
EB Collector D	0.97	0.06	3.613	A	A
NB Collector E	1.39	0.09	3.586	A	A

Queue Variation Results for each time segment

Queue Variation results: (08:00-08:15)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
WB Collector D	0.30	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
SB Collector E	0.07	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
EB Collector D	0.06	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB Collector E	0.09	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

Queue Variation results: (08:15-08:30)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
WB Collector D	0.39	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
SB Collector E	0.09	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
EB Collector D	0.08	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB Collector E	0.11	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

Queue Variation results: (08:30-08:45)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
WB Collector D	0.39	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
SB Collector E	0.09	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
EB Collector D	0.08	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB Collector E	0.11	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

Queue Variation results: (08:45-09:00)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
WB Collector D	0.30	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
SB Collector E	0.07	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
EB Collector D	0.06	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB Collector E	0.09	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

C-85 - 2024, PM

Data Errors and Warnings

Severity	Area	Item	Description
Warning	DemandSets	D2 - 2024, PM	Time results are shown for central hour only. (Model is run for a 90 minute period.)

Analysis Set Details

Name	Roundabout Capacity Model	Description	Include In Report	Use Specific Demand Set(s)	Specific Demand Set(s)	Locked	Network Flow Scaling Factor (%)	Network Capacity Scaling Factor (%)	Reason For Scaling Factors
C-85	ARCADY		✓				100.000	100.000	

Demand Set Details

Name	Scenario Name	Time Period Name	Description	Traffic Profile Type	Model Start Time (HH:mm)	Model Finish Time (HH:mm)	Model Time Period Length (min)	Time Segment Length (min)	Results For Central Hour Only	Single Time Segment Only	Locked	Run Automatically	Use Relationship	Relationship
2024, PM	2024	PM		ONE HOUR	07:45	09:15	90	15	✓			✓		

Intersection Network

Intersections

Intersection	Name	Intersection Type	Leg Order	Grade Separated	Large Roundabout	Do Geometric Delay	Intersection Delay (s)	Intersection LOS
1	untitled	Roundabout	2,3,4,1				4.46	A

Intersection Network Options

Driving Side	Lighting	Network Residual Capacity (%)	First Leg Reaching Threshold
Right	Normal/unknown	196	WB Collector D

Legs

Legs

Name	Leg	Name	Description
WB Collector D	2	WB Collector D	
SB Collector E	3	SB Collector E	
EB Collector D	4	EB Collector D	
NB Collector E	1	NB Collector E	

Capacity Options

Name	Minimum Capacity (PCE/hr)	Maximum Capacity (PCE/hr)	Assume Flat Start Profile	Initial Queue (PCE)
WB Collector D	0.00	99999.00		0.00
SB Collector E	0.00	99999.00		0.00
EB Collector D	0.00	99999.00		0.00
NB Collector E	0.00	99999.00		0.00

Roundabout Geometry

Name	V - Approach road half-width (m)	E - Entry width (m)	l' - Effective flare length (m)	R - Entry radius (m)	D - Inscribed circle diameter (m)	PHI - Conflict (entry) angle (deg)	Exit Only
WB Collector D	4.25	4.25	0.00	20.00	40.00	20.00	
SB Collector E	4.25	4.25	0.00	20.00	40.00	20.00	
EB Collector D	4.25	4.25	0.00	20.00	40.00	20.00	
NB Collector E	4.25	4.25	0.00	20.00	40.00	20.00	

Slope / Intercept / Capacity

Leg Intercept Adjustments

Name	Type	Reason	Direct Intercept Adjustment (PCE/hr)	Percentage Intercept Adjustment (%)
WB Collector D	Percentage			85.00
SB Collector E	None			
EB Collector D	Percentage			85.00
NB Collector E	Percentage			85.00

Roundabout Slope and Intercept used in model

Name	Enter slope and intercept directly	Entered slope	Entered intercept (PCE/hr)	Final Slope	Final Intercept (PCE/hr)
WB Collector D		(calculated)	(calculated)	0.579	1132.570
SB Collector E		(calculated)	(calculated)	0.579	1332.435
EB Collector D		(calculated)	(calculated)	0.579	1132.570
NB Collector E		(calculated)	(calculated)	0.579	1132.570

The slope and intercept shown above include any corrections and adjustments.

Leg Capacity Adjustments

Name	Type	Reason	Direct Capacity Adjustment (PCE/hr)	Percentage Capacity Adjustment (%)
WB Collector D	Percentage			100.00
SB Collector E	None			
EB Collector D	Percentage			100.00
NB Collector E	Percentage			100.00

Traffic Flows

Demand Set Data Options

Default Vehicle Mix	Vehicle Mix Varies Over Time	Vehicle Mix Varies Over Turn	Vehicle Mix Varies Over Entry	Vehicle Mix Source	PCE Factor for a Truck (PCE)	Default Turning Proportions	Estimate from entry/exit counts	Turning Proportions Vary Over Time	Turning Proportions Vary Over Turn	Turning Proportions Vary Over Entry
		✓	✓	Truck Percentages	2.00				✓	✓

Entry Flows

General Flows Data

Name	Profile Type	Use Turning Counts	Average Demand Flow (Veh/hr)	Flow Scaling Factor (%)
WB Collector D	ONE HOUR	✓	267.00	89.000
SB Collector E	ONE HOUR	✓	84.00	100.000
EB Collector D	ONE HOUR	✓	269.00	89.000
NB Collector E	ONE HOUR	✓	174.00	89.000

Direct/Resultant Flows

Direct Flows Data

Time Segment	Name	Direct Demand Entry Flow (Veh/hr)	DirectDemandEntryFlowInPCE (PCE/hr)	Direct Demand Exit Flow (Veh/hr)	Direct Demand Pedestrian Flow (Ped/hr)
08:00-08:15	WB Collector D	240.03	244.83		
08:00-08:15	SB Collector E	75.51	75.51		
08:00-08:15	EB Collector D	241.83	246.66		
08:00-08:15	NB Collector E	156.42	156.89		
08:15-08:30	WB Collector D	293.97	299.85		
08:15-08:30	SB Collector E	92.49	92.49		
08:15-08:30	EB Collector D	296.17	302.10		
08:15-08:30	NB Collector E	191.58	192.15		
08:30-08:45	WB Collector D	293.97	299.85		
08:30-08:45	SB Collector E	92.49	92.49		
08:30-08:45	EB Collector D	296.17	302.10		
08:30-08:45	NB Collector E	191.58	192.15		
08:45-09:00	WB Collector D	240.03	244.83		
08:45-09:00	SB Collector E	75.51	75.51		
08:45-09:00	EB Collector D	241.83	246.66		
08:45-09:00	NB Collector E	156.42	156.89		

Turning Proportions

Turning Counts / Proportions (Veh/hr) - untitled (for whole period)

		To			
		WB Collector D	SB Collector E	EB Collector D	NB Collector E
	WB Collector D	0.000	0.000	235.000	32.000

From	SB Collector E	12.000	0.000	0.000	72.000
	EB Collector D	237.000	0.000	0.000	32.000
	NB Collector E	26.000	148.000	0.000	0.000

Turning Proportions (Veh) - untitled (for whole period)

		To			
From		WB Collector D	SB Collector E	EB Collector D	NB Collector E
	WB Collector D	0.00	0.00	0.88	0.12
	SB Collector E	0.14	0.00	0.00	0.86
	EB Collector D	0.88	0.00	0.00	0.12
	NB Collector E	0.15	0.85	0.00	0.00

Vehicle Mix

Average PCE Per Vehicle - untitled (for whole period)

		To			
From		WB Collector D	SB Collector E	EB Collector D	NB Collector E
	WB Collector D	1.020	1.000	1.020	1.020
	SB Collector E	1.000	1.000	1.000	1.000
	EB Collector D	1.020	1.000	1.020	1.020
	NB Collector E	1.020	1.000	1.020	1.020

Truck Percentages - untitled (for whole period)

		To			
From		WB Collector D	SB Collector E	EB Collector D	NB Collector E
	WB Collector D	2.0	0.0	2.0	2.0
	SB Collector E	0.0	0.0	0.0	0.0
	EB Collector D	2.0	0.0	2.0	2.0
	NB Collector E	2.0	0.0	2.0	2.0

Results

Results Summary for whole modelled period

Name	Max V/C Ratio	Max Delay (s)	Max Queue (Veh)	Max 95th percentile Queue (Veh)	Max LOS	Average Demand (Veh/hr)	Total Intersection Arrivals (Veh)	Total Queueing Delay (Veh-min)	Average Queueing Delay (s)	Rate Of Queueing Delay (Veh-min/min)	Inclusive Total Queueing Delay (Veh-min)	Inclusive Average Queueing Delay (s)
WB Collector D	0.25	4.70	0.34	~1	A	237.63	237.63	17.82	4.50	0.20	23.94	4.39
SB Collector E	0.08	3.32	0.09	~1	A	84.00	84.00	4.54	3.24	0.05	6.16	3.20
EB Collector D	0.25	4.64	0.34	~1	A	239.41	239.41	17.76	4.45	0.20	23.87	4.35
NB Collector E	0.17	4.42	0.21	~1	A	154.86	154.86	10.99	4.26	0.12	14.81	4.17

Main Results for each time segment

Main results: (08:00-08:15)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
WB Collector D	213.62	53.41	213.41	221.00	118.31	0.00	1043.21	738.71	0.205	0.20	0.26	4.337	A
SB Collector E	75.51	18.88	75.46	118.31	213.41	0.00	1206.40	896.16	0.063	0.05	0.07	3.182	A
EB Collector	215.22	53.81	215.02	187.84	101.04	0.00	1052.71	550.39	0.204	0.20	0.26	4.296	A

D														
NB Collector E	139.22	34.80	139.09	115.84	200.22	0.00	1011.42	769.76	0.138	0.13	0.16	4.127	A

Main results: (08:15-08:30)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
WB Collector D	261.64	65.41	261.30	270.60	144.86	0.00	1028.13	738.71	0.254	0.26	0.34	4.692	A
SB Collector E	92.49	23.12	92.41	144.86	261.30	0.00	1178.11	896.16	0.079	0.07	0.08	3.315	A
EB Collector D	263.60	65.90	263.27	229.99	123.73	0.00	1039.77	550.39	0.254	0.26	0.34	4.634	A
NB Collector E	170.50	42.63	170.31	141.85	245.15	0.00	984.99	769.76	0.173	0.16	0.21	4.417	A

Main results: (08:30-08:45)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
WB Collector D	261.64	65.41	261.63	270.92	145.02	0.00	1028.04	738.71	0.255	0.34	0.34	4.696	A
SB Collector E	92.49	23.12	92.49	145.02	261.63	0.00	1177.92	896.16	0.079	0.08	0.09	3.315	A
EB Collector D	263.60	65.90	263.59	230.27	123.84	0.00	1039.71	550.39	0.254	0.34	0.34	4.638	A
NB Collector E	170.50	42.63	170.50	141.99	245.45	0.00	984.82	769.76	0.173	0.21	0.21	4.420	A

Main results: (08:45-09:00)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
WB Collector D	213.62	53.41	213.95	221.53	118.58	0.00	1043.05	738.71	0.205	0.34	0.26	4.345	A
SB Collector E	75.51	18.88	75.59	118.58	213.95	0.00	1206.08	896.16	0.063	0.09	0.07	3.186	A
EB Collector D	215.22	53.81	215.54	188.31	101.23	0.00	1052.61	550.39	0.204	0.34	0.26	4.302	A
NB Collector E	139.22	34.80	139.41	116.07	200.70	0.00	1011.14	769.76	0.138	0.21	0.16	4.130	A

Queueing Delay Results for each time segment

Queueing Delay results: (08:00-08:15)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
WB Collector D	3.78	0.25	4.337	A	A
SB Collector E	0.99	0.07	3.182	A	A
EB Collector D	3.77	0.25	4.296	A	A
NB Collector E	2.35	0.16	4.127	A	A

Queueing Delay results: (08:15-08:30)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
WB Collector D	4.99	0.33	4.692	A	A
SB Collector E	1.26	0.08	3.315	A	A
EB Collector D	4.97	0.33	4.634	A	A
NB Collector E	3.07	0.20	4.417	A	A

Queueing Delay results: (08:30-08:45)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
WB Collector D	5.10	0.34	4.696	A	A
SB Collector E	1.27	0.08	3.315	A	A
EB Collector D	5.07	0.34	4.638	A	A
NB Collector E	3.13	0.21	4.420	A	A

Queueing Delay results: (08:45-09:00)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
WB Collector D	3.96	0.26	4.345	A	A
SB Collector E	1.02	0.07	3.186	A	A
EB Collector D	3.95	0.26	4.302	A	A
NB Collector E	2.45	0.16	4.130	A	A

Queue Variation Results for each time segment

Queue Variation results: (08:00-08:15)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
WB Collector D	0.26	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
SB Collector E	0.07	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
EB Collector D	0.26	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB Collector E	0.16	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

Queue Variation results: (08:15-08:30)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
WB Collector D	0.34	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
SB Collector E	0.08	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
EB Collector D	0.34	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB Collector E	0.21	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

Queue Variation results: (08:30-08:45)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
WB Collector D	0.34	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
SB Collector E	0.09	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
EB Collector D	0.34	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB Collector E	0.21	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

Queue Variation results: (08:45-09:00)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
WB Collector D	0.26	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
SB Collector E	0.07	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
EB Collector D	0.26	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB Collector E	0.16	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

Junctions 8

ARCADY 8 - Roundabout Module

Filename: CA01 - Coll D at Lewis.arc8
Path: G:\Legacy\SernasTransTech\Projects\2018\Fruitland TIS\Analysis\Arcady
Report generation date: 10/28/2018 10:43:41 PM

Summary of intersection performance

	AM							PM						
	95% Queue (Veh)	Delay (s)	V/C Ratio	LOS	Intersection Delay (s)	Intersection LOS	Network Residual Capacity	95% Queue (Veh)	Delay (s)	V/C Ratio	LOS	Intersection Delay (s)	Intersection LOS	Network Residual Capacity
	C-85 - 2024													
WB Collector D	~1	4.67	0.22	A	4.07	A	197 % [WB Collector D]	~1	4.11	0.16	A	4.18	A	191 % [SB Lewis]
SB Lewis	~1	3.39	0.13	A				~1	3.98	0.27	A			
EB Collector D	~1	3.85	0.11	A				~1	4.49	0.19	A			
NB Lewis	~1	4.07	0.17	A				~1	4.34	0.15	A			

Values shown are the maximum values over all time segments. Delay is the maximum value of average delay per arriving vehicle. Intersection LOS and Intersection Delay are demand-weighted averages. Network Residual Capacity indicates the amount by which network flow could be increased before a user-definable threshold (see Analysis Options) is met.

"D1 - 2024, AM " model duration: 7:45 AM - 9:15 AM
"D2 - 2024, PM" model duration: 7:45 AM - 9:15 AM

Run using Junctions 8.0.6.541 at 10/28/2018 10:43:18 PM

File summary

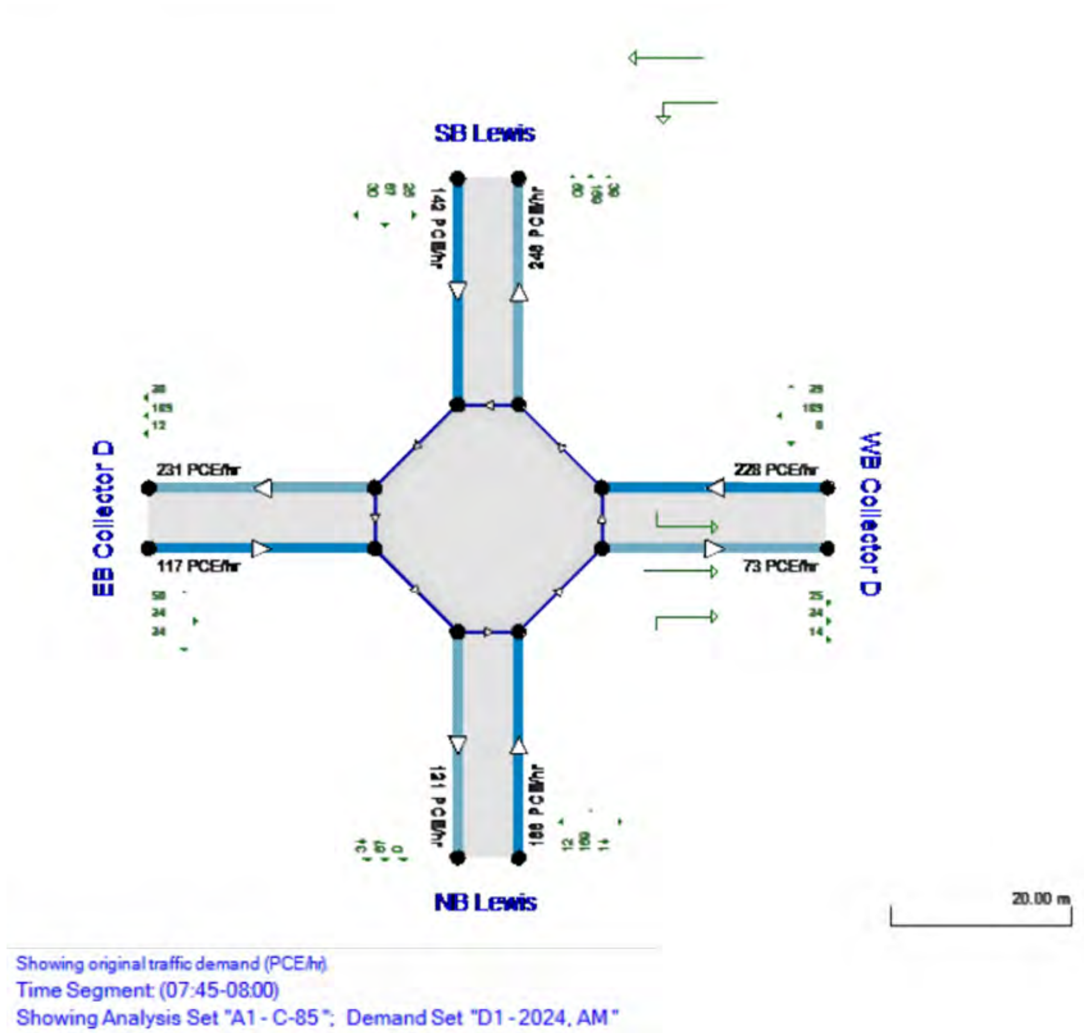
Title	(untitled)
Location	
Site Number	
Date	11/18/2014
Version	
Status	Conceptual
Identifier	
Client	
Jobnumber	
Analyst	
Description	

Analysis Options

Vehicle Length (m)	Do Queue Variations	Calculate Residual Capacity	Residual Capacity Criteria Type	V/C Ratio Threshold	Average Delay Threshold (s)	Queue Threshold (PCE)
7.00	✓	✓	Delay	0.85	36.00	20.00

Units

Distance Units	Speed Units	Traffic Units Input	Traffic Units Results	Flow Units	Average Delay Units	Total Delay Units	Rate Of Delay Units
m	kph	Veh	Veh	perHour	s	-Min	perMin



The intersection diagram reflects the last run of ARCADY.

C-85 - 2024, AM

Data Errors and Warnings

Severity	Area	Item	Description
Warning	DemandSets	D1 - 2024, AM	Time results are shown for central hour only. (Model is run for a 90 minute period.)

Analysis Set Details

Name	Roundabout Capacity Model	Description	Include In Report	Use Specific Demand Set(s)	Specific Demand Set(s)	Locked	Network Flow Scaling Factor (%)	Network Capacity Scaling Factor (%)	Reason For Scaling Factors
C-85	ARCADY		✓				100.000	100.000	

Demand Set Details

Name	Scenario Name	Time Period Name	Description	Traffic Profile Type	Model Start Time (HH:mm)	Model Finish Time (HH:mm)	Model Time Period Length (min)	Time Segment Length (min)	Results For Central Hour Only	Single Time Segment Only	Locked	Run Automatically	Use Relationship	Relationship
2024, AM	2024	AM		ONE HOUR	07:45	09:15	90	15	✓			✓		

Intersection Network

Intersections

Intersection	Name	Intersection Type	Leg Order	Grade Separated	Large Roundabout	Do Geometric Delay	Intersection Delay (s)	Intersection LOS
1	untitled	Roundabout	2,3,4,1				4.07	A

Intersection Network Options

Driving Side	Lighting	Network Residual Capacity (%)	First Leg Reaching Threshold
Right	Normal/unknown	197	WB Collector D

Legs

Legs

Name	Leg	Name	Description
WB Collector D	2	WB Collector D	
SB Lewis	3	SB Lewis	
EB Collector D	4	EB Collector D	
NB Lewis	1	NB Lewis	

Capacity Options

Name	Minimum Capacity (PCE/hr)	Maximum Capacity (PCE/hr)	Assume Flat Start Profile	Initial Queue (PCE)
WB Collector D	0.00	99999.00		0.00
SB Lewis	0.00	99999.00		0.00
EB Collector D	0.00	99999.00		0.00
NB Lewis	0.00	99999.00		0.00

Roundabout Geometry

Name	V - Approach road half-width (m)	E - Entry width (m)	l' - Effective flare length (m)	R - Entry radius (m)	D - Inscribed circle diameter (m)	PHI - Conflict (entry) angle (deg)	Exit Only
WB Collector D	4.25	4.25	0.00	20.00	40.00	20.00	
SB Lewis	4.25	4.25	0.00	20.00	40.00	20.00	
EB Collector D	4.25	4.25	0.00	20.00	40.00	20.00	
NB Lewis	4.25	4.25	0.00	20.00	40.00	20.00	

Slope / Intercept / Capacity

Leg Intercept Adjustments

Name	Type	Reason	Direct Intercept Adjustment (PCE/hr)	Percentage Intercept Adjustment (%)
WB Collector D	Percentage			85.00
SB Lewis	None			
EB Collector D	Percentage			85.00
NB Lewis	Percentage			85.00

Roundabout Slope and Intercept used in model

Name	Enter slope and intercept directly	Entered slope	Entered intercept (PCE/hr)	Final Slope	Final Intercept (PCE/hr)
WB Collector D		(calculated)	(calculated)	0.579	1132.570
SB Lewis		(calculated)	(calculated)	0.579	1332.435
EB Collector D		(calculated)	(calculated)	0.579	1132.570
NB Lewis		(calculated)	(calculated)	0.579	1132.570

The slope and intercept shown above include any corrections and adjustments.

Leg Capacity Adjustments

Name	Type	Reason	Direct Capacity Adjustment (PCE/hr)	Percentage Capacity Adjustment (%)
WB Collector D	Percentage			100.00
SB Lewis	None			
EB Collector D	Percentage			100.00
NB Lewis	Percentage			100.00

Traffic Flows

Demand Set Data Options

Default Vehicle Mix	Vehicle Mix Varies Over Time	Vehicle Mix Varies Over Turn	Vehicle Mix Varies Over Entry	Vehicle Mix Source	PCE Factor for a Truck (PCE)	Default Turning Proportions	Estimate from entry/exit counts	Turning Proportions Vary Over Time	Turning Proportions Vary Over Turn	Turning Proportions Vary Over Entry
		✓	✓	Truck Percentages	2.00				✓	✓

Entry Flows

General Flows Data

Name	Profile Type	Use Turning Counts	Average Demand Flow (Veh/hr)	Flow Scaling Factor (%)
WB Collector D	ONE HOUR	✓	224.00	89.000
SB Lewis	ONE HOUR	✓	142.00	100.000
EB Collector D	ONE HOUR	✓	116.00	89.000
NB Lewis	ONE HOUR	✓	185.00	89.000

Direct/Resultant Flows

Direct Flows Data

Time Segment	Name	Direct Demand Entry Flow (Veh/hr)	DirectDemandEntryFlowInPCE (PCE/hr)	Direct Demand Exit Flow (Veh/hr)	Direct Demand Pedestrian Flow (Ped/hr)
08:00-08:15	WB Collector D	201.37	204.70		
08:00-08:15	SB Lewis	127.66	127.66		
08:00-08:15	EB Collector D	104.28	105.47		
08:00-08:15	NB Lewis	166.31	166.78		
08:15-08:30	WB Collector D	246.63	250.70		
08:15-08:30	SB Lewis	156.34	156.34		
08:15-08:30	EB Collector D	127.72	129.17		
08:15-08:30	NB Lewis	203.69	204.26		
08:30-08:45	WB Collector D	246.63	250.70		
08:30-08:45	SB Lewis	156.34	156.34		
08:30-08:45	EB Collector D	127.72	129.17		
08:30-08:45	NB Lewis	203.69	204.26		
08:45-09:00	WB Collector D	201.37	204.70		
08:45-09:00	SB Lewis	127.66	127.66		
08:45-09:00	EB Collector D	104.28	105.47		
08:45-09:00	NB Lewis	166.31	166.78		

Turning Proportions

Turning Counts / Proportions (Veh/hr) - untitled (for whole period)

		To			
		WB Collector D	SB Lewis	EB Collector D	NB Lewis
From	WB Collector D	0.000	39.000	185.000	0.000
	SB Lewis	25.000	0.000	30.000	87.000
	EB Collector D	33.000	50.000	0.000	33.000
	NB Lewis	14.000	159.000	12.000	0.000

Turning Proportions (Veh) - untitled (for whole period)

		To			
		WB Collector D	SB Lewis	EB Collector D	NB Lewis
From	WB Collector D	0.00	0.17	0.83	0.00
	SB Lewis	0.18	0.00	0.21	0.61
	EB Collector D	0.28	0.43	0.00	0.28
	NB Lewis	0.08	0.86	0.06	0.00

Vehicle Mix

Average PCE Per Vehicle - untitled (for whole period)

		To			
		WB Collector D	SB Lewis	EB Collector D	NB Lewis
From	WB Collector D	1.020	1.000	1.020	1.020
	SB Lewis	1.000	1.000	1.000	1.000
	EB Collector D	1.020	1.000	1.020	1.020
	NB Lewis	1.020	1.000	1.020	1.020

Truck Percentages - untitled (for whole period)

		To			
		WB Collector D	SB Lewis	EB Collector D	NB Lewis
From	WB Collector D	2.0	0.0	2.0	2.0
	SB Lewis	0.0	0.0	0.0	0.0
	EB Collector D	2.0	0.0	2.0	2.0
	NB Lewis	2.0	0.0	2.0	2.0

Results

Results Summary for whole modelled period

Name	Max V/C Ratio	Max Delay (s)	Max Queue (Veh)	Max 95th percentile Queue (Veh)	Max LOS	Average Demand (Veh/hr)	Total Intersection Arrivals (Veh)	Total Queueing Delay (Veh-min)	Average Queueing Delay (s)	Rate Of Queueing Delay (Veh-min/min)	Inclusive Total Queueing Delay (Veh-min)	Inclusive Average Queueing Delay (s)
WB Collector D	0.22	4.67	0.28	~1	A	199.36	199.36	14.87	4.47	0.17	19.97	4.37
SB Lewis	0.13	3.39	0.15	~1	A	142.00	142.00	7.82	3.30	0.09	10.61	3.26
EB Collector D	0.11	3.85	0.12	~1	A	103.24	103.24	6.48	3.77	0.07	8.82	3.72
NB Lewis	0.17	4.07	0.20	~1	A	164.65	164.65	10.85	3.95	0.12	14.70	3.89

Main Results for each time segment

Main results: (08:00-08:15)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
WB Collector D	179.22	44.81	179.04	60.03	176.68	0.00	1013.42	557.03	0.177	0.17	0.21	4.313	A
SB Lewis	127.66	31.91	127.57	198.26	157.46	0.00	1239.44	1031.92	0.103	0.09	0.11	3.237	A
EB Collector D	92.81	23.20	92.74	184.42	100.62	0.00	1062.22	653.87	0.087	0.08	0.10	3.712	A
NB Lewis	148.02	37.00	147.90	104.54	88.82	0.00	1077.81	752.22	0.137	0.13	0.16	3.871	A

Main results: (08:15-08:30)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
WB Collector D	219.50	54.87	219.22	73.52	216.35	0.00	990.80	557.03	0.222	0.21	0.28	4.665	A
SB Lewis	156.34	39.09	156.22	242.77	192.80	0.00	1218.57	1031.92	0.128	0.11	0.15	3.388	A
EB Collector D	113.67	28.42	113.57	225.80	123.21	0.00	1049.29	653.87	0.108	0.10	0.12	3.847	A
NB Lewis	181.28	45.32	181.10	128.02	108.76	0.00	1066.23	752.22	0.170	0.16	0.20	4.066	A

Main results: (08:30-08:45)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
WB Collector D	219.50	54.87	219.50	73.58	216.56	0.00	990.68	557.03	0.222	0.28	0.28	4.667	A
SB Lewis	156.34	39.09	156.34	243.01	193.04	0.00	1218.43	1031.92	0.128	0.15	0.15	3.388	A
EB Collector D	113.67	28.42	113.67	226.07	123.31	0.00	1049.23	653.87	0.108	0.12	0.12	3.847	A
NB Lewis	181.28	45.32	181.28	128.12	108.86	0.00	1066.17	752.22	0.170	0.20	0.20	4.068	A

Main results: (08:45-09:00)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
WB Collector D	179.22	44.81	179.49	60.14	177.03	0.00	1013.22	557.03	0.177	0.28	0.22	4.319	A
SB Lewis	127.66	31.91	127.78	198.67	157.85	0.00	1239.21	1031.92	0.103	0.15	0.12	3.241	A
EB Collector D	92.81	23.20	92.91	184.85	100.79	0.00	1062.13	653.87	0.087	0.12	0.10	3.713	A
NB Lewis	148.02	37.00	148.19	104.72	88.98	0.00	1077.72	752.22	0.137	0.20	0.16	3.874	A

Queueing Delay Results for each time segment

Queueing Delay results: (08:00-08:15)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
WB Collector D	3.15	0.21	4.313	A	A
SB Lewis	1.70	0.11	3.237	A	A
EB Collector D	1.41	0.09	3.712	A	A
NB Lewis	2.34	0.16	3.871	A	A

Queueing Delay results: (08:15-08:30)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
WB Collector D	4.17	0.28	4.665	A	A
SB Lewis	2.17	0.14	3.388	A	A
EB Collector D	1.79	0.12	3.847	A	A
NB Lewis	3.01	0.20	4.066	A	A

Queueing Delay results: (08:30-08:45)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
WB Collector D	4.25	0.28	4.667	A	A
SB Lewis	2.20	0.15	3.388	A	A
EB Collector D	1.82	0.12	3.847	A	A
NB Lewis	3.06	0.20	4.068	A	A

Queueing Delay results: (08:45-09:00)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
WB Collector D	3.30	0.22	4.319	A	A
SB Lewis	1.75	0.12	3.241	A	A
EB Collector D	1.46	0.10	3.713	A	A
NB Lewis	2.44	0.16	3.874	A	A

Queue Variation Results for each time segment

Queue Variation results: (08:00-08:15)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
WB Collector D	0.21	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

SB Lewis	0.11	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
EB Collector D	0.10	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB Lewis	0.16	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

Queue Variation results: (08:15-08:30)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
WB Collector D	0.28	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
SB Lewis	0.15	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
EB Collector D	0.12	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB Lewis	0.20	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

Queue Variation results: (08:30-08:45)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
WB Collector D	0.28	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
SB Lewis	0.15	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
EB Collector D	0.12	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB Lewis	0.20	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

Queue Variation results: (08:45-09:00)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
WB Collector D	0.22	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
SB Lewis	0.12	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
EB Collector D	0.10	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB Lewis	0.16	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

C-85 - 2024, PM

Data Errors and Warnings

Severity	Area	Item	Description
Warning	DemandSets	D2 - 2024, PM	Time results are shown for central hour only. (Model is run for a 90 minute period.)

Analysis Set Details

Name	Roundabout Capacity Model	Description	Include In Report	Use Specific Demand Set(s)	Specific Demand Set(s)	Locked	Network Flow Scaling Factor (%)	Network Capacity Scaling Factor (%)	Reason For Scaling Factors
C-85	ARCADY		✓				100.000	100.000	

Demand Set Details

Name	Scenario Name	Time Period Name	Description	Traffic Profile Type	Model Start Time (HH:mm)	Model Finish Time (HH:mm)	Model Time Period Length (min)	Time Segment Length (min)	Results For Central Hour Only	Single Time Segment Only	Locked	Run Automatically	Use Relationship	Relationship
2024, PM	2024	PM		ONE HOUR	07:45	09:15	90	15	✓			✓		

Intersection Network

Intersections

Intersection	Name	Intersection Type	Leg Order	Grade Separated	Large Roundabout	Do Geometric Delay	Intersection Delay (s)	Intersection LOS
1	untitled	Roundabout	2,3,4,1				4.18	A

Intersection Network Options

Driving Side	Lighting	Network Residual Capacity (%)	First Leg Reaching Threshold
Right	Normal/unknown	191	SB Lewis

Legs

Legs

Name	Leg	Name	Description
WB Collector D	2	WB Collector D	
SB Lewis	3	SB Lewis	
EB Collector D	4	EB Collector D	
NB Lewis	1	NB Lewis	

Capacity Options

Name	Minimum Capacity (PCE/hr)	Maximum Capacity (PCE/hr)	Assume Flat Start Profile	Initial Queue (PCE)
WB Collector D	0.00	99999.00		0.00
SB Lewis	0.00	99999.00		0.00
EB Collector D	0.00	99999.00		0.00
NB Lewis	0.00	99999.00		0.00

Roundabout Geometry

Name	V - Approach road half-width (m)	E - Entry width (m)	l' - Effective flare length (m)	R - Entry radius (m)	D - Inscribed circle diameter (m)	PHI - Conflict (entry) angle (deg)	Exit Only
WB Collector D	4.25	4.25	0.00	20.00	40.00	20.00	
SB Lewis	4.25	4.25	0.00	20.00	40.00	20.00	
EB Collector D	4.25	4.25	0.00	20.00	40.00	20.00	
NB Lewis	4.25	4.25	0.00	20.00	40.00	20.00	

Slope / Intercept / Capacity

Leg Intercept Adjustments

Name	Type	Reason	Direct Intercept Adjustment (PCE/hr)	Percentage Intercept Adjustment (%)
WB Collector D	Percentage			85.00
SB Lewis	None			
EB Collector D	Percentage			85.00
NB Lewis	Percentage			85.00

Roundabout Slope and Intercept used in model

Name	Enter slope and intercept directly	Entered slope	Entered intercept (PCE/hr)	Final Slope	Final Intercept (PCE/hr)
WB Collector D		(calculated)	(calculated)	0.579	1132.570
SB Lewis		(calculated)	(calculated)	0.579	1332.435
EB Collector D		(calculated)	(calculated)	0.579	1132.570
NB Lewis		(calculated)	(calculated)	0.579	1132.570

The slope and intercept shown above include any corrections and adjustments.

Leg Capacity Adjustments

Name	Type	Reason	Direct Capacity Adjustment (PCE/hr)	Percentage Capacity Adjustment (%)
WB Collector D	Percentage			100.00
SB Lewis	None			
EB Collector D	Percentage			100.00
NB Lewis	Percentage			100.00

Traffic Flows

Demand Set Data Options

Default Vehicle Mix	Vehicle Mix Varies Over Time	Vehicle Mix Varies Over Turn	Vehicle Mix Varies Over Entry	Vehicle Mix Source	PCE Factor for a Truck (PCE)	Default Turning Proportions	Estimate from entry/exit counts	Turning Proportions Vary Over Time	Turning Proportions Vary Over Turn	Turning Proportions Vary Over Entry
		✓	✓	Truck	2.00				✓	✓

				Percentages						

Entry Flows

General Flows Data

Name	Profile Type	Use Turning Counts	Average Demand Flow (Veh/hr)	Flow Scaling Factor (%)
WB Collector D	ONE HOUR	✓	172.00	89.000
SB Lewis	ONE HOUR	✓	299.00	100.000
EB Collector D	ONE HOUR	✓	188.00	89.000
NB Lewis	ONE HOUR	✓	144.00	89.000

Direct/Resultant Flows

Direct Flows Data

Time Segment	Name	Direct Demand Entry Flow (Veh/hr)	DirectDemandEntryFlowInPCE (PCE/hr)	Direct Demand Exit Flow (Veh/hr)	Direct Demand Pedestrian Flow (Ped/hr)
08:00-08:15	WB Collector D	154.62	157.21		
08:00-08:15	SB Lewis	268.79	268.79		
08:00-08:15	EB Collector D	169.01	171.81		
08:00-08:15	NB Lewis	129.45	130.82		
08:15-08:30	WB Collector D	189.38	192.55		
08:15-08:30	SB Lewis	329.21	329.21		
08:15-08:30	EB Collector D	206.99	210.43		
08:15-08:30	NB Lewis	158.55	160.22		
08:30-08:45	WB Collector D	189.38	192.55		
08:30-08:45	SB Lewis	329.21	329.21		
08:30-08:45	EB Collector D	206.99	210.43		
08:30-08:45	NB Lewis	158.55	160.22		
08:45-09:00	WB Collector D	154.62	157.21		
08:45-09:00	SB Lewis	268.79	268.79		
08:45-09:00	EB Collector D	169.01	171.81		
08:45-09:00	NB Lewis	129.45	130.82		

Turning Proportions

Turning Counts / Proportions (Veh/hr) - untitled (for whole period)

		To			
		WB Collector D	SB Lewis	EB Collector D	NB Lewis
From	WB Collector D	0.000	28.000	144.000	0.000
	SB Lewis	82.000	0.000	95.000	122.000
	EB Collector D	141.000	32.000	0.000	15.000
	NB Lewis	51.000	68.000	25.000	0.000

Turning Proportions (Veh) - untitled (for whole period)

		To			
		WB Collector D	SB Lewis	EB Collector D	NB Lewis
From	WB Collector D	0.00	0.16	0.84	0.00
	SB Lewis	0.27	0.00	0.32	0.41
	EB Collector D	0.75	0.17	0.00	0.08
	NB Lewis	0.35	0.47	0.17	0.00

Vehicle Mix

Average PCE Per Vehicle - untitled (for whole period)

		To			
		WB Collector D	SB Lewis	EB Collector D	NB Lewis
From	WB Collector D	1.020	1.000	1.020	1.020
	SB Lewis	1.000	1.000	1.000	1.000
	EB Collector D	1.020	1.000	1.020	1.020
	NB Lewis	1.020	1.000	1.020	1.020

Truck Percentages - untitled (for whole period)

		To			
		WB Collector D	SB Lewis	EB Collector D	NB Lewis
From	WB Collector D	2.0	0.0	2.0	2.0
	SB Lewis	0.0	0.0	0.0	0.0
	EB Collector D	2.0	0.0	2.0	2.0
	NB Lewis	2.0	0.0	2.0	2.0

Results

Results Summary for whole modelled period

Name	Max V/C Ratio	Max Delay (s)	Max Queue (Veh)	Max 95th percentile Queue (Veh)	Max LOS	Average Demand (Veh/hr)	Total Intersection Arrivals (Veh)	Total Queueing Delay (Veh-min)	Average Queueing Delay (s)	Rate Of Queueing Delay (Veh-min/min)	Inclusive Total Queueing Delay (Veh-min)	Inclusive Average Queueing Delay (s)
WB Collector D	0.16	4.11	0.19	~1	A	153.08	153.08	10.20	4.00	0.11	13.83	3.94
SB Lewis	0.27	3.98	0.36	~1	A	299.00	299.00	18.97	3.81	0.21	25.44	3.71
EB Collector D	0.19	4.49	0.23	~1	A	167.32	167.32	12.06	4.32	0.13	16.24	4.23
NB Lewis	0.15	4.34	0.17	~1	A	128.16	128.16	8.96	4.19	0.10	12.09	4.11

Main Results for each time segment

Main results: (08:00-08:15)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
WB Collector D	137.62	34.40	137.50	227.13	99.92	0.00	1056.79	828.49	0.130	0.12	0.15	3.916	A
SB Lewis	268.79	67.20	268.57	102.32	135.10	0.00	1252.64	864.56	0.215	0.22	0.27	3.658	A
EB Collector D	150.42	37.60	150.28	220.43	183.24	0.00	1009.71	778.12	0.149	0.14	0.17	4.189	A
NB Lewis	115.21	28.80	115.11	121.57	211.94	0.00	998.01	567.94	0.115	0.10	0.13	4.077	A

Main results: (08:15-08:30)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
WB Collector D	168.54	42.14	168.37	278.11	122.35	0.00	1043.97	828.49	0.161	0.15	0.19	4.110	A
SB Lewis	329.21	82.30	328.85	125.29	165.43	0.00	1234.73	864.56	0.267	0.27	0.36	3.972	A
EB Collector D	184.22	46.06	184.01	269.92	224.36	0.00	986.29	778.12	0.187	0.17	0.23	4.486	A
NB Lewis	141.11	35.28	140.95	148.86	259.51	0.00	970.46	567.94	0.145	0.13	0.17	4.340	A

Main results: (08:30-08:45)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
WB Collector D	168.54	42.14	168.54	278.42	122.49	0.00	1043.89	828.49	0.161	0.19	0.19	4.112	A
SB Lewis	329.21	82.30	329.20	125.43	165.60	0.00	1234.63	864.56	0.267	0.36	0.36	3.975	A
EB													

Collector D	184.22	46.06	184.22	270.20	224.61	0.00	986.15	778.12	0.187	0.23	0.23	4.488	A
NB Lewis	141.11	35.28	141.10	149.02	259.80	0.00	970.29	567.94	0.145	0.17	0.17	4.341	A

Main results: (08:45-09:00)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
WB Collector D	137.62	34.40	137.78	227.64	100.15	0.00	1056.66	828.49	0.130	0.19	0.15	3.918	A
SB Lewis	268.79	67.20	269.15	102.55	135.38	0.00	1252.48	864.56	0.215	0.36	0.27	3.664	A
EB Collector D	150.42	37.60	150.63	220.90	183.63	0.00	1009.49	778.12	0.149	0.23	0.18	4.192	A
NB Lewis	115.21	28.80	115.37	121.84	212.42	0.00	997.73	567.94	0.115	0.17	0.13	4.081	A

Queueing Delay Results for each time segment

Queueing Delay results: (08:00-08:15)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
WB Collector D	2.20	0.15	3.916	A	A
SB Lewis	4.02	0.27	3.658	A	A
EB Collector D	2.57	0.17	4.189	A	A
NB Lewis	1.92	0.13	4.077	A	A

Queueing Delay results: (08:15-08:30)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
WB Collector D	2.83	0.19	4.110	A	A
SB Lewis	5.33	0.36	3.972	A	A
EB Collector D	3.37	0.22	4.486	A	A
NB Lewis	2.50	0.17	4.340	A	A

Queueing Delay results: (08:30-08:45)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
WB Collector D	2.88	0.19	4.112	A	A
SB Lewis	5.43	0.36	3.975	A	A
EB Collector D	3.43	0.23	4.488	A	A
NB Lewis	2.54	0.17	4.341	A	A

Queueing Delay results: (08:45-09:00)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
WB Collector D	2.29	0.15	3.918	A	A
SB Lewis	4.19	0.28	3.664	A	A
EB Collector D	2.68	0.18	4.192	A	A
NB Lewis	2.00	0.13	4.081	A	A

Queue Variation Results for each time segment

Queue Variation results: (08:00-08:15)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
WB Collector D	0.15	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
SB Lewis	0.27	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
EB Collector D	0.17	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB Lewis	0.13	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

Queue Variation results: (08:15-08:30)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
WB Collector D	0.19	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
SB Lewis	0.36	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
EB Collector D	0.23	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB Lewis	0.17	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

Queue Variation results: (08:30-08:45)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
WB Collector D	0.19	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
SB Lewis	0.36	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
EB Collector D	0.23	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB Lewis	0.17	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

Queue Variation results: (08:45-09:00)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
WB Collector D	0.15	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
SB Lewis	0.27	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
EB Collector D	0.18	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB Lewis	0.13	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

Junctions 8

ARCADY 8 - Roundabout Module

Filename: CA01 - Coll D at McNeilly.arc8
Path: G:\Legacy\SernasTransTech\Projects\2018\Fruitland TIS\Analysis\Arcady
Report generation date: 10/28/2018 10:20:49 PM

Summary of intersection performance

	AM							PM						
	95% Queue (Veh)	Delay (s)	V/C Ratio	LOS	Intersection Delay (s)	Intersection LOS	Network Residual Capacity	95% Queue (Veh)	Delay (s)	V/C Ratio	LOS	Intersection Delay (s)	Intersection LOS	Network Residual Capacity
	C-85 - 2024													
SB McNeilly	~1	4.10	0.12	A	4.82	A	123 % [WB Collector D]	1.00	5.46	0.36	A	5.02	A	126 % [SB McNeilly]
NB McNeilly	~1	4.38	0.25	A				~1	4.84	0.29	A			
WB Collector D	1.00	5.50	0.32	A				~1	4.56	0.23	A			

Values shown are the maximum values over all time segments. Delay is the maximum value of average delay per arriving vehicle. Intersection LOS and Intersection Delay are demand-weighted averages. Network Residual Capacity indicates the amount by which network flow could be increased before a user-definable threshold (see Analysis Options) is met.

"D1 - 2024, AM " model duration: 7:45 AM - 9:15 AM
"D2 - 2024, PM" model duration: 7:45 AM - 9:15 AM

Run using Junctions 8.0.6.541 at 10/28/2018 10:20:38 PM

File summary

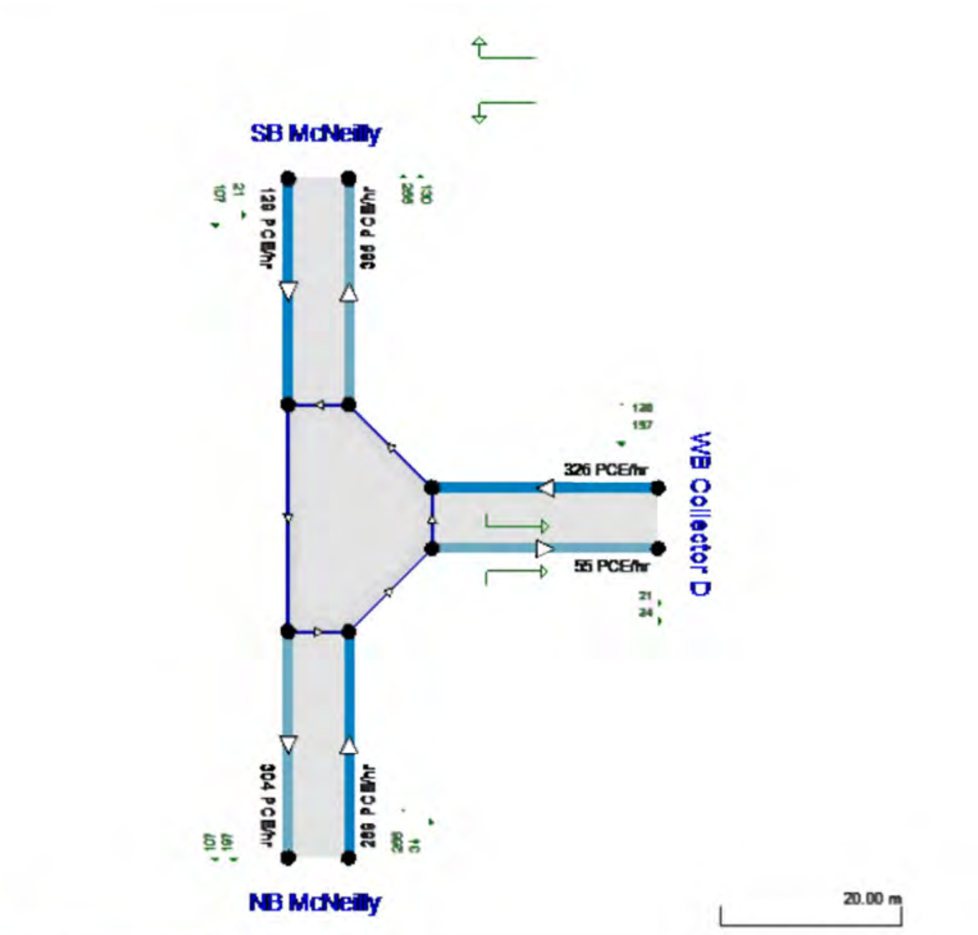
Title	(untitled)
Location	
Site Number	
Date	11/18/2014
Version	
Status	Conceptual
Identifier	
Client	
Jobnumber	
Analyst	
Description	

Analysis Options

Vehicle Length (m)	Do Queue Variations	Calculate Residual Capacity	Residual Capacity Criteria Type	V/C Ratio Threshold	Average Delay Threshold (s)	Queue Threshold (PCE)
7.00	✓	✓	Delay	0.85	36.00	20.00

Units

Distance Units	Speed Units	Traffic Units Input	Traffic Units Results	Flow Units	Average Delay Units	Total Delay Units	Rate Of Delay Units
m	kph	Veh	Veh	perHour	s	-Min	perMin



Showing original traffic demand (PCE/hr)
Time Segment: (07:45-08:00)
Showing Analysis Set "A1 - C-85"; Demand Set "D1 - 2024, AM"

The intersection diagram reflects the last run of ARCADY.

C-85 - 2024, AM

Data Errors and Warnings

Severity	Area	Item	Description
Warning	DemandSets	D1 - 2024, AM	Time results are shown for central hour only. (Model is run for a 90 minute period.)

Analysis Set Details

Name	Roundabout Capacity Model	Description	Include In Report	Use Specific Demand Set(s)	Specific Demand Set(s)	Locked	Network Flow Scaling Factor (%)	Network Capacity Scaling Factor (%)	Reason For Scaling Factors
C-85	ARCADY		✓				100.000	100.000	

Demand Set Details

Name	Scenario Name	Time Period Name	Description	Traffic Profile Type	Model Start Time (HH:mm)	Model Finish Time (HH:mm)	Model Time Period Length (min)	Time Segment Length (min)	Results For Central Hour Only	Single Time Segment Only	Locked	Run Automatically	Use Relationship	Relationship
2024, AM	2024	AM		ONE HOUR	07:45	09:15	90	15	✓			✓		

Intersection Network

Intersections

Intersection	Name	Intersection Type	Leg Order	Grade Separated	Large Roundabout	Do Geometric Delay	Intersection Delay (s)	Intersection LOS
1	untitled	Roundabout	1,3,4				4.82	A

Intersection Network Options

Driving Side	Lighting	Network Residual Capacity (%)	First Leg Reaching Threshold
Right	Normal/unknown	123	WB Collector D

Legs

Legs

Name	Leg	Name	Description
SB McNeilly	1	SB McNeilly	
NB McNeilly	3	NB McNeilly	
WB Collector D	4	WB Collector D	

Capacity Options

Name	Minimum Capacity (PCE/hr)	Maximum Capacity (PCE/hr)	Assume Flat Start Profile	Initial Queue (PCE)
SB McNeilly	0.00	99999.00		0.00
NB McNeilly	0.00	99999.00		0.00
WB Collector D	0.00	99999.00		0.00

Roundabout Geometry

Name	V - Approach road half-width (m)	E - Entry width (m)	l' - Effective flare length (m)	R - Entry radius (m)	D - Inscribed circle diameter (m)	PHI - Conflict (entry) angle (deg)	Exit Only
SB McNeilly	4.25	4.25	0.00	20.00	40.00	20.00	
NB McNeilly	4.25	4.25	0.00	20.00	40.00	20.00	
WB Collector D	4.25	4.25	0.00	20.00	40.00	20.00	

Slope / Intercept / Capacity

Leg Intercept Adjustments

Name	Type	Reason	Direct Intercept Adjustment (PCE/hr)	Percentage Intercept Adjustment (%)
SB McNeilly	Percentage			85.00
NB McNeilly	Percentage			85.00
WB Collector D	Percentage			85.00

Roundabout Slope and Intercept used in model

Name	Enter slope and intercept directly	Entered slope	Entered intercept (PCE/hr)	Final Slope	Final Intercept (PCE/hr)
SB McNeilly		(calculated)	(calculated)	0.579	1132.570
NB McNeilly		(calculated)	(calculated)	0.579	1132.570
WB Collector D		(calculated)	(calculated)	0.579	1132.570

The slope and intercept shown above include any corrections and adjustments.

Leg Capacity Adjustments

Name	Type	Reason	Direct Capacity Adjustment (PCE/hr)	Percentage Capacity Adjustment (%)
SB McNeilly	Percentage			100.00
NB McNeilly	Percentage			100.00
WB Collector D	Percentage			100.00

Traffic Flows

Demand Set Data Options

Default Vehicle Mix	Vehicle Mix Varies Over Time	Vehicle Mix Varies Over Turn	Vehicle Mix Varies Over Entry	Vehicle Mix Source	PCE Factor for a Truck (PCE)	Default Turning Proportions	Estimate from entry/exit counts	Turning Proportions Vary Over Time	Turning Proportions Vary Over Turn	Turning Proportions Vary Over Entry
		✓	✓	Truck Percentages	2.00				✓	✓

Entry Flows

General Flows Data

Name	Profile Type	Use Turning Counts	Average Demand Flow (Veh/hr)	Flow Scaling Factor (%)
SB McNeilly	ONE HOUR	✓	126.00	89.000
NB McNeilly	ONE HOUR	✓	283.00	89.000
WB Collector D	ONE HOUR	✓	320.00	89.000

Direct/Resultant Flows

Direct Flows Data

Time Segment	Name	Direct Demand Entry Flow (Veh/hr)	DirectDemandEntryFlowInPCE (PCE/hr)	Direct Demand Exit Flow (Veh/hr)	Direct Demand Pedestrian Flow (Ped/hr)
08:00-08:15	**SB McNeilly**	113.27	115.54		
08:00-08:15	**NB McNeilly**	254.41	259.50		
08:00-08:15	**WB Collector D**	287.67	293.43		
08:15-08:30	**SB McNeilly**	138.73	141.50		
08:15-08:30	**NB McNeilly**	311.59	317.82		
08:15-08:30	**WB Collector D**	352.33	359.37		
08:30-08:45	**SB McNeilly**	138.73	141.50		
08:30-08:45	**NB McNeilly**	311.59	317.82		
08:30-08:45	**WB Collector D**	352.33	359.37		
08:45-09:00	**SB McNeilly**	113.27	115.54		
08:45-09:00	**NB McNeilly**	254.41	259.50		
08:45-09:00	**WB Collector D**	287.67	293.43		

Turning Proportions

Turning Counts / Proportions (Veh/hr) - untitled (for whole period)

		To		
		SB McNeilly	**NB McNeilly**	**WB Collector D**
From	**SB McNeilly**	0.000	105.000	21.000
	NB McNeilly	250.000	0.000	33.000
	WB Collector D	127.000	193.000	0.000

Turning Proportions (Veh) - untitled (for whole period)

		To		
		SB McNeilly	**NB McNeilly**	**WB Collector D**
From	**SB McNeilly**	0.00	0.83	0.17
	NB McNeilly	0.88	0.00	0.12
	WB Collector D	0.40	0.60	0.00

Vehicle Mix

Average PCE Per Vehicle - untitled (for whole period)

		To		
		SB McNeilly	**NB McNeilly**	**WB Collector D**
From	**SB McNeilly**	1.020	1.020	1.020
	NB McNeilly	1.020	1.020	1.020
	WB Collector D	1.020	1.020	1.020

Truck Percentages - untitled (for whole period)

		To		

		SB McNeilly	NB McNeilly	WB Collector D
From	SB McNeilly	2.0	2.0	2.0
	NB McNeilly	2.0	2.0	2.0
	WB Collector D	2.0	2.0	2.0

Results

Results Summary for whole modelled period

Name	Max V/C Ratio	Max Delay (s)	Max Queue (Veh)	Max 95th percentile Queue (Veh)	Max LOS	Average Demand (Veh/hr)	Total Intersection Arrivals (Veh)	Total Queueing Delay (Veh-min)	Average Queueing Delay (s)	Rate Of Queueing Delay (Veh-min/min)	Inclusive Total Queueing Delay (Veh-min)	Inclusive Average Queueing Delay (s)
SB McNeilly	0.12	4.10	0.14	~1	A	112.14	112.14	7.46	3.99	0.08	10.12	3.93
NB McNeilly	0.25	4.38	0.34	~1	A	251.87	251.87	17.77	4.23	0.20	23.98	4.15
WB Collector D	0.32	5.50	0.48	1.00	A	284.80	284.80	24.51	5.16	0.27	32.53	4.98

Main Results for each time segment

Main results: (08:00-08:15)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
SB McNeilly	100.81	25.20	100.73	301.33	154.23	0.00	1021.06	905.34	0.099	0.09	0.11	3.911	A
NB McNeilly	226.43	56.61	226.22	238.17	16.79	0.00	1100.64	1023.00	0.206	0.21	0.26	4.116	A
WB Collector D	256.03	64.01	255.72	43.17	199.84	0.00	994.65	587.11	0.257	0.27	0.34	4.869	A

Main results: (08:15-08:30)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
SB McNeilly	123.47	30.87	123.34	368.94	188.81	0.00	1001.04	905.34	0.123	0.11	0.14	4.101	A
NB McNeilly	277.31	69.33	277.00	291.60	20.56	0.00	1098.46	1023.00	0.252	0.26	0.34	4.382	A
WB Collector D	313.57	78.39	313.05	52.86	244.70	0.00	968.68	587.11	0.324	0.34	0.47	5.486	A

Main results: (08:30-08:45)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
SB McNeilly	123.47	30.87	123.47	369.42	189.12	0.00	1000.86	905.34	0.123	0.14	0.14	4.102	A
NB McNeilly	277.31	69.33	277.31	292.01	20.58	0.00	1098.45	1023.00	0.252	0.34	0.34	4.383	A
WB Collector D	313.57	78.39	313.56	52.91	244.97	0.00	968.52	587.11	0.324	0.47	0.48	5.496	A

Main results: (08:45-09:00)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
SB McNeilly	100.81	25.20	100.93	302.11	154.73	0.00	1020.78	905.34	0.099	0.14	0.11	3.915	A
NB McNeilly	226.43	56.61	226.73	238.84	16.82	0.00	1100.62	1023.00	0.206	0.34	0.26	4.122	A
WB Collector D	256.03	64.01	256.54	43.26	200.29	0.00	994.39	587.11	0.257	0.48	0.35	4.881	A

Queueing Delay Results for each time segment

Queueing Delay results: (08:00-08:15)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
SB McNeilly	1.61	0.11	3.911	A	A
NB McNeilly	3.80	0.25	4.116	A	A
WB Collector D	5.07	0.34	4.869	A	A

Queueing Delay results: (08:15-08:30)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
SB McNeilly	2.07	0.14	4.101	A	A
NB McNeilly	4.95	0.33	4.382	A	A
WB Collector D	6.96	0.46	5.486	A	A

Queueing Delay results: (08:30-08:45)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
SB McNeilly	2.10	0.14	4.102	A	A
NB McNeilly	5.04	0.34	4.383	A	A
WB Collector D	7.14	0.48	5.496	A	A

Queueing Delay results: (08:45-09:00)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
SB McNeilly	1.68	0.11	3.915	A	A
NB McNeilly	3.97	0.26	4.122	A	A
WB Collector D	5.35	0.36	4.881	A	A

Queue Variation Results for each time segment

Queue Variation results: (08:00-08:15)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
SB McNeilly	0.11	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB McNeilly	0.26	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
WB Collector D	0.34	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

Queue Variation results: (08:15-08:30)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
SB McNeilly	0.14	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB McNeilly	0.34	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
WB Collector D	0.47	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

Queue Variation results: (08:30-08:45)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
SB McNeilly	0.14	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB McNeilly	0.34	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
WB Collector D	0.48	0.00	0.00	0.00	1.00			N/A	N/A

Queue Variation results: (08:45-09:00)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
SB McNeilly	0.11	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB						Percentiles could not be calculated. This may be			

McNeilly	0.26	~1	~1	~1	~1	because the mean queue is very small or very big.		N/A	N/A
WB Collector D	0.35	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

C-85 - 2024, PM

Data Errors and Warnings

Severity	Area	Item	Description
Warning	DemandSets	D2 - 2024, PM	Time results are shown for central hour only. (Model is run for a 90 minute period.)

Analysis Set Details

Name	Roundabout Capacity Model	Description	Include In Report	Use Specific Demand Set(s)	Specific Demand Set(s)	Locked	Network Flow Scaling Factor (%)	Network Capacity Scaling Factor (%)	Reason For Scaling Factors
C-85	ARCADY		✓				100.000	100.000	

Demand Set Details

Name	Scenario Name	Time Period Name	Description	Traffic Profile Type	Model Start Time (HH:mm)	Model Finish Time (HH:mm)	Model Time Period Length (min)	Time Segment Length (min)	Results For Central Hour Only	Single Time Segment Only	Locked	Run Automatically	Use Relationship	Relationship
2024, PM	2024	PM		ONE HOUR	07:45	09:15	90	15	✓			✓		

Intersection Network

Intersections

Intersection	Name	Intersection Type	Leg Order	Grade Separated	Large Roundabout	Do Geometric Delay	Intersection Delay (s)	Intersection LOS
1	untitled	Roundabout	1,3,4				5.02	A

Intersection Network Options

Driving Side	Lighting	Network Residual Capacity (%)	First Leg Reaching Threshold
Right	Normal/unknown	126	SB McNeilly

Legs

Legs

Name	Leg	Name	Description
SB McNeilly	1	SB McNeilly	
NB McNeilly	3	NB McNeilly	
WB Collector D	4	WB Collector D	

Capacity Options

Name	Minimum Capacity (PCE/hr)	Maximum Capacity (PCE/hr)	Assume Flat Start Profile	Initial Queue (PCE)
SB McNeilly	0.00	99999.00		0.00
NB McNeilly	0.00	99999.00		0.00
WB Collector D	0.00	99999.00		0.00

Roundabout Geometry

Name	V - Approach road half-width (m)	E - Entry width (m)	l' - Effective flare length (m)	R - Entry radius (m)	D - Inscribed circle diameter (m)	PHI - Conflict (entry) angle (deg)	Exit Only
SB McNeilly	4.25	4.25	0.00	20.00	40.00	20.00	
NB McNeilly	4.25	4.25	0.00	20.00	40.00	20.00	
WB Collector D	4.25	4.25	0.00	20.00	40.00	20.00	

Slope / Intercept / Capacity

Leg Intercept Adjustments

Name	Type	Reason	Direct Intercept Adjustment (PCE/hr)	Percentage Intercept Adjustment (%)
SB McNeilly	Percentage			85.00
NB McNeilly	Percentage			85.00
WB Collector D	Percentage			85.00

Roundabout Slope and Intercept used in model

Name	Enter slope and intercept directly	Entered slope	Entered intercept (PCE/hr)	Final Slope	Final Intercept (PCE/hr)
SB McNeilly		(calculated)	(calculated)	0.579	1132.570
NB McNeilly		(calculated)	(calculated)	0.579	1132.570
WB Collector D		(calculated)	(calculated)	0.579	1132.570

The slope and intercept shown above include any corrections and adjustments.

Leg Capacity Adjustments

Name	Type	Reason	Direct Capacity Adjustment (PCE/hr)	Percentage Capacity Adjustment (%)
SB McNeilly	Percentage			100.00
NB McNeilly	Percentage			100.00
WB Collector D	Percentage			100.00

Traffic Flows

Demand Set Data Options

Default Vehicle Mix	Vehicle Mix Varies Over Time	Vehicle Mix Varies Over Turn	Vehicle Mix Varies Over Entry	Vehicle Mix Source	PCE Factor for a Truck (PCE)	Default Turning Proportions	Estimate from entry/exit counts	Turning Proportions Vary Over Time	Turning Proportions Vary Over Turn	Turning Proportions Vary Over Entry
		✓	✓	Truck Percentages	2.00				✓	✓

Entry Flows

General Flows Data

Name	Profile Type	Use Turning Counts	Average Demand Flow (Veh/hr)	Flow Scaling Factor (%)
SB McNeilly	ONE HOUR	✓	373.00	89.000
NB McNeilly	ONE HOUR	✓	307.00	89.000
WB Collector D	ONE HOUR	✓	236.00	89.000

Direct/Resultant Flows

Direct Flows Data

Time Segment	Name	Direct Demand Entry Flow (Veh/hr)	DirectDemandEntryFlowInPCE (PCE/hr)	Direct Demand Exit Flow (Veh/hr)	Direct Demand Pedestrian Flow (Ped/hr)
08:00-08:15	SB McNeilly	335.32	342.03		
08:00-08:15	NB McNeilly	275.99	281.51		
08:00-08:15	WB Collector D	212.16	216.40		
08:15-08:30	SB McNeilly	410.68	418.89		
08:15-08:30	NB McNeilly	338.01	344.77		
08:15-08:30	WB Collector D	259.84	265.04		
08:30-08:45	SB McNeilly	410.68	418.89		
08:30-08:45	NB McNeilly	338.01	344.77		
08:30-08:45	WB Collector D	259.84	265.04		
08:45-09:00	SB McNeilly	335.32	342.03		
08:45-09:00	NB McNeilly	275.99	281.51		
08:45-09:00	WB Collector D	212.16	216.40		

Turning Proportions

Turning Counts / Proportions (Veh/hr) - untitled (for whole period)

		To		
		SB McNeilly	NB McNeilly	WB Collector D
From	SB McNeilly	0.000	256.000	117.000
	NB McNeilly	158.000	0.000	149.000
	WB Collector D	86.000	150.000	0.000

Turning Proportions (Veh) - untitled (for whole period)

		To		
		SB McNeilly	NB McNeilly	WB Collector D
From	SB McNeilly	0.00	0.69	0.31
	NB McNeilly	0.51	0.00	0.49
	WB Collector D	0.36	0.64	0.00

Vehicle Mix

Average PCE Per Vehicle - untitled (for whole period)

		To		
		SB McNeilly	NB McNeilly	WB Collector D
From	SB McNeilly	1.020	1.020	1.020
	NB McNeilly	1.020	1.020	1.020
	WB Collector D	1.020	1.020	1.020

Truck Percentages - untitled (for whole period)

		To		
		SB McNeilly	NB McNeilly	WB Collector D
From	SB McNeilly	2.0	2.0	2.0
	NB McNeilly	2.0	2.0	2.0
	WB Collector D	2.0	2.0	2.0

Results

Results Summary for whole modelled period

Name	Max V/C Ratio	Max Delay (s)	Max Queue (Veh)	Max 95th percentile Queue (Veh)	Max LOS	Average Demand (Veh/hr)	Total Intersection Arrivals (Veh)	Total Queueing Delay (Veh-min)	Average Queueing Delay (s)	Rate Of Queueing Delay (Veh-min/min)	Inclusive Total Queueing Delay (Veh-min)	Inclusive Average Queueing Delay (s)
SB McNeilly	0.36	5.46	0.55	1.00	A	331.97	331.97	28.38	5.13	0.32	37.69	4.95
NB McNeilly	0.29	4.84	0.40	~1	A	273.23	273.23	21.05	4.62	0.23	28.21	4.50
WB Collector D	0.23	4.56	0.29	~1	A	210.04	210.04	15.35	4.38	0.17	20.66	4.29

Main Results for each time segment

Main results: (08:00-08:15)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
SB McNeilly	298.43	74.61	298.08	195.03	119.90	0.00	1040.94	807.40	0.287	0.31	0.40	4.844	A
NB McNeilly	245.63	61.41	245.38	324.48	93.50	0.00	1056.23	963.72	0.233	0.24	0.30	4.439	A
WB Collector D	188.82	47.21	188.64	212.59	126.28	0.00	1037.24	823.18	0.182	0.18	0.22	4.241	A

Main results: (08:15-08:30)

Name	Total Demand	Intersection	Entry Flow	Exit Flow	Circulating	Pedestrian Demand	Capacity	Saturation Capacity	V/C	Start Queue	End Queue	Delay	LOS

	(Veh/hr)	Arrivals (Veh)	(Veh/hr)	(Veh/hr)	Flow (Veh/hr)	(Ped/hr)	(Veh/hr)	(Veh/hr)	Ratio	(Veh)	(Veh)	(s)	
SB McNeilly	365.51	91.38	364.91	238.79	146.81	0.00	1025.36	807.40	0.356	0.40	0.55	5.446	A
NB McNeilly	300.83	75.21	300.43	397.25	114.46	0.00	1044.09	963.72	0.288	0.30	0.40	4.839	A
WB Collector D	231.26	57.81	230.98	260.27	154.62	0.00	1020.84	823.18	0.227	0.22	0.29	4.557	A

Main results: (08:30-08:45)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
SB McNeilly	365.51	91.38	365.50	239.09	146.98	0.00	1025.26	807.40	0.357	0.55	0.55	5.456	A
NB McNeilly	300.83	75.21	300.83	397.83	114.65	0.00	1043.98	963.72	0.288	0.40	0.40	4.843	A
WB Collector D	231.26	57.81	231.25	260.65	154.82	0.00	1020.72	823.18	0.227	0.29	0.29	4.559	A

Main results: (08:45-09:00)

Name	Total Demand (Veh/hr)	Intersection Arrivals (Veh)	Entry Flow (Veh/hr)	Exit Flow (Veh/hr)	Circulating Flow (Veh/hr)	Pedestrian Demand (Ped/hr)	Capacity (Veh/hr)	Saturation Capacity (Veh/hr)	V/C Ratio	Start Queue (Veh)	End Queue (Veh)	Delay (s)	LOS
SB McNeilly	298.43	74.61	299.02	195.52	120.19	0.00	1040.77	807.40	0.287	0.55	0.40	4.856	A
NB McNeilly	245.63	61.41	246.02	325.41	93.79	0.00	1056.05	963.72	0.233	0.40	0.31	4.446	A
WB Collector D	188.82	47.21	189.09	213.20	126.62	0.00	1037.05	823.18	0.182	0.29	0.22	4.248	A

Queueing Delay Results for each time segment

Queueing Delay results: (08:00-08:15)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
SB McNeilly	5.87	0.39	4.844	A	A
NB McNeilly	4.44	0.30	4.439	A	A
WB Collector D	3.27	0.22	4.241	A	A

Queueing Delay results: (08:15-08:30)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
SB McNeilly	8.04	0.54	5.446	A	A
NB McNeilly	5.91	0.39	4.839	A	A
WB Collector D	4.29	0.29	4.557	A	A

Queueing Delay results: (08:30-08:45)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
SB McNeilly	8.26	0.55	5.456	A	A
NB McNeilly	6.04	0.40	4.843	A	A
WB Collector D	4.37	0.29	4.559	A	A

Queueing Delay results: (08:45-09:00)

Name	Queueing Total Delay (Veh-min)	Queueing Rate Of Delay (Veh-min/min)	Average Delay Per Arriving Vehicle (s)	Unsignalised Level Of Service	Signalised Level Of Service
SB McNeilly	6.21	0.41	4.856	A	A
NB McNeilly	4.66	0.31	4.446	A	A
WB Collector D	3.42	0.23	4.248	A	A

Queue Variation Results for each time segment

Queue Variation results: (08:00-08:15)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
SB						Percentiles could not be calculated. This may be			

McNeilly	0.40	~1	~1	~1	~1	because the mean queue is very small or very big.		N/A	N/A
NB McNeilly	0.30	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
WB Collector D	0.22	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

Queue Variation results: (08:15-08:30)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
SB McNeilly	0.55	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB McNeilly	0.40	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
WB Collector D	0.29	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

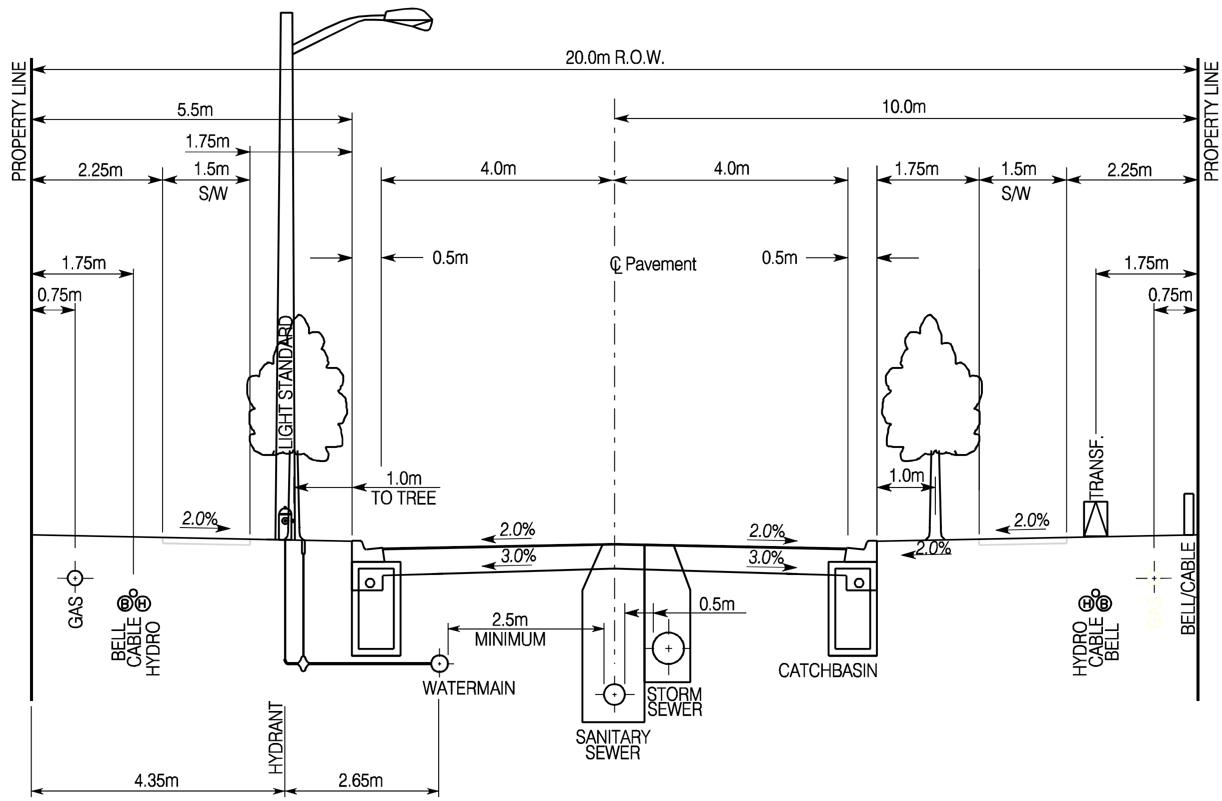
Queue Variation results: (08:30-08:45)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
SB McNeilly	0.55	0.00	0.00	0.00	1.00			N/A	N/A
NB McNeilly	0.40	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
WB Collector D	0.29	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

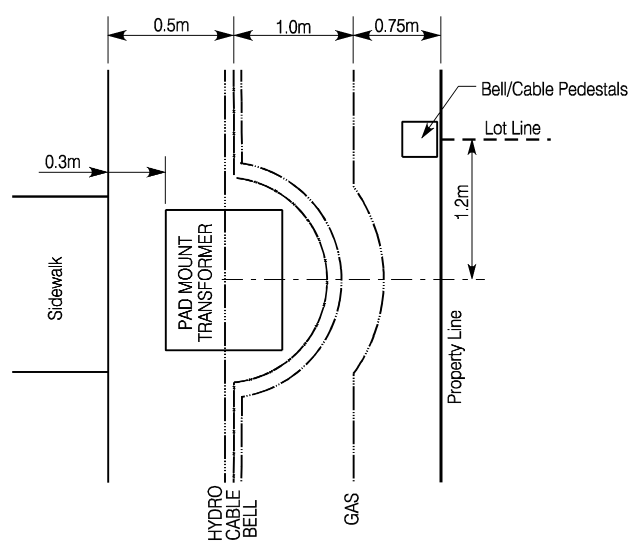
Queue Variation results: (08:45-09:00)

Name	Mean (Veh)	Q05 (Veh)	Q50 (Veh)	Q90 (Veh)	Q95 (Veh)	Percentile Message	Marker Message	Probability Of Reaching Or Exceeding Marker	Probability Of Exactly Reaching Marker
SB McNeilly	0.40	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
NB McNeilly	0.31	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A
WB Collector D	0.22	~1	~1	~1	~1	Percentiles could not be calculated. This may be because the mean queue is very small or very big.		N/A	N/A

Appendix H
Local Urban Residential – 20m R.O.W



MINIMUM DEPTH OF COVER
SANITARY SEWER - 2.75m
STORM SEWER - 2.75m
WATERMAIN - 1.6m
HYDRO - 0.9m
CABLE - 0.9m
BELL - 0.9m
GAS - 0.6m



PLAN
(AT PAD MOUNT TRANSFORMER)

City of Hamilton
Public Works Department

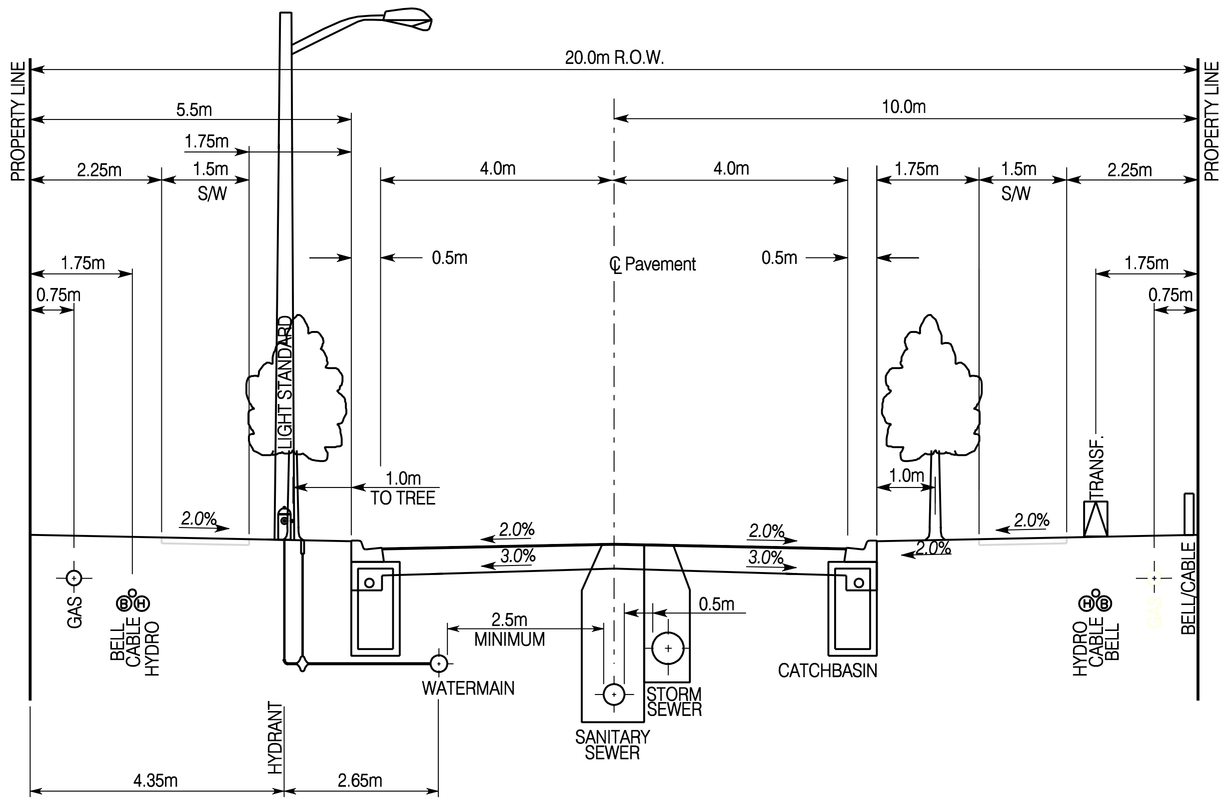
LOCAL URBAN RESIDENTIAL - 20.0m R.O.W.

DIMENSIONS SHOWN ARE IN MILLIMETRES UNLESS OTHERWISE NOTED (N.T.S.)	DATE November 2005	REV No		HAMILTON STD No RD-113.01

APPENDIX L
STANDARD ROW CROSS-SECTION

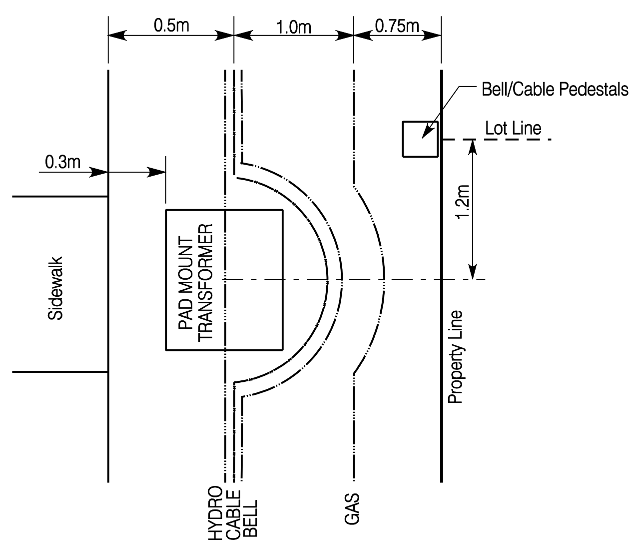
L-1 Local Roads – 20 m ROW

APPENDIX L-1
Local Roads – 20 m ROW



MINIMUM DEPTH OF COVER

SANITARY SEWER - 2.75m
STORM SEWER - 2.75m
WATERMAIN - 1.6m
HYDRO - 0.9m
CABLE - 0.9m
BELL - 0.9m
GAS - 0.6m



PLAN
(AT PAD MOUNT TRANSFORMER)

City of Hamilton
Public Works Department

LOCAL URBAN RESIDENTIAL - 20.0m R.O.W.

DIMENSIONS SHOWN ARE IN MILLIMETRES UNLESS OTHERWISE NOTED (N.T.S.)	DATE November 2005	REV No		HAMILTON STD No	RD-113.01

APPENDIX M
AGENCY COMMENTS AND CONSULTANT RESPONSES

Urbantech West, A Division of Leighton-Zec West Ltd.
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www.urbantech.com

City of Hamilton Comments to Final Draft Report - Block 3 Servicing Strategy - Urbantech	January 16-Feb 14, 2020 Comment period).

Comment No.	Report Reference	Comment Details	Commentor's Name	Staff's Area of work - Department, Division, Area	Consultant Responses March 2020
SMW - Engineering Comments			Zakia Sultana	Project Manager, Infrastructure Planning, Growth Management Division, Planning & Economic Development, City of Hamilton	
1		The final Block Servicing Strategy Report (BSS) should be signed and stamped by a Qualified Professional Engineer.			The Final Report has been stamped by Rob Merwin, P.Eng.
2	MIKE 11 Hydrologic Analysis	The current BSS SWM strategy is based on continuous modelling using MIKE 11. However, the report included the flow results for design storm event simulation from the 2nd BSS submission in several sections, which are outdated. Please ensure that during final submission, the relevant report sections, appendices and engineering drawings are including the flow assessment results based on the latest DHI memo (Jan 15, 2020). Some examples of inconsistencies are: Table 5-9, SWM pond target scenario tables for ponds 2 and 3 in Appendix H, Drawings SWM-5 and SWM-6.			All tables and appendices have been updated to reflect the latest memo from DHI.
3	LIDs	***Previous comment 18:*** table 5-15 should revise the topsoil depth to a minimum 200mm and include the option of rear yard swales with 150mm perforated pipe with granular materials.			Rob to address
4	Table 5.12-Section 5.7	Please verify the unitary volume calculations for Pond 3. The storage volumes should be "m3/imp-ha" to be consistent with that of Pond-2.			This ha been corrected in the report.
5	Hydro-G Report (Appendix B)	**a)** The Hydrogeological Investigation Report (Landtek, July, 2019) included sections for water taking evaluation and impact assessment, monitoring and mitigation plans during construction. Please clarify why these sections are removed from the Jan, 2020 report.			These sections were deleted inadvertently from the Hydrogeological investigation. These sections have been reinserted in this report.
		b) The water balance assessment results in Appendix I are not consistent with report section 3.2 and the July, 2019 report. Please verify.			Pre and Post water balance in the report has been revised to be consistent with they Hydrogeological Report
6	Sanitary Sewer Design Sheet (Appendix I)	**a)** Please note that as per City standards sanitary sewers should be maximum 75% full. The proposed sewer from MH15A-W to MH12A-W should be upsized, which is shown to be 81% full. This sewer leg has an intermediate manhole, MH 24A-W, which should be added in the design sheet.			Required sewers have been upsized to be less than 75% full
		b) In sanitary-west option 2 design sheet, please verify the population densities for West condo, EX5, EX6, EX7, EX8; and ensure consistency with sanitary drainage area plans.			Populations have been coordinated and revised between plans and design sheets.
		c) In sanitary sewer design sheets for the west area, the flows from MH 24A-W to MH12A-W and MH 24A-W(1) to MH12A-W are not added downstream. Please revise.			The design sheet has been updated.
		d) Please clarify the outlet of catchment 16 (1.42 ha) in the sanitary drainage area plans. Is it going to Street D or Street E?			Cathcment 16 drains to Street D. We have modified a mahole in plan view for clarity.
		e) For option 2, the existing McNeilly Road sanitary sewer north of Barton Street is shown to be 97% full. Please note that during detailed design stage (for higher population densities) , sewer upgrade may trigger based on flow monitoring of the existing sewer along McNeilly Road.			It is understood that if at the detailed design stage proposed populations are in keeping with Option 2 and flow moniitoring determines it is required, then the McNeilly Road sanitary sewer will be requrired to be upsized.
7	DWG GR-1	***Previous comment 4g*** : based on section A-A, it appears that partial drainage from existing lots fronting McNeilly Road currently goes through the Block 3 lands and the proposed fill will block this drainage. During detailed design, a temporary/interim ditch inlet should be considered to pick up the external drainage from the existing lots.			It is understood that interim drainage provisions may be required to accommodate existing drainage patterns. This will be determined at the detailed design stage of the various applications.
8	DWGs SAN-1 to SAN-4, SAN- 1A to SAN-4A	**a)** During detailed design, please ensure that additional manholes are provided at locations, where currently two pipes are shown leaving from the same manhole at different directions, therefore the conveyance systems should be separated to avoid any interaction.			At the detailed design stage, all sanitary sewer design will be in accordance with City of Hamilton requirements including manhole spacing, etc.
		b) DWGs SAN-1 and SAN-1A: the proposed sanitary sewer from MH 25A-W to MH 7A-W is going through private lands. Please note that a suitable block should be dedicated to the City for this proposed sewer. The land owner should acknowledge in writing, about the proposed sanitary sewer through his lands.			The developer will convey appropriate blocks for all required municipal infrasturucture. A note has been added to that effect on the drawings.
		c) DWGs SAN-1 and SAN 1-A: please verify the top and inverts at MH 33 A-W and MH 31A-W. During detailed design, please ensure that minimum 2.75m cover is provided for all sanitary sewers as per City standards.			The tops have been revised. These were incorrect.
		d) A note should be added in the drainage plans for the external drainage from HWY-8 to EX.MH 10 (20.45 ha in sanitary sewer design sheet).			EX 10 is now indicated on the drawings.
		e) Please show the north limit of catchment 1, immediately south-east of Barton Street and Lewis Road.			The North limit was drawin underneath the proposed sanitary sewer. It has been offset in the updated drawings for clarity.
		f) *Previous comment 20g* : catchment 3 should divided to separate areas north and south of Barton Street.			Cathcment 3 has been divided a requested.
9	DWG STM-1	***Previous comment 11h*** : please clarify the park servicing strategy. We understand that the minor flows will be captured by the proposed park stub connection to Street D storm sewer. Please clarify whether major flows will be conveyed overland to public streets.			Drawing SWM 1 has been updated to indicate that the minor system for the majority of the park is to connect to the road netowrk. During detailed design of the park should the grades require it a minor system connection to the pond can be made to provide drainage for swales etc. Again at detailed design the majority of the major system can be accomodated in the road network. It is likely that there will be locallized swales and transition grading that requires minor system connections to the pond.

10	DWG-STM3 (External Bypass Pipe)	Please provide MIKE 11 flow results for catchment 300 and 200, the 2nd submission BSS included the 100-year hydrographs showing the 100-year peak flows for these catchments, which is removed from this submission. Based on the continuous simulation results (BSS, Jan 2020), 100-year peak flows for catchments 300 and 200 are 2.648 m^3/s and 1.474 m^3/s respectively. Based on single event modeling (BSS 2nd submission), 100-year peak flows for catchments 300 and 200 were 4.017 m^3/s and 1.5 m^3/s respectively. While for both modelling scenarios, catchment 200 flows are in good agreement, catchment 300 flows are significantly different. Based on the reduced flows for catchment 300, the sewer size from MH 7C to MH6C is reduced to 1350mm in the storm sewer design sheet; however the drainage area plans are still showing a 1500mm sewer. The external bypass sewer design should be kept same as the BSS 2nd submission scenario 2a, therefore sewer from MH7C to MH6C should be kept as 1500mm. Please revise the storm sewer design sheet accordingly.			The sewer in the design sheet has been revised to a 1500mm as requested.
11	DWG STM-4	**Previous comments 6c,10b,11f**: please verify the drainage area of catchments EXT 4.1 and EXT 4.2, there appears to be typo. The BSS should include discussions about the SWM/drainage strategy for the external areas north-east of Barton Street and McNeilly Road. Drainage to the venetian meat channel, Arvin Avenue storm sewer and existing watercourse should be documented. A note should be added that the option of extending the existing 1950mm storm sewer from McNeilly Road to Arvin Avenue may be considered during detailed design stage, which may allow EXT 4.1 lands to drain to Arvin Avenue storm sewer.			The drainage areas have been corrected. A note has been added to the design sheet along with a schematic sewer indicating the option to extned the 1950mm storm sewer from McNeilly Road to Arvin Avenue.
12	DWGs SWM-1 to SWM-4	**a)** During detailed design, major overland flow route for both ponds should be directed to the wet cell. If 100-year flows are captured in storm sewers, a split manhole may be required to divert the major flows to the wet cell, or the forebay may be upsized considering the additional flows.			Noted. To be addressed at detailed design stage.
		b) DWG SWM-1(***Previous comment 14.2b***): the drawings are still showing pond 2 access road from Barton Street. During detailed design stage access road should be provided from internal streets as noted in the response letter.			Maintenance access has now been indicated from internal road network. The other items are connections for pedestiran movements.
		c) DWG SWM-2 (***Previous comment 4i***): during detailed design stage, the proposed berm design at Barton Street should be confirmed.			Noted. To be addressed at detailed design stage.
		d) DWG SWM-3: the drawings are not showing any connection of internal streets to Pond 3 access Road. During detailed design, access should be provided from internal streets, not Lewis Road.			Maintenance access has been added.
13	DWG SWM-7	Please verify the drainage area of catchment 101A, which is 1.98 ha in other drawings.			Drainage areas have been corrected.
Natural Heritage					
14	Appendix C-Section 1.1.2 (page2)	**Previous comment (Sept. 12, 2019) 2 a) i)** has not been addressed. On page 2 it is stated "Schedule B of the UHOP shows the Hamilton Natural Heritage System which does not identify Core Areas on and adjacent to the site". As identified in previous comments, there are features within the Natural Heritage System that have not been mapped. These features incude habitat for Species at Risk (SAR) and Significant Wildlife Habitat (SWH). The statement needs to be revised to include this caveat.	Melissa Kiddie	Natural Heritage Planner: Development Planning, Heritage and Design, Planning and Economic Development, City of Hamilton	A statement has been added to Section 1.12 of the EIS.
15	Appendix C-Section 1.1.4 (page 3)	**Previous comment (Sept. 12, 2019) 2 a) ii)** has not been addressed. On page 3, the discussion within Section 1.1.4 (Fruitland Winona Secondary Plan) focuses on the Stoney Creek Urban Boundary Expansion Subwatershed Study and not on policies of the Secondary Plan (policies 7.4.2.5-natural heritage principles; 7.4.11-Natural Heritage System general policies and 7.4.14-Block Servicing Strategy). This section is to be revised to include these policies.			This section has been updated to reflect the policies within the Secondary Plan.
16	Appendix C-Section 3.4 (page 15)	On page 15, Section 3.4 has been labelled as "Species at Risk Screening". While this label describes the first three paragraphs, section 3.4.1 describes Significant Wildlife Habitat. Significant Wildlife Habitat should be its own section.			Significant Wildlife Habitat has been provided it's own section (3.5).
17	Appendix C-Section 5 (page 22)	**Previous comment (Sept. 12, 2019) 2 e) iv)** has not been addressed: On page 22 it has been stated that "Monarch depends on milkweed for its life cycle, however milkweed is common and plentiful in the Stoney Creek area". It is important to note that additional habitat within the vicinity does not recognize the potential habitat that will be lost as a result of development within this area.			This section has been modified to reflect compensation recommednation for loss of habitat.
18	Appendix C-Section 6 (page 24)	**Previous comment (Sept. 12, 2019) 2 d)**: As a measure to mitigate the impacts on the locally rare Carolina Wren, it has been identified that nest boxes could be provided within green spaces. It is important to note that this may be difficult to implement as part of development of this area.			This section has been updated to relfect that development may make it difficult to implement this recommendation
19	Appendix C-Appendix D: Breeding Birds	**Previous comment (Sept. 12, 2019) 2 e) ii)**: The locations of Eastern Meadowlark/Bobolink surveys have been provided on Figure D-1. The stations have been labelled in red and are very difficult to read. This figure needs to be revised to clearly identify the station numbers.			The figure has been updated to clearly identify the station numbers
20	Appendix C-Appendix D: Breeding Birds	**Previous comment (Sept. 12, 2019) 2 e) iii)** has not been addressed: Within the breeding bird table provided within Appendix D, Barn Swallow, a "threatened" species has been identified as possibly breeding within the study area. There is concern with this evaluation. Within the text of Appendix C, it has been noted that Barn Swallow was only found foraging within the area and that no breeding habitat was available for this species (page 22). This table needs to be revised to reflect this information.			The table has been updated as required.
Public Consultation /Administrative					
21	Appendix N - 1, Public Stakeholder List	Remove staff names' rows, down to Councillors. Remove last 2 columns for the entire list - not needed and some of these are internal - City directions. Replace staff names with my name - Margaret Fazio - Liaison to City staff/Project Team and internal communications.	M.Fazio	Growth Management Division, Infrastructure Planning.	The contact list has been updated as required.
22	Appendix N - 2	Change title from "Notice of Public Comment" to "Notice of 30 day Public Review"			The title has been modified.
23	Appendix N-4	Leave the notice but need to add your PIC panels - preferably in colour here. Feb 23, 2016 Returned letters/Landowner Inquiries - this list shows peoples names and addresses, and if you wish to follow City's privacy protection best practices, we suggest removing this list. You may wish to just mention in numbers, in the main body of the report, how many people registered letters were sent to, include your mailing list map/refer to the study map, how many were returned and how many provided comments. This is the kind of information Coucil would be interested in. By the Way, Council Members are treated as the rest of the public.			PIC panels are included in colour. We have removed the list including peoples names etc. and updated the report to include approximate number of people who attended.
24	Appendix N - 3	Out of order with N-3 in hard copy - please check the e copy as well. Title says PIC but there are no panels, but where the N-3 says there are letters, there are maps in that section?...May just be out of order. If providing the sign in sheet, please either provide a blank (which we don't have, I know), or black out attendee names & contact information to protect their privacy.			The hard copy of the document was out of order. N-3 is the various communications sent to landowners etc. N-4 is information on the PIC. A blacked out verion of the PIC sign in sheet is provided.

25	Executive Summary	Provide long form of EIS. Also, discussions with transportation staff indicated - as per concept map, that further intersection control measures are to be determined at Application submission/Detailed Design stage. Therefore, we woudd like to suggest to reword to the following: " If changes are made to the road network the City has the right to ask for Traffic Impact Studies, if found to be required. As development proceeds, the determination of intersection controls (stop-control or mini-roundabout), within each development area will be required."	M. Fazio & Mohan Philip	Growth Management & Transportation Planning	The Executive Summary has been updated as suggested.
26	Introduction, fourth paragraph	Suggest changing last sentence to" This study pertains to the Block 3 area within the Secondary Plan.			The introduction has been updated as suggested.
27	Introduction - Overall Comment	Please use an accronym for Block 3 SS consistently. Currently there are BSS, Block 3, Block 3 SS in use. Suggest sticking to just one for clarity.			The study has been updated to use one acronym.
28	Purpose	NHS - introduce the long form before using the accronym			The study has been updated.
29	Official Public Comment	Please reword the first sentence - it is repetitive. Please reword the tense of this section into past tense, rather than future. Thiurd sentence please change to: "The hard copy of the study report was made available at City Hall - Clerk's Dest, and 6th Floor - front counter..."			The section has been reworded.
30	SCUBE Subwatershed Study	Second Paragraph - last sentence - suggest removing. Not sure it's needed? When you are describing Phases does Phase 3 mean this current study? Sorry - not clear. Perhaps it should be stated earlier in this Section 1.7, that SCUBE Subwatershed Studies followed a Municipal Class Environmental Assessment process, which fulfilled the requirements of Phases 1 & 2, - at teh bottom of the second paragraph? It would provide more process clarity. You refer to Phase 3 for this study (third paragraph - page 10), but we are not technically carrying out Phase 3 EA process, so would suggest refraining from using thatPhase 3 reference here. Just state that ...."this BSS provides an implementation strategy for the Block 3 area".... Last paragraph - top line mentions "SWMF" - please provide long form. - I don't know what it is? Could you please use Pond 2 & 3 naming consistently, and always mention "East" and "West" when referring to POnds by number. Also, please add a statement which talks about SCUBE Subwatershed Study East establishing the numbering system for the Ponds. Just so nobody is wondering what happened to Pond 1.			The section of the report has been updated as requested.
31	Section 4.2 Roadworks; pg 29	Please place the first setence of the first paragraph below the first paragraph - under the bullers. Otherwise the sentence doesn't feel like it's pertaining to roadworks, but is speaking to general grading for the entire site...we know it's dependent on roads, so moving it will make that relationship clearer. Second Paragraph - it is likely that cycling will also be included on the east-west collector, so the bottom sentence should also include a statement			The section of the report has been updated as requested.
32	Roadworks continued	Please reword the bottom paragraph to indicate that Barton and Fifty Road Phases 3 & 4 Municipal Class EA (EA) , as well as Highway 8 Phases 3 & 4 EA are ongoing at the time of writing of this report. McNeilly and Lewis were not identified in SCUBE TMP (sub-set of the Secondary PLan), to trigger a need for further study. All roads which are rural will become urbanized within BLock 3 SS. Until Barton and Highway 8 EA are completed the ROW width is determined by the Secondary Plan policies. Barton Road is classified as a major arterial roadway, currently identified in the Secondary Plan to require 40.576m ROW, which is 36.576 m from centre line, with additional off set of 4m to the south. Highway 8 is an arterial roadway with the ROW of 36.576m, however. The ongoing EAs may amend these ROW widths. McNeilly and Lewis Roads will remain classified as collector roads, with ROW width 26.213m. Please note that local road ROW is not 20m exactly but 20.117m.	M.Fazio	Growth Management Division, Infrastructure Planning.	The section of the report has been updated as requested.
33	4.3 STORM DRAINAGE, pg 30	Second Paragraph - fourth sentence suggest rewording to "The ponds are not intended to accommodate additional drainage.....controls need to ensure that downstream exceedances don't occu". Currently the sentence feels disjointed and hard to follow.			The section of the report has been updated as requested.
34	4.3.2 External Storm Drainage Requirements	Bottom of second paragraph..."...Mike 11 model results are greater than those determined using the rational method"...suggest putting "rational method" in quotation marks, because to a non-specialist this sounds like Mike 11 is irrational, therefore shouldn't be used?:) ALso, suggest putting in brackets after "rational method" (standard calculation used to determine flows).			The section of the report has been updated as requested.
35	5.3 SWM Targets & Design Criteria, pg. 34	Replace MOE, with MECP, in this section and throughout the document.			This has been updatd in the report.
36	5.7.1 Extended Detention Storage, pg 56	Please remove the reference to Meander Belt calculations, and the associated Appendix, except for Erosion analyses - downstream. Meander belt is no longer applicable.			Meander Belt Appendix and text references have been removed.
37	5.7.3 Sediment Forebay pg. 58	Please make references to SWM Ponds consistent with the rest of the Report...SWM West (Pond 2), SWM East (Pond 3).			Nomenclature has been updated.
38	5.9.1 LID BMPS for GROUNDWATER RECHARGE	Second Paragraph - second sentence. Please replace "will" with "were".			This has been correct to "will be".
39	8 TRAFFIC/ TRANSPORTATION	Not sure if this needs to be repeated from Roadworks? If yes see pg. 30 comments provided above.			These references have been removed.
40	8.2 FUTURE BACKGROUND TRAFFIC CONDITIONS	First sentence - please add "at full build out scenario" in brackets after 2024 or add the number 2024 after the bottom sentence...so that whoever is reading it can connect the dots.			This has been clarified in the report.
41	8.3 FUTURE TOTAL TRAFFIC CONDITIONS pg. 82	Please remove the last sentence of the bottom paragraph. Barton street EA, at intersections with Lewis and McNeilly has identified a need for signalized intersections. If we can just leave it out we're covered. Also, please see above for wording on intersection control - comments on Executive Summary.			This section has been updated.

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#	Comment #	City of Hamilton Submission 1 Comments	Submission 2 Response	City of Hamilton Submission 2 Comments	Submission 3 Response	Responsibility
1	1	The limit of the proposed lot /block/ SWM facility on land use concept plan do not match at the rear of the existing properties fronting McNeilly Rd, Barton Street, east of Lewis Road (Concept plan, Glen Schnarr, July 20, 2018). There might be an opportunity to expand the SWM Pond 3 or move the pond further north. Please verify. Please note that grading/storm servicing strategy should be prepared in consideration with potential development on the existing properties along the existing boundary roads.	The SWM pond blocks have been develop with regard for ultimate development, recognizing that due to grading constraints portions of the land cannot be drained by gravity to the proposed SWM ponds. This has been accounted for in the design of the SWM facilities.	We understand that the BSS did not provide grading details along the existing properties within Block 3 lands. As a result, this study cannot confirm the required setback/buffer land on the proposed lot/block abutting the existing homes to maintain the existing grading and drainage system. However, during zoning & draft plan application stage for Block 3 lands, the Functional Servicing Report (FSR) must identify the required setback on the proposed lots/blocks to demonstrate how external grading and drainage will be handled in accordance with City's standards.	Acknowledged. No further response required at this stage. Further details to be provided during the draft plan approval stages for individual developments.	
2	2	Please justify and explain why a walkway has been proposed within Stormwater conveyance block from HWY8 to Street D.	The walkway and conveyance block have been removed.	Acknowledged.	No further response required.	
3	3	The park block, north of Street D, must be a square park land as identified in the secondary plan. SWM Pond should not encroach into the park lands.	In accordance with our meeting of June 18, 2019 we understand the park block layout is acceptable.	Acknowledged.	No further response required.	
4	4a	Grading plans (and the other engineering drawings) should show the widening limit of future urbanized Barton Street, in accordance with Barton Street EA.	At this time the EA for Barton Street has not been finalized. The engineering plans are based on the current concept plan and are designed in a way to accommodate interim and ultimate conditions. Detailed engineering plans will be prepared and submitted as part of the detailed development applications.	Acknowledged.	No further response required.	
5	4b	b) Existing and proposed grades should be provided along the rear limits of the existing properties on Barton Street, Lewis Road, McNeilly Road and HWY8. Please verify and confirm that the proposed grades on future road can accommodate servicing and appropriate lot grading matching the existing grades along the rear lot line of existing properties fronting on all boundary roads. Currently all grades appear to be proposed as per the legend. Please clarify/confirm.	This request is premature. The BSS indicates how the overall area can be serviced in accordance with the requirements of the secondary plan. Individual development applications will be required to demonstrate how they match in to existing/interim conditions.	We understand that the BSS did not provide grading details along the existing properties within Block 3 lands. As a result, this study cannot confirm the required setback/buffer land on the proposed lot/block abutting the existing homes to maintain the existing grading and drainage system. However, during zoning & draft plan application stage for Block 3 lands, the Functional Servicing Report (FSR) must identify the required setback on the proposed lots/blocks to demonstrate how external grading & drainage will be handled in accordance with City's standards.	Acknowledged. No further response required at this stage. Further details to be provided during the draft plan approval stages for individual developments.	

#	Comment #	City of Hamilton Submission 1 Comments	Submission 2 Response	City of Hamilton Submission 2 Comments	Submission 3 Response	Responsibility
6	4c	Existing grades should be provided along south-west property limit of the existing school at Barton Street and Lewis Road. Please confirm whether any school drainage will drain to Pond 2.	This request is premature. The BSS indicates how the overall area can be serviced in accordance with the requirements of the secondary plan. Individual development applications will be required to demonstrate how they match in to existing/interim conditions. No drainage from the school block will drain to Pond 2.	Noted.	Acknowledged. No further response required at this stage. Further details to be provided during the draft plan approval stages for individual developments.	
7	4d	Existing and proposed grades should be provided for the park lands north- west of Street D and Lewis Road. If the park is not developed concurrently with Block 3 and pond 2, please demonstrate how the park lands will drain to the pond 2.	This request is premature. The BSS indicates how the overall area can be serviced in accordance with the requirements of the secondary plan. Individual development applications will be required to demonstrate how they match in to existing/interim conditions. At the time of the detailed application for the SWM pond, if interim drainage collection is required it will be detailed at that time.	Acknowledged.	Acknowledged. No further response required at this stage. Further details to be provided during the draft plan approval stages for individual developments.	
8	4e	Please provide future potential grades of the west condo block. Will there be an overland flow route from this block to Pond 2? Please confirm.	Details of individual site plan blocks are premature at this time. Each individual application will be required to show adequate overland flow routes and/or control to the sewer capacity.	Noted.	Acknowledged. No further response required at this stage. Further details to be provided during the draft plan approval stages for individual developments.	
9	4f	Please show the existing grades for existing properties fronting HWY 8 (1117 to 1135 HWY8). Please also clarify why no servicing strategy is provided for these lands.	Servicing for these lots is included in the Highway 8 sewers. Again detailed grading plans for individual lots/blocks will be developed at the individual development application stage.	Noted.	Acknowledged. No further response required at this stage. Further details to be provided during the draft plan approval stages for individual developments.	
10	4g	Please provide existing grades at the east property limit of existing houses south-east of Barton street and McNeilly road (fronting McNeilly).	This request is premature. The BSS indicates how the overall area can be serviced in accordance with the requirements of the secondary plan. Individual development applications will be required to demonstrate how they match in to existing/interim conditions.	We understand that the BSS did not provide grading details along the existing properties within Block 3 lands. As a result, this study cannot confirm the required setback/buffer land on the proposed lot/block abutting the existing homes to maintain the existing grading and drainage system. However, during zoning & draft plan application stage for Block 3 lands, the Functional Servicing Report (FSR) must identify the required setback on the proposed lots/blocks to demonstrate how external grading & drainage will be handled in accordance with City's standards.	Existing grades have been provided at the rear yards of lots along McNeilly along with a cross section indicating the potential relationship between the development lands and existing lots on McNeilly.	

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#	Comment #	City of Hamilton Submission 1 Comments	Submission 2 Response	City of Hamilton Submission 2 Comments	Submission 3 Response	Responsibility
11	4h	Please provide existing grades at the south property limit of existing houses south-east of Barton street and Lewis road (fronting Barton).	This request is premature. The BSS indicates how the overall area can be serviced in accordance with the requirements of the secondary plan. Individual development applications will be required to demonstrate how they match in to existing/interim conditions	We understand that the BSS did not provide grading details along the existing properties within Block 3 lands. As a result, this study cannot confirm the required setback/buffer land on the proposed lot/block abutting the existing homes to maintain the existing grading and drainage system. However, during zoning & draft plan application stage for Block 3 lands, the Functional Servicing Report (FSR) must identify the required setback on the proposed lots/blocks to demonstrate how external grading & drainage will be handled in accordance with City's standards.	Existing grades have been provided at the rear yards of lots along Barton Street east of Lewis along with a cross section indicating the potential relationship between the development lands and existing lots on Barton.	
12	4i	Grading plans should include the pond grades, permanent pool and 100-year water levels. Any berm requirements along Barton Street should be identified. Please show some cross sections across Barton Street. No grading encroachment will be allowed within future ROW limit.	Grading plans have been updated accordingly. It is understood that no grading encroachments into the future ROW will be allowed. Detailed design of the SWM facility will be carried out in conjunction with appropriate development applications.	The proposed Pond 2 grading encroaches the future ROW limit, which is not supportable. During detailed design, the pond design should not consider any berm along the ROW limit.	The portion of Pond 2 (West) fronting Barton St. has been graded to avoid encroachment into the future ROW limit. Refer to	
13	4j	Proposed grades should be included for Winona Hills subdivision (City file: 25T-201711, FSR by Urbantech, Nov 2018).	Detailed grading for Winona Hills is not included in this BSS but detailed in the appropriate development application. Centre line road grades are provided.	Acknowledged.	Acknowledged. No further response required at this stage.	
14	4k	The grading plans should include conceptual grades for future lots/blocks. Alternatively, please provide a statement in the report noting that future lots/blocks grading will be designed as per City standards and will be consistent with proposed road grades.	A statement has been included in the report to this effect.	Acknowledged.	No further response required.	
15	4l	A continuous overland flow route to the proposed SWM facilities should be provided on the major overland flow routes/streets. Minimum 0.75% road grade should be provided, as per City standards. Currently the internal roads are proposed to be graded mostly at 0.50% which is contrary to City standards. Please review and rationale for non-standard road grades.	As per discussions with City staff it is understood that the 0.75% minimum standard is flexible when it can be demonstrated that a reduced grade of 0.50% is more practical from an earthworks and overland flow perspective. The grading plan has been developed to minimize the import of material to the site and ensure adequate overland flow routes are available. Detailed applications for individual development blocks will be required to justify grading, earthworks and overland flow routes. At the detailed design stage final grading will be established and where possible limiting grades less than 0.75%.	Acknowledged.	No further response required.	

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#	Comment #	City of Hamilton Submission 1 Comments	Submission 2 Response	City of Hamilton Submission 2 Comments	Submission 3 Response	Responsibility
16	5	Detailed gradients for major and minor system should be provided along all streets to confirm adequate depth of cover for services and to identify any potential servicing conflict.	The BSS indicates how the overall area can be serviced in accordance with the requirements of the secondary plan. We have included inverts for services and approximate tope of manholes on the drainage plans. Sufficient cover is available. Individual development applications will be required to demonstrate how servicing will be accommodated. Road grades and service slopes are provided in the conceptual design drawings. Trunk services where they are crossing existing infrastructure have been analyzed (including profile drawings) to confirm conflicts do not exist.	Acknowledged.	No further response required.	
17	6a	Please provide potential future sanitary sewer inverts within the block (site) to justify the required depth of cover for sewers on Barton Street.	Sanitary inverts and manhole tops are indicated on the sanitary drainage plan.	Acknowledged.	No further response required.	
18	6b	The proposed sanitary sewer on Barton Street from Street E to McNeilly road should be connected into the existing 525 mm sanitary sewer at the McNeilly and Barton Street intersection in accordance with the original design of the system. Please revise the design.	Revising this section of sanitary sewer would reduce the available cover, thereby limiting the amount of drainage from the north that could be provided by gravity. It is our recommendation that this sewer continues to be designed to flow to the east.	Based on the attached DWG: 10-H-64_1, there is more than 5m depth of cover on the existing sanitary sewer at the intersection of McNeilly Road and Barton street. Please explain why the proposed sanitary sewer in Block 3 including a portion of Barton Street cannot be designed and constructed in accordance with City's original Polygon.	A portion of the sanitary drainage from Block 3 has been re-routed to the Mcneilly sanitary sewer in keeping with the City's Polygon.	
19	6c	The proposed storm sewer on Barton Street from McNeilly road to Lewis road can get an outlet into the Venetian meat channel so that it can get adequate depth of cover to service the lands fronting Barton Street. Stormwater quality control can be handled by OGS units. Drainage allocation from properties north of Barton Street, into this sewer, should be discussed with the City.	As per the Metrolinx November 2013 design the existing flows from the lands north of Barton drain to the north and will be collected in swales constructed as part of the Metrolinx development. The majority of the Barton Street sewer is designed to outlet to the proposed SWM facility. Very little of the lands north of Barton could be serviced by gravity through a sewer within Barton Street. It is our recommendation that these lands continue to drain north with onsite controls when development occurs.	Please include grades of the lands north of Barton Street to demonstrate that lands north of Barton Street cannot drain to Barton Street, due to grading constraints and the sewer invert proposed on Barton Street. The drainage area plan should show the drainage split line and total drainage areas between Barton Street and Metrolinx property that will be conveyed to WC # 7 & WC # 9. The BSS should also state that an appropriate storm sewer can be considered within the Future Arvin Avenue ROW or within an easement on private lands.	Existing and preliminary future grades for lands north of Barton Street are shown on **GR-1. Drawing SWM-5** has been updated to show the drainage conveyed to WC 7 and WC9.	
20	6d	Please show future storm sewer details on Barton Street from Tuscani Drive to Lewis road.	A storm sewer has been added on Barton Street.	Noted.	No further response required.	
21	7a	Please clarify whether the existing 300mm storm sewer along Lewis road will be decommissioned, while constructing the proposed bypass sewer. Please also demonstrate how the ditch drainage will be picked up, during interim conditions.	With the urbanization of Lewis Road the existing 300mm storm sewer will be decommissioned. Lewis Road drainage has been accounted for within the proposed storm sewer. Detailed design will demonstrate interim conditions if required.	Acknowledged.	No further response required.	

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#	Comment #	City of Hamilton Submission 1 Comments	Submission 2 Response	City of Hamilton Submission 2 Comments	Submission 3 Response	Responsibility
22	7b	The existing sanitary sewer appears to be very close to the proposed bypass sewer. Please confirm if there will be any issues from construction perspective.	The current servicing concepts are schematic. Detailed design will confirm exact service location, proximity/conflict with other services and any specialty construction methods.	Acknowledged.	No further response required.	
23	7c	The proposed bypass pipe is below the existing sanitary sewer. It may have potential exfiltration from sanitary to storm sewer. Special construction material (such as lean concrete) should be used to seal the sanitary sewer system.	Noted. To be confirmed at detailed design.	Acknowledged.	No further response required.	
24	7d	The proposed storm sewer on Lewis road should be extended up to the existing culvert on Hwy #8 and east of Lewis Rd to convey the external drainage from south of Hwy #8.	The proposed storm sewer has been extended as requested.	Acknowledged.	No further response required.	
25	8a	The preferred Stormwater management facility design strategy is subject to hydrologic modelling approach and model results to demonstrate downstream impacts. We recommend a meeting with consultant and HCA staff to discuss HCA's comments so that a consensus can be reached on the modelling and downstream assessment.	A meeting with HCA and the City was held on June 18, 2019. This second submission of the BSS is based on the agreed to Post Development Drainage Assessment.	Two alternate storm servicing strategy is proposed for external drainage south of HWY8, with two alternate design options for SWM Pond 2. City cannot support scenario 2b which involves routing the external drainage through park land and Pond 2; including two box culverts on the Lewis Road from HWY8 to Street D. Scenario 2b was not discussed in the meeting. This is totally a new option.	A meeting with HCA and City of Hamilton was held on Oct 29, 2019. The 3rd submission is based on the agreed SWM stratergy. Scenario 2b proposed in the 2nd submission has been eliminated. External drainage is conveyed through the proposed sewers on Lewis Road.	
26	8b	During detailed design the following should be provided/confirmed for the proposed SWM ponds: - Stage-storage-discharge curve based on proposed outlet structure and pond configuration. Any potential tail-water condition should be considered while sizing the outlet; - Forebay sizing; - Equalization pipe calculations; - Drawdown time calculations; - Emergency Spillway sizing calculations; - Decanting Area sizing calculations;	Noted. To be provided at detailed design	Acknowledged.	No further response required.	
27	8c	During detailed design, pond rating curves in VO5 model should be consistent with the actual stage-storage-discharge curve, currently in model setup the storage is optimized based on target flows, instead of using the actual storage based on pond configuration.	Noted. To be provided at detailed design.	Acknowledged.	No further response required.	

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#	Comment #	City of Hamilton Submission 1 Comments	Submission 2 Response	City of Hamilton Submission 2 Comments	Submission 3 Response	Responsibility
28	8d	An additional emergency spillway structure should be considered in the pond to avoid emergency spillage on Barton St. The outlet sewers on Barton Street should be designed accordingly. The study should document this option.	The BSS has been revised to discuss the provision of a spillway structure. The details of this structure would be determined at the Draft Plan and Detailed Design stage as they are highly dependent on the final pond configuration and conflicts with existing services.	Acknowledged.	No further response required.	
29	9a	The preferred Stormwater management facility design strategy is subject to hydrologic modelling approach and model results to demonstrate downstream impacts. We recommend a meeting with consultant and HCA staff to discuss HCA's comments so that a consensus can be reached on the modelling and downstream assessment. - Rational Method; - Mike 11 and VO5 models; - Maximum Capacity of existing culverts on HWY8 under operating head up to road centreline elevation.	A meeting with HCA and the City was held on June 18, 2019. This second submission of the BSS is based on the agreed Post Development Drainage Assessment. Since the culverts will be removed based on proposed servicing of the external lands, the bypass pipe has been sized based on the Mike 11 Post Development flows which is greater than the rational method flows.	It is acknowledged that the bypass pipe is designed based on MIKE 11 flows. City does not support scenario 2b which involves routing the external drainage through park land & Pond 2; including two box pipes on Lewis Road from HWY8 to Street D	Noted. Scenario 2b proposed in the 2nd submission has been eliminated. External drainage is conveyed through the proposed sewers on Lewis Road.	
30	9b	The study should recommend that no development can proceed until the external drainage pipe has been installed to convey the external drainage bypassing the site.	We do not agree with this comment. The external drainage pipe may not be required during the first phases of development. Further discussion with the City and Landowners should be undertaken to discuss timing and funding of external infrastructure.	We note that timing for this external infrastructure will be discussed with the City during draft plan approval stage. Please note that as per local servicing policy (LSP) outlined in the DC document, watercourses enclosed by the development are not subsequently eligible for storm sewer oversizing under D.C. Local development is responsible for conveyance of upstream external flows through its development.	Acknowledged.	
31	9c	Please ensure that in VO5 post-development model, the external flows are routed through the bypass pipe, consistent with design. The flows are routed in VO5 using "ROUTE CHANNEL" command. Please use "ROUTE PIPE" command.	The model has been updated to use the "Route Pipe" command.	Acknowledged.	No further response required.	
32	9d	A minimum of 9 m storm servicing block from HWY8 to Street D should be provided for the proposed bypass sewer to convey drainage from south of HWY 8.	The bypass sewer has been rerouted and a servicing block is no longer required.	Acknowledged.	No further response required.	
33	9e	The proposed external conveyance pipe on Lewis road should be extended to pick the drainages from catchments 200 (28.8 ha) and 201A (4.14 ha). Under interim condition, interim ditch inlets should also be provided to pick up the external drainage from catchment 201A.	The external conveyance pipe has been extended as required. Detailed design will provide for any temporary collection requirements.	Acknowledged.	No further response required.	

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#	Comment #	City of Hamilton Submission 1 Comments	Submission 2 Response	City of Hamilton Submission 2 Comments	Submission 3 Response	Responsibility
34	9f	Please clarify how the HWY8 ROW drainage west of Lewis Road will be accommodated into the proposed bypass sewer or into the internal sewer to SWM facility.	The proposed storm sewer has been designed including Drainage Area 300, which includes Highway 8 all the way to McNeilly Road. As the EA for Highway 8 proceeds the details of stormwater conveyance will be determined.	Acknowledged.	No further response required.	
35	10a	This drawing should show all existing culvert locations as mentioned in Table 3-1 of the report. Culvert capacity calculations should be provided.	All culverts are indicated on the existing conditions plan (Figure 2). Under proposed conditions all culverts are being removed as such calculations are not required.	Acknowledged.	No further response required.	
36	10b	Existing lands north-west of Barton Street and Lewis Road (identified as subarea 2 in the report) are partially developed by Metrolinx. Please update the drainage area plan showing the developed Metrolinx development. In addition, please clarify the current drainage outlet of the remaining lands in subarea 2.	Extents of the developed Metrolinx property are indicated on the Drawings SWM-5 and SWM-6, -6A. Also note, only a small portion (approximately 12%) of the Metrolinx lands fall within sub-area 2. Current drainage outlet for the lands north of Barton Street are overland to existing ditches/culverts.	Please include grades of the lands north of Barton Street to demonstrate that lands north of Barton Street cannot drain to Barton Street, due to grading constraints and the sewer invert proposed on Barton Street. The drainage area plan should show the drainage split line and total drainage areas between Barton Street and Metrolinx property that will be conveyed to WC # 7 & WC # 9.The BSS should also state that an appropriate storm sewer can be considered within the Future Arvin Avenue ROW or within an easement on private lands.	Existing and preliminary future grades for lands north of Barton Street are shown on **GR-1. Drawing SWM-5** has been updated to show the drainage conveyed to WC 7 and WC9.	
37	11a	DWG SWM-7 should show all existing/proposed culvert locations. Culvert capacity calculations should be provided in the report.	The existing culverts are shown on Drawing SWM-5. Refer to STM-1, -2, -3 and -3A for proposed servicing. All existing culverts within the study area are proposed to be removed.	Acknowledged.	No further response required.	
38	11b	We note that the proposed Winona Hills development (City file: 25T-201711) will be serviced by Pond 3, under ultimate condition. An interim Stormwater management strategy is proposed for these lands, by Urbantech (FSR, dated Nov 2018). City has requested a 4.5m overland flow easement at the east limit of these lands to convey external drainage to Barton Street. Block 3 engineering drawings should include this design information	As previously discussed, interim conditions are not included in the BSS as it represents ultimate servicing. Individual draft plans are required to demonstrate interim measures.	Acknowledged. Please note that the overland flow easement along east limit of Winona Hills lands is permanent.	Acknowledged.	

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#	Comment #	City of Hamilton Submission 1 Comments	Submission 2 Response	City of Hamilton Submission 2 Comments	Submission 3 Response	Responsibility
39	11c	We understand that due to grading constraints the drainages from the Barton street ROW east of Lewis road and the existing properties fronting on the same (catchment 202: 6.66 ha, DWG- STM2) cannot drain into Pond 3. Please demonstrate minor and major system conveyances for this catchment to Barton Street and Lewis Road intersection. We note that as part of interim storm servicing strategy of Winona Hills lands, a storm sewer is proposed along Barton Street, which will outlet to the existing storm sewer along Arvin Avenue. Can a portion of catchment 202 be drained into this sewer? Please explore the option of using this sewer.	We have reviewed available capacity within the proposed system and there is insufficient capacity to provide additional servicing.	Noted.	No further response required.	
40	11d	Storm sewer design and servicing plans (grading and plan & profile) should accommodate a storm outlet for McNeilly Road, from HWY8 to Barton Street, considering future urbanization of the road.	Drainage for McNeilly Road is accommodated within the proposed storm sewer and SWM facility. Improvements to McNeilly Road can include a storm sewer connection.	Noted.	No further response required.	
41	11e	Storm sewer design (internal sewer or bypass pipe) should accommodate a storm outlet for HWY8 drainage from McNeilly Road to Lewis Road.	Drainage from HWY 8 is included in the proposed storm sewer. Improvements to Highway 8 can include a storm sewer connection.	Acknowledged.	No further response required.	
42	11f	Please demonstrate a suitable storm outlet for the area between Metrolinx property and Barton St (catchment 100: 17.2 ha, DWG SWM-7) The following both options should be considered: - A deeper Storm sewer on Barton Street from McNeilly or from Street E to the Venetian Meat channel. - A new storm sewer on future Arvin Ave ROW to Venetian Meat channel.	Under existing conditions, Sub-area 2 drains away from Barton, northwards. It is recommended that the existing drainage be maintained when the lands are developed. Per the SCUBE study, the pond block is sized based on drainage areas south of Barton Road only. The ponds cannot accommodate additional drainage from Sub-area 2 which will require on-site SWM controls, when developed, to ensure downstream exceedances don't occur. Under future developed conditions, a portion of sub-area 2 is proposed to drain towards McNeilly Road and a portion of the site will outlet as existing to the Venetian Meats channel.	The drainage area plan should show the drainage split line and total drainage area between Barton Street and Metrolinx property that will be conveyed to WC # 7 & WC # 9. The BSS should also state that an appropriate storm sewer can be considered within the Future Arvin Avenue ROW or within an easement on private lands.	**Drawing SWM-5** has been updated to show the drainage conveyed to WC 7 and WC9.	

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#	Comment #	City of Hamilton Submission 1 Comments	Submission 2 Response	City of Hamilton Submission 2 Comments	**Submission 3 Response**	Responsibility
43	11g	City has installed a 1950mm storm sewer immediately south of CNR tracks, immediately west of McNeilly Road. A 1650mm storm stub is provided for lands east of McNeilly Road. Please consider this sewer as a potential outlet for the lands west of catchment 100 (DWG SWM-7) up to McNeilly road. A new storm on future Arvin ROW can be considered. An easement will be required through Metrolinx land to accommodate the storm outlet into the existing 1650 mm stub. Please document this storm outlet option.	Noted. Storm servicing option has been included in the BSS.	No details are provided in the BSS.	Details of existing storm sewers have been added to the drawings. Provisions have been made for the possible drainage of lands north of Barton Street to either the 1650mm storm sewer or the future Arvin Avenue ROW.	
44	11h	The storm servicing strategy for the park blocks is not clear from the storm sewer design sheet. Please verify and confirm that the minor flows from the park blocks will be captured within the sewers and the major system flow will go overland via Public Street to the proposed SWM ponds.	Storm manholes have been provided to the park block and the major system flows are currently designed to go overland via Public Streets to the proposed SWM block. If during detailed design of the Park directly west of Lewis it is determined that it is more feasible to have the overland drain directly to the pond this will be accommodated in the detailed design of the pond.	Noted. The city does not support the overland flow directly to the pond.	The major system, 100-year minus 5-year event is conveyed to the overland. Just upstream of the ponds, the major system is captured in the sewers and conveyed directly into the wet cell. Refer to **Drawing STM-1** and **STM-2.**	
45	11i	Please confirm and document the minor and major storm servicing strategy for the residential condo and commercial blocks. Please note that the residential/condo blocks should be accommodated within the ponds, with adequate minor and major flow conveyance on Public Street (i.e. no additional onsite control requirements).	As part of the second submission, the minor system is adequately sized to convey the 10-year design storm. The ponds are sized to provide quality and quantity control. During the detailed design, major flow conveyance will be assessed to determine if flows can be conveyed to the pond via the right-of-way.	Please note that the minor system is designed to convey for 5-year flows, not to convey 10-year flows.	Noted. The minor system is designed to convey the 5-year flows. Any mention of the of the 10-year event as the minor system is rectified in the report text.	
46	11j	The report should include an overland flow capacity assessment for the proposed roads.	The overland flow for the roads immediately upstream of the ponds were assessed for capacity as this portion of the roadway conveys the largest possible drainage area. Refer to Appendix G.	Acknowledged.	No further response required.	
47	11k	The upstream storm sewer inverts should be set higher than the 100-year pond operating level. An exception may be considered for few runs connecting into the pond, depending on the site constraints. Otherwise, 5-yr. HGL should not exceed the obvert of the pipes. 100-year HGL should be 0.3m below RLCB top and the road grade. Please demonstrate and confirm the followings: MH inverts /depth of cover, sewer sizes, HGL's.	HGL analysis will be completed at detailed design.	Acknowledged.	No further response required.	

#	Comment #	City of Hamilton Submission 1 Comments	Submission 2 Response	City of Hamilton Submission 2 Comments	Submission 3 Response	Responsibility
48	12	**Storm Sewer Design Sheet:** Pond outlet pipes should be sized to allow additional flows into the storm sewer system to avoid emergency spillage on Barton Street and Lewis Road.	The outlet for the west pond (under Scenario 2a) is 825 mm and 1200 mm (under Scenario 2b) and the outlet for the east pond is 300mm. The pipes have been sized to convey the 100-year controlled flow. There is additional capacity in the storm sewers that can convey a portion of the emergency spillage with anything else spilling onto the right-of-way.	Acknowledged.	No further response required.	
49	13a	Please verify the permanent pool volume calculations of Pond 2.	The permanent pool volume is based on the Table 3.2 of the MOE Stormwater planning and design manual.	Acknowledged.	No further response required.	
50	13b	Decanting areas should be sized with a minimum cleanout frequency of 10 years.	Refer to calculation attached in Appendix H of the report.	Acknowledged.	No further response required.	
51	14.1 a	Pond design should be optimized to avoid the additional permanent pool volume. Please evaluate different options, such as raising the pond bottom close to permanent pool elevation, staging of pond bottom, etc.	The permanent pool has been sized to provide the minimum volume to provide Enhanced Level 1 quality control. Refinements to the provided volume will be addressed in detail design of the ponds.	Acknowledged.	No further response required.	
52	14.1 b	We note that pond outlet configuration will be provided during detailed design stage. However, pond outlet invert should be confirmed, which will affect the pond operating levels. Please clarify whether pond outlet will be under tail-water conditions (if any) in Venetian Meat channel (Pond 2) and HGL in bypass sewer on Lewis road (Pond 3).	The permanent pool elevation is set to 85.37 for Pond 2 and 86.35 for Pond 3. The pond operating levels and outflows will have to be finalized following discussion with HCA and the City of Hamilton. Based on the MIKE 11 modelling results, the 100-year water level in the VM channel is 85.47 which is 10cm above the Permanent Pool elevation of the west pond. It is unlikely that this will result in any tailwater impact. At detailed design, pond outlet will take tailwater conditions into consideration and the outlet will be modified if necessary.	Acknowledged.	No further response required.	
53	14.1 c	Please note that additional inlets should be considered at 100-year pond operating level so that additional flows can get into the proposed storm sewer along Barton Street (Pond 2) and Lewis Road (Pond 3). This will reduce spillage across the streets under emergency conditions.	The pipes have been sized to convey the 100-year controlled flow. However additional capacity is available in the pipes to convey a portion of the emergency spillage. An emergency grate within the pond outlet manhole, whose invert can be set just above the emergency operating level can be assessed during detailed design to convey additional flows to the storm sewers.	Acknowledged.	No further response required.	

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#	Comment #	City of Hamilton Submission 1 Comments	Submission 2 Response	City of Hamilton Submission 2 Comments	Submission 3 Response	Responsibility
54	14.1 d	As per City standards, maximum 5:1 slope should be provided above planting shelf (within active storage). The proposed 4:1 slope in both ponds is contrary to City standards. Please revise.	4:1 slope above planting shelf have been provided. MOE design recommendations indicate a minimum of 3:1 and 4:1 as the preferred criteria.	The proposed 4:1 slope above the planting shelf is contrary to City standards and not acceptable. New Comment: please ensure that the proposed active storage depth in both ponds is in accordance with City standards (2.5m maximum). We noted that Pond 2 active storage depth for both scenarios exceed 2.5m (2.7m Scenario 2a and 3.13m in scenario 2b), which should be revised.	4:1 sloping above the planting shelf has been revised to 5:1 as per the city standards.	
55	14.1 e	Based on the storm sewer design calculations provided in the report, it appears that 100-year flows to the ponds, will mostly be overland with few 100-year capture locations. Instead of providing the expensive flow splitter structures, the forebay should be designed to accommodate the additional flows (i.e. 5-yr+100yr flows, as applicable).	Forebay has been sized for the 100-year flows. Refer to calculations included in Appendix H. Under pond design for Scenario 2b, the external drainage area will be conveyed directly to the Wet Cell. Flow splitters have been removed from all plans.	The storm sewer design sheet shows that all sewers are sized for 5-year flows only with a few 100-year flow captured flows at various locations. In addition, all drawings show major overland flow routes to sediment forebay and the BSS (section 4.3.1, pg. 28) also noted overland flow route to forebay, which is contrary to City's SWM design standards. During detailed design, an adequate major overland flow route should be provided to main wet cell, bypassing the forebay.	The overland flow route and pond design has been updated to convey the major system flows into the wet cell. Refer to Drawing **STM-1** and **STM-2** and Section X of the report.	
56	14.1 f	All drawings should show only the HWY8 drainage bypass pipe as "green" line. The other sewers should be "blue".	Noted. Refer to DWG-STM 3 and -3A.	Please check DWG STM-3a, where green line is used for catchment 300 boundary.	DWG STM-3a is no longer relevant as part of the 3rd Submission	
57	14.1 g	Tables should be provided in the report listing allowable and proposed flows for both ponds. Stage-storage-discharge charts should be provided to confirm that ponds meet the allowable flows and storage targets.	Noted. Refer to Section 5.6.2 of the BSS.	Acknowledged.	No further response required.	
58	14.2 a	DWG SWM-1 should include grades on Barton Street and the future widening limit of Barton street. In additions, grades should be added for the existing school lands, at south and east limits of the pond.	The Barton EA has not been finalized. Existing grades on are shown DWG SWM-1.	Acknowledged.	No further response required.	
59	14.2 b	Pond 2 cross-sections should show the Barton Street future ROW limit and a 5m buffer should be provided from the future ROW limit. Please note that pond perimeter grades should not exceed more than 0.6m of Barton street grade. The pond perimeter grade should be set 0.3 m above the maximum water elevation on emergency spillway on the pond berm.	0.30 m of free board has been provided above the high-water level. The plan and section view of the drawings consider the Barton Street Widening ROW limit. A buffer in the form of the access road has been provided and will be confirmed in detailed design.	The proposed grading for Pond 2 encroaches the future ROW limit. During detailed design, the berm along the ROW limit should be eliminated. New Comment: the proposed pond access from Barton Street should be eliminated. Pond maintenance access should be from internal streets.	Pond 2 has been graded to avoid encroachment into the future ROW limit. The maintenance acces roads from Barton Street have been removed and replaced with a pedestrian trail to acces the proposed Park. The proposed maintenance acces has been revised to connect to the internal street L.	

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#	Comment #	City of Hamilton Submission 1 Comments	Submission 2 Response	City of Hamilton Submission 2 Comments	Submission 3 Response	Responsibility
60	14.2 c	As per current design, major flows are proposed to be mostly overland, Pond 2 footprints should clearly show a major flow route to the main pond by-passing the forebay.	Noted. Refer to DWG SWM-1, -1A.	No overland flow route is provided to wet cell, bypassing the forebay. During detailed design, an adequate major overland flow route should be provided to pond wet cell, bypassing the forebay.	The overland flow route and pond design has been updated to convey the major system flows into the wet cell, bypassing the forebay (where possible). One bypass is still proposed where unavoidable for the sewer entering Pond 2 from Barton St. Refer to Drawing **STM-1** and **STM-2** and Section 5.3.1 of the report.	
61	14.2 d	City does not support the major flow pipe within forebay berm. Please consider a single forebay option for this pond. The inlet/outlet locations should be optimized to avoid any potential short-circuiting.	Comment Response.	No response provided for this comment.	Comment is no longer relevant. Pond has been reconfigured to convey major flows to the wet cell and bypasses the forebay. Refer to Drawing STM-1 and STM-2	
62	14.2 e	Please consider a Walkway along the east limit of pond to the park.	Noted.	Acknowledged.	No further response required.	
63	14.2 f	Decanting area within park land (south-east corner) should be removed.	Decanting area provided in pond block.	Noted.	No further response required.	
64	14.2 g	Pond 2 layout should be revised addressing the above comments.	Noted.	Acknowledged.	No further response required.	
65	14.3 a	DWG SWM-3 should include grades at the south limit of existing lots fronting Barton Street; future grades at east and south pond limits.	Noted. Existing grades shown on SWM-3.	Noted.	No further response required.	
66	14.3 b	As per current design, major flows are proposed to be mostly overland; Pond 3 footprint should clearly show a major flow route to the pond.	Noted. Refer to Drawing SWM-3.	During detailed design, an adequate major overland flow route should be provided to pond wet cell, bypassing the forebay.	Acknowledged. No further response required at this stage. Further details to be provided during the draft plan approval stages for individual developments.	
67	14.3 c	Section A3-A3: please label the access road.	4.0m Maintenance Road shown on Section A3-A3.	**New Comment:** the proposed pond access from Lewis Road should be eliminated. Pond maintenance access should be from internal streets	Clarification. No access road from Lewis Road was proposed. This was the emergency spillway. It has been labelled accordingly.	
68	14.3 d	Section A4-A4: it should be extended to show the grades at existing properties fronting Barton street and future grades at Street E.	Noted. Section A4-A4 extends to Barton Street and future grades E.	Acknowledged.	No further response required.	
69	14.3 e	Section A5-A5: this section should be extended up to Street A	Noted. Section A5-A5 extends up to Street A.	Acknowledged.	No further response required.	

#	Comment #	City of Hamilton Submission 1 Comments	Submission 2 Response	City of Hamilton Submission 2 Comments	Submission 3 Response	Responsibility
70	15a	The erosion threshold assessment recommends the allowable flows based on the bed/bank materials, which is much higher than the flows recommended by the SCUBE sub-watershed EA study based on a continuous simulation. We recommend a meeting with consultant and HCA staff to discuss about the preferred erosion targets to be used for SWM pond sizing.	A conference call was conducted with the City, HCA and Geomorphix on July 2, 2019. The purpose of this call was to discuss the difference between the SCUBE Study and the site-specific assessment completed by Geo Morphix in determining the flows to prevent erosion in the downstream channel. It was confirmed during this call that approach used in the SCUBE study was not based on field verification and does not account for assimilation capacity of the receiving watercourse. The field-based methodology is better tailored to the receiving watercourses as it accounts for cumulative inputs from Stormwater Management Facilities. The conclusion was that the proposed SWM controls will result in a minor reduction in erosion of the receiving watercourse.	Acknowledged.	No further response required.	
71	15b	The Erosion Threshold Assessment Memo (Geomorphix, Dec 2018) should be stamped.	The updated memo dated August 7, 2019 has been stamped.	Acknowledged.	No further response required.	
72	15c	Please provide a figure showing the reaches assessed by Geomorphix, for erosion threshold.	Refer to Appendix A in the updated memo dated August 7, 2019.	Acknowledged.	No further response required.	
73	16	**Appendix B-4:** it appears that the DHI memo (Jan 2019) has missing pages.	The memo has been updated and included in Appendix F of the BSS. An additional email from Patrick Delaney (dated July 31, 2019) has been appended with the memo as an update to the results.	Acknowledged.	No further response required.	
74	17	The hydrogeological assessment should provide sump pump details (pump rating curve, sump pit sizes etc.) if the basement of the houses is being proposed below the ground water table.	Analysis will be completed at detailed design after basement elevations have been determined.	Noted.	No further response required.	
75	18	Recommendations should be provided for feasible LIDs for the proposed development. Currently report discussed a variety of LIDs (such as soakaway pits, bio-retention cells, etc.) which may not be feasible in residential areas, due to maintenance issues. Please document other alternatives such as: a minimum of 200 mm topsoil for entire site; a 150mm perforated pipe with granular materials on the rear yard swale, etc.	Refer to Section 5.15 of the BSS report.	The options are not documented in the report as requested in previous comment. Please revise the BSS accordingly.	Refer to Section 5.15 of the BSS report. A note has been added to table Table 5-17. Details of feasible LIDs (such as increased topsoil) in residential lots have also been included	
76	19a	Please add area IDs in the design sheet, consistent with sanitary drainage area plans.	Area IDs have been added to the design sheet.	Acknowledged.	No further response required.	

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#	Comment #	City of Hamilton Submission 1 Comments	Submission 2 Response	City of Hamilton Submission 2 Comments	Submission 3 Response	Responsibility
77	19b	Please note that as per City standards sanitary sewers should be maximum 75% full. The proposed 84% full sewers along Street D (MH 6A-E to MH 4A-E) and Street E (MH 14A-W to MH12A-W), are contrary to City standards.	All sewers have been sized to be at 75% of full flow capacity or less.	Acknowledged.	No further response required.	
78	20a	h) Population densities for sanitary sewer sizing should be in accordance with the Fruitland Winona Secondary plan. Currently for low density residential areas a density of 60 persons/hectare is used. However, as per the secondary plan, Low Density Residential areas in Block 3 will mostly have a designation 2 and 3. As per the Secondary Plan policy document (Nov, 2018) these designations are defined as follows: - Low Density Residential 2: density shall be 20 to 40 units/hectare - Low Density Residential 3: density shall be 40 to 60 units/hectare Based on average 3 persons/unit, the average population densities for "Low Density Residential 2" and "Low Density Residential 3" will be 110 and 150 persons/hectare, respectively (average). We understand at draft plan stage, population densities may increase depending on type of development proposed. Therefore, the following two options should be considered (and documented) for sanitary sewer sizing: - Option 1: Considering 60 persons/hectare for low density residential areas (the current design); - Option 2: considering higher population densities, as discussed above.	Both options are now documented in the report.	The wastewater servicing section (section 6.2) should include a discussion about two population density options, to document whether any upgrade is required for the existing sanitary infrastructure for either of the scenarios. Please clarify why DWG SAN-1 is showing a population density of 110 persons/ha for catchments 1 and 2. The density should be 250 person/ha as per the concept plan. Please justify 121, 140 and 142 persons/ha density for catchments 13, 15 and 8 respectively, in DWG SAN-1A. Please justify 124 and 201 persons/ha density for catchments 17 and 18 respectively, in DWG SAN-2A.	Catchments 1 and 2 have been modelled both ways. One per the city standard and one per the concept plan densities. Catchment areas 13,15,8,17 and 18 populations per Ha are composite values based on the potential unit types stated on the concept plan provided by GSAI.	

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#	Comment #	City of Hamilton Submission 1 Comments	Submission 2 Response	City of Hamilton Submission 2 Comments	Submission 3 Response	Responsibility
79	20b	The proposed sanitary sewers should be designed in accordance with the City sewer polygon. A comprehensive sanitary drainage area plan should be provided showing the extent of external drainage areas contributing to Lewis Road and Barton street sanitary sewers. A copy of the City sewer polygon map will be provided.	The drainage plans and design sheets have been updated accordingly.	As noted in our previous comments, the proposed sanitary sewer along Barton Street from Street E to McNeilly Road, should be connected to the existing sewer along McNeilly Road, as per original design polygon of the system. New Comment: Please clarify the rationale for using a population density of 125 person/hectare for areas north of Barton Street and west of Lewis Road (DWGs. SAN-1, SAN-1A). Please verify the area of catchment EX 12 south of HWY8 and confirm consistency with City sewer polygon. Please confirm in DWG SAN-3, whether population noted for EX 1 and catchment 1.1 is total population or population/ha.	Sanitary sewer has been redirected to match the City's polygon. As mentioned in the previous comment response population densities have been modelled in two scenarios; the first being city standard and the second being based on the concept plan. Catchment EX 12 has been confirmed. A portion of the lands north of Highway 8 have been designed to flow to the north internally ultimately into Barton St. This is due to expected grading and lot frontages per the Concept Plan. Population noted for EX 1 and Ex 1.1 are population per hectare based on City standards.	
80	20c	Please show the sanitary sewer east of HWY 8.	Based on the mapping provided there is no sanitary sewer east of Lewis on Highway 8.	Acknowledged.	No further response required.	
81	20d	Proposed development blocks fronting HWY8 should be serviced from the existing sanitary sewer on HWY8.	The development lands along Highway 8 have been designed to be serviced by the Highway 8 sanitary sewer with the exception of the development block at Lewis and McNeilly.	Except two commercial blocks (Comm-2 and Comm-3), all development lands are shown to be serviced by Block 3 internal sanitary sewers. Please explain and demonstrate why these lands cannot get an adequate sanitary outlet to HWY 8.	Due to the significant fall from south to north it was determined to provide capacity within the internal sanitary sewers within the development. At the detailed application stages if it is more advantageous (possible) to drain to the existing Highway 8 sewer this would not be precluded.	
82	20e	Please verify the existing sanitary sewer size on Lewis Road south of Barton Street. Based on City records, this sewer is 450mm, instead of 600mm currently shown on the plans.	This has been revised to reflect an existing 450mm sanitary sewer south of Barton.	Acknowledged.	No further response required.	
83	20f	Please verify and confirm the sanitary sewer outlet of EX 1 (3 ha). Based on City records, it appears to drain to the Arvin Avenue sanitary sewer.	This has been corrected to contribute to the Arvin Avenue sanitary sewer.	This catchment is still accounted to drain to Barton Street sanitary sewer as shown in the sanitary drainage area plan and sanitary sewer design sheet. Please verify.	Based on a site servicing plan prepared in 2007 (city file drawing# LSP_2537) the site drains to EX.MH3A along Barton street. Drawing enclosed in **Appendix M**.	
84	20g	Subcatchments 1, 2, 3 should be split to separate areas north and south of Barton Street. Population density (250 person/hectare) seems to be overestimated for areas north of Barton Street.	Sub catchments have been divided and appropriate population densities have been applied.	Subcatchments 1 and 3 are not divided to separate areas north and south of Barton Street; and still a density of 250 person/hectare is used for areas north of Barton Street. Please verify.	Catchment EX1 has no been seperated based on land use. The rationale for catchment 1,2 & 3 to be 250 Persons/hectare is based on the concept plan prepared by GSAI the lands will be deemed medium density Residential.	

#	Comment #	City of Hamilton Submission 1 Comments	Submission 2 Response	City of Hamilton Submission 2 Comments	Submission 3 Response	Responsibility
85	20h	As Per Winona Hills FSR (Urbantech, Nov 2018) proposed population density for Winona Hills is 83 pp/ha; while the drainage plans are showing 60 pp/ha. Please clarify and confirm the density.	Proposed population density for Winona Hills has been updated.	Acknowledged.	No further response required.	
86	20i	Please fix the typo for existing sanitary sewer along HWY-8 in DWG SAN-1. It should be labelled as SAN.	The typo has been corrected.	Acknowledged.	No further response required.	
87	20j	Please clarify sanitary drainage outlet for the area north of Barton Street between Lewis Road and McNeilly Road (Sub area 2).	Sanitary drainage will be to Barton Street. The drawings and drainage area plans have been updated.	Acknowledged.	No further response required.	
88	21	Please clarify the population density scenario(s) used to size the watermains and to test the impact on the pressure district. Water system servicing scenarios should be developed for all population density scenarios.	The water modelling includes all density scenarios included in the 2006 Master Plan and the proposed concept plan which is in keeping with the secondary plan.	Acknowledged.	No further response required.	
89	22	As per City records, there is a 300mm watermain stub at Lewis Road and HWY8, which indicates future potential upsizing of the existing 150mm watermain on Lewis Road to 300mm. The watermain analysis for Block 3 should assess whether a future 300mm watermain will be required on Lewis Road	WSP has demonstrated that this future watermain is not required to service the subject lands.	Acknowledged.	No further response required.	
90	23	As per City standards, if more than 100 lots are serviced by one watermain feed, a second watermain feed shall be required. Please verify and confirm, whether additional looping is required for proposed watermain along Street P.	Each block has sufficient services as confirmed by Hamilton Water.	Acknowledged.	No further response required.	
91	24	All tables provided in the report for pond rating curves, pond outflow/volume results, etc. should include an additional column indicating the corresponding storm event (i.e. extended detention level, 2-year, 5-year, etc.).			Tables referencing pond design, stage storage curves have been updated to include storm event	
92	25	Please confirm the unit (m3/ha or m3/imp-ha) of volumes noted in tables 5-18 and 5-22. Pond 3 volumes should be same for both scenarios.			Unit rates for Pond 2 and 3 have been updated. Refer to Table 5-14	
93	B			B. Land Use Planning – The last version of the Concept Plan (attached here for clarity) indicates a window road. This is not desirable from the Planning perspective. If however, you still wish to pursue this there are mitigation measures which are attached, which we would recommend for Application stage.	It is understood that should a detailed application propose window roads that additional urban design mitigation measures would be required.	

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#	Comment #	City of Hamilton Submission 1 Comments	Submission 2 Response	City of Hamilton Submission 2 Comments	Submission 3 Response	Responsibility
95	C			**Public Consultation** - The comments in this section pertain to the Main body of the Report s. 1.5 AGENCY AND PUBLIC CONSULTATION undertaken during the study process, and the associated the corresponding Appendices M and N, in that order:		
96	D a.			a. Section 1.5 – description of public engagement, while well written, should provide more detail since Council typically wants to know things like i. "how many people" were at each PIC ii. how many engaged throughout the process, iii. which agencies were contacted, iv. comments/areas of concern raised and how were they resolved. This information will need to be included for 30-day review and when drafting the Report to Council. Also, you may wish to identify who bought into the study process/land owners who are part of it, and those who are not, and how you engaged with both types.	The section on Public Engagement has been modfied to provide further details.	
97	D b.			You mention in this section that registered letters were sent out to the land owners. This section is where we would recommend that you voice any key location's lack of response, which you identify yourselves as non-responsive. The location staff questioned in the past was land under Pond No. 2 – did they ever acknowledge they're aware of the process? What was the outcome and what measures did you employ to reach all the non-responders – i.e. did you exhaust all options available to you – typically employed in such a process? Staff need to know that (and to show all the work you did in this) and need to have this in the Report to be able to defend our collective certainty of implementability of this Block.	Copies of letters provided to landowners are included in **Appendix N** of the report. Multiple mail outs were sent to the owner of the property where the east pond is proposed with no response. In addition we attended the site and left a copy of the letter in the mailbox with no response.	

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#	Comment #	City of Hamilton Submission 1 Comments	Submission 2 Response	City of Hamilton Submission 2 Comments	Submission 3 Response	Responsibility
98	D c.			The TOR for this process asked that all Blocks follow the Municipal Class Environmental Assessment process. Normally this entails sending a notice of project PIC to Agencies. Were agencies included in your mail outs? If yes, please include their list and any correspondence received in Appendix M. Block 2 sent their Notices to Agencies for the combined Notice, so you can use our list, if you wish, for that, if you did as well. The question remains – did Block 3 receive any comments, specific to your area, outside of the Hamilton Conservation Authority?	Agencies included in the City circulation list have been provided a copy of the notice of comment period. A copy of the list is included in **Appendix N** of the report.	
99	D d.			Appendix M – in Natural Heritage above, we have identified that proof of dialogue/correspondence with the appropriate Ministry is required to show that the process being followed is fulfilling their requirements.	Refer to Arcadis summary responses.	
100	D e. i.			The letters included in the appendix that contain blacked out information were blacked out unsuccessfully, i.e. we can still read the names and addresses of individuals being addressed. This should be remedied before the Report is finalized.	Black outs have been updated.	
101	D e. ii.			Please include ALL correspondence, i.e. also e-mails included, also redacted, for a complete record of this portion of the Report. The reason that we want this here is that it will form proof to council, that public engagement took place and when you summarize number of how many land owners/members of the public were engaged, the appendix will provide that proof, i.e. provide your entire study record of public consultation in this appendix. (Just a friendly warning is that from our experience we can advise that this may mean that your Report may gain a whole additional volume.)	Very little correspondence was received from landowners. Some phone calls were received and I asked that they document their concerns in writing.	

#	Comment #	City of Hamilton Submission 1 Comments	Submission 2 Response	City of Hamilton Submission 2 Comments	Submission 3 Response	Responsibility
102	D e. iii.			Please provide blank sign-in sheets that you would have used at the PICs/any meetings. Please note that there is no need to include the actual sheets that were signed since they'll all have to be blacked out, except for members representing public bodies/agencies/businesses – it is deemed to be acceptable to show the blank sheet and just provided a counted number of those who signed in. If some attendees did not sign in, this can be noted in the Report portion as well.	Sign in sheets and blank comment sheets are included from the PIC.	
103	D e. iv.			Please provide photocopies of Newspaper Notices provided for each PIC (If this were an appealable MCEA process, the MECP would ask for physical copies cut out from the newspaper – in your company records as proof, in case of an appeal). We would suggest that a labelled sheet /tab be placed to separate discussions according to key points in the project process public engagement, i.e. include PIC Notice #1, corresponding sign in sheet, followed by any letters/emails, etc. until the next period of engagement, if you have a lot of materials. The next PIC/Meeting should also provide the same order of information in this appendix, for ease of finding/following the discussions.	The only newspaper ad we have prepared is the one for the notice of public comment. The city prepared the one for the joint PIC.	
104	D e . v.			Also, please provide copies of PIC panels/meeting materials for each public meeting held during the study process.	PIC meeting materials are included in **Appendix N**.	
105	E			Water/Wastewater – Please see a separate comment attached.	All water and wastewater comments have been addressed in this submission.	
106	F			Transportation – Consistent with Secondary Plan and Thank you for connecting the Collector "F" to Highway 8. On the Traffic Study - Appendix K of the Report	Refer to GHD Response Table Attached.	
107	F a.			Executive Summary Page i: LOS F at intersection of McNeilly, and Lewis Road on Barton St. The intersection analysis data and results should be passed on to the Barton St, & Hwy8 study consultant for their review and consideration. (NOTE: Margaret Fazio has already passed this on).	Refer to GHD Response Table Attached.	

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#	Comment #	City of Hamilton Submission 1 Comments	Submission 2 Response	City of Hamilton Submission 2 Comments	Submission 3 Response	Responsibility
108	F b.			Item 2.2.3, 3rd paragraph: Local Road ROW, unclear if the on-street parking is beyond the roadway pavement width of 8m. It should be additional. Make it clear. Include a proposed cross section, in Appendix L and cross reference it in the description.	Refer to GHD Response Table Attached.	
109	F c.			Item 3.1: Existing McNeilly and Lewis Roads; • TIS does not discuss road cross sections. It is recognized, however, that the main body of this Draft Report Section 4.2 Roadworks (pg. 27) discusses road ROWs and proposed cross section features to be designed according to City standards, as well as Appendix L which provides the Local Road Cross section. • The Main Report also considers reports used in this study. The list is missing a couple of Reports, which guide the cross sections for collector roads. They are i. the Pedestrian Mobility Plan, https://d3fpllf1m7bbt3.cloudfront.net/sites/default/files/media/browser/2014-12-17/hamilton-pedestrian-mobility-plan.pdf ii. and the Cycling Master Plan. https://d3fpllf1m7bbt3.cloudfront.net/sites/default/files/media/browser/2018-06-06/draft-tmp-backgroundreport-cyclingmp-11-1.pdf • Please note that SCUBE TMP is used as a guiding document for further transportation related Municipal Class Environmental Assessment (MCEA) requirements within the Fruitland-Winona Secondary Plan area, and it does not recommend that any further studies should be conducted for the above mentioned existing roadways. Thus, detailed design and construction are to be urbanized and are expected to be implemented through the	Refer to GHD Response Table Attached.	
110	F d.			Item 5.3: Block 3 Study Area is currently not a developed area and so, we are not sure if the TTS data can be utilized for site distribution traffic? This may need to be monitored during the phasing of implementation process.	Refer to GHD Response Table Attached.	

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#	Comment #	City of Hamilton Submission 1 Comments	Submission 2 Response	City of Hamilton Submission 2 Comments	Submission 3 Response	Responsibility
111	F e.			Item 8.4: Proposed Internal Intersection Control: Recommendation should be included to consider mini-roundabout/traffic circle during the draft plan stage, as a traffic control & calming measure to address safety, speeding issues etc. Recommendation to consider other forms of traffic control should also be included. Include these in Section 9.2, Summary Recommendations	Refer to GHD Response Table Attached.	
112	G			Urban Design - Comments are based on the Concept Plan for Area #3 submitted as part of the report. Generally the comments are focused on ensuring the proposed block and street network will integrate well into context and achieves good interfaces within the community.		
113	G a.			Window road condition – on Highway 8, east of Lewis Rd		
114	G b.			This condition is not ideal from the point of view of streetscaping along Highway 8: the lack of frontage will minimize pedestrian activity and impact views from the street. It is also not ideal for its environmental impacts either, seeing how it doubles up on asphalt surfacing. Potential design solutions (the list below is not exhaustive):	It is understood that should a detailed application propose window roads that additional urban design mitigation measures would be required.	
115	G c.			Enhanced window road design: Should no other block layout be feasible at this location, a good physical and visual interface between the two roads could be achieved by upgrading the landscape strip separating the paved roadways. Upgrades should consist of berms, dense tree plantings, and decorative fencing (or segments of decorative fencing). The consolidation of ROWs could result in only one walkway, maximizing space for landscaping.	It is understood that should a detailed application propose window roads that additional urban design mitigation measures would be required.	

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#	Comment #	City of Hamilton Submission 1 Comments	Submission 2 Response	City of Hamilton Submission 2 Comments	Submission 3 Response	Responsibility
116	G d.			Attached is an Landscape Plan (approved) for a Mattamy subdivision in Waterdown, where a similar window road, adjacent to a multi-purpose trail, was treated with a staggered row of street trees, portions of decorative (cross-buck) fencing, and where pedestrian connections were appropriate, masonry columns marking those connections to the public sidewalk	It is understood that should a detailed application propose window roads that additional urban design mitigation measures would be required.	
117	G e.			Different block and road layout: The other solution would be to plan for housing typologies capable to front both Highway 8 and Collector Rd D. As individual driveways may not be supported along Highway 8, dual frontage townhouses could work in this scenario - with vehicular access provided by means of a private laneway at the rear of the unit. It is important that the rear frontages are treated as street frontages, with high quality architectural detail and preferably a secondary building entrance.	It is understood that should a detailed application propose window roads that additional urban design mitigation measures would be required. Alternative designs for various blocks will be further explored at Draft Plan/Site Plan stage.	
118	G f.			There are a number of built precedents for this type of unit, either with detached garages and private rear yards, or with attached garages and elevated private amenity areas in the rear (such as a balcony or terrace above the garage). Attached are a few examples of lane townhouses.	It is understood that should a detailed application propose window roads that additional urban design mitigation measures would be required. Alternative designs for various blocks will be further explored at Draft Plan/Site Plan stage.	
119	G g.			Visibility of neighbourhood parks in larger community		
120	G h.			It is important that neighbourhood parks have generous street frontage. The objective is to maximize eyes on park (informal supervision) and to take advantage of this land-use as an organizing and character-generating element in community design as it provides a focal point and sense of place.	The concept plan is based on the established locations for collector road interesections. The concept plan has been developed based on these principles, meetings with staff and direction from staff that the configuratino of the western park cannot differ from the Secondary plan configuration.	
121	G i.			Western Neighborhood Park: Please reconsider the block/street network to fully expose at least two of the parks edges to streets in the contextual neighbourhood.	The concept plan is based on the established locations for collector road interesections. The concept plan has been developed based on these principles, meetings with staff and direction from staff that the configuratino of the western park cannot differ from the Secondary plan configuration.	

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#	Comment #	City of Hamilton Submission 1 Comments	Submission 2 Response	City of Hamilton Submission 2 Comments	Submission 3 Response	Responsibility
122	G j.			An option may be to extend the local road adjacent to the eastern edge of the park north towards Collector Rd 'D', and west (along the southern edge of the park) to McNeilly Rd.	At a meeting with staff it was agreed to defer this design element to Draft Plan/Site Plan stages.	
123	G k.			New Collector Rds. – McNeilly and Lewis		
124	G l.			These roads should achieve an urban profile, in terms of including pedestrian facilities on both sides of the road along with tree planted boulevards, to establish a pedestrian-friendly environment.	The BSS has been updated to provide drawings indicating how the urbanization of these roads could happen both with particpation of lands fronting these roads and in context of existing development. Refer to **Drawing ROW-1**.	
125	G m.			Community design		
126	G n.			Unit types: All streetscapes, internal and external. should incorporate street trees. For this reason townhouse units incorporating front garages should be at least 6m wide, to allow for sufficient space in their front yards for street trees. Note the City's soil volume standards for street trees (min $21m^3$ soil/tree in single planting bed, $16m^3$ soil/tree in shared planting bed). This standard applies to street townhouses as well since the frequency of driveways impacts contiguous soil volumes in ROW boulevards.	To be addressed at the Draft Plan/Site Plan./Detailed Design stage.	
127	G o.			SWM pond: Ensure the SWM pond is designed to complement streetscapes and allow the integration of pedestrian walkways, where feasible.	To be addressed at the Draft Plan/Site Plan./Detailed Design stage.	
128	H			Water/Wastewater – Please see a separate comment attached.	All water and wastewater comments have been addressed in this submission.	

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#	Comment #	HCA Sub 2 Comment	Sub 3 Response	Responsibility
1	1	Natural Heritage Features and Watercourses In Section 3, Existing Conditions, it is noted that discussions between the City of Hamilton • (City) and HCA resulted in the determination that regulated watercourse features 1, 2, 3 and 4 did not require protection and could be enclosed. With respect to feature 1 (Watercourse 9), it is indicated enclosure was allowed given downstream infrastructure constraints. In Section 3.6, it is further noted enclosure was allowed given City concerns related to flooding and safety. In addition to this, the City's preference for an enclosed system was also related to concerns over consistency with the Secondary Plan, parkland requirements and useable recreational space, as well as anticipated long-term maintenance costs associated with an open watercourse feature. HCA suggests these additional considerations raised by the City should be identified in the report. HCA staff continue to note there was insufficient fisheries sampling work completed to determine if fish may be present at certain times or to support the conclusions made in the report that the drainage features within the block do not provide or support fish habitat (Section 3.7 and App C, EIS, Section 3.1.2.3). Appendix E of the EIS (Arcadis, Updated July 2019) provides a DFO fish habitat self-assessment, which acknowledges there may be some surface water conveyance from the block to downstream sections that do comprise fish habitat. HCA suggests this should be noted in the body of the EIS and main report, along with the limitations of the assessment work completed. In HCA staff's opinion, based on the work completed, the report should note the on-site intermittent streams likely provide some form of contributory function as fish habitat, which will need to be considered at the time of development. While the report has completed a DFO self-assessment, HCA staff notes recent changes to the Fisheries Act will likely require further review to determine the potential for impacts and need for an authorization from DFO at the time of development. HCA suggest this should be noted in the final report. Table 9-1 states fish rescue permits and/or a LOA will not be required. In the absence of more detailed information or staging plan to identify when construction/enclosure will occur, HCA suggests this statement in Table 9-1 is potentially misleading. Survey work completed as part of the EIS recorded Barn swallow foraging on site. Monarch was also recorded as part of survey work completed for the study. HCA staff suggest that indicating there is additional habitat for these species in the surrounding area does not recognize the considerable area of potential habitat that will be lost as a result of development of the block (as well as the surrounding blocks), nor is it clear which surrounding habitat areas are being referred to. While the EIS has included some correspondence with the MECP regarding species at risk; there is nothing included to indicate all issues have been resolved to MECP's satisfaction. If additional information/correspondence is available HCA suggests it should be included in the final report. The EIS includes a limited discussion regarding Significant Wildlife Habitat (SWH). This section could be expanded to address all potential categories/types of SWH. For example, while Monarch are discussed in terms of the site's function as a migratory stop over (seasonal concentration areas), the site is not reviewed as potential habitat for a species of conservation concern. HCA staff support the limited recommendations made in Section 6 (Mitigation Measures) and 7 (Recommendations) of the EIS.•Further consideration could be given to retaining hedgerows in the development concept (e.g. in association with the SWM pond, school and neighbourhood parks).	The requested revisions have been made to the EIS and the body of the report.	

#	Comment #	HCA Sub 2 Comment	Sub 3 Response	Responsibility
2	2	Lack of Model Calibration, Validation or Parameter Sensitivity Analysis Given the significant revisions to the original MIKE 11 modeling (and the considerable changes in peak flow rates), HCA staff had previously suggested that some form of model calibration or validation is warranted. Due to the lack of available flow observations in Watercourse 9, this review was expected to focus on a fulsome comparison of peak flow rates under existing conditions and future uncontrolled conditions (at all key comparison locations) to peak flow rates determined by previous approved modeling studies (SCUBE SWS 2013, FDRP, etc.). Also, a sensitivity analysis of key model parameters was suggested, to further validate the revised modeling results. The intended sensitivity analysis was not provided in the revised submission. HCA staff had expected a review of changes in peak flow rates resulting from changes in the values selected for key parameters (within justified ranges). It was staff's expectation that this review would help address concerns regarding the accuracy and confidence in the peak flow rates modelled by the Block Servicing Study. Due to the errors found in the original SCUBE Subwatershed Study 2013 MIKE 11 model, a peak flow comparison to this study was not relied on. Table 5-12 and 5-13, compares the existing and future uncontrolled peak flows determined by the updated MIKE 11 design event model, SCUBE 2013, and FDRP 1989. However, there appears to be errors in the tables. The FDRP future uncontrolled drainage areas do not appear consistent with the FDRP report. Although not relied upon, it was also observed that the SCUBE 2013 peak flows are not consistent with the 151 submission report. HCA staff completed a comparison of the design event model peak flows to FDRP 1989 results. Given the magnitude of the increases, HCA staff have concerns regarding the accuracy and confidence in the peak flow rates modelled by the Block Servicing Study. The existing condition peak flows determined using the single event (design event) modelling are significantly greater than the peak flows previously determined by the FDRP. At the downstream crossings of CNR and QEW (Nodes 11 & 13), the current study 100-year existing conditions peak flows are 40 and 65 % larger than the FDRP results (when normalizing for drainage area differences). The future uncontrolled condition peak flows determined using the single event (design event) modelling are also significantly greater than the peak flows previously determined by the FDRP. At the downstream crossings of CNR and QEW (Nodes 11 & 13), the current study 100-year peak flows are 50 and 30% larger than the FDRP results (when normalizing for drainage area differences). Some differences between the peak flows was expected given the different modelling approach (design event versus continuous), different model software and differing parametrization choices. However, significantly higher existing conditions peak flows (with respect to previous assessments) would result in greater allowable release rates from the development Without further confirmation as to the accuracy and confidence in the modelledresults, there is concern about the potential for an increase in actual peak flow rates downstream (compared to current in-field conditions). In addition to the above, the continuous model peak flows (from the 1st submission) were also compared to FDRP results. It was noted that the 100-year existing conditions peak flow rates determined using the continuous modelling were -45% and -5% smaller than the FDRP results (when normalizing for drainage area differences), at the downstream crossings of CNR and QEW. The 100-year future uncontrolled conditions peak flow rates determined using the continuous modelling (as presented in the 1st submission), were -25% and -15% smaller than the FDRP results (when normalizing for drainage area differences), at the downstream crossings of CNR and QEW. As detailed in Review Comment 4 below, the unexpectedly large increases in peak flow rates (for both existing and future uncontrolled conditions) between the design event and continuous versions of the Block Servicing Study model increases HCA staff's concern regarding the accuracy and confidence in the peak flow rates modelled.	An email was received from HCA indicating that the model results are in keeping with their experience in other areas and as such further calibration is not required. The email is included in **Appendix M**	
3	3	Corrected Errors from the Original SCUBE SWS 2013 MIKE 11 Modeling HCA had suggested that the report provide further detail regarding the errors that were found and corrected in the original SCUBE SWS 2013 MIKE 11 modeling, as this information forms another aspect of the validation of the revised peak flows. It is HCA staff's suggestion that the details provided in the DHI memo dated June 12, 2018 (Subject: Scube East Model Update- Corrected Slopes) be included in the report, as this memo describes the key error (considerably low values for urban catchment slope) found and corrected from the original SCUBE Subwatershed Study 2013 MIKE 11 model. The DHI memo dated June 12, 2018 also identifies significant differences in peak flows when the original SCUBE Subwatershed Study 2013 MIKE 11 model (using 2007 version of MIKE 11) was re-run using the 2017 version of MIKE 11. Although it is acknowledged that the 2017 re-run produced lower peak flows, the magnitude of differences and lack of understanding of reasons for the differences increases HCA staff's concern regarding the accuracy and confidence in the peak flow rates modelled by the Block Servicing Study.	The memo documenting the errors in the orginal SCUBE MIKE 11 model and corrections and updates has been attached in Appendix F	

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#	Comment #	HCA Sub 2 Comment	Sub 3 Response	Responsibility
4	4	Recommend the Use of Design Storm Assessments, given Statistical Issues with the Frequency Flow Analysis Given the Frequency Flow Analysis concerns, HCA had suggested that further consideration be given to the use of a design storm I single event modeling approach for all required assessments (SWM pond design, impacts of Proposed Conditions with SWM Controls on downstream Existing Condition peak flow rates, revised Future Uncontrolled Conditions), and that appropriate validation I sensitivity analysis of the adopted design event modeling would be necessary. In reviewing the revised submission, HCA notes the peak flows determined using the single event (design event) modelling are significantly greater than the peak flows determined using the continuous modelling (as presented in the pt submission). HCA staff had suggested the design event approach given the expected inaccuracies in the frequency flow analysis. However, HCA staff had not expected such large increases in peak flow rates. For example, at Nodes 1, 10, 11, and 13, the 100-year existing conditions peak flows determined using the design event modelling were 65%, 32%, 55%, and 74% greater than the continuous modeling results. Also, the 100-year future uncontrolled conditions peak flows at Nodes 10, 11, and 13 increased by 101%, 105%, and 53%, respectively.	Noted. As part of the third submission, the SWM targets for the BSS lands are established based on existing conditions return period flows as determined from the MIKE 11 continuous modelling results. DHI has updated the model and completed a statistical regression of the results. The memo is attached in Appendix F.	
5	4a	Flood Storage and Flow Attenuation Within Feature 1 Further discussions are suggested regarding how (or if) the flood storage and flow attenuation of Drainage Area 300 within the existing onsite Feature 1 should be accounted for, if the Block Servicing Study continues to propose enclosure of this feature with external flows re-routed to the downstream Venetian Meats channel.	After discussions with City of Hamilton and HCA staff, it was concluded that the external catchment 300 will be conveyed by the proposed storm sewers on Lewis Rd and should exceedances occur, the downstream infrastructures (culverts and constructed channels) will be assessed to ensure sufficient capacity. Since the release rate established from the pond design in the 2nd BSS submission is significantly lower than the existing scenario flows from the catchment 302B and 202 (Refer to Table 5-4), the pond rating curves developed as part of the 2nd submission were used in Mike 11 model's post-development scenario to minimize downstream exceedances to the greatest possible extent. Capacity assessment of the VM's channel and culverts has been completed in section 5.6.2 of the report	
6	4b	Assessing the Potential Effects of Enlarging the Highway 8, Lewis Road and Barton Street Culvert Crossings The proposed upgrades to culvert crossings may reduce flow attenuation, and possibly increase flows, water levels and velocities downstream of the crossings. Depending on the proposed upgrades, a downstream impact assessment may be required, and would be based on a comparison of the following scenarios: • Existing land use, with existing SWM (if any), existing conditions at all hydraulic structures, and accounting for the flow attenuation at the crossings. • Proposed site land use, existing land use offsite, with proposed site SWM and existing offsite SWM (if any), proposed crossing details, existing conditions at all offsite hydraulic structures and downstream channel sections, and accounting for the flow attenuation at ALL hydraulic structures. • The review is requested to include the range of storms evaluated in the overall study. This recommended assessment differs from the assessments undertaken to date to support this study, where flow attenuation at hydraulic structures appears to have been ignored.	The updated Mike 11 continuous model accounted for the proposed and existing infrastrucutre and the model simulates the hydraulic impacts of the various strctures including attenuation.	
7	5	Comparison of Peak Flows under Proposed Conditions with SWM Controls to Existing Conditions for Four Storm Events This previous HCA review comment has been addressed.	No further response required.	
8	6	Peak Flow Comparison Locations Downstream of the Site for the Various Pond Rating Curve Scenarios This previous HCA review comment has been addressed.	No further response required.	
9	7	Channel Capacity in the Venetian Meats Channel This previous HCA review comment has been addressed.	No further response required.	
10	8	Comparison of Peak Flows under Proposed Conditions with SWM Controls to Existing Culvert & Channel Capacities HCA had recommended that a table be included comparing the peak flow rates under Proposed Conditions with SWM Controls to the existing flow capacities of culverts and channel sections downstream of the site. It is expected that the previous HCA review comment will be addressed at the Detailed Design stage.	The capacity of the VM's channel and downstream culvert is compared to the generated 100-year flow (with and without controls) in Table 5-6 and 5-7 of the report	

#	Comment #	HCA Sub 2 Comment	Sub 3 Response	Responsibility
11	9	Comparison of Peak Flows under Future Uncontrolled Conditions to Existing Culvert & Channel Capacities As an update to the same evaluation from the SCUBE 2013 study, HCA had recommended that there be a comparison of peak flow rates under Future Uncontrolled Conditions (Regional and 100 year event) to the existing flow capacities of culverts and channel sections at the QEW and CNR crossings downstream of the site. It is expected that the previous HCA review comment will be addressed at the Detailed Design stage.	The capacity of the VM's channel and downstream culvert is compared to the generated 100-year flow (with and without controls) in Table 5-6 and 5-7 of the report. Location of the culverts has also been shown in Table 5-7	
12	10	Reduced Peak Flow Rates between Node 1 and Node 5 under Existing Conditions The previous HCA review comment has been addressed.	No further response required.	
13	11	Lack of Change in 100 year Storm Event Peak Flow Rate between Node 5 and Node 8 under Existing Conditions The previous HCA review comment has been addressed.	No further response required.	
14	12	Reduced Peak Flow Rates between Node 13 and Node 14 under Existing Conditions The previous HCA review comment has been addressed.	No further response required.	
15	13	Drainage of Catchments 200 & 201A The previous HCA review comment has been addressed.	No further response required.	
16	14	External Conveyance Sewer System: The previous HCA review comment has been addressed.	No further response required.	
17	15	Statistical Distribution Selection -Appendix F The previous HCA review comment has been addressed.	No further response required.	
18	16	Proposed Condition with SWM Control Peak Flows for Node 1 The previous HCA review comment has been addressed.	No further response required.	
19	17	Final Hydrology and Hydraulics Modeling Files to be Provided Once finalized, HCA would request that a copy of all modelling files be provided.	Noted	
20	18-23	SWM Pond Design All previous HCA review comments related to SWM pond design (comments #18-23) have been addressed.	Acknowledged	
21	24	Proposed % Imperviousness Values HCA had suggested it should be confirmed the proposed imperviousness values are consistent with the Fruitland Winona Secondary Plan and SCUBE SWS 2013. In reviewing the revised report and responses, HCA notes the proposed % imperviousness (approximately 70%) are considerably larger than that which was assumed in the SCUBE 2013 Subwatershed Study (50%). Notwithstanding the on-going review of the modelling, it is noted the proposed increase in imperviousness could potentially increase the regulatory floodplain downstream.	Noted.	
22	25	Recommended Runoff Coefficients by Land Use See comment #24 above.	No further response required.	
23	26	Available Topography Data Used in the Study HCA had requested additional details regarding the topographic data used for this study, including source, date created, contour interval, etc. The previous HCA review comment has been addressed. That said, it is expected that there is a typo, and that the contour interval of the GTA Mass Points and Breaklines 2002 data is 1.0m, not 10.0m. It is also expected that the 2017 Mclaren topographic survey was the primary source of topographic data for the study.	The 2017 Mclaren topographic is the primary source of the topographic data. The typo has been fixed in the report.	

December 4, 2019

Rob Merwin, P.Eng.
Urbantech
2030 Bristol Circle, Suite 201
Oakville Ontario L6H 0H2

Our ref: 88/11747/

Dear Mr. Merwin

Re: Block 3 Servicing Strategy (B3SS) Traffic Impact Study

Response to City Comments

GHD was retained to prepare a Traffic Impact Study (TIS) for the proposed Fruitland-Winona Secondary Plan-Tertiary Plan residential subdivision development located on the north side of Highway Way 8 and south side of Barton Street, between McNeilly road and Winona Road, in Stoney Creek, City of Hamilton.

GHD had previously received comments from City staff pertaining to the Block Servicing Strategy (BSS) Area #3, dated May 11, 2017 and February 16, 2019. Subsequently GHD provided an updated traffic study dated July 2019, which the City has now commented on in their response letter dated October 11, 2019.

The purpose of this letter is to provide GHD's response to those comments.

F. <u>Transportation</u>

a. *Executive Summary Page i: LOS F at intersection of McNeilly, and Lewis Road on Barton St. The intersection analysis data and results should be passed on to the Barton St, & Hwy8 study consultant for their review and consideration.*

GHD Response:

It is our understanding that the City has already passed this information along to the Barton Street and Hwy 8 Study consultant.

b. *Item 2.2.3, 3rd paragraph: Local Road ROW, unclear if the on-street parking is beyond the roadway pavement width of 8m. It should be additional. Make it clear. Include a proposed cross section, in Appendix L and cross reference it in the description.*

GHD Response:

The proposed 20 metre Local Road ROW is consistent with the City's Standard No. RD-113.01 and includes an 8 metre pavement width and provides sidewalks on both sides of the road and on-street parking. A cross section figure is provided in Appendix H of the report.

c. *Item 3.1: Existing McNeilly and Lewis Roads;*

- *TIS does not discuss road cross sections. It is recognized, however, that the main body of this Draft Report Section 4.2 Roadworks (pg. 27) discusses road ROWs and proposed cross section features to be designed according to City standards, as well as Appendix L which provides the Local Road Cross section.*

  GHD Response:

  The July 2019 TIS provides a discussion of road cross sections in Section 2.2.3 of the report. Appendix H of the report provides the Local Road Cross section.

- *The Main Report also considers reports used in this study. The list is missing a couple of Reports, which guide the cross sections for collector roads. They are*
  i. *the Pedestrian Mobility Plan,* *https://d3fpllf1m7bbt3.cloudfront.net/sites/default/files/media/browser/2014-12-17/hamilton-pedestrian-mobility-plan.pdf*

  ii. *and the Cycling Master Plan.* *https://d3fpllf1m7bbt3.cloudfront.net/sites/default/files/media/browser/2018-06-06/draft-tmp-backgroundreport-cyclingmp-11-1.pdf*

  GHD Response:

  Noted. No further response required.

- *Please note that SCUBE TMP is used as a guiding document for further transportation related Municipal Class Environmental Assessment (MCEA) requirements within the Fruitland-Winona Secondary Plan area, and it does not recommend that any further studies should be conducted for the above mentioned existing roadways. Thus, detailed design and construction are to be urbanized and are expected to be implemented through the development process.*

  GHD Response:

  Noted. No further response required.

d. *Item 5.3: Block 3 Study Area is currently not a developed area and so, we are not sure if the TTS data can be utilized for site distribution traffic? This may need to be monitored during the phasing of implementation process.*

GHD Response:

TTS data specific to Block 3 is not available in TTS and therefore the distribution was based averaging the data provided within TTS for the areas of Hamilton, Stoney Creek and Grimsby to origin/destinations locally and the GTA.

e. *Item 8.4: Proposed Internal Intersection Control: Recommendation should be included to consider mini-roundabout/traffic circle during the draft plan stage, as a traffic control & calming measure to address safety, speeding issues etc. Recommendation to consider other forms of traffic control should also be included. Include these in Section 9.2, Summary Recommendations*

GHD Response:

Noted. The report has been revised to include these recommendations.

Should you have any questions on the above, feel free to contact us below for further clarification.

Sincerely,

GHD

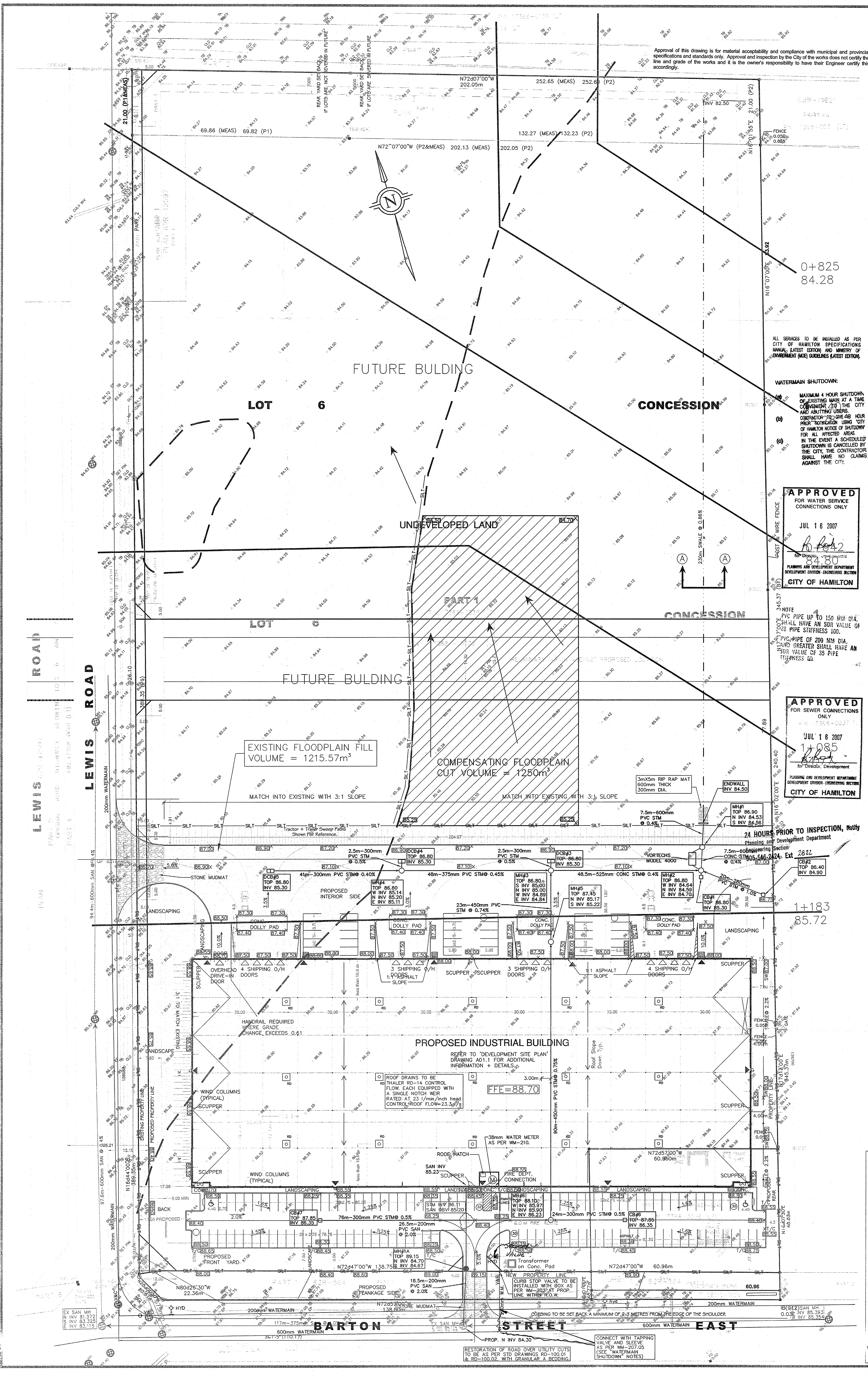
William Maria, P.Eng.
Senior Project Manager

Arcadis Response to City of Hamilton Comments, dated September 12, 2019

No.	City of Hamilton Comment	Arcadis Response
1	A Comment Response table has not been provided with the revised Block 3 Servicing Strategy. This would be helpful to ensure that all previous comments have been addressed.	Comment response table is now provided.
2a i	Policy Review: A policy review has been provided within Section 1.1 of the EIS. There is concern that a comprehensive discussion has not been provided. Natural Heritage System: Based on mapping within Volumes 1 and 2 of the Urban Hamilton Official Plan (UHOP), a Natural Heritage System has not been identified within Block 3. It was identified within previous comments (April 3, 2019) that there are features within the Natural Heritage System that are not mapped. These features include habitat for Species at Risk (SAR) and Significant Wildlife Habitat (SWH). There is concern that this has not been discussed within the EIS.	Section 1.1 has been updated.
2a ii	Fruitland Winona Secondary Plan: Block 3 is located within the Fruitland Winona Secondary Plan. There is concern with Section 1.1.4 (Fruitland Winona Secondary Plan) of the revised EIS. Discussions focus on the Stoney Creek Urban Boundary Expansion Subwatershed Study and not on policies of the Secondary Plan.	Section 1.1.4 has been updated.
2b i	Field Surveys: Generally, field surveys were undertaken according to approved protocols. Watercourses: Within Table 2-1 (Summary of Natural Environment Surveys Completed), it has been identified that aquatic habitat assessments were completed June 26, July 3, and July 10, 2019. Since these watercourses may exhibit ephemeral conditions, there is concern that the field surveys were not completed in spring or fall.	An additional fall survey of the watercourses was completed on November 22, 2019.
2c i	Watercourses: A Fish Habitat Assessment has been included within Appendix E; however, there is concern that discussions have not been provided within the main EIS. Further clarification is required.	The discussion on fish habitat has been revised.
2c ii	The Fish Habitat Assessment focuses on the field survey that was undertaken on July 10, 2019. Within Table 2-1 (Summary of Natural Environment Surveys Completed), it was identified that assessments were completed June 26, July 3 and	The Fish Habitat Assessment has been updated and includes the fall visit. Findings from all other assessments were the same at each Site visit.

No.	City of Hamilton Comment	Arcadis Response
	July 10, 2019. Further clarification is required on why the other assessments have not been discussed.	
2c iii	Discussions within the Fish Habitat Assessment are focused on direct fish habitat. There is concern that indirect habitat has not been thoroughly considered. Further clarification is required.	Additional discussion has been provided.
2d	Locally Rare Species: Carolina Wren, a locally rare species has been observed breeding within the study area. Within previous comments (April 3, 2019), there was concern that the impact of development on this species was not considered. Based on review of the revised EIS, there is concern that this comment has not been adequately addressed. Discussions with regards to this species are missing from Sections 3.3.1 (Breeding Bird Surveys) and 5 (Identification and Assessment of Impacts). In addition, there is concern with the limited discussion that has been provided within Sections 6 (Mitigation Measures) and 7 (Recommendations). Further discussion is required.	Additional discussion has been provided.
2e i	SAR: SAR is under the jurisdiction of the Ministry of Environment, Conservation and Parks (MECP) (formerly Ministry of Natural Resources and Forestry (MNRF)). In previous comments (April 3, 2019), there was concern that correspondence from MECP/MNRF was not included in the report. While correspondence has been provided from MECP in Appendix F (Communications), there is concern that this does not adequately address the previous comment.	No additional communication with MECP is available.
2e ii	Eastern Meadowlark/Bobolink: Surveys were undertaken to determine if these species ("threatened") were found within the Block 3 study area. The locations of the survey sites have been provided on Figure D-1 (Appendix D: Breeding Bird Surveys); however, this figure is very difficult to read. Further clarification is required.	The format of Figure D-1 has been changed to make it clearer.
2e iii	Barn Swallow: Within Appendix D (Breeding Bird Surveys), Barn Swallow, a "threatened" species was identified as possibly breeding within the study area. There is concern that this species has not been considered in the development of this area.	Barn swallow would be breeding offsite as they attach their nest on or in buildings and no buildings (or any other suitable structures) are present on Site. Barn swallow prefer barns or sheds for nesting, they attach nests either inside on walls or beams or on the outside of those types of buildings where there is an overhang. They generally return to their old nests.
2e iv	Within Section 5 (Identification and Assessment of Impacts) it has been identified that there is extensive feeding areas available in the vicinity of the area for Barn Swallow and Monarch and impacts on these species are not expected. There is	Section 5 has been revised.

No.	City of Hamilton Comment	Arcadis Response
	concern with this statement. Additional habitat within the vicinity does not recognize the potential habitat that will be lost as a result of development of this area.	
2f	SWH: Monarch, a species of "Special Concern" has been observed within the study area. Based on the Ministry of Natural Resources and Forestry (MNRF) SWH Criteria Schedules for Ecoregion 7E (January 2015), habitat for Species of Conservation Concern (not including Endangered or Threatened Species) has been identified as SWH. Included in this category are all Special Concern and Provincially Rare (S1-S3; SH) plant and animal species. Within previous comments (April 3, 2019), there was concern that this had not been discussed within the report. Based on review of the revised EIS, there is concern that this comment has not been adequately addressed. The discussion in Section 3.4.1 (Significant Wildlife Habitat) focusses on Monarch stopover areas and does not discuss this species as a Species of Conservation Concern.	Additional discussion has been provided in Section 3.4.1.
2g	Opportunities for Enhancement: In previous comments (April 3, 2019) there was concern that opportunities to retain hedgerows should be included within the development concept. While it has been identified that a tree preservation plan should be completed, there is concern that the incorporation of hedgerows has not been considered within the development concepts.	In Section 6 Mitigation Measures- it is recommended to incorporate hedgerow like plantings in the landscape design wherever possible.



General Notes:

Water

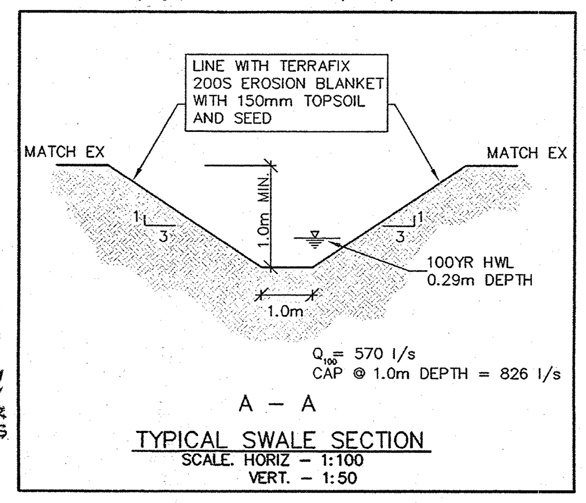
1. Water services to be installed as per Region of Hamilton-Wentworth Specifications Manual (latest edition) and Ministry of Environment (MOE) Guidelines (latest edition).
2. Minimum horizontal separation between sewer and water services to be 2.5 m. Minimum vertical separation to be 0.15m when a water service passes over a sewer and 0.50m when a water service passes under a sewer. Minimum depth cover over water services to be 1.6m.
3. As a fire service is proposed to a building, a backflow preventer may be required in accordance with the Ontario Building Code. If a backflow preventer is required it must be located at the service point of entry to the Building.
4. Watermain bedding and cover material to be installed as per WM-200.01 (concrete and PVC watermains and services) and WM-200.02 (ductile iron watermains and services) with Granular "A" for both bedding and cover.
5. "Watermain Shutdown"
(a) Maximum 4 hour shutdown of existing main at a time convenient to the City of Hamilton and abutting users.
(b) Contractor to give 48 hour prior notification using the "City of Hamilton Notice of Shutdown" for all affected areas.
(c) In the event a scheduled shutdown is cancelled by the City of Hamilton, the contractor shall have no claims against the City.
6. Thrust blocks as per RWS-400 to be installed at all water service elbows, plugs, tees etc.
7. All hydrants are to be installed as per WM-203.01 and/or WM-203.02, as applicable, and are to be complete with a secondary valve.
8. PVC watermain material, tracer wire and cathodic protection installation to be as per Regional Standard Form RHW-1600.
9. The main fire hydrant valve to be opened left, with clear markings cast in the bonnet showing an open left directional indicator arrow, as per former City of Stoney Creek standards.

Sanitary Sewer

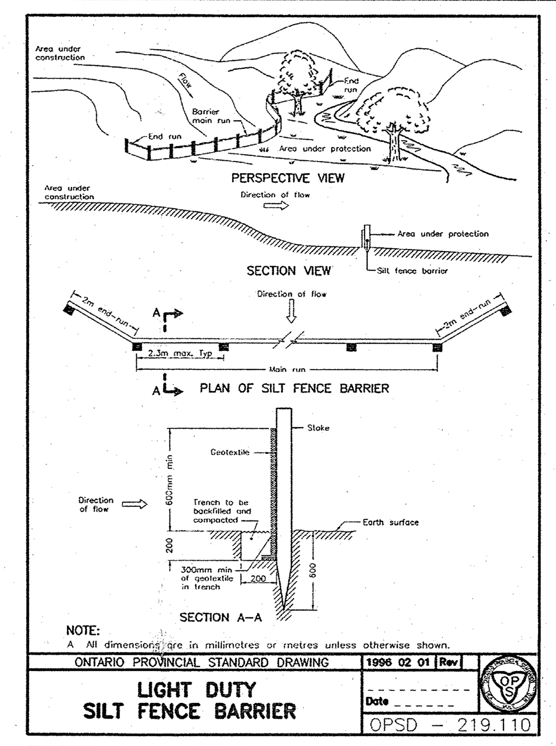
1. Sanitary sewer services to be installed as per Region of Hamilton -Wentworth Specifications Manual (latest edition) and Ministry of Environment (MOE) Guidelines (latest edition).
2. Sanitary maintenance holes to be as per OPSD 701.010, and are to be sumpless.
3. Sanitary sewers to be installed with a minimum cover of 2.20m at the property line below the final grade or at such higher elevation only as may be necessitated by the elevation of the main sewer. On private property the minimum cover is to be no less than 1.2 m.
4. All proposed sanitary sewers to be PVC SDR 35 material.
5. Sewer bedding, cover and backfill must be as per OPSD 802.010 with Granular 'A' for both bedding and cover.

Storm Sewer

1. All proposed storm sewers to be PVC SDR 35 material.
2. Sewer bedding, cover and backfill must be as per OPSD 802.010 with Granular 'A' for both bedding and cover.
3. Proposed catchbasins to be constructed as per OPSD 705.010 (single) and OPSD 705.020 (double).

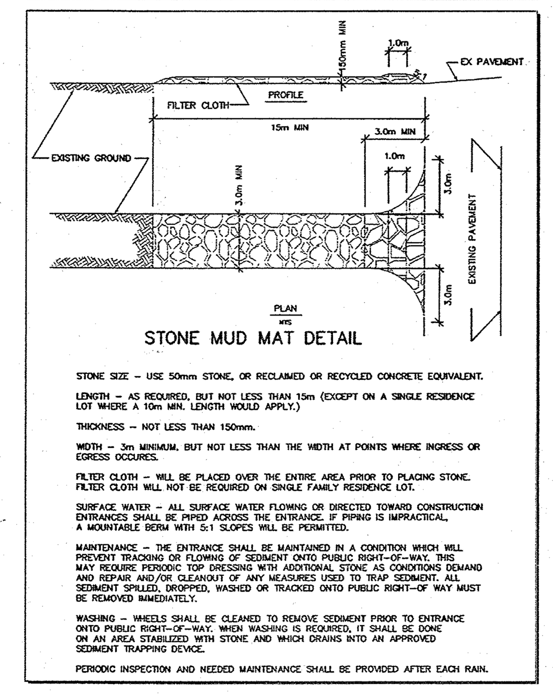


TYPICAL SWALE SECTION
SCALE: HORIZ. = 1:100
VERT. = 1:50

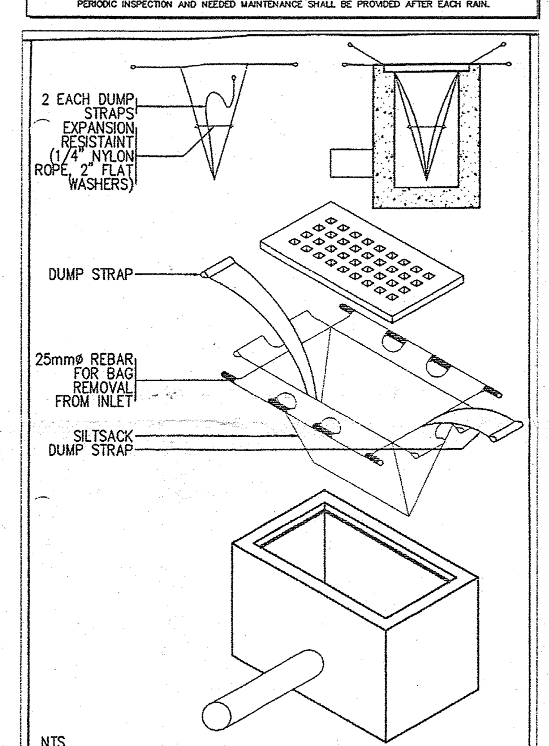


LIGHT DUTY SILT FENCE BARRIER

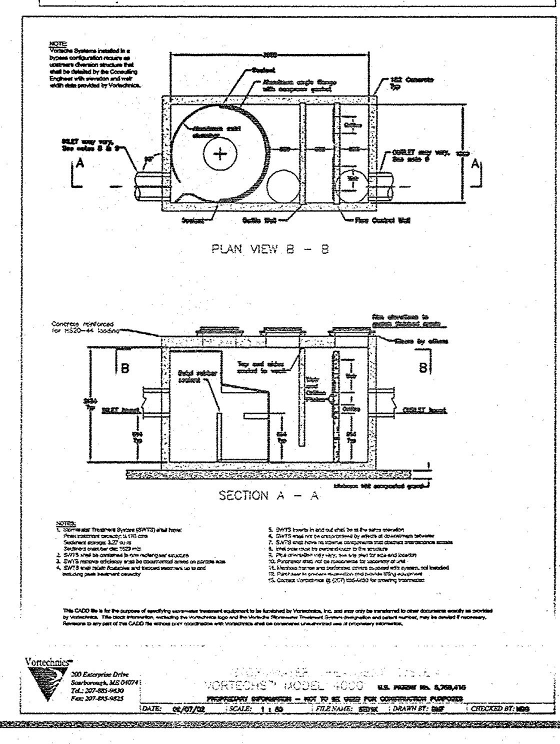
OPSD - 219.110

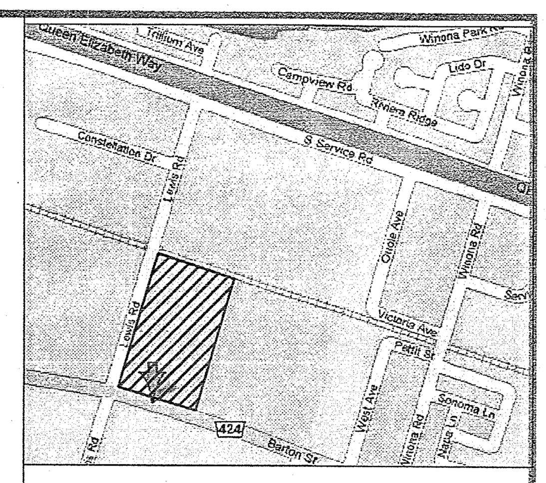


STONE MUD MAT DETAIL



SILT PROTECTION FOR ROADWAY CATCH BASIN'S (SILTSACK)





KEY PLAN SITE:

PART OF LOT 6
CONCESSION 1
CITY OF STONEY CREEEK

REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH

(GEOGRAPHIC TOWNSHIP OF SALTFLEET)

BENNETT YOUNG LIMITED
PROFESSIONAL LAND SURVEYORS

BENCH MARK

ELEVATIONS ARE GEODETIC AND REFERRED TO GEODETIC SURVEY OF CANADA BENCHMARK No. 75U228, HAVING A PUBLISHED ELEVATIONOF 88.001 METRES.

DEVELOPMENT + SITE STATISTICS

DEVELOPMENT AREA	28,369.4 SM	305,376 SF	7.01 AC.
BUILDING AREA / COVERAGE	13,368.1 SM	143,898 SF	47.1 %
TOTAL GROSS FLOOR AREA	13,351.5 SM	143,719 SF	47.0 %
LANDSCAPED & SEEDED AREA	9,623.2 SM	103,587 SF	33.9 %
PAVED VEHICLE ACCESS AREA	5,378.1 SM	57,891 SF	19.0 %
PAVED AREA OUTSIDE DEVELOPMENT AREA	297.4 SM	3,201 SF	

SETBACKS - BUILDING	REQUIRED	PROVIDED
SOUTH-FLANKAGE SIDE YARD	9.0m MIN.	27.080m
NORTH-INTERIOR SIDE YARD	3.0m MIN.	36.576m
WEST-FRONT YARD	9.0m MIN.	17.055m
EAST-REAR YARD	7.5m MIN.	7.540m

TOTAL SITE AREA	80,697.18 sq.m.	19.94 acres
SITE AREA FOR PROPOSED BLD	28,369.40 sq.m.	7.01 acres
AREA OF SEVERANCE - NORTH	50,827.09 sq.m.	12.56 acres
AREA OF ROAD WIDENING	1,500.69 sq.m.	0.37 acres

NOTE: AREAS TO BE CONFIRMED BY AN ONTARIO LAND SURVEYOR.

PARKING
REQUIRED INDUSTRIAL (1 SPACES/100sm) 134

PARKING PROVIDED		
TYPICAL PARKING SPACE	2.7m X 5.8m	149 SPACES
H/C PARKING SPACE	4.4m X 5.8m	2 SPACES
TOTAL		151 SPACES
ACCESS DRIVEWAY	6.0m	

LOADING SPACES	REQUIRED	PROVIDED
COMMERCIAL	-	14 SPACES

LEGEND

- CATCHBASIN
- DOUBLE CATCHBASIN
- PROPOSED STORM MANHOLE
- PROPOSED CATCHBASIN MANHOLE
- PROPOSED SANITARY MANHOLE
- VALVE AND BOX
- VALVE AND CHAMBER
- HYDRANT AND VALVE
- 89.70 PROPOSED ELEVATION
- EXISTING ELEVATION
- EXISTING REGULATORY FLOODLINE (PHILIPS ENGINEERING OCT 2005)
- 1+085 / 84.77 HEC RAS CROSS-SECTION; FLOODPLAIN CROSS SECTION LOCATION; FLOODPLAIN ELEVATION
- STONE MUDMAT
- —SILT— SILT FENCE OPSD 219.110

REVISIONS AND DISTRIBUTION LOG

Rev.	Date	Note
1	FEB 28/07	COMPLETED SITE SERVICING, GRADING AND STORMWATER MANAGEMENT DESIGN
2	MAY 23/07	RE-ISSUED FOR CITY, HCA REVIEW
3	JUNE 15/07	REVISED AS PER CITY COMMENTS

THE CONTRACTOR SHALL CHECK ALL DIMENSIONS AND REPORT DISCREPANCIES TO THE ARCHITECT.

ALL DIMENSIONS ARE GIVEN IN MILLIMETRES UNLESS OTHERWISE INDICATED.

DO NOT SCALE DRAWINGS.

a.m.candaras associates inc.
consulting engineers
8551 Weston rd., suite 203
Woodbridge ont. L4L 9R4
905-850-8020 Fax 905-850-8099
Email: civil@amcai.com

Giffels
30 International Blvd.
Toronto (Rexdale), Ontario
M9W 5P3
Giffels Design-Build Inc.
Tel. #(416) 798-5500

LICENSED PROFESSIONAL ENGINEER — JUNE 18/07 — A. M. CANDARAS — PROVINCE OF ONTARIO

EP03240A
EP03239A
LSP_2537

Project:
MULTI-TENANT BUILDING
1175 BARTON STREET E
CLIENT

STONEY CREEK ONTARIO

Drawing Title: Site Servicing / Grading / Stormwater Management

Drawn By:	Checked By:	Date Checked:	Project No.
N.A.C.	N.A.C.	__	0575

Date Plotted: Jun 18, 2007 - 9:34am | Scale: 1:500

Drawing Name: 0575-G1 | Revision No.: NO.1

APPENDIX N
PUBLIC CONSULTATION

N-1 Public Stakeholder List
N-2 Notice of 30 Day Public Review
N-3 Landowner Letters
N-4 PIC Materials

APPENDIX N-1
Public Stakeholder List

Last Name	*First Name*	*Title*	*Job Title*	*Organization*	*Street Address*	*City and Province*	*Postal Code*	*Contact Information*
City of Hamilton Staff **TO BE SENT ELECTRONIC COPY OF MAILOUT***								
Fazio	Margaret		Liason to City Staff/Project Team		28 James Street North, 5th Floor	Hamilton, ON	L8R 2K1	905-546-2424 x2218
Councillors								
Johnson	Brenda	Ms.	Councillor, Ward 11	City of Hamilton	71 Main Street West, 2nd Floor	Hamilton, ON	L8P 4Y5	905-546-2424 x4513
Pearson	Maria	Ms.	Councillor, Ward 10	City of Hamilton	74 Main Street West, 2nd Floor	Hamilton, ON	L8P 4Y5	905-546-2424 x2701
Other Municipalities								
Ranjan	Kumar	Mr.	Associate Director Transportation Planning Public Works	Niagara Region	2201 St. David's Road	Thorold, ON	L2V 4T7	905-685-1571 x3226 Fax 905-687-4977 pam.gilroy@regional.niagara.on.ca
Vout	Katherine	Ms.	Town Clerk	Town of Grimsby	160 Livingston Avenue P.O. Box 159	Grimsby, ON	L3M 4G3	905-945-9634 x2003 Fax 905-945-5010 kvout@town.grimsby.on.ca
Conservation Authority								
Peck	Scott	Mr.	Director, Watershed Planning & Engineering	Hamilton Conservation Authority	838 Mineral Springs Road, Box 81067	Ancaster, ON	L9G 4X1	905-525-2181 x130 Fax: 905-648-4622 tspeck@conservationhamilton.ca
Stone	Michael	Mr.	Manager, Watershed Planning Services	Hamilton Conservation Authority	838 Mineral Springs Road, Box 81067	Ancaster, ON	L9G 4X1	(905) 525-2181 ext 133 mstone@conservationhamilton.ca
Provinicial Authorities								
Environmental Assessment & Approvals Branch			E/A Project Co-ordination Section	Ministry of the Environment and Climate Change	2 St. Clair Ave. W. 14th Floor	Toronto, ON	M4V 1L5	MEA.NOTICES.EAAB@ontario.ca
Graham-Watson	Loraine	Ms.	Regional Director - Hamilton/Niagara Regional Office	Ministry of Community and Social Services	119 King St. W. 7th Floor	Hamilton, ON	L8P 4Y7	905-521-7844
Head - Highway Engineering - Hamilton & Niagara				Ministry of Transportation	1201 Wilson Ave., Bldg. D., 3rd Floor	Downsview, ON	M4V 1L5	416-235-4540 Fax 416-235-3576
		Sir/Madam	Consultation Unit	Ministry of Indigenous Relations and Reconciliation	160 Bloor Street East, 9th Floor	Toronto, ON	M7A 2E6	Tel: (416) 326-4740 Fax: (416) 325-1066 MAA.EA.REVIEW@ontario.ca
Hagman	Ian	Mr.	District Manager, Guelph District Office	Ministry of Natural Resources	1 Stone Rd. W.	Guelph, ON	N1G 4Y2	519-826-4931 Fax 519-826-4929
Slattery	Barbara	Ms.	Environmental Assessment & Planning Co-ordinator	Ministry of the Environment and Climate Change	119 King St. W., 12th Floor	Hamilton, ON	L8P 4Y7	905-521-7864 Fax 905-521-7806 barbara.slattery@ontario.ca
Troje	Corwin	Mr.	Manager, Ministry Partnerships Unit	Ministry of Aboriginal Affairs Consultation Unit	160 Bloor Street East, 9th Floor	Toronto, ON	M7A 2E6	
Van Room	Pauline	Ms.	Highway Engineering Hamilton	Ministry of Transportation	1201 Wilson Ave; Bldg. D. 4th Floor	Downsview, ON	M4V 1L5	
Weeks	J. R.	Staff Sargeant		Ontario Provincial Police, Burlington Detachment	1160 North Shore Blvd. E., P.O. Box 5021,Stn. "A"	Burlington, ON	L7R 3Y8	
Whitebread	Ken	Mr.	Manager	Niagara Escarpment Commission	232 A Guelph Street	Georgetown, ON	L7G 4B1	

Whittingham	Carlene	Ms.	Planner	Ministry of Municipal Affairs & Housing	777 Bay St., 13th Floor	Toronto, ON	M5G 2C8	P: 416-585-6062
Hatcher	Laura		Team Lead - Heritage Land Use Planning	Ministry of Tourism, Culture & Sport	401 Bay Street, 17th Floor	Toronto, ON	M7A 0A7	416-314-3108 Fax 416-314-7175 laura.e.hatcher@ontario.ca
Federal Authorities								
Consultation and Accommodation Unit				Indigenous and Northern Affairs Canada	300 Sparks Street, Room 205	Ottawa, ON	K1A 0H4	UCA-CAU@aadnc-aandc.gc.ca This email will distribute any notice to appropriate staff within AANDC
Environmental Assessment & Approvals Branch		Sir/Madam	E/A Project Co-ordination Section		2 St. Clair Ave. W. 14th Floor	Toronto, ON	M4V 1L5	MEA.NOTICES.EAAB@ontario.ca
Hall	John	Mr.	Remedial Action Plan (RAP)	Canadian Center for Inland Waters	867 Lakeshore Road P.O. Box 5050	Burlington, ON	L7R 4A6	
Knox	Louise	Ms.	Director, Ontario Region	Canadian Environmental Assessment Agency	55 St. Clair Ave E. Room 907	Toronto, ON	M4T 1M2	416-952-1575 Fax 416-952-1573 louise.knox@ceaa-acee-gc.ca
Ministry of Health & Long Term Care, Emergency Health Services Health		Sir/Madam	Integrated Policy & Planning Division		80 Grosvenor Street - 8th Floor, Hepburn Block	Toronto, ON	M7A 1R3	hamiltoncaccalerts@ontario.ca
Pachoil	Carol	Ms.	Retail Business Manager	Canada Post Commercial Service Centre	27 Legend Crt	Ancaster, ON	L9K 1J0	905-304-2225
Speller	Rachel	Ms.	Environment Officer- Environment Unit, Ontario Region	Lands and Trusts Services Env. Unit INAC	25 St. Clair Ave. E. 8th floor	Toronto, ON	M4T 1M2	416-973-5899 Fax 416-954-4328
Waters	Susan	Ms.	Director, General Land and Environment Department	Indigenous and Northern Affairs Canada Land and Environment Department	10 Wellington St.	Gatineau, QC	K1A 0H4	Telephone: 819-997-8883 Fax: 819-953-3201 susan.waters@aandc.gc.ca
			Environmental Coordinator	Transport Canada	4900 Yonge Street, 4th Floor (PHE)	North York, ON	M2N 6A5	
First Nations								
Durand	Tina	Ms.	Secretary Political Sector	Huron-Wendat Nation Council	255 Place Chef Michel-Laveau	Wendake, QC	G0A 4V0	418-843-3767 1-877-712-3767 Fax: 418-842-1108
General	Paul	Mr.	Lands & Resources	Six Nations Eco-Centre	1721 Chiefswood Road	Oshweken, ON	N0A 1M0	519-445-0330 pgeneral@sixnations.ca
Bomberry	Lonny	Mr.	Director of Lands & Resources	Six Nations of the Grand River Territory	P.O. Box 5000, 2498 Chiefswood Road	Oshweken, ON	N0A 1M0	519-445-2201 Fax: 519-445-4208
Hill	Leroy	Hohahes	Secretary to Haudenosaunee Conferacy Chiefs Council	Haudenosaunee Chiefs Council	2634 6th Line RR2	Oshweken, ON	N0A 1M0	(519) 753-0665 Fax (519) 753-3449

LaForme	Mark	Mr.	Director, Department of Consultation and Accomodation	Mississaugas of New Credit First Nation	6 First Line, R.R. #6	Hagersville, ON	N0A 1H0	Tel: (905) 768-4260 Fax: (905) 768-9751 Cell: (289) 527-6577 Email: Mark.Laforme@Newcreditfirstnation.com, doca@newcreditfirstnation.com
Sault	Fawn		Manager, Department of Consultaiton and Accomodation	Mississaugas of New Credit First Nation	6 First Line, R.R. #6	Hagersville, ON	N0A 1H0	Fawn.sault@newcreditfirstnation.com
Utilities								
Ardelli	Terri	Ms.	Land Analyst, Urban	TransCanada Pipelines	450-1st Street S.W.	Calgary, AB	T2P 5H1	403-920-7370
Blakely	John	Mr.	Senior Right-of-Way Agent	Enbridge Pipelines Inc.	1086 Modeland Road,	Sarnia, ON	N7S 6L2	john.blakely@enbridge.com
Carello	Jack	Mr.	Manager, Utilities East	Canadian Pacific Railway	1290 Central Parkway West,	Mississauga, ON	L5C 4R3	Phone: 905-803-3417
Greco	Enzo	Mr.	Construction Project Manager	Union Gas	918 South Service Road	Stoney Creek, ON	L8E 5M4	Phone: (289) 649-2061 Cell: (905) 741-8395 Email: egreco@uniongas.com
Harten	Ron	Mr.	General Manager, Hamilton Community Energy	Hamilton Utilities Corporation	The Textile Building 10 George Street Suite 300	Hamilton, ON	L8P 1C8	Ron.Harten@hamiltonucorp.com
Oriotis	Jim	Mr.		Hydro One	483 Bay Street, North Tower 15th Floor	Toronto, ON	M5G 2P5	jim.oriotis@hydroone.com
Lane	Paul	Mr.		Sun Canadian Pipeline	830 Highway 6 North P.O. Box 470	Waterdown, ON	L0R 2H0	905-689-6641 x136 Fax 514-395-5613 plane@sun-canadian-com
Leppert	Randy	Mr.	Planning Lead Hand Niagara/Hamilton	Cogeco Cable Inc	7170 McLeod Rd	Niagara Falls, ON	L2G 3H5	Phone: 289-296-6228 Cell: 905- 351-3771 randy.leppert@cogeco.com
Linder	Stefan	Mr.	Manager, Public Works Design & Construction	CN	4 Welding Way off Administration Road	Vaughan, ON	L4K 1B9	905-669-3264 email: Stefan.Linder@cn.ca
Milano	Bruno	Mr.	Planner/Designer	Source Cable	1090 Upper Wellington St	Hamilton, ON	L9A 3S6	Work # 905-318-4663 Cell # 905-971-2762
Mitchell	Colleen	Ms.	Land Agent - Eastern Pipeline Operations	Imperial Oil Products & Chemical Division	100 - 5th Concession Rd. E.	Waterdown, ON	L0R 2H1	1-888-242-6660 x242 colleen.m.mitchell@esso.com
Newman	Ann	Ms.	Crossings Co-ordinator, Eastern Region	Enbridge Pipelines Inc.	1086 Modeland Road, Building 1050	Sarnia, ON	N7S 6L2	(519)339-0503 ann.newman@enbridge.com
Ontario Power Generation	Sir/Madam				700 University Avenue	Toronto, ON	M5G 1X6	416-592-2555
Jakubowski	Mark	Mr.	Acting Manager of Capital Projects	Horizon Utilities Corporation	55 John St. N., 6th Floor	Hamilton, ON	L8R 3M8	
				Bell Canada	20 Hunter St. W.	Hamilton, ON	L8N 3H2	
Winkley	John	Mr.	Regional Director - Marketing	Southern Ontario Railway	241 Stuart St. W.	Hamilton, ON	L8N 3P9	
Hospitals								
Schools								
White	Todd	Mr.	Chair	Hamilton-Wentworth District School Board	20 Education Court	Hamilton, ON	L9A 0B9	289-237-1644
Daly	Pat		Hamilton District Catholic School Baord	90 Mulberry Street	P.O. Box 2012	Hamilton, ON	L8N 3R9	
Pace	P.		Hamilton District Catholic School Baord	90 Mulberry Street	P.O. Box 2012	Hamilton, ON	L8N 3R9	
McKerrall	Dan	Mr.	Accommodation & Planning	Hamilton-Wentworth District School Board	100 Main St. W. P.O. Box 2558	Hamilton, ON	L8N 3L1	

Mckerlie	Ron	Mr.	President	Mohawk College	135 Fennell Avenue West P.O. Box 2034	Hamilton, ON	L8N 3T2	
Labrecque	S.			French Public School Board	116 Cornelius Parkway	Toronto, ON	M6L 2K5	
Beaudin	A.			French Catholic School Board	110 Drewry Avenue	North York, ON	M2M 1c8	
Transportation								
Best	John	Mr.	Executive Director	Southern Ontario Gateway Council	140 King Street East, Suite 14	Hamilton, ON	L8N 1B2	905-667-0317
Burke	Chris	Mr.	Acting Director of Service Planning	Metrolinx	97 Front Street West, 4th Floor	Toronto, ON	M5J 1E6	
Ceille	Kaye	Mrs.	President	Zipcar	129 Spadina Avenue	Toronto, ON	M5V 2L3	416-977-9008
Chahal	Jagtar Singh	Mr.	Chairman & CEO	Hamilton Cab	430 Cannon Street East	Hamilton, ON	L8L 2C8	905-522-0748
Leach	Dave	Mr.	President & Chief Executive Officer	Greyhound	36 Hunter Street East	Hamilton, ON	l8N 3W8	905-521-3088
Rizzuto	Anthony F.	Mr.	President	Blue Line Taxi	160 John Street South	Hamilton, ON	L8N 2C4	905-525-2788
Salsberg	Lisa	Mr.	Manager, Strategic Strategy and Policy	Metrolinx	97 Front St W, 4th Floor	Toronto, ON	M5J 1E6	416-202-5955 ext 25955 lisa.salsberg@metrolinx.com
Seymour	Mark.	Mr.	Chairman	Ontario Trucking Association	555 Dixon Road	Toronto, ON	M9W 1H8	416-249-7401
Sir/Madam				Canada Coach	791 Webber Avenue	Peterborough, ON	K9J 7B1	705-748-6411
Sir/Madam				Community CarShare	175 Longwood Road South, Suite 304A	Hamilton, ON	L8P 0A1	905-543-4411
Sir/Madam				Hamilton Cycling Committee				
Sir/Madam				Smart Commute Hamilton				smartcommute@hamilton.ca
Wasik	Gene	Mr.	Executive Director	Social Bicycle (SoBi)	126 Catherine Street North	Hamilton, ON	L8R 1J4	289-768-2453
Other								
Loomis	Keanin	Mr.	President & CEO	Hamilton Chamber of Commerce	120 King St. West Suite 507, Plaza Level	Hamilton, ON	L8P 4V2	(905) 522-1151
Platts	Megan	Ms.	Manager, Government & External Relations	REALTORS Association of Hamilton-Burlington	505 York Blvd.	Hamilton, ON	L8R 3K4	905-529-8101 ext. 295 fax: 905-529-4349 email: meganp@rahb.ca
Roshko	Allan J.	Mr.	President	Hamilton-Halton Home Builders Association	1112 Rymal Road East	Hamilton, ON	L8W 3N7	905-575-3344

urbantech west

APPENDIX N-2
Notice of 30 day Public Review

Notice of Draft Study Report Completion and 30 Day Public Review

The Study

Urbantech West consultant team has completed the Block Servicing Strategy for **Block 3** lands, as required in the Fruitland-Winona Secondary Plan (see map below). The Servicing Strategy describes how Block 3 lands can be serviced by considering: stormwater management facilities, stormwater drainage, wastewater and water infrastructure, local road network, air drainage, traffic and natural heritage.

The Process

The study generally fulfilled the requirements outlined in the Municipal Engineers Association Municipal Class Environmental Assessment document (EA) (2000, amended 2008, 2011 and 2015), for public consultation. Public appeal is not applicable for this project.

PUBLIC COMMENTS ARE WELCOME:

WHEN: January 16, 2020 - February 14, 2020, in order for the comments to be considered in the study process.

WHERE:

Hard copies will be available for review at:

- Stoney Creek Municipal Service Centre – Library – 777 Highway 8, Stoney Creek
- City Hall – City Clerk's Office – 1st Floor – 71 Main Street West
- City Hall – 6th Floor Front Desk – 71 Main Street West

Electronic version of the report will be available at:

- https://www.hamilton.ca/blockservicingstrategies

HOW: Direct All Comments To:

Rob Merwin, P. Eng.
Project Manager – Urbantech West
(905) 829-8818
rmerwin@urbantech.com

NEXT STEPS: Study will be considered as finalized once it is approved by City of Hamilton Council.

Information will be collected and reviewed in accordance with City of Hamilton policies. With the exception of personal information, all comments will be included in the project record.
Published in the Stoney Creek News January 16, 2020 and on the City of Hamilton Twitter account.

APPENDIX N-3
Landowner Letters

urbantech
west

February 23, 2016

[redacted]

Stoney Creek O[redacted]

Re: BLOCK 3 SERVICING STRATEGY STUDY
FRUITLAND WINONA SECONDARY PLAN AREA
LOWER STONEY CREEK
CITY OF HAMILTON

We are writing to you to inform you that a Block Servicing Study is commencing for an area that encompasses your landholding in Lower Stoney Creek, City of Hamilton.

As background, the City of Hamilton's Fruitland Winona Secondary Plan provides policies and requirements to implement the Secondary Plan. One of the requirements is the completion of a Block Servicing Strategy Study (BSS).

1312733 ONTARIO INC. has retained Urbantech West to complete the BSS for Area 3. This Area is bordered by Highway #8, Barton Street, McNeilly Road and Lewis Road which includes your Lands.

The BSS is a comprehensive study providing technical analysis and design concepts for the BSS area incorporating land use, stream systems, terrestrial and aquatic features, grading, drainage and servicing, stormwater management, hydrology, transportation and air drainage analysis.

The Study is being completed in an open and transparent process which will include Public Open Houses. Input will be welcomed by landowners and residents of the study area and input will be provided by the City of Hamilton and the Hamilton Conservation Authority.

At this time, on behalf of 1312733 Ontario Inc. we are inquiring if you would like to be an active participant in the BSS study.

Urbantech West, A Division of Leighton-Zec West Ltd.
2030 Bristol Circle, Suite 201 Oakville, Ontario L6H 0H2
TEL: 905.829.8818 FAX: 905.829.4804
www.urbantech.com

If there is interest in participating please respond to this letter by means of a letter, e-mail or a phone call to the undersigned. You will then be added to the contact list for the Study.

Sincerely,

Paul Brown
Senior Associate
Email: pbrown@urbantech.com

Cc: Jason Mosdell, 1312733 ONTARIO INC.

GLEN SCHNARR & ASSOCIATES INC.
URBAN & REGIONAL PLANNERS, LAND DEVELOPMENT CONSULTANTS

PARTNERS
GLEN SCHNARR, MCIP, RPP
GLEN BROLL, MCIP, RPP
COLIN CHUNG, MCIP, RPP

ASSOCIATES
JASON AFONSO, MCIP, RPP
KAREN BENNETT, MCIP, RPP
CARL BRAWLEY, MCIP, RPP
JIM LEVAC, BAA, MCIP, RPP

December 6, 2016

Our File: 656-001C

Name
Address1
Address2

Re: Block 3 Servicing Strategy
Fruitland-Winona Secondary Plan Area
City of Hamilton

We are writing to inform you that a Block Servicing Strategy (the "Strategy") is being initiated for an area that includes your landholdings in lower Stoney Creek, in the City of Hamilton (the "City"). This area is known as the Block 3 Servicing Strategy Area ("Block 3") and is shown on the attached plan.

The preparation of the Strategy is a requirement of the City Fruitland-Winona Secondary Plan and must be completed prior to development of the lands within Block 3 proceeding. The purpose of the Strategy is to develop grading and detailed servicing plans so that development may proceed in a coordinated and comprehensive manner. The Strategy will be used by the City to guide the review of planning applications within the Study area. All development within Block 3 must conform to the Strategy.

The Strategy must identify the land use designations, densities, and natural features within Block 3. It must also include:

- The location and configuration of schools and parks;
- A detailed local road pattern and trail system;
- The distribution of housing types;
- Meander Belt Width Assessments for all watercourses;
- A preliminary grading, servicing, and stormwater management strategy and functional design plan;
- Plans for the phasing of development and the external road infrastructure;
- The identification and consideration of all areas regulated by the Conservation Authority;
- A scoped Air Drainage Analysis Brief to assess impacts on tender fruit and grape production;
- A hydrogeological investigation; and,
- Implementation of the Fruitland-Winona Secondary Plan Urban Design Guidelines.

10 KINGSBRIDGE GARDEN CIRCLE
SUITE 700
MISSISSAUGA, ONTARIO
L5R 3K6
TEL (905) 568-8888
FAX (905) 568-8894
www.gsai.ca

1312733 Ontario Inc. (Branthaven) has retained Glen Schnarr & Associates Inc. and Urbantech West to manage and complete the Strategy to have it approved by the City as expeditiously as possible. The lands within Block 3 that are owned by 1312733 Ontario Inc. are indicated on the attached plan.

As a landowner who will be affected by the completion of the Strategy, we are writing to invite you to participate in the landowners group who will be coordinating and funding the Strategy work program. We would appreciate your response expressing your interest in participating in the landowners group.

We intend to coordinate a landowners group meeting in January 2017 to inform and explain the next steps in the Strategy process. If we do not hear from you by Friday December 23, 2016, we will take your non-response as not being interested in participating in the landowners group.

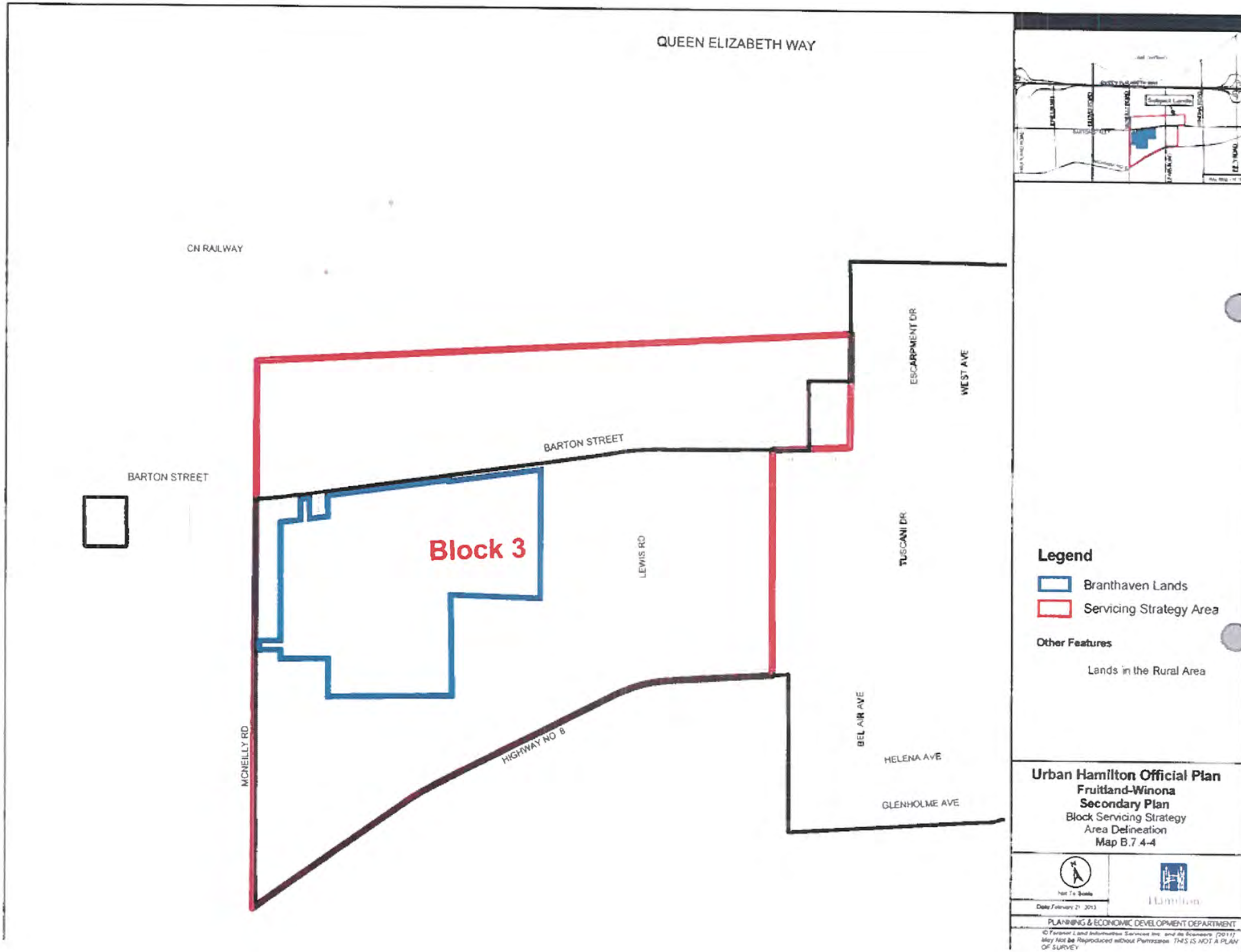
If you have any questions, please do not hesitate to contact me or Mark Bradley of our office at (905) 568-8888 or at markb@gsai.ca.

Yours very truly,

GLEN SCHNARR & ASSOCIATES INC.

Colin Chung, MCIP, RPP
Partner

C: C. Newbold, City of Hamilton
A. Mahood, City of Hamilton
M. Fazio, City of Hamilton
A. Semper, Branthaven Development Corp.
H. Sewell, Branthaven Development Corp


QUEEN ELIZABETH WAY
CN RAILWAY
BARTON STREET
BARTON STREET
Block 3
LEWIS RD
MCNEILLY RD
HIGHWAY NO 8
ESCARPMENT DR
WEST AVE
TUSCANI DR
BEL AIR AVE
HELENA AVE
GLENHOLME AVE
Legend
Branthaven Lands
Servicing Strategy Area
Other Features
Lands in the Rural Area
Urban Hamilton Official Plan
Fruitland-Winona
Secondary Plan
Block Servicing Strategy
Area Delineation
Map B.7.4-4
PLANNING & ECONOMIC DEVELOPMENT DEPARTMENT

GLEN SCHNARR & ASSOCIATES INC.
URBAN & REGIONAL PLANNERS, LAND DEVELOPMENT CONSULTANTS

PARTNERS:
GLEN SCHNARR, MCIP, RPP
GLEN BROLL, MCIP, RPP
COLIN CHUNG, MCIP, RPP

ASSOCIATES:
JASON AFONSO, MCIP, RPP
KAREN BENNETT, MCIP, RPP
CARL BRAWLEY, MCIP, RPP
JIM LEVAC, BAA, MCIP, RPP

February 17, 2017

Our File: 656-001E

[redacted]

Re: **Block 3 Servicing Strategy**
Fruitland-Winona Secondary Plan Area
City of Hamilton

This letter is further to our letter dated December 6, 2016, informing you that a Block Servicing Strategy (the "Strategy") is being initiated for an area that includes your landholdings in lower Stoney Creek, in the City of Hamilton. This area is known as the Block 3 Servicing Strategy Area and is shown on the attached plan.

As a landowner who has expressed an interest in participating in the Strategy, we are writing to invite you to a meeting on March 7, 2017, where we will present the project and answer any questions that you have. The meeting will be held in the Council Chambers of the former Stoney Creek City Hall from 6:00 p.m. to 8:00 p.m. The address is 777 Highway 8, Stoney Creek.

The agenda for the evening is as follows:

1. Open House - 6:00 to 6:45 p.m.
   - Informal review of the Block Servicing Strategy Study Area, Fruitland-Winona Secondary Plan, the Tertiary Plan, and the Servicing Plans
2. Block Servicing Strategy Presentation – 6:45 to 7:30 p.m.
   - Introduction and Purpose of the Meeting
   - Block Servicing Strategy Study Overview
   - Team Introductions
   - Tertiary Plan Overview
   - Servicing Plan Overview
   - Funding Agreement Discussion
   - Discussion of Next Steps

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FAX (905) 568-8894
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3. Question and Answer Period – 7:30 to 8:00 p.m.

If you have any questions, please do not hesitate to contact me at (905) 568-8888 or markb@gsai.ca.

Yours very truly,

GLEN SCHNARR & ASSOCIATES INC.

M. Bradley

Mark Bradley, MCIP, RPP
Senior Planner & Project Manager

C: C. Newbold, City of Hamilton
A. Mahood, City of Hamilton
M. Fazio, City of Hamilton
A. Semper, Branthaven Development Corp.
H. Sewell, Branthaven Development Corp.

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May 10, 2017 **Project:** 12-062W

[redacted]

Re: Block 3 Servicing Strategy
Fruitland-Winona Secondary Plan Area
City of Hamilton

We are writing to inform you that a Block Servicing Strategy (the "Strategy") is being initiated for an area that includes your landholdings in lower Stoney Creek, in the City of Hamilton (the "City"). This area is known as the Block 3 Servicing Strategy Area ("Block 3") and is shown on the attached plan.

The preparation of the Strategy is a requirement of the City Fruitland-Winona Secondary Plan and must be completed prior to development of the lands within Block 3 proceeding. The purpose of the Strategy is to develop grading and detailed servicing plans so that development may proceed in a coordinated and comprehensive manner. The Strategy will be used by the City to guide the review of planning applications within the Study area. All development within Block 3 must conform to the Strategy.

The Strategy must identify the land use designations, densities, and natural features within Block 3. It must also include:

- The location and configuration of schools and parks;
- A detailed local road pattern and trail system;
- The distribution of housing types;
- Meander Belt Width Assessments for all watercourses;
- A preliminary grading, servicing, and stormwater management strategy and functional design plan;
- Plans for the phasing of development and the external road infrastructure;
- The identification and consideration of all areas regulated by the Conservation Authority;
- A scoped Air Drainage Analysis Brief to assess impacts on tender fruit and grape production;

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- A hydrogeological investigation; and,
- Implementation of the Fruitland-Winona Secondary Plan Urban Design Guidelines.

1312733 Ontario Inc.(Branthaven) has retained Glen Schnarr & Associates Inc. and Urbantech West to manage and complete the Strategy to have it approved by the City as expeditiously as possible. The lands within Block 3 that are owned by 1312733 Ontario Inc. are indicated on the attached plan. In addition we are providing you with the latest draft concept plan for the lands.

As a landowner who will be affected by the completion of the Strategy, we are writing to invite you to participate in the landowners group who will be coordinating and funding the Strategy work program. We would appreciate your response expressing your interest in participating in the landowners group.

At this time there are currently a number of landowners who have decided to participate in the group. If you could please review and respond to this letter by May 26, 2017 it would be appreciated. We will take your non-response as not being interested in participating in the landowners group.

If you have any questions, please do not hesitate to contact me at 905 829-8818 or rmerwin@urbantech.com.

Regards,
Urbantech West

Rob Merwin, P. Eng.
Associate

cc: C. Newbold, City of Hamilton
A. Mahood, City of Hamilton
M. Fazio, City of Hamilton
A. Semper, Branthaven Development Corp.
H. Sewell, Branthaven Development Corp.

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west

May 7, 2019

[redacted]

RE: Block Servicing Strategy for Stoney Creek
Block 3 Concept Plan

To Whom it May Concern:

As you may be aware the Block 3 Servicing Strategy (BSS) is currently being undertaken by some of the landowners within the Block 3 area. This study is a requirement of the Fruitland Winona Secondary Plan. The purpose of this study is to develop a servicing strategy for the Block 3 lands. As part of this study a concept plan for the lands has been prepared in consultation with City of Hamilton staff. A copy of the current concept plan is attached to this letter. This plan has been included in the first submission of the BSS to the City of Hamilton in January of 2019.

This plan shows a possible concept for development of the subject lands. Should you have any feedback or questions please email rmerwin@urbantech.com or by phone at 905-829-8818 ext 1010.

Sincerely,

Rob Merwin, P.Eng.
Sr. Associate, Land Development

C:\Users\dstein\Documents\19-05-07-Landowner letter R Merwin.docx

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Rob Merwin

From: [redacted]
Sent: February 13, 2020 11:08 PM
To: Rob Merwin; Margaret Fazio
Subject: B3SS Final Draft Report Public Comments

Follow Up Flag: Follow up
Due By: February 19, 2020 4:00 PM
Flag Status: Flagged

February 13th, 2020

To: Mr. Rob Merwin, Urbantech, and
Mrs. Margaret Fazio, City of Hamilton

Re: Block 3 Servicing Strategy Notice of Completed Final Draft Report Public Comments

Dear Mr. Merwin,

We have been the owners and growers since 1974 of the agricultural specialty tender fruit property at [redacted] located in the north-west corner of Sub-area 1.

Thank you for sending us the pdf drawings and figures.

The gsai concept plan that is the basis for this B3SS study and Final Draft Report differs in density allocations from the Urban Hamilton Official Plan and Fruitland-Winona Secondary Plan Land Use Map B.7.4-1 which results in a changed density for our property at [redacted]

It would appear more practical to place Street Q on the property line.

Sincerely,

[redacted]

Rob Merwin

From:	Mahood, Alissa <Alissa.Mahood@hamilton.ca>
Sent:	February 20, 2020 9:03 AM
To:	Fazio, Margaret; Belair, Nada
Cc:	Yong-Lee, Sally; Rob Merwin
Subject:	RE: REQUEST FOR INPUT: B3SS Final Draft Report Public Comments

Hi Margaret,
I have reviewed the land use and generally it follows the secondary plan.
Thanks! Alissa

Alissa Mahood, MCIP, RPP
She/her
Senior Project Manager, Community Planning & GIS
Planning and Economic Development Department
City of Hamilton, 71 Main St W, 5th Floor, L8P 4Y5
Ph: 905.546.2424 ext. 1250
Hamilton

From: Fazio, Margaret <Margaret.Fazio@hamilton.ca>
Sent: February 14, 2020 12:45 PM
To: Mahood, Alissa <Alissa.Mahood@hamilton.ca>; Belair, Nada <Nada.Belair@hamilton.ca>
Cc: Yong-Lee, Sally <Sally.Yong-Lee@hamilton.ca>; Rob Merwin (rmerwin@urbantech.com) <rmerwin@urbantech.com>
Subject: REQUEST FOR INPUT: B3SS Final Draft Report Public Comments

Hi Alissa and/or Nada,

Could you please check the accuracy of the comment/maps of Block 3 SS Concept Plan with the FWSP?
From what I can see online, there is no discrepancy between the Block 3 SS Concept Plan and the FWSP.

Secondary Plan:
https://www.hamilton.ca/sites/default/files/media/browser/2015-01-16/urbanhamiltonofficialplan-volume2-mapb-7-4-1tomapb-7-4-4-fruitlandwinonasecondaryplan-nov2018.pdf

Property location:
https://spatialsolutions.maps.arcgis.com/apps/webappviewer/index.html?id=9b58282e4cd8424b82f5a82551020540

Also, the comment on Street Q – there is no Street Q – I assume they mean Collector D? And the Secondary Plan has a slight gap between the property line of the property just south of 262 McNeilly and 262 McNeilly itself. Block 3 SS is showing the road as abutting 262 McNeilly.
Could you please let me know if these comments make sense to you?

I'm off next week, and Rob (Urbantech) will be working on finalization of Bock 3 SS Report.

Please keep Sally and Rob both in the loop, if responding to this inquiry next week.

Thank you,
Margaret

From: [redacted]
Sent: February 13, 2020 11:08 PM
To: Rob Merwin (rmerwin@urbantech.com) <rmerwin@urbantech.com>; Fazio, Margaret <Margaret.Fazio@hamilton.ca>
Subject: B3SS Final Draft Report Public Comments

February 13th, 2020

To: Mr. Rob Merwin, Urbantech, and
Mrs. Margaret Fazio, City of Hamilton

Re: Block 3 Servicing Strategy Notice of Completed Final Draft Report Public Comments

Dear Mr. Merwin,

We have been the owners and growers since 1974 of the agricultural specialty tender fruit property at [redacted] located in the north-west corner of Sub-area 1.

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The gsai concept plan that is the basis for this B3SS study and Final Draft Report differs in density allocations from the Urban Hamilton Official Plan and Fruitland-Winona Secondary Plan Land Use Map B.7.4-1 which results in a changed density for our property at [redacted]

It would appear more practical to place Street Q on the property line.

Sincerely,

[redacted]

Rob Merwin

From: Rob Merwin
Sent: February 25, 2020 1:24 PM
To: [redacted]
Subject: RE: B3SS Final Draft Report Public Comments

Hello [redacted]
We have been advised by the City that the concept plan generally follows the secondary plan.
Please advise if you have any further comments.
Rob

Rob Merwin, P.Eng.
Sr.Associate, Land development
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From: Rob Merwin <rmerwin@urbantech.com>
Sent: February 18, 2020 9:57 AM
To: [redacted]Margaret Fazio <Margaret.Fazio@hamilton.ca>
Subject: RE: B3SS Final Draft Report Public Comments

Hi [redacted]
Thank you very much for your comments.
We in conjunction with the City are reviewing the concept plan against the land use plan and will respond on this item. In terms of Street Q, all of the local roads in the Concept Plan are intended to show how development could proceed. They do not represent an actual development application. An application for your lands or the neighbouring lands for draft plan approval will indicate the exact proposed location of local roads.
Thanks again,

Rob

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From: [redacted]
Sent: February 13, 2020 11:08 PM
To: Rob Merwin <rmerwin@urbantech.com>; Margaret Fazio <Margaret.Fazio@hamilton.ca>
Subject: B3SS Final Draft Report Public Comments

February 13th, 2020

To: Mr. Rob Merwin, Urbantech, and
Mrs. Margaret Fazio, City of Hamilton

Re: Block 3 Servicing Strategy Notice of Completed Final Draft Report Public Comments

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It would appear more practical to place Street Q on the property line.

Sincerely,

[redacted]

Rob Merwin

From: Rob Merwin
Sent: February 18, 2020 9:57 AM
To: [redacted]
Subject: RE: B3SS Final Draft Report Public Comments

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Thanks again,

Rob

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From: [redacted]
Sent: February 13, 2020 11:08 PM
To: Rob Merwin <rmerwin@urbantech.com>; Margaret Fazio <Margaret.Fazio@hamilton.ca>
Subject: B3SS Final Draft Report Public Comments

February 13th, 2020

To: Mr. Rob Merwin, Urbantech, and
Mrs. Margaret Fazio, City of Hamilton

Re: Block 3 Servicing Strategy Notice of Completed Final Draft Report Public Comments

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It would appear more practical to place Street Q on the property line.

Sincerely,

[redacted]

Ministry of Heritage, Sport, Tourism, and Culture Industries

Programs and Services Branch
401 Bay Street, Suite 1700
Toronto, ON M7A 0A7
Tel: 416.314.7147

Ministère des Industries du Patrimoine, du Sport, du Tourisme et de la Culture

Direction des programmes et des services
401, rue Bay, Bureau 1700
Toronto, ON M7A 0A7
Tél: 416.314.7147

February 25, 2020 EMAIL ONLY

Rob Merwin, P.Eng.
Project Manager
Urbantech West
rmerwin@urbantech.com

MHSTCI File	**:**	**0006855**
Proponent	**:**	**City of Hamilton**
Subject	**:**	**Notice of Draft Study Report Completion**
Project	**:**	**Block Servicing Strategy for Block 3 Lands, Fruitland-Winona**
Location	**:**	**City of Hamilton, Ontario**

Dear Mr. Merwin:

Thank you for providing the Ministry of Heritage, Sport, Tourism and Culture Industries (MHSTCI) with the Notice of Draft Study Report Completion for the above-referenced project. MHSTCI's interest in this Environmental Assessment (EA) project relates to its mandate of conserving Ontario's cultural heritage, which includes:

- Archaeological resources, including land and marine;
- Built heritage resources, including bridges and monuments; and,
- Cultural heritage landscapes.

We have reviewed the Draft Study Report and offer the following comments.

There is no mention in the draft report of cultural heritage resources in study area, potential effects of the proposed undertaking on them, or mitigation measures to address those effects. As noted in MHSTCI (then MTCS)'s letter of June 22, 2017, consideration of cultural heritage resources is part of the Municipal Class EA process, and the need for cultural heritage technical studies in support of an EA process is normally determined through MHSTCI's *Criteria for Evaluating Archaeological Potential* and *Criteria for Evaluating Potential for Built Heritage Resources and Cultural Heritage Landscapes* checklists. In this draft report there is no indication as to whether these checklists were completed, or whether some previous study ruled out the need for archaeological assessment and/or heritage impact assessment, or whether such technical studies have in fact been completed. Where completed, these technical studies should inform the decisions and commitments made in the EA report.

The final Study Report should explain how cultural heritage considerations were either addressed or found not to be applicable.

Thank you for consulting MHSTCI on this project and please continue to do so throughout the EA process. If you have any questions or require clarification, do not hesitate to contact me.

Sincerely,

Dan Minkin
Heritage Planner
Dan.Minkin@Ontario.ca

Rob Merwin

From: Rob Merwin
Sent: February 26, 2020 10:06 AM
To: [redacted] (MHSTCI)
Cc: [redacted]
Subject: RE: Block 3 Lands Fruitland-WInona Draft ESR - MHSTCI Comments

Hello [redacted],
Thank you for your comments. I have copied [redacted] of the City of Hamilton on this email so she is aware of this exchange. This question has also been raised by others and responded by Margaret. Margaret I hope it is okay but I am going to cut and paste your commentary below:

"….. first I should mention that Archaeology Stage 1 would have been included during the earlier study – Fruitland-Winona Secondary Plan (FWSP)
It was finalized in 2009, but appeals were resolved in 2014. If the Stage 1 carried out at that time recommended a Stage 2 Archaeological consideration, we would then require it from the developer-applicants at the draft plan stage.

This study generally covers the Municipal Class Environmental Assessment process **from the public consultation perspective only** , i.e. Public Information Centres and 30 day review, Notification of various agencies etc.

The ultimate decision of approval lies with Council, as the projects in question have already gone through an extensive appeal – available public engagement process and full consideration of alternatives which included natural environment, socio-economic considerations and Cultural Heritage, including Archaeology, among others.

Please note that the Arterial and Collector Roads are set by the FWSP, and are closely following that layout. Local roads remain subject to change – at development process stage.

Stormwater Ponds locations were generally indicated by the SCUBE Subwatershed Studies, and locations are fine tuned now.

Servicing Strategies are new to the City of Hamilton – in preparation of development process, to facilitate coordination of servicing. They are only done as a result of the above steps first being taken/finalized."

As [redacted] stated that if the studies in the Secondary Plan identify the need for further work, this work would be done by the developer at the time of Draft Plan Applications. This stage will follow the approval of the Block Servicing Study.

I hope this helps, and please let me know if you have any further questions.

Rob

Rob Merwin, P.Eng.
Sr.Associate, Land development
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From: [redacted] (MHSTCI) <[redacted]>
Sent: February 25, 2020 5:45 PM
To: Rob Merwin <rmerwin@urbantech.com>
Subject: Block 3 Lands Fruitland-WInona Draft ESR - MHSTCI Comments

Good afternoon,
Please see our comments attached. I apologise for sending these comments after the stated review period but hope they can still be incorporated.

[redacted]
Heritage Planner
Ministry of Heritage, Sport, Tourism and Culture Industries
Heritage, Tourism and Culture Division | Programs and Services Branch | Heritage Planning Unit
401 Bay Street, Suite 1700
Toronto, Ontario M7A 0A7
Tel. 416.314.7147 | Fax. 416.314.7175

Rob Merwin

From: [redacted]
Sent: February 26, 2020 2:52 PM
To: [redacted]
Subject: RE: Block 3 Lands Fruitland-Winona Draft ESR - MHSTCI Comments

[redacted]

We are working on formulating a detailed response to your previous questions – hope to have something back to you tomorrow.

To address the new question you now posed based regarding the project website, please note that the website holds three different Block Servicing Strategies (SS) – i.e. Blocks 1, 2 & 3 and a Gordon Dean Ave. EA – Phases 3 &4 MCEA process project.
Of the four ONLY mentioned projects the latter is the only “true” MCEA project which legally requires the MCEA process to be followed.

Please note that Gordon Dean Ave. falls outside of the Block 3 study area – it is located within Block 1, and each strategy has been led as a separate process (different proponents). Gordon Dean is also led by different private land owners from those leading Block 3 SS. The City of Hamilton has placed all content for the Strategies on its website to facilitate public engagement, and to allow faster sharing of content and consistency with everyone involved.

Sorry for any confusion this may have caused.

Hope this helps?

Thank you,
[redacted]

From: [redacted]
Sent: [redacted]
To: Rob Merwin <rmerwin@urbantech.com>
Cc: [redacted]
Subject: RE: Block 3 Lands Fruitland-WInona Draft ESR - MHSTCI Comments

Thanks again Rob. On point 1, I would certainly appreciate clarification, perhaps from Margaret. I was a bit confused because the draft report doesn’t seem to explicitly call itself an ESR under the MCEA or follow the typical format of one, but the Notice of Draft Study Report Completion does invoke the MCEA, as does the project website, which even specifies Schedule C.

On point 2, would these future development applications include the infrastructure projects that are subject to EA? I’m used to the typical dichotomy whereby public infrastructure is planned through the EA process under municipal (or other public-sector) proponency, and then development applications by private entities are made to the municipality for the development of private property. Are there in this case going to be smaller-scale EA processes for individual development applications that include infrastructure construction?

[redacted]
Heritage Planner
Ministry of Heritage, Sport, Tourism and Culture Industries
Heritage, Tourism and Culture Division | Programs and Services Branch | Heritage Planning Unit
401 Bay Street, Suite 1700
Toronto, Ontario M7A 0A7
Tel. 416.314.7147 | Fax. 416.314.7175

From: Rob Merwin <rmerwin@urbantech.com>
Sent: February 26, 2020 11:39 AM
To: [redacted]
Cc: [redacted]
Subject: RE: Block 3 Lands Fruitland-WInona Draft ESR - MHSTCI Comments

Hi [redacted]
I will defer to Margaret on this, however my understanding is as follows:

1. This is not an EA but a servicing strategy study that dictates how the lands can be serviced in accordance with the secondary plan contemplated land uses.
2. The future development applications will have to satisfy the conditions of the MCEA process. The level of EA is dependent on the various factors in the guidelines, however my understanding is that dependent on the level the planning process can cover off the requirements of the EA. Margaret, please chime in here.

I will defer to [redacted] for further context.

Rob Merwin, P.Eng.
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From: [redacted]
Sent: February 26, 2020 11:15 AM
To: Rob Merwin <rmerwin@urbantech.com>
Cc: [redacted]
Subject: RE: Block 3 Lands Fruitland-WInona Draft ESR - MHSTCI Comments

Hi Rob, thank you for your quick reply.

The thing that makes this study format a little complicated of course is that we are talking about a combination of planned development subject to secondary plan under the Planning Act, and associated public infrastructure subject to the Environmental Assessment Act. MHSTCI does not comment on processes/approvals under the Planning Act unless they are circulated through MMAH's One Window service, so in this case our concerns are limited to the Environmental Assessment component of the process, which basically amounts to the planning of the municipal infrastructure.

The SCUBE Subwatershed Study also did not contain any cultural heritage investigation, and when I pointed this out in our comments I was sent a letter in reply from the City of Hamilton stating, similarly, that the Fruitland-Winona Secondary Plan sets policies for archaeological assessment and protection of cultural heritage resources at the development approval stage.

But again, planning approval and EA coverage are two different things for different kinds of undertaking. For the market development that will be carried out pursuant to the Secondary Plan, the City of Hamilton is the approval authority, as it is for the Secondary Plan itself, and the Province is not involved on a planning level; archaeological assessments and other heritage studies would typically be required of private applicants by the City. For infrastructure such as roads and stormwater ponds, however, the requirements of the Environmental Assessment Act – and more specifically in this case, the Municipal Class EA – apply, and need to be reflected in the Environmental Study Report. We have still not seen how the cultural heritage requirements of the MCEA process have been fulfilled, with respect to the components of this project that are subject to it.

If previous or pending stages of study make it unnecessary to address cultural heritage on a technical level during the Block 3 Class EA process, the ESR should spell this out explicitly. I would also recommend including any relevant cultural heritage technical studies as appendices.

[redacted]
Heritage Planner
Ministry of Heritage, Sport, Tourism and Culture Industries
Heritage, Tourism and Culture Division | Programs and Services Branch | Heritage Planning Unit
401 Bay Street, Suite 1700
Toronto, Ontario M7A 0A7
Tel. 416.314.7147 | Fax. 416.314.7175

From: Rob Merwin <rmerwin@urbantech.com>
Sent: February 26, 2020 10:06 AM
To: [redacted]
Cc: [redacted]
Subject: RE: Block 3 Lands Fruitland-WInona Draft ESR - MHSTCI Comments

Hello [redacted]
Thank you for your comments. I have copied [redacted] of the City of Hamilton on this email so she is aware of this exchange. This question has also been raised by others and responded by [redacted] I hope it is okay but I am going to cut and paste your commentary below:

"….. first I should mention that Archaeology Stage 1 would have been included during the earlier study – Fruitland-Winona Secondary Plan (FWSP)
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I hope this helps, and please let me know if you have any further questions.

Rob

Rob Merwin, P.Eng.
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From: [redacted]
Sent: February 25, 2020 5:45 PM
To: Rob Merwin <rmerwin@urbantech.com>
Subject: Block 3 Lands Fruitland-WInona Draft ESR - MHSTCI Comments

Good afternoon,
Please see our comments attached. I apologise for sending these comments after the stated review period but hope they can still be incorporated.

[redacted]
Heritage Planner
Ministry of Heritage, Sport, Tourism and Culture Industries
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Toronto, Ontario M7A 0A7
Tel. 416.314.7147 | Fax. 416.314.7175

urbantech®
west

February 4, 2020

[redacted]

[redacted]

We are in receipt of your letter dated January 27, 2020 (attached). We want to thank you for your comments, and we offer the following clarifications (numbered in accordance with your letter of January 27, 2020):

1. Figure 1 is a site location plan indicating the location of the subject site and surrounding roads. The concept plan is also represented on this figure for context. This figure does not indicate any existing or proposed drainage patterns. Please refer to the STM drawings for the existing and proposed drainage patterns. In terms of future drainage of McNeilly Road the Servicing Study has indicated the construction of a storm sewer within the Barton Street Right of Way from McNeilly Road to the proposed stormwater management facility located directly west of the existing school. This sewer is sized for McNeilly Road drainage including the existing east side properties fronting on McNeilly, both in the existing condition and in the future if McNeilly Road is fully urbanized. In addition, no external drainage is proposed to be directed towards existing properties or structures.

2. The current sanitary drainage plan has been modified to direct a portion of the proposed sanitary drainage towards the intersection of McNeilly Road and Barton Street in accordance with the original design of the existing sewer on McNeill Road. This modification arose through comments received from City of Hamilton staff indicating that the existing infrastructure at McNeilly Road and Barton Street had been sized to accommodate a portion of the development lands. Included in the Servicing Study are Sanitary Design Sheets which detail the expected sanitary sewage generation from the development lands and demonstrate that proposed and existing infrastructure can accommodate those future flows. In addition, these design sheets account for the existing and future flows from west of McNeilly Road.

3. As described above the proposed sanitary drainage patterns are in accordance with the original design of the existing sewer on McNeill Road in accordance with the City of

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Hamilton's direction and the existing infrastructure has been sized to accommodate the proposed flows.

4. Drawing SAN4 indicates a portion of the subject lands drain to the McNeilly Road and Barton St. intersection. The majority of the development lands drain to the east to infrastructure located at the intersection of Barton Street and Lewis Road. The existing infrastructure at both locations has been sized to accommodate the development lands and the supporting design sheets within the Servicing Study indicate that the capacity is sufficient once development occurs.

In regards to the items identified under the Comments section of your letter:

1. At the PIC meeting the display boards for Block 3 did not identify any servicing of lands south of Barton Street being accommodated within the future Arvin Avenue. At this time it is still not clear if Arvin Avenue will be extended. The plans within the servicing study demonstrate how development can be accommodated through existing infrastructure and the extension of new municipal infrastructure for both the future and existing conditions.

2. A Stormwater Management Pond is not required at the south east intersection of Barton Street and McNeilly Road as all drainage south of Barton Street and McNeilly Road is accommodated within the proposed Stormwater Management Pond directly west of the existing school property.

3. There is no proposal to increase flows to Watercourse. No drainages from Block 3 have been proposed to watercourse # 7 through McNally Road, north of Barton Street.

We hope that the above clarifies the proposed servicing concepts. If you have further questions or require further clarifications, we would be happy to meet with you and discuss further.

City of Hamilton and Urbantech staff would be happy to meet with you and/or your neighbours to discuss any further questions about the above mentioned matters at either City Hall or within the study area e.g. your residence. The project schedule dictates that any meeting would need to take by Friday, February 14, 2020 at the latest, between the hours 8:30 a.m. – 4: 30 p.m., if possible.

Please contact Margaret Fazio, the City's liaison staff member for this project, as well as the undersigned, as soon as possible if you still wish to meet, so that our collective schedules can be coordinated.

Margaret's Contact information is as follows:

Margaret Fazio, B.Sc., *EP, MCIP, RPP*
Senior Project Manager, Infrastructure Planning
Growth Management, Planning and Economic Development Department
City of Hamilton, 71 Main Street West, 6th Floor, Hamilton, ON, Canada, L8R 4Y5
Tel: 905-546-2424 ext. 2218; Fax: 905-540-5611; e-mail: Margaret.Fazio@hamilton.ca

Yours truly,

Rob Merwin, P.Eng.
Sr. Associate, Land Development.

Cc: Maria Pearson, Councillor New Ward 10 Stoney Creek, City of Hamilton
Cc: Margaret Fazio, Councillor City of Hamilton

[redacted]

January 27th 2020

Rob Merwin, P. Eng
Project Manager - Urbantech West
2030 Bristo Cir., # 105
Oakville, On L8H 0H2

registered mail

Maria Pearson, Councilor
New Ward 10 Stoney Creek
City of Hamilton

inter office courier

RE; Draft Study Report Block Servicing Strategy **Block 3**

I recently compared the June 2017 public meeting presentation to the January 16th 2020 above Servicing Strategy and note that the differences are substantial in nature.

1. Storm Water Drainage
   Map 12-062W Dated Aug 18 Drawing # 1
   This map shows drainage on the property line of 280 & 282 McNeilly Rd. which did not previously exist. This proposal will require the removal of privacy fencing and over 12 trees. More over the increased volumes of water within 1 meter of a cement block foundation is an expensive disaster in the making if not for the present homeowners but in the future. Now you have effectively **devalued** two McNeilly Rd. properties and restricting future redevelopment of 282 McNeilly Rd.

   Since there is no storm sewer south of Barton ST. the increase in water volume will increase the frequency of Barton St. flooding which currently already occurs on the west side of McNeilly Rd. This plan effectively increases flooding for all homes down Stream especially for those north of Barton St. as well as effecting insurance rates and resale values.

2. Sanitary Drainage West
Map 12-062W Dated Aug. 2018 Drawing - SAN – 1A

This map shows the sewage flow has once again been altered from the June 2017 public presentation. Originally the flow was east to Lewis Rd. Now all flows West to McNeilly Rd. along Barton and down McNeilly North of Barton.

This change increases long-term maintenance costs to the taxpayer and restricts future development west of McNeilly Rd. and south of Barton. Since the City already owns three road access on the west side long term planning should dictate that the current development pay a portion of increasing the sanitary sewer from Barton to the Collector road off McNeilly as well as a portion of Urbanizing McNeilly road to the collector to help facilitate the increased traffic flow.

3. Sanitary drainage West
Map 12-062 Dated Aug 2018 DWG – SAN – 4A

This map also shows drainage from the Barton St. collector road to McNeilly road is completely opposite to the representations at the public meeting and once again increases McNeilly road volumes.

4. Sanitary West North of Barton
Map 12-062 Dated Aug 2018 DWG – SAN – 4

This map and all other maps for services in this area show all drainage has been redirected from the north perimeter south to Barton St. and WEST TO McNeilly road.

COMMENTS

At the public meeting we were assured that all services would drain to the New Arvin Ave. then west to McNeilly Road where the Arvin Ave extension built in 2019 would have a relief outlet at Water Course 7 to eliminate the current water over McNeilly road. We were also assured that this would pick up the drainage pipe that currently runs at the rear of the residences on the east side of McNeilly Rd from Barton to the train track. The amended proposal does not identify or plan to do this.

A storm water pond has been omitted in the south east corner of Barton and McNeilly to match the pond on the east side of the development. The lack of a pond clearly indicates that the intent is to devalue the homes on McNeilly Rd.

Watercourse 7 improvements were never designed to accept Block 3 development. To transfer block 3 will not only increase frequency and intensity of flooding of McNeilly Rd it will restrict Block 2 development it is essentially increasing costs for them. Further more it eventfully blocks and increases costs for the Barton. Hwy #8; Glover, McNeilly block when it is finally re zoned.

This entire redesign should go back to a PUBLIC MEETING with full and honest disclosure.

This whole process hiding the substantial changes from the McNeilly Rd residence condensing our comment period to 30 days when you have known for approximately 18 months is a sham. Had we know this in June 2017 or August 2018 these comments would be supported with numerous pictures.

We look forward to a meeting and Public meeting.

APPENDIX N-4
PIC Materials

Thursday, June 8, 2017

Block Servicing Strategies 1 and 2 PIC No. 2, and Block 3 Servicing Strategy PIC No. 1 Comment Sheet

Please take a moment to provide us with input regarding the three above mentioned projects. This questionnaire is your opportunity to provide your comments on all three. ***Given that your views are important to us, please kindly complete this questionnaire (please print) and deposit it in the "Comment Sheets" box provided or by mail, email/scan or fax to the address provided on the fourth page. Thank you.***

1. My relation to this Project is: (Please check all that apply)

[ ] resident within the project limit

[ ] land or business owner within the project limit

[ ] user of roads or lands within the study areas but not within project limit

[ ] member of an interest group (Please specify) ______________________________

[ ] member of the general public not within the project limit

[ ] other (Please specify) ______________________________

2. My interest is: (Please check all that apply?

[ ] property/land impacts

[ ] stormwater management

[ ] pedestrian / bicycle safety

[ ] traffic volume

[ ] traffic signals

[ ] other:____

[ ] recreational

[ ] natural environment and creeks

[ ] speed limits

[ ] general interest

3. Please provide your comments as they relate to the Block 1 Concept Plans presented here today.

____

____

____

Personal information collected at public meetings or submitted in writing is collected under the authority of the *Municipal Act, 2001*, and will be used by members of the City of Hamilton. The written submissions including names and contact information and the report of the public meeting will be used for the purposes of assessing number of attendees, areas of interest, and contact information.

4. Please provide your comments as they relate to the Block 2 details provided here today.

5. Please provide your comments as they relate to the Block 3 details provided here today.

6. How did you hear about this Public Information Centre (PIC)? (Please checkmark)

[ ] Newspaper [ ] Website [ ] Friend [ ] Notice in the mail [ ] Other: ____________________

7. Please indicate your satisfaction with the following:

	Satisfied (Y/N)	**If not satisfied, please specify your preference below**
Location of Meeting		
Time of Meeting		
Day of Week		

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Accessibility of the Location	

8. On a scale of 1 to 5, where "1" is "very" and "5" is "not at all", please rate the following by circling the appropriate number:

a) How informative were the display materials? (please circle)

Very		Somewhat		Not at all
1	**2**	**3**	**4**	**5**

b) How helpful were the Municipal staff and consultants in attendance? (please circle)

Very		Somewhat		Not at all
1	**2**	**3**	**4**	**5**

9. Were all your questions answered satisfactorily?

[ ] Yes [ ] No [ ] If No, can someone contact you? ________________________

10. Please provide any additional comments.

____

____

____

____

____

11. Do you require a written response to your comments?

[ ] Yes [ ] No

If yes, please provide us with your contact information below should you wish to receive a written response to your comments (please print clearly):

Name:	**Telephone:**

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Address:	
City/Province/Postal Code:	Email:

As noted, please mail, scan/email, or fax your completed questionnaire by June 22, 2017 to:

Amec Foster Wheeler (Block 1) **Angelo Cutaia, P.Eng.** **Consultant Project Manager** **3215 North Service Road,** **Burlington, ON L7N 3G2** **Tel: 905.335.2353** **Fax: 905.335.1414** **Email: *Angelo.Cutaia@amecfw.com***
City of Hamilton (Block 2) **Margaret Fazio, B.Sc., EP, MCIP, RPP** **Senior Project Manager** **City of Hamilton** **71 Main Street West, 6th Floor,** **Hamilton, ON L8P 4Y5** **Tel: 905.546.2424 Ext.2218** **Fax: 905.540.5611** **Email: *iplanning@hamilton.ca***
Urbantech West (Block 3) **Rob Merwin, P.Eng.** **Urbantech® West,** **A Division of Leighton-Zec West Ltd.** **2030 Bristol Circle, Suite 201** **Oakville,. ON L6H 0H2** **TEL: 905-829-8818 Ext.102** **Mob:416.997.0101 FAX: 905.829.4804** **Email:*rmerwin@urbantech.com***

Thank you for your time and participation!

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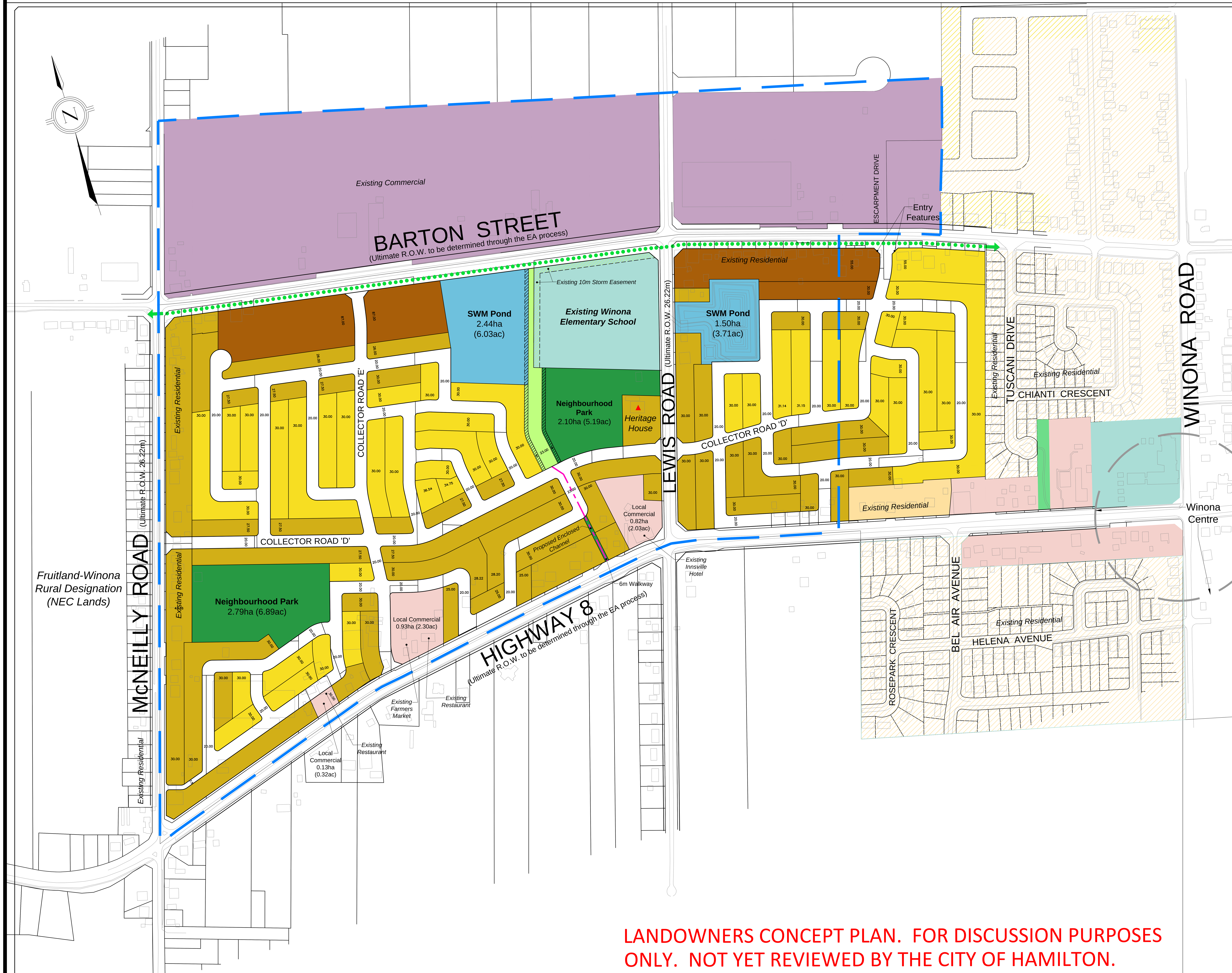

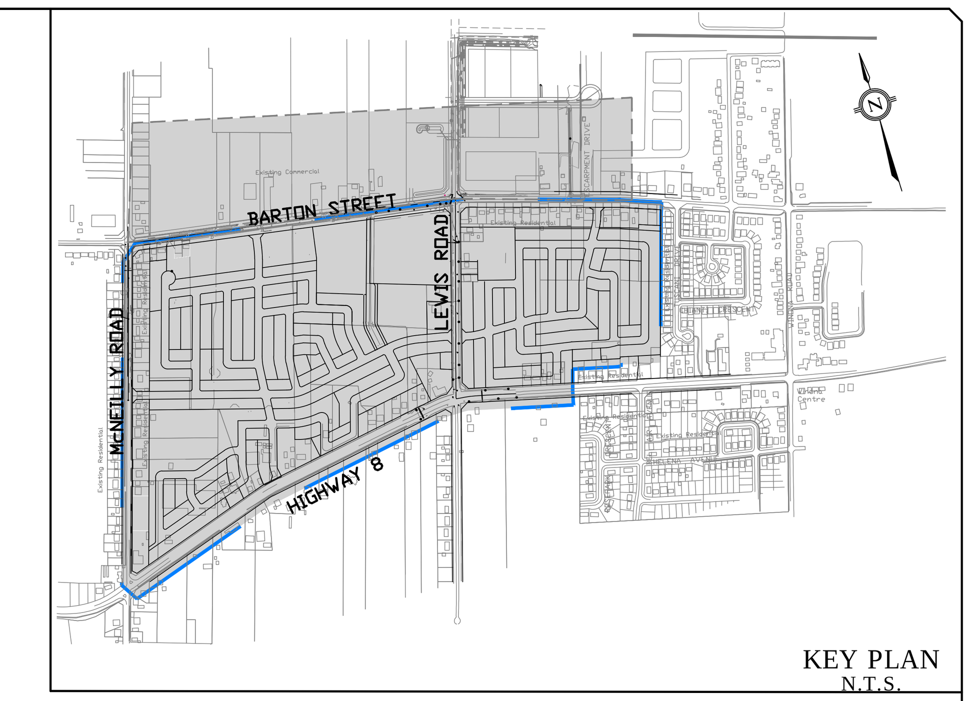

KEY PLAN
N.T.S.

Legend

- Low Density Residential 1; 0-20 upnha (0-8 upnac)
- Low Density Residential 2; 20-40 upnha (8-16 upnac)
- Low Density Residential 3; 40-60 upnha (16-24 upnac)
- Medium Density Residential 2; 60-75 upnha
- Local Commercial
- Neighbourhood Park
- Institutional
- SWM Pond
- Proposed Channel
- 6m Access Allowance
- Barton Street Pedestrian Promenade (Conceptually shown 4.0m wide within ROW)
- Designated Heritage Properties
- Fruitland-Winona Secondary Plan Boundary
- Block 3 Servicing Strategy Area
- Existing Low Density Residential 1
- Existing Low Density Residential 2
- Proposed Enclosed Channel
- Business Park

Block Servicing Strategy Area #3
Stoney Creek Expansion Area

urbantech
Urbantech Consulting, A Division of Leighton-Zec Ltd.
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tel: 905.946.9461 fax: 905.946.9595
www.urbantech.com

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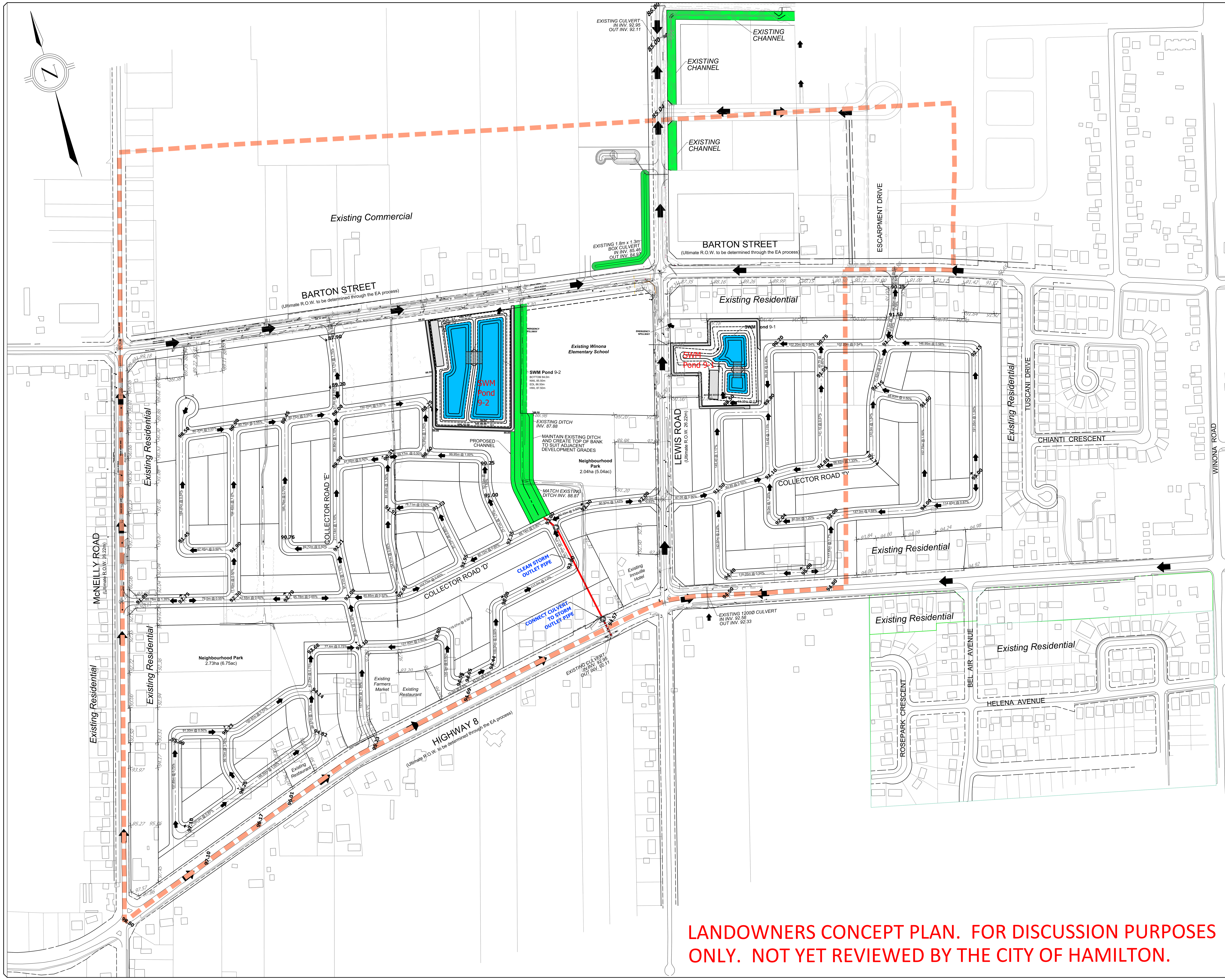
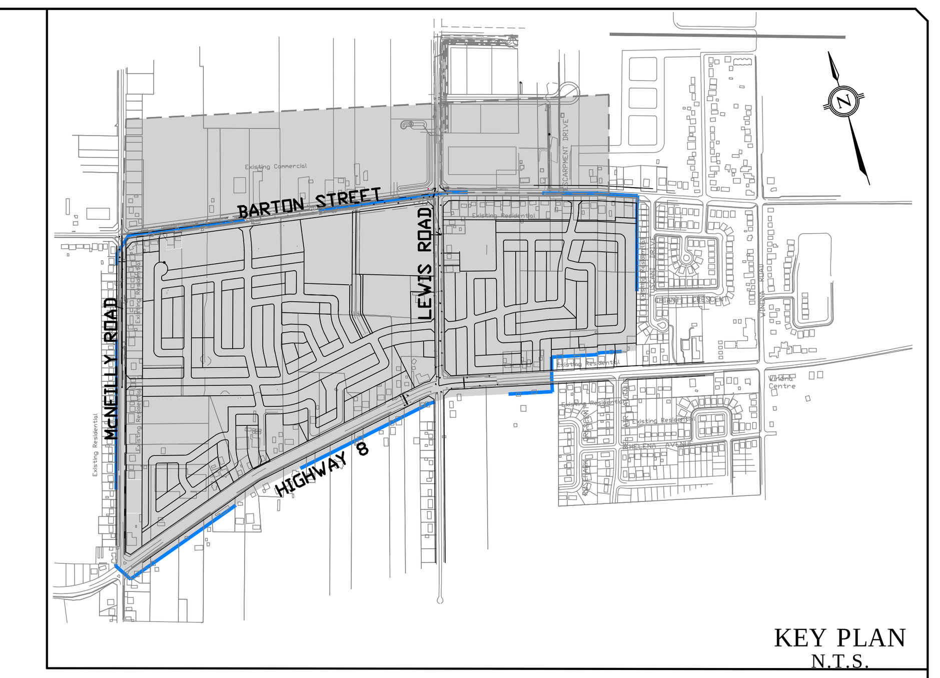
URBAN & REGIONAL PLANNERS, LAND DEVELOPMENT CONSULTANTS
SUITE 700 10 KINGSBRIDGE GARDEN CIRCLE,
MISSISSAUGA, ONTARIO, L5R 3K6
TEL (905) 568-8888 FAX (905) 568-8894 www.gsai.ca

CONCEPT PLAN FOR P.I.C

Project No. 12-062
Date : June 2017
Scale: NTS





LEGEND:

(dashed orange line)	LIMIT OF STUDY AREA
87.54	EXISTING ELEVATION
92.00	PROPOSED ELEVATION
(arrow)	OVERLAND FLOW DIRECTION

Block Servicing Strategy Area #3
Stoney Creek Expansion Area

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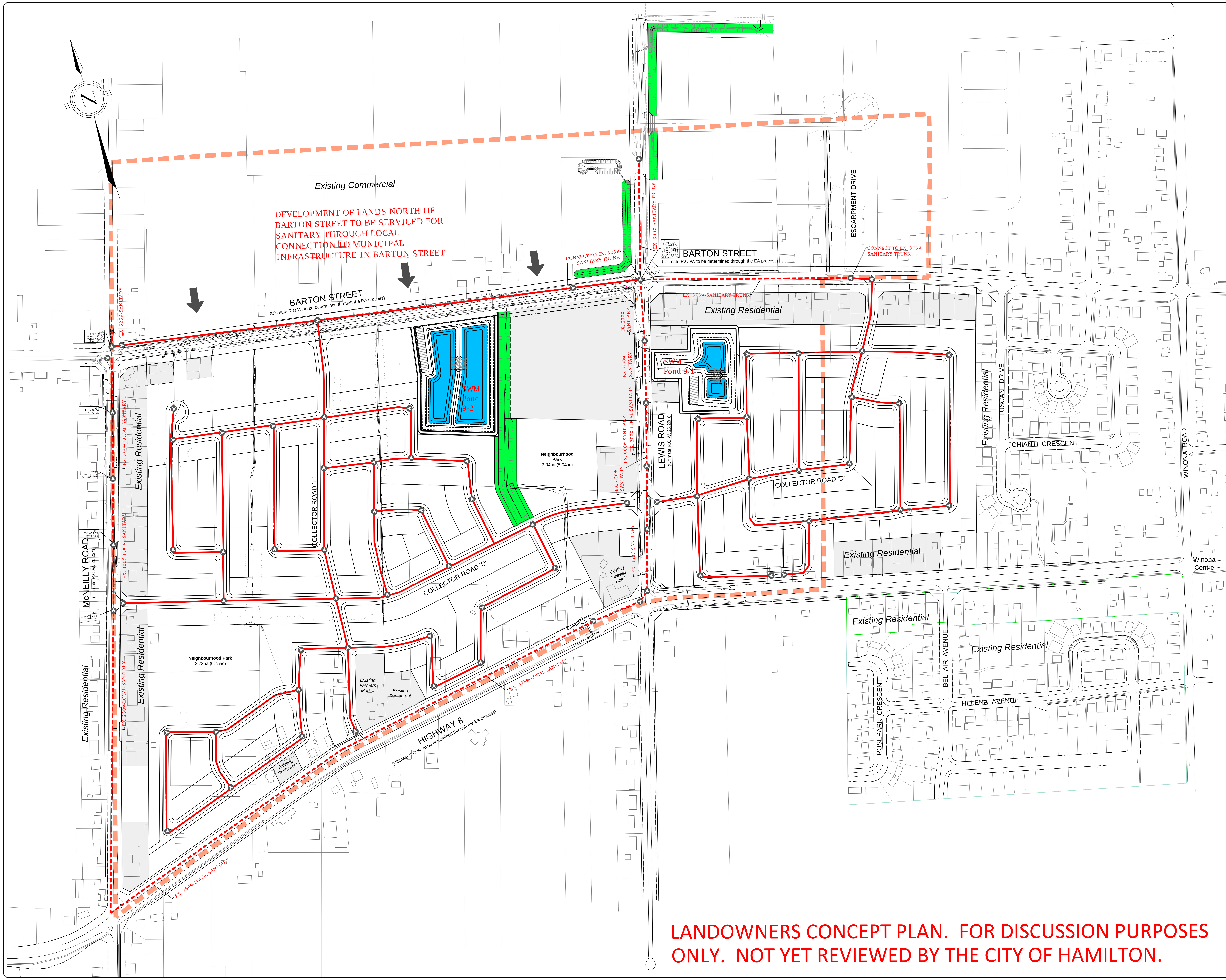
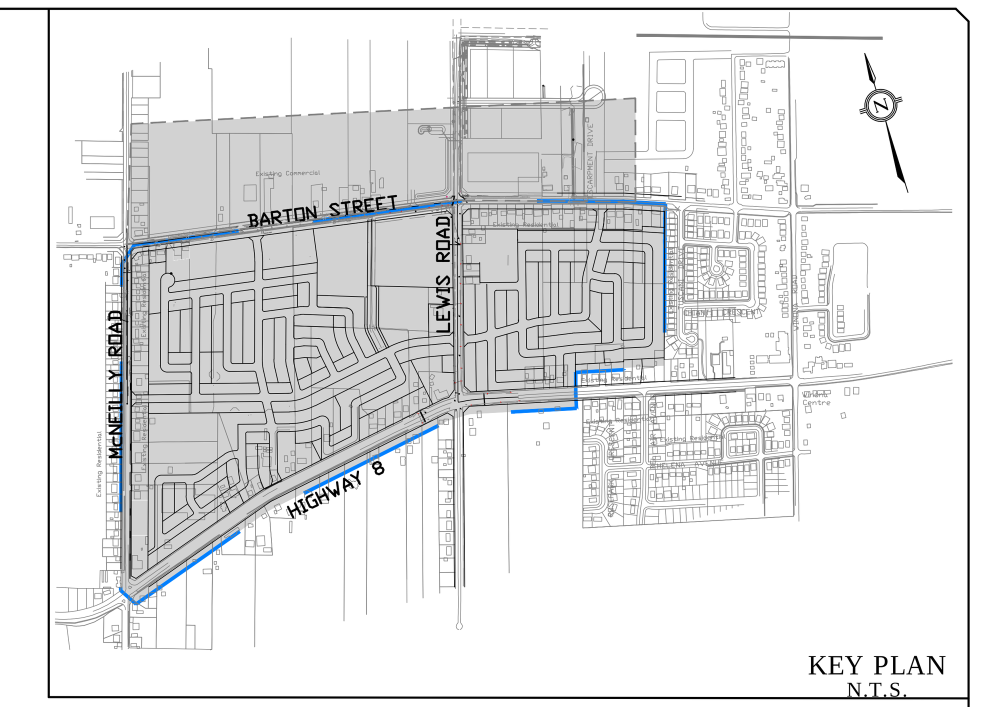
PRELIMINARY GRADING PLAN FOR P.I.C

LANDOWNERS CONCEPT PLAN. FOR DISCUSSION PURPOSES ONLY. NOT YET REVIEWED BY THE CITY OF HAMILTON.

Project No. 12-062
Date : June 2017
Scale: NTS



LANDOWNERS CONCEPT PLAN. FOR DISCUSSION PURPOSES ONLY. NOT YET REVIEWED BY THE CITY OF HAMILTON.



KEY PLAN
N.T.S.

LEGEND:

- EXISTING SANITARY SEWER
- PROPOSED SANITARY SEWER
- LIMIT OF STUDY AREA
- DIRECTION OF SANITARY DRAINAGE

Block Servicing Strategy Area #3
Stoney Creek Expansion Area

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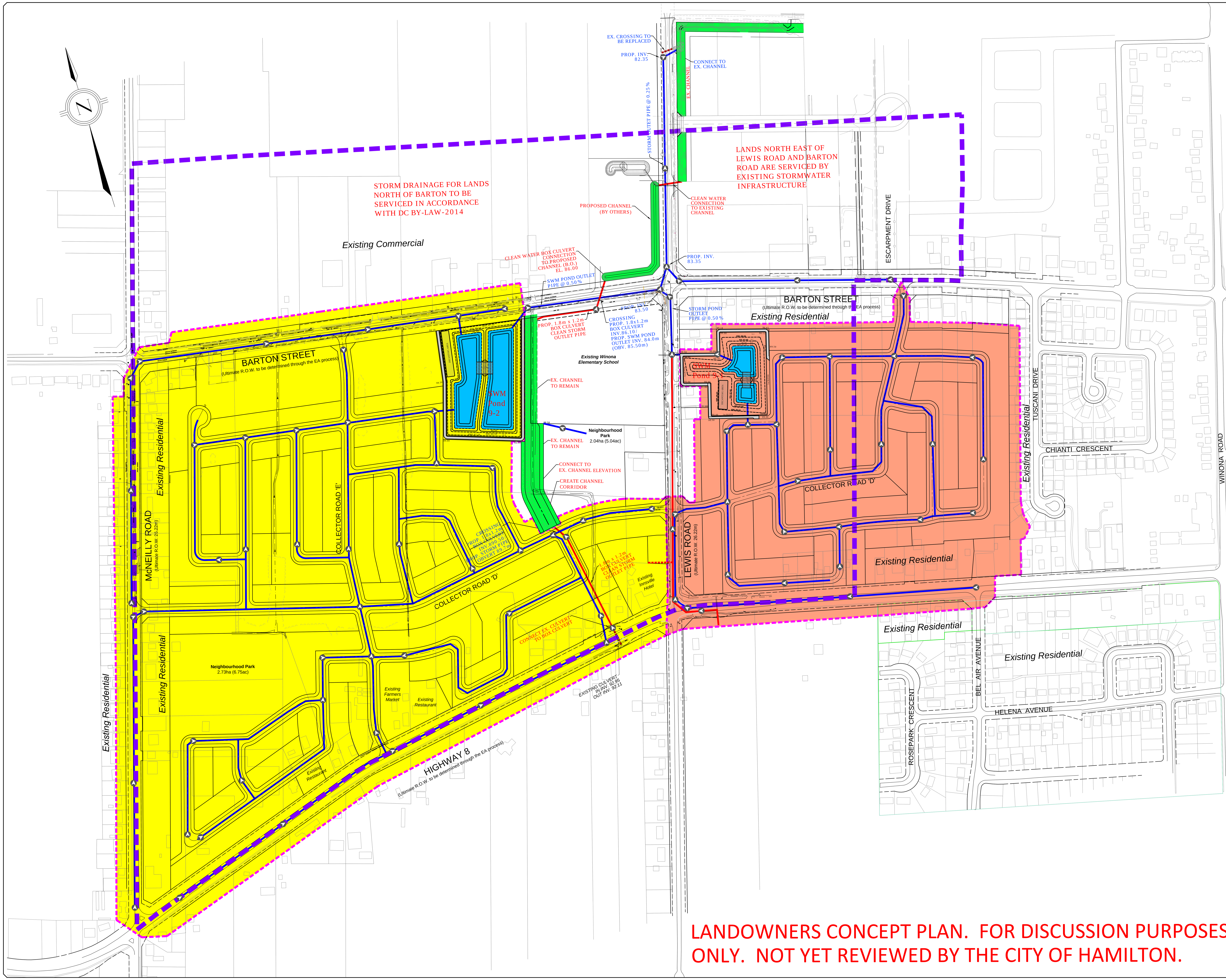
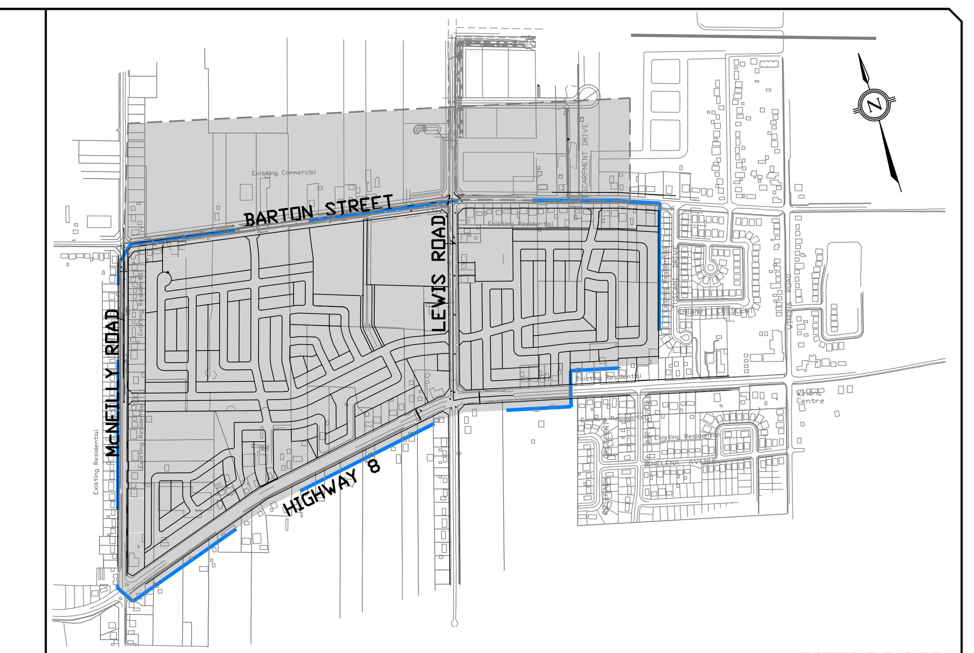
PRELIMINARY
SANITARY SERVICING PLAN FOR P.I.C

Project No. 12-062
Date : June 2017
Scale: NTS





KEY PLAN
N.T.S.

LEGEND:

- LIMIT OF STUDY AREA
- HOLDOUT PROPERTY
- EXISTING/PROPOSED CHANNEL CORRIDOR
- EXISTING WATERCOURSE
- PROPOSED CLEAN WATER PIPE
- PROPOSED STORM SEWER
- PROPOSED CONTRIBUTING DRAINAGE AREA BOUNDARY TO SWM POND 9-1
- PROPOSED CONTRIBUTING DRAINAGE AREA BOUNDARY TO SWM POND 9-1

Block Servicing Strategy Area #3
Stoney Creek Expansion Area

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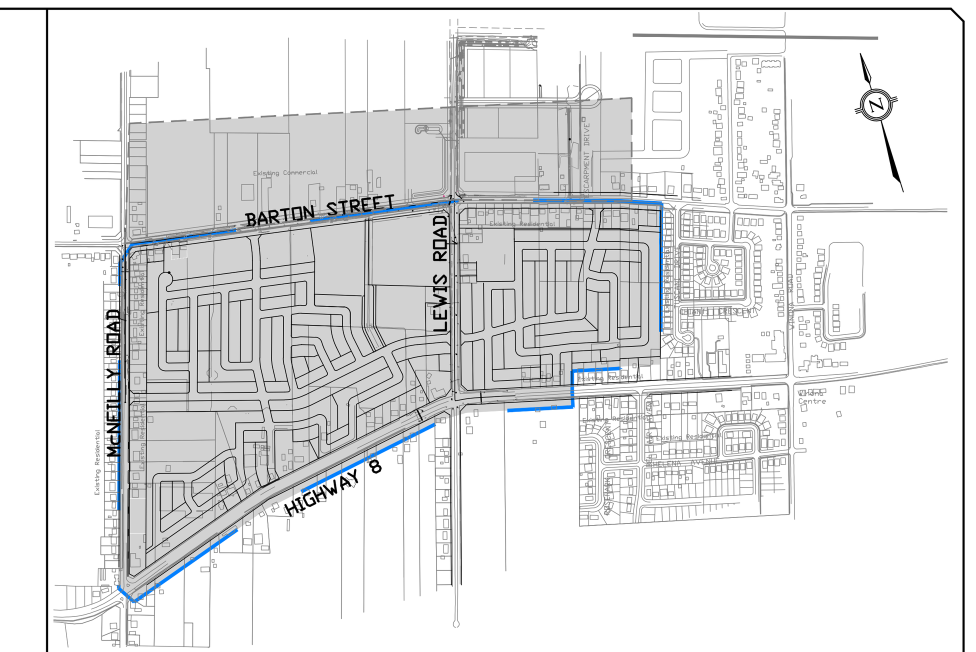
PRELIMINARY
STORM SERVICING
PLAN FOR P.I.C

Project No. 12-062
Date : June 2017
Scale: NTS

“LANDOWNERS CONCEPT PLAN. FOR DISCUSSION PURPOSES ONLY. NOT YET REVIEWED BY THE CITY OF HAMILTON”.



KEY PLAN
N.T.S.

LEGEND:

- EXISTING WATERMAIN
- PROPOSED WATERMAIN
- LIMIT OF STUDY AREA

Block Servicing Strategy Area #3
Stoney Creek Expansion Area

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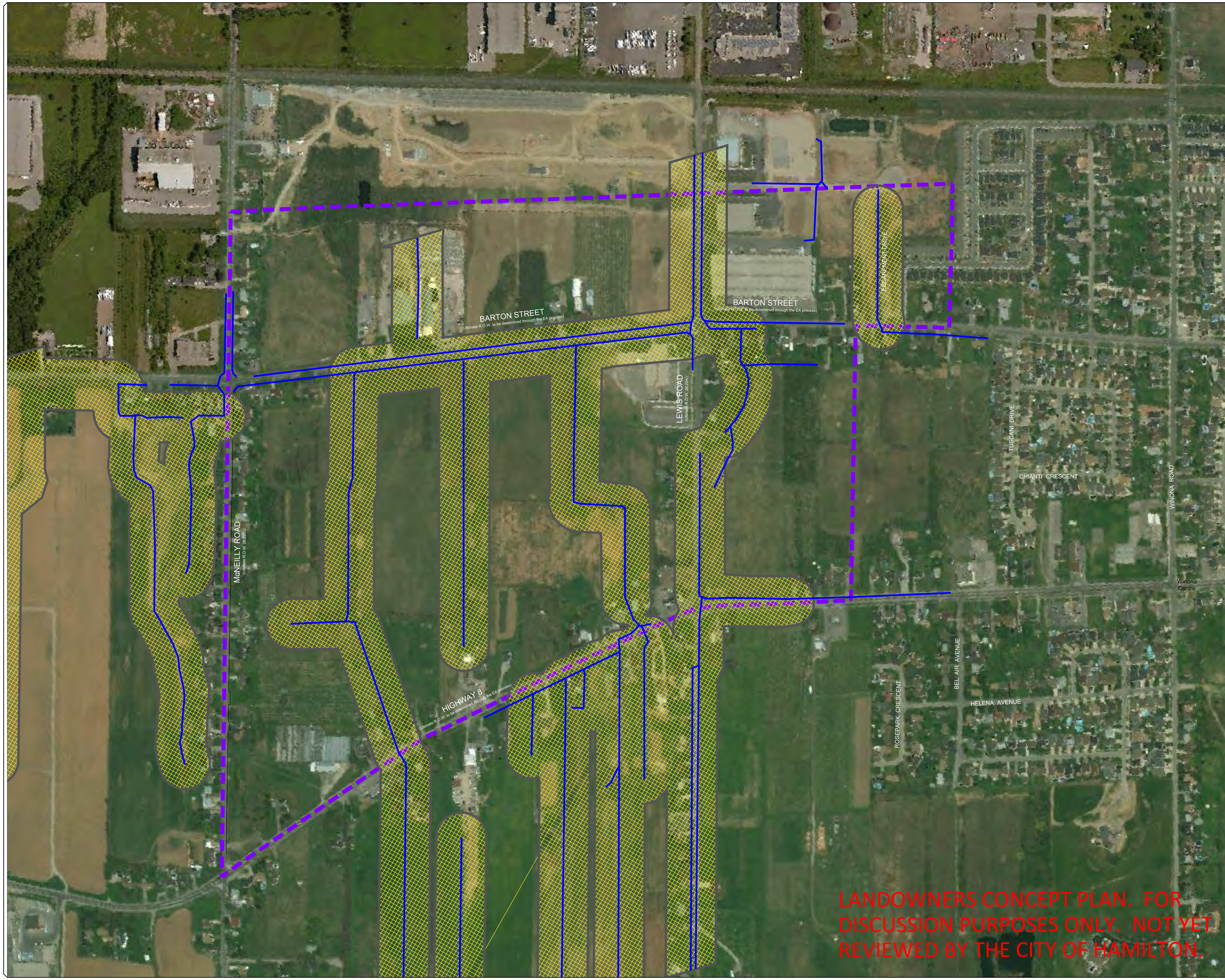
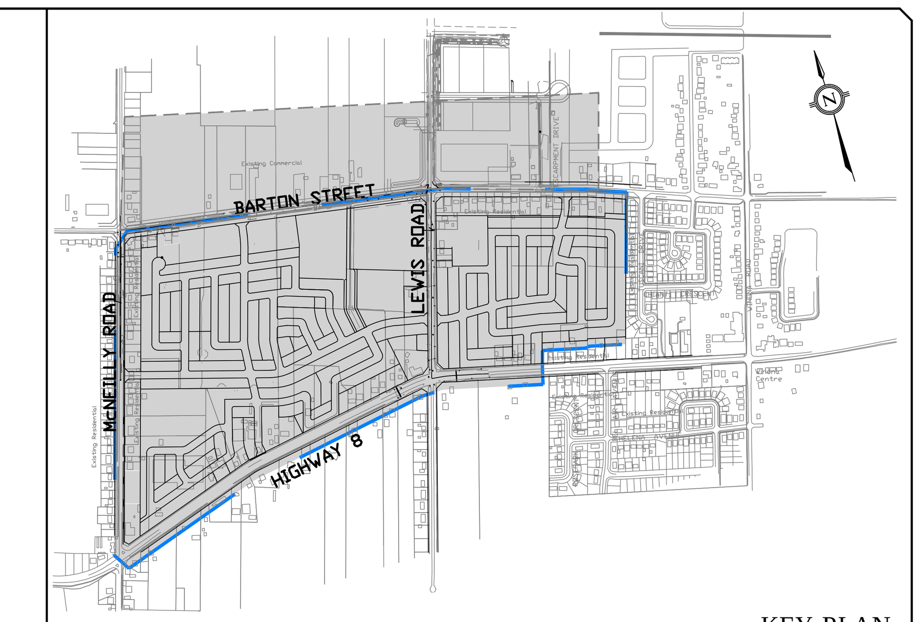
PRELIMINARY WATERMAIN PLAN FOR P.I.C

Project No. 12-062
Date : June 2017
Scale: NTS





KEY PLAN
N.T.S.

LEGEND:

- HAMILTON CONSERVATION AUTHORITY REGULATED AREA
- REGULATED WATERCOURSE
- BSS BOUNDARY LINE

Block Servicing Strategy Area #3
Stoney Creek Expansion Area

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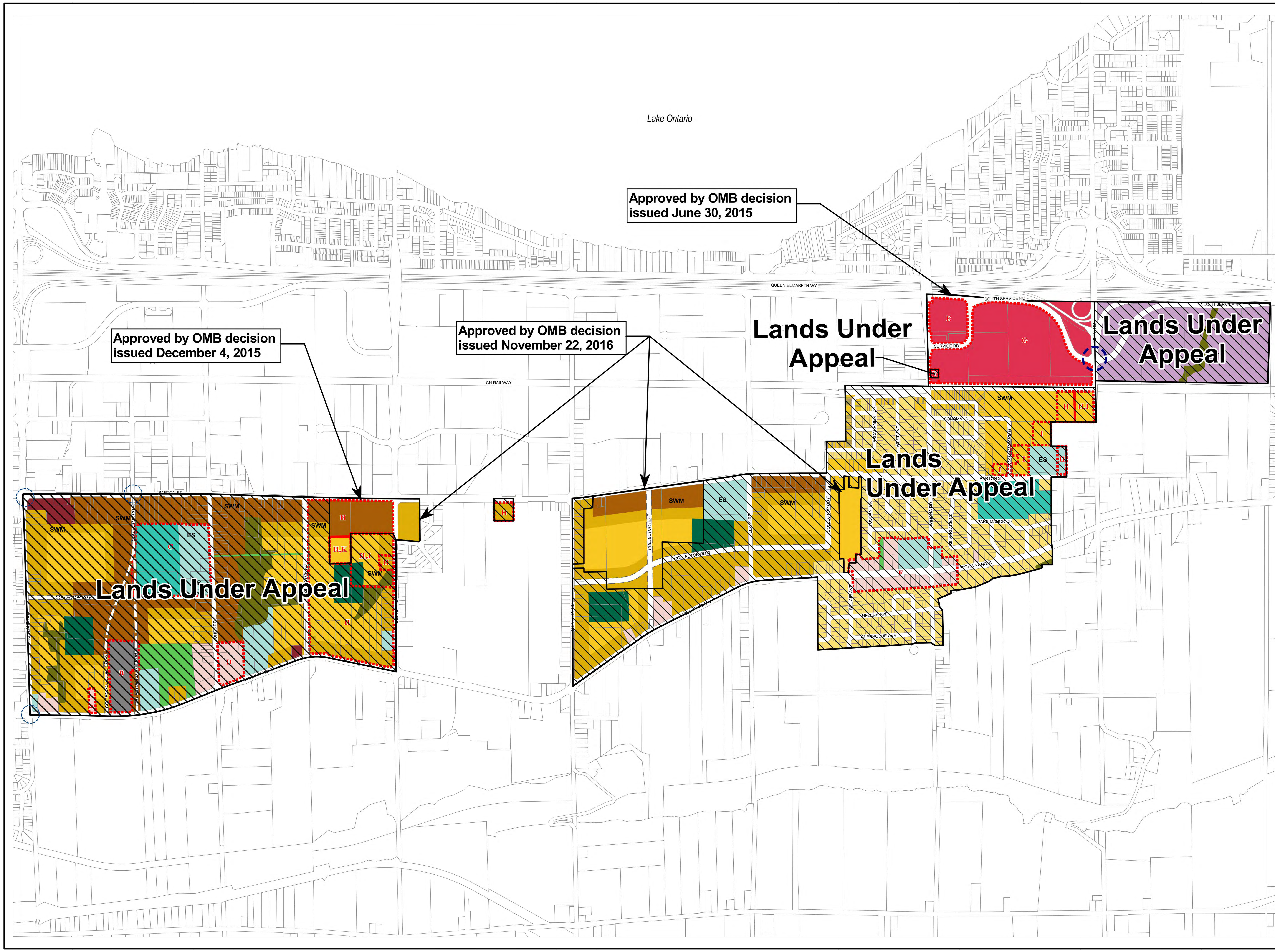
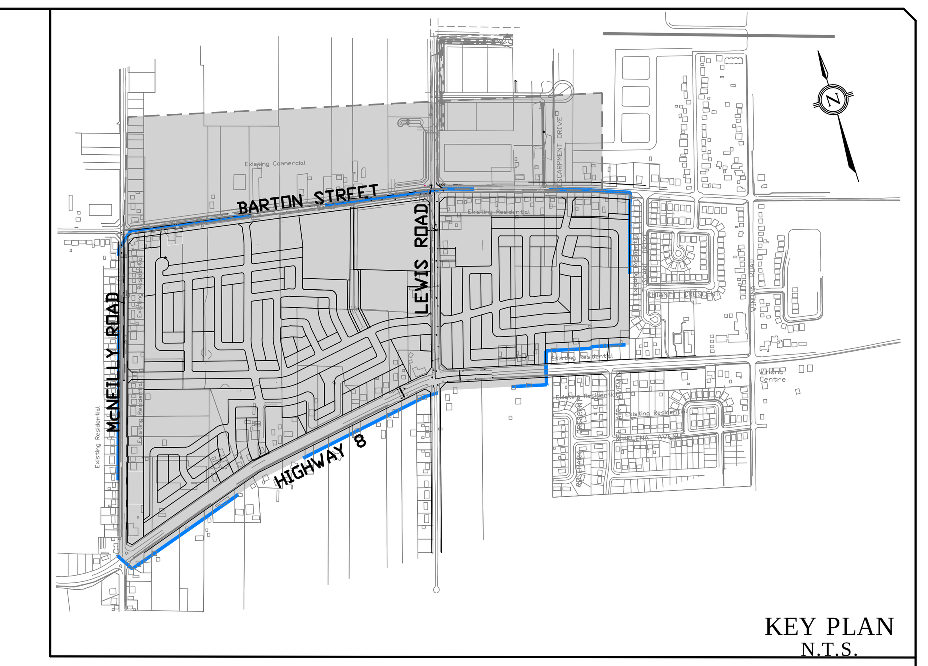
EXISTING NATURAL HERITAGE FEATURES FOR P.I.C

Project No. 12-062
Date : June 2017
Scale: NTS





Block Servicing Strategy Area #3
Stoney Creek Expansion Area

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Secondary Land Use Plan

Source: Urban Hamilton Official Plan
Map B.7.4-1

Project No. 12-062
Date : June 2017
Scale: NTS

Name	E-mail	Address (Please include Postal Code)
[redacted]		
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