Waterdown Road Corridor Class Environmental Assessment

Drainage and Hydrology Report
January 2010

City of Hamilton
City of Burlington
Halton Region

Project No. 08-9020

Submitted by

Dillon Consulting Limited

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1.0 INTRODUCTION

A detailed drainage study was completed to provide input to Phase 3 & 4 of the Municipal Class Environmental Assessment planning and design process that was triggered by the Waterdown/Aldershot Transportation Master Plan (WATMP). The WATMP involves the Waterdown Road Improvement and the New East-West Corridor within the study area bounded by Concession 5 East in the north, Highway 407 in the east, Plains Road in the south, and Highway No. 6 in the west, as illustrated in ***Figure 1***. This report only addresses drainage components of the north-south Waterdown Road corridor.

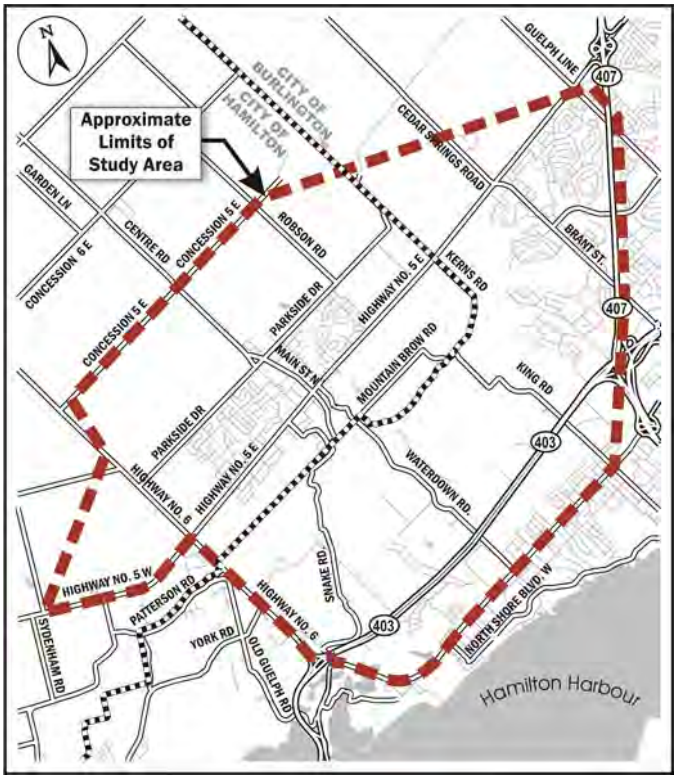


Figure 1 WATMP Study Area

1.1 Study Objectives

The objectives of this drainage study are to evaluate the impacts of the proposed roadway improvements on the surface water systems, to assess potential impacts of roadway runoff on receiving watercourses, and to assist in the selection of appropriate management measures. These management measures will be taken to a preliminary level of design. The drainage study

results will provide input and guidance to the detailed design process with the objective of achieving protection, preservation, and enhancement of the local subwatershed environments. Specifically, the purpose of this study is to undertake the following activities within the context of the Waterdown Road areas:

- establish existing hydraulic conditions of the watercourses at existing and proposed crossing locations within the Waterdown Road;
- establish design criteria;
- evaluate proposed road crossing structures to meet design criteria;
- identify the potential impacts on natural water systems and hydrologic processes resulting from proposed changes, such as increased flooding and erosion potential and water quality impairment;
- identify specific opportunities for protection, enhancement and rehabilitation of local watercourses, including SWM measures that meet design criteria;
- prepare preliminary design details for watercourse crossing and SWM measures; and,
- identify criteria for detailed design.

Specific drainage management goals include the following:

- to convey upstream run-off through the roadway without adverse impacts on the road and upstream and downstream lands;
- to convey runoff from the road right-of-way to downstream watercourses; and
- to ensure that runoff from the right-of-way does not adversely impact the natural environment of receiving water bodies.

1.2 Data Collection

Background studies and information were collected and reviewed, and conditions associated with the road development were considered in the drainage analysis. Below is the list of documents reviewed:

South Waterdown Subwatershed Study Stage 2 Report

This report provides a management strategy for the South Waterdown development, reflecting opportunities and constraints to the development and providing a management guide for future land use changes within the South Waterdown lands. The recommended stormwater management strategy was utilized in finalizing the recommended road drainage design.

Grindstone Creek Watershed Study, Halton Region Conservation Authority, June 1998
In this study, the entire watershed was divided into four sections and regeneration plans for each area were prepared to promote the integrity and legacy of the creek. The areas identified in the regeneration plans and located within the road EA study area were considered in the road drainage analysis.

Grindstone Creek Subwatershed Study, Cosburn Patterson Wardman Ltd., January 1995
The subwatershed extends from Hwy 403 in the south to Waterdown in the north and from the main Grindstone Creek Valley to the east of Waterdown Road, covering a 560 ha area. A Subwatershed Management Plan was recommended for the future development and considered into the road drainage analysis.

2.0 HYDRAULIC ASSESSMENT

The evaluation of hydraulic conditions for the existing and proposed road crossing structures was based on the study objectives and is summarized in the sections below. Detailed hydraulic and hydrological modelling outputs are provided in Appendixes.

2.1 Road Drainage Area Characteristics

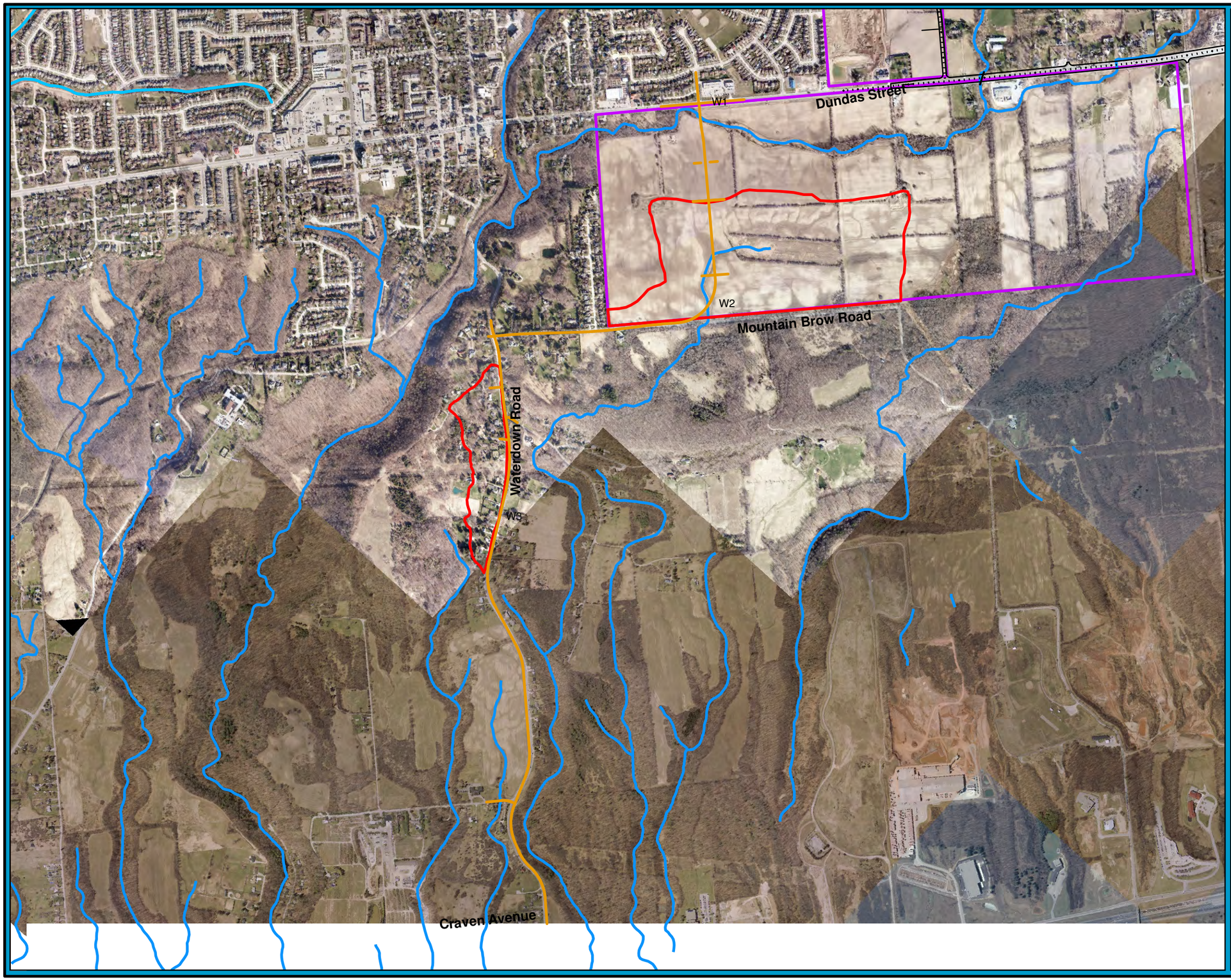
The proposed north-south corridor extends southerly from Dundas Street through the Waterdown South development land, turns west along Mountain Brown Road and south on Waterdown Road, and ends near Craven Avenue. Drainage of the section of Waterdown Road south of Craven Avenue is addressed by the MTO Waterdown/Hwy 403 interchange improvement project which is currently under construction. The drainage area is within the Grindstone Creek watershed under the jurisdiction of Conservation Halton (CH). Drainage features and water crossing locations within the study area are presented in ***Figure 2***.

There are three water crossings within the proposed Waterdown Road corridor. As shown in ***Figure 2***, Crossing W1 is a new structure associated with the new roadway to be constructed through the South Waterdown development land across a tributary of Grindstone Creek. Crossing W2 and W3 are existing structures which are to be extended or replaced due to the road improvement.

2.2 Design Criteria

Consultation with the City of Hamilton and CH was conducted at the beginning of the study. Comments on the preliminary road alignment were provided by CH in a letter dated September 17, 2008. The comments related to road drainage components in the letter have been fully addressed in this drainage report. Based on City of Hamilton Design Guidelines and comments from CH, the road crossing structures have been designed to meet the following design criteria:

- Based on the road classification and the span of the proposed structure, the appropriate design event should be determined according to the design flood criteria indicated in MTO Directive B-100 (and as per the City of Hamilton Design Guidelines);
- Required freeboard (culverts) or clearance (bridges) of the structure is to be provided as per the design flood criteria;
- At existing watercourse crossings, upstream flood levels for the Regulatory event (i.e., Hurricane Hazel) have to be maintained or improved, if possible;
- At new watercourse crossings, the existing flood levels for the Regulatory event (i.e., Hurricane Hazel) must be established so that it can be demonstrated that there are no adverse impacts on the flood hazard; and,
- Safe access and egress should be provided for both pedestrian and vehicular traffic during the flood event. Per MNR guidelines, safe access and egress is defined by a depth velocity product of less than 0.4 m^2/s, with a maximum flooding depth over the road of less than 0.3 m, and a maximum velocity over the road of less than 1.7 m/s.



Proposed Waterdown Road Corridor

Figure 2
Road Crossing Structures

Legend

- Preferred Waterdown Corridor
- Road Crossing Structure
- structure_drainage_WD
- Grindstone Creek System
- UrbanExpansionBoundary

1:15,000

Meters

240 120 0 240 480

Notes:
Base mapping provided by the City of Hamilton, the City of Burlington and the Region of Halton. Additional mapping provided by Halton Region Conservation Authority and the Ministry of Natural Resources.

Please note that the land uses depicted on this map reflect the land uses derived from the City of Hamilton and City of Burlington OPs and airphotos in order to derive the nature of the land use. Areas along Waterdown Road were classified as residential.

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```
     Unit Hyd Qpeak  (cms)=    .586

     PEAK FLOW       (cms)=    .272 (i)
     TIME TO PEAK    (hrs)=  10.000
     RUNOFF VOLUME    (mm)= 151.826
     TOTAL RAINFALL   (mm)= 212.000
     RUNOFF COEFFICIENT   =    .716

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0020) |   Area    (ha)=   5.46   Curve Number   (CN)= 96.0
|ID= 1 DT=15.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .48

     Unit Hyd Qpeak  (cms)=    .432

     PEAK FLOW       (cms)=    .706 (i)
     TIME TO PEAK    (hrs)=  10.250
     RUNOFF VOLUME    (mm)= 196.065
     TOTAL RAINFALL   (mm)= 212.000
     RUNOFF COEFFICIENT   =    .925

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------


 FINISH
================================================================================================================================
```

Visual OTTHYMO 2.0 Simulation Results
Outlets W3 to W5
Future Conditions

Simulation No.	Design Event
1	2 Year
2	5 Year
3	10 Year
4	25 Year
5	50 Year
6	100 Year
7	25 mm

NASHYD ID	Outlet ID
29	W3
30	W4
31	W5

```
       V    V   I    SSSSS  U   U    A    L
       V    V   I    SS     U   U   A A   L
        V  V    I     SS    U   U  AAAAA  L
        V  V    I      SS   U   U  A   A  L
         VV     I    SSSSS  UUUUU  A   A  LLLLL

        OOO   TTTTT  TTTTT  H   H  Y   Y  M   M   OOO    TM, Version 2.0
       O   O    T      T    H   H   Y Y   MM MM  O   O
       O   O    T      T    H   H    Y    M   M  O   O   Licensed To: Dillon Consulting Ltd

        OOO     T      T    H   H    Y    M   M   OOO                 vo2-0082
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***** D E T A I L E D O U T P U T *****

Input filename: C:\Program Files\Visual OTTHYMO v2.0\voin.dat

Output filename: M:\PROJECTS\DRAFT\08\089020~1\WATERR~1\DILLON~1\VO2MOD~1\STORMW~2\SWM090~1\Future design storms.out
Summary filename: M:\PROJECTS\DRAFT\08\089020~1\WATERR~1\DILLON~1\VO2MOD~1\STORMW~2\SWM090~1\Future design storms.sum

DATE: 1/25/2010 TIME: 3:43:54 PM

USER:

COMMENTS: _____

**** SIMULATION NUMBER: 1 ****

MASS STORM	Filename: M:\PROJECTS\DRAFT\08\089020~1\WATERR~1\DILLON~1\VO2MOD~1\SCS12HII 15min.mst
Ptotal= 44.40 mm	Comments: SCS 12 HOUR TYPE II STORM DISTRIBUTION

Duration of storm = 12.00 hrs
Mass curve time step = 30.00 min
New Storm time step = 15.00 min

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
.25	.44	3.25	1.78	6.25	23.98	9.25	1.78
.50	.89	3.50	1.78	6.50	7.99	9.50	1.78
.75	.89	3.75	1.78	6.75	5.77	9.75	1.33
1.00	.89	4.00	1.78	7.00	3.55	10.00	.89
1.25	.89	4.25	2.22	7.25	3.11	10.25	.89
1.50	.89	4.50	2.66	7.50	2.66	10.50	.89
1.75	.89	4.75	3.11	7.75	2.66	10.75	.89
2.00	.89	5.00	3.55	8.00	2.66	11.00	.89
2.25	1.33	5.25	4.44	8.25	2.22	11.25	.89
2.50	1.78	5.50	5.33	8.50	1.78	11.50	.89
2.75	1.78	5.75	22.64	8.75	1.78	11.75	.89
3.00	1.78	6.00	39.96	9.00	1.78	12.00	.89

CALIB NASHYD (0029) ID= 1 DT=15.0 min	Area (ha)= 7.53 Curve Number (CN)= 88.3 Ia (mm)= 5.00 # of Linear Res.(N)= 3.00 U.H. Tp(hrs)= .35

NOTE: RAINFALL WAS TRANSFORMED TO 15.0 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
.250	.44	3.250	1.78	6.250	23.98	9.25	1.78
.500	.89	3.500	1.78	6.500	7.99	9.50	1.78
.750	.89	3.750	1.78	6.750	5.77	9.75	1.33
1.000	.89	4.000	1.78	7.000	3.55	10.00	.89
1.250	.89	4.250	2.22	7.250	3.11	10.25	.89
1.500	.89	4.500	2.66	7.500	2.66	10.50	.89

1.750	.89	4.750	3.11	7.750	2.66	10.75	.89
2.000	.89	5.000	3.55	8.000	2.66	11.00	.89
2.250	1.33	5.250	4.44	8.250	2.22	11.25	.89
2.500	1.78	5.500	5.33	8.500	1.78	11.50	.89
2.750	1.78	5.750	22.64	8.750	1.78	11.75	.89
3.000	1.78	6.000	39.96	9.000	1.78	12.00	.89

Unit Hyd Qpeak (cms)= .830

PEAK FLOW (cms)= .300 (i)
TIME TO PEAK (hrs)= 6.250
RUNOFF VOLUME (mm)= 20.816
TOTAL RAINFALL (mm)= 44.289
RUNOFF COEFFICIENT = .470

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

CALIB			
NASHYD (0030)	Area (ha)=	2.38	Curve Number (CN)= 91.1
ID= 1 DT=15.0 min	Ia (mm)=	5.00	# of Linear Res.(N)= 3.00
	U.H. Tp(hrs)=	.16	

Unit Hyd Qpeak (cms)= .586

PEAK FLOW (cms)= .117 (i)
TIME TO PEAK (hrs)= 6.000
RUNOFF VOLUME (mm)= 18.841
TOTAL RAINFALL (mm)= 44.289
RUNOFF COEFFICIENT = .425

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

CALIB			
NASHYD (0031)	Area (ha)=	5.68	Curve Number (CN)= 92.4
ID= 1 DT=15.0 min	Ia (mm)=	5.00	# of Linear Res.(N)= 3.00
	U.H. Tp(hrs)=	.48	

Unit Hyd Qpeak (cms)= .449

PEAK FLOW (cms)= .226 (i)
TIME TO PEAK (hrs)= 6.500
RUNOFF VOLUME (mm)= 25.587
TOTAL RAINFALL (mm)= 44.289
RUNOFF COEFFICIENT = .578

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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** SIMULATION NUMBER: 2 **
****

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Ptotal= 62.40 mm	Comments: SCS 12 HOUR TYPE II STORM DISTRIBUTION

Duration of storm = 12.00 hrs
Mass curve time step = 30.00 min
New Storm time step = 15.00 min

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
.25	.62	3.25	2.50	6.25	33.70	9.25	2.50
.50	1.25	3.50	2.50	6.50	11.23	9.50	2.50
.75	1.25	3.75	2.50	6.75	8.11	9.75	1.87
1.00	1.25	4.00	2.50	7.00	4.99	10.00	1.25
1.25	1.25	4.25	3.12	7.25	4.37	10.25	1.25
1.50	1.25	4.50	3.74	7.50	3.74	10.50	1.25
1.75	1.25	4.75	4.37	7.75	3.74	10.75	1.25
2.00	1.25	5.00	4.99	8.00	3.74	11.00	1.25
2.25	1.87	5.25	6.24	8.25	3.12	11.25	1.25
2.50	2.50	5.50	7.49	8.50	2.50	11.50	1.25
2.75	2.50	5.75	31.82	8.75	2.50	11.75	1.25
3.00	2.50	6.00	56.16	9.00	2.50	12.00	1.25

CALIB			
NASHYD (0029)	Area (ha)=	7.53	Curve Number (CN)= 88.3
ID= 1 DT=15.0 min	Ia (mm)=	5.00	# of Linear Res.(N)= 3.00
	U.H. Tp(hrs)=	.35	

NOTE: RAINFALL WAS TRANSFORMED TO 15.0 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
.250	.62	3.250	2.50	6.250	33.70	9.25	2.50
.500	1.25	3.500	2.50	6.500	11.23	9.50	2.50
.750	1.25	3.750	2.50	6.750	8.11	9.75	1.87
1.000	1.25	4.000	2.50	7.000	4.99	10.00	1.25
1.250	1.25	4.250	3.12	7.250	4.37	10.25	1.25
1.500	1.25	4.500	3.74	7.500	3.74	10.50	1.25
1.750	1.25	4.750	4.37	7.750	3.74	10.75	1.25
2.000	1.25	5.000	4.99	8.000	3.74	11.00	1.25
2.250	1.87	5.250	6.24	8.250	3.12	11.25	1.25
2.500	2.50	5.500	7.49	8.500	2.50	11.50	1.25
2.750	2.50	5.750	31.82	8.750	2.50	11.75	1.25
3.000	2.50	6.000	56.16	9.000	2.50	12.00	1.25

Unit Hyd Qpeak (cms)= .830

PEAK FLOW (cms)= .516 (i)
TIME TO PEAK (hrs)= 6.250
RUNOFF VOLUME (mm)= 35.467
TOTAL RAINFALL (mm)= 62.244
RUNOFF COEFFICIENT = .570

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

CALIB NASHYD (0030)	ID= 1 DT=15.0 min

Area (ha)= 2.38 Curve Number (CN)= 91.1
Ia (mm)= 5.00 # of Linear Res.(N)= 3.00
U.H. Tp(hrs)= .16

Unit Hyd Qpeak (cms)= .586

PEAK FLOW (cms)= .197 (i)
TIME TO PEAK (hrs)= 6.000
RUNOFF VOLUME (mm)= 31.249
TOTAL RAINFALL (mm)= 62.244
RUNOFF COEFFICIENT = .502

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

CALIB NASHYD (0031)	ID= 1 DT=15.0 min

Area (ha)= 5.68 Curve Number (CN)= 92.4
Ia (mm)= 5.00 # of Linear Res.(N)= 3.00
U.H. Tp(hrs)= .48

Unit Hyd Qpeak (cms)= .449

PEAK FLOW (cms)= .370 (i)
TIME TO PEAK (hrs)= 6.250
RUNOFF VOLUME (mm)= 41.817
TOTAL RAINFALL (mm)= 62.244
RUNOFF COEFFICIENT = .672

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

****
** SIMULATION NUMBER: 3 **
****

MASS STORM	Ptotal= 74.40 mm

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Comments: SCS 12 HOUR TYPE II STORM DISTRIBUTION

Duration of storm = 12.00 hrs
Mass curve time step = 30.00 min
New Storm time step = 15.00 min

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
.25	.74	3.25	2.98	6.25	40.18	9.25	2.98
.50	1.49	3.50	2.98	6.50	13.39	9.50	2.98
.75	1.49	3.75	2.98	6.75	9.67	9.75	2.23
1.00	1.49	4.00	2.98	7.00	5.95	10.00	1.49
1.25	1.49	4.25	3.72	7.25	5.21	10.25	1.49
1.50	1.49	4.50	4.46	7.50	4.46	10.50	1.49
1.75	1.49	4.75	5.21	7.75	4.46	10.75	1.49
2.00	1.49	5.00	5.95	8.00	4.46	11.00	1.49

2.25	2.23	5.25	7.44	8.25	3.72	11.25	1.49
2.50	2.98	5.50	8.93	8.50	2.98	11.50	1.49
2.75	2.98	5.75	37.94	8.75	2.98	11.75	1.49
3.00	2.98	6.00	66.96	9.00	2.98	12.00	1.49

CALIB			
NASHYD (0029)	Area (ha)=	7.53	Curve Number (CN)= 88.3
ID= 1 DT=15.0 min	Ia (mm)=	5.00	# of Linear Res.(N)= 3.00
	U.H. Tp(hrs)=	.35	

NOTE: RAINFALL WAS TRANSFORMED TO 15.0 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
.250	.74	3.250	2.98	6.250	40.18	9.25	2.98
.500	1.49	3.500	2.98	6.500	13.39	9.50	2.98
.750	1.49	3.750	2.98	6.750	9.67	9.75	2.23
1.000	1.49	4.000	2.98	7.000	5.95	10.00	1.49
1.250	1.49	4.250	3.72	7.250	5.21	10.25	1.49
1.500	1.49	4.500	4.46	7.500	4.46	10.50	1.49
1.750	1.49	4.750	5.21	7.750	4.46	10.75	1.49
2.000	1.49	5.000	5.95	8.000	4.46	11.00	1.49
2.250	2.23	5.250	7.44	8.250	3.72	11.25	1.49
2.500	2.98	5.500	8.93	8.500	2.98	11.50	1.49
2.750	2.98	5.750	37.94	8.750	2.98	11.75	1.49
3.000	2.98	6.000	66.96	9.000	2.98	12.00	1.49

Unit Hyd Qpeak (cms)= .830

PEAK FLOW (cms)= .666 (i)
TIME TO PEAK (hrs)= 6.250
RUNOFF VOLUME (mm)= 45.822
TOTAL RAINFALL (mm)= 74.214
RUNOFF COEFFICIENT = .617

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

CALIB			
NASHYD (0030)	Area (ha)=	2.38	Curve Number (CN)= 91.1
ID= 1 DT=15.0 min	Ia (mm)=	5.00	# of Linear Res.(N)= 3.00
	U.H. Tp(hrs)=	.16	

Unit Hyd Qpeak (cms)= .586

PEAK FLOW (cms)= .251 (i)
TIME TO PEAK (hrs)= 6.000
RUNOFF VOLUME (mm)= 39.870
TOTAL RAINFALL (mm)= 74.214
RUNOFF COEFFICIENT = .537

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

CALIB			
NASHYD (0031)	Area (ha)=	5.68	Curve Number (CN)= 92.4
ID= 1 DT=15.0 min	Ia (mm)=	5.00	# of Linear Res.(N)= 3.00
	U.H. Tp(hrs)=	.48	

Unit Hyd Qpeak (cms)= .449

PEAK FLOW (cms)= .470 (i)
TIME TO PEAK (hrs)= 6.250
RUNOFF VOLUME (mm)= 53.002
TOTAL RAINFALL (mm)= 74.214
RUNOFF COEFFICIENT = .714

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

****
** SIMULATION NUMBER: 4 **
****

MASS STORM	Filename: M:\PROJECTS\DRAFT\08\089020~1\WATERR~1\DILLON~1\VO2MOD~1\SCS12HII 15min.mst
Ptotal= 90.00 mm	Comments: SCS 12 HOUR TYPE II STORM DISTRIBUTION

Duration of storm = 12.00 hrs
Mass curve time step = 30.00 min
New Storm time step = 15.00 min

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
.25	.90	3.25	3.60	6.25	48.60	9.25	3.60
.50	1.80	3.50	3.60	6.50	16.20	9.50	3.60
.75	1.80	3.75	3.60	6.75	11.70	9.75	2.70
1.00	1.80	4.00	3.60	7.00	7.20	10.00	1.80
1.25	1.80	4.25	4.50	7.25	6.30	10.25	1.80
1.50	1.80	4.50	5.40	7.50	5.40	10.50	1.80
1.75	1.80	4.75	6.30	7.75	5.40	10.75	1.80
2.00	1.80	5.00	7.20	8.00	5.40	11.00	1.80
2.25	2.70	5.25	9.00	8.25	4.50	11.25	1.80
2.50	3.60	5.50	10.80	8.50	3.60	11.50	1.80
2.75	3.60	5.75	45.90	8.75	3.60	11.75	1.80
3.00	3.60	6.00	81.00	9.00	3.60	12.00	1.80

CALIB NASHYD (0029) ID= 1 DT=15.0 min	Area (ha)= 7.53	Curve Number (CN)= 88.3
	Ia (mm)= 5.00	# of Linear Res.(N)= 3.00
	U.H. Tp(hrs)= .35	

NOTE: RAINFALL WAS TRANSFORMED TO 15.0 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
.250	.90	3.250	3.60	6.250	48.60	9.25	3.60
.500	1.80	3.500	3.60	6.500	16.20	9.50	3.60
.750	1.80	3.750	3.60	6.750	11.70	9.75	2.70
1.000	1.80	4.000	3.60	7.000	7.20	10.00	1.80
1.250	1.80	4.250	4.50	7.250	6.30	10.25	1.80
1.500	1.80	4.500	5.40	7.500	5.40	10.50	1.80
1.750	1.80	4.750	6.30	7.750	5.40	10.75	1.80
2.000	1.80	5.000	7.20	8.000	5.40	11.00	1.80
2.250	2.70	5.250	9.00	8.250	4.50	11.25	1.80
2.500	3.60	5.500	10.80	8.500	3.60	11.50	1.80
2.750	3.60	5.750	45.90	8.750	3.60	11.75	1.80
3.000	3.60	6.000	81.00	9.000	3.60	12.00	1.80

Unit Hyd Qpeak (cms)= .830

PEAK FLOW (cms)= .866 (i)
TIME TO PEAK (hrs)= 6.250
RUNOFF VOLUME (mm)= 59.715
TOTAL RAINFALL (mm)= 89.775
RUNOFF COEFFICIENT = .665

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

CALIB NASHYD (0030) ID= 1 DT=15.0 min	Area (ha)= 2.38	Curve Number (CN)= 91.1
	Ia (mm)= 5.00	# of Linear Res.(N)= 3.00
	U.H. Tp(hrs)= .16	

Unit Hyd Qpeak (cms)= .586

PEAK FLOW (cms)= .323 (i)
TIME TO PEAK (hrs)= 6.000
RUNOFF VOLUME (mm)= 51.322
TOTAL RAINFALL (mm)= 89.775
RUNOFF COEFFICIENT = .572

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

CALIB NASHYD (0031) ID= 1 DT=15.0 min	Area (ha)= 5.68	Curve Number (CN)= 92.4
	Ia (mm)= 5.00	# of Linear Res.(N)= 3.00
	U.H. Tp(hrs)= .48	

Unit Hyd Qpeak (cms)= .449

PEAK FLOW (cms)= .600 (i)
TIME TO PEAK (hrs)= 6.250
RUNOFF VOLUME (mm)= 67.791
TOTAL RAINFALL (mm)= 89.775
RUNOFF COEFFICIENT = .755

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

****

```
  ** SIMULATION NUMBER:   5 **
  ****************************

--------------------
| MASS STORM       |    Filename: M:\PROJECTS\DRAFT\08\089020~
|                  |              1\WATERR~1\DILLON~1\VO2MOD~1\
|                  |              SCS12HII 15min.mst
| Ptotal=100.80 mm |    Comments: SCS 12 HOUR TYPE II STORM DISTRIBUTION
--------------------
                       Duration of storm    = 12.00 hrs
                       Mass curve time step = 30.00 min
                       New Storm time step  = 15.00 min

                TIME    RAIN |  TIME    RAIN |  TIME    RAIN |  TIME    RAIN
                 hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr
                 .25    1.01 |  3.25    4.03 |  6.25   54.43 |  9.25    4.03
                 .50    2.02 |  3.50    4.03 |  6.50   18.14 |  9.50    4.03
                 .75    2.02 |  3.75    4.03 |  6.75   13.10 |  9.75    3.02
                1.00    2.02 |  4.00    4.03 |  7.00    8.06 | 10.00    2.02
                1.25    2.02 |  4.25    5.04 |  7.25    7.06 | 10.25    2.02
                1.50    2.02 |  4.50    6.05 |  7.50    6.05 | 10.50    2.02
                1.75    2.02 |  4.75    7.06 |  7.75    6.05 | 10.75    2.02
                2.00    2.02 |  5.00    8.06 |  8.00    6.05 | 11.00    2.02
                2.25    3.02 |  5.25   10.08 |  8.25    5.04 | 11.25    2.02
                2.50    4.03 |  5.50   12.10 |  8.50    4.03 | 11.50    2.02
                2.75    4.03 |  5.75   51.41 |  8.75    4.03 | 11.75    2.02
                3.00    4.03 |  6.00   90.72 |  9.00    4.03 | 12.00    2.02

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0029) |   Area    (ha)=   7.53   Curve Number   (CN)= 88.3
|ID= 1 DT=15.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .35

         NOTE:  RAINFALL WAS TRANSFORMED TO  15.0 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
                .250    1.01 | 3.250    4.03 | 6.250   54.43 |  9.25    4.03
                .500    2.02 | 3.500    4.03 | 6.500   18.14 |  9.50    4.03
                .750    2.02 | 3.750    4.03 | 6.750   13.10 |  9.75    3.02
               1.000    2.02 | 4.000    4.03 | 7.000    8.06 | 10.00    2.02
               1.250    2.02 | 4.250    5.04 | 7.250    7.06 | 10.25    2.02
               1.500    2.02 | 4.500    6.05 | 7.500    6.05 | 10.50    2.02
               1.750    2.02 | 4.750    7.06 | 7.750    6.05 | 10.75    2.02
               2.000    2.02 | 5.000    8.06 | 8.000    6.05 | 11.00    2.02
               2.250    3.02 | 5.250   10.08 | 8.250    5.04 | 11.25    2.02
               2.500    4.03 | 5.500   12.10 | 8.500    4.03 | 11.50    2.02
               2.750    4.03 | 5.750   51.41 | 8.750    4.03 | 11.75    2.02
               3.000    4.03 | 6.000   90.72 | 9.000    4.03 | 12.00    2.02

     Unit Hyd Qpeak  (cms)=    .830

     PEAK FLOW       (cms)=   1.005 (i)
     TIME TO PEAK    (hrs)=   6.250
     RUNOFF VOLUME    (mm)=  69.535
     TOTAL RAINFALL   (mm)= 100.548
     RUNOFF COEFFICIENT   =    .692

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0030) |   Area    (ha)=   2.38   Curve Number   (CN)= 91.1
|ID= 1 DT=15.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .16

     Unit Hyd Qpeak  (cms)=    .586

     PEAK FLOW       (cms)=    .372 (i)
     TIME TO PEAK    (hrs)=   6.000
     RUNOFF VOLUME    (mm)=  59.361
     TOTAL RAINFALL   (mm)= 100.548
     RUNOFF COEFFICIENT   =    .590

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| CALIB            |
| NASHYD    (0031) |   Area    (ha)=   5.68   Curve Number   (CN)= 92.4
|ID= 1 DT=15.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .48
```

Unit Hyd Qpeak (cms)= .449

PEAK FLOW (cms)= .690 (i)
TIME TO PEAK (hrs)= 6.250
RUNOFF VOLUME (mm)= 78.139
TOTAL RAINFALL (mm)= 100.548
RUNOFF COEFFICIENT = .777

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

****
** SIMULATION NUMBER: 6 **
****

MASS STORM	Filename: M:\PROJECTS\DRAFT\08\089020~1\WATERR~1\DILLON~1\VO2MOD~1\SCS12HII 15min.mst
Ptotal=111.60 mm	Comments: SCS 12 HOUR TYPE II STORM DISTRIBUTION

Duration of storm = 12.00 hrs
Mass curve time step = 30.00 min
New Storm time step = 15.00 min

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
.25	1.12	3.25	4.46	6.25	60.26	9.25	4.46
.50	2.23	3.50	4.46	6.50	20.09	9.50	4.46
.75	2.23	3.75	4.46	6.75	14.51	9.75	3.35
1.00	2.23	4.00	4.46	7.00	8.93	10.00	2.23
1.25	2.23	4.25	5.58	7.25	7.81	10.25	2.23
1.50	2.23	4.50	6.70	7.50	6.70	10.50	2.23
1.75	2.23	4.75	7.81	7.75	6.70	10.75	2.23
2.00	2.23	5.00	8.93	8.00	6.70	11.00	2.23
2.25	3.35	5.25	11.16	8.25	5.58	11.25	2.23
2.50	4.46	5.50	13.39	8.50	4.46	11.50	2.23
2.75	4.46	5.75	56.92	8.75	4.46	11.75	2.23
3.00	4.46	6.00	100.44	9.00	4.46	12.00	2.23

CALIB NASHYD (0029) ID= 1 DT=15.0 min	Area (ha)= 7.53 Curve Number (CN)= 88.3 Ia (mm)= 5.00 # of Linear Res.(N)= 3.00 U.H. Tp(hrs)= .35

NOTE: RAINFALL WAS TRANSFORMED TO 15.0 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
.250	1.12	3.250	4.46	6.250	60.26	9.25	4.46
.500	2.23	3.500	4.46	6.500	20.09	9.50	4.46
.750	2.23	3.750	4.46	6.750	14.51	9.75	3.35
1.000	2.23	4.000	4.46	7.000	8.93	10.00	2.23
1.250	2.23	4.250	5.58	7.250	7.81	10.25	2.23
1.500	2.23	4.500	6.70	7.500	6.70	10.50	2.23
1.750	2.23	4.750	7.81	7.750	6.70	10.75	2.23
2.000	2.23	5.000	8.93	8.000	6.70	11.00	2.23
2.250	3.35	5.250	11.16	8.250	5.58	11.25	2.23
2.500	4.46	5.500	13.39	8.500	4.46	11.50	2.23
2.750	4.46	5.750	56.92	8.750	4.46	11.75	2.23
3.000	4.46	6.000	100.44	9.000	4.46	12.00	2.23

Unit Hyd Qpeak (cms)= .830

PEAK FLOW (cms)= 1.146 (i)
TIME TO PEAK (hrs)= 6.250
RUNOFF VOLUME (mm)= 79.477
TOTAL RAINFALL (mm)= 111.321
RUNOFF COEFFICIENT = .714

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

CALIB NASHYD (0030) ID= 1 DT=15.0 min	Area (ha)= 2.38 Curve Number (CN)= 91.1 Ia (mm)= 5.00 # of Linear Res.(N)= 3.00 U.H. Tp(hrs)= .16

Unit Hyd Qpeak (cms)= .586

PEAK FLOW (cms)= .421 (i)
TIME TO PEAK (hrs)= 6.000
RUNOFF VOLUME (mm)= 67.465

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     TOTAL RAINFALL   (mm)= 111.321
     RUNOFF COEFFICIENT   =    .606

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| CALIB              |
| NASHYD    (0031) |   Area    (ha)=   5.68   Curve Number   (CN)= 92.4
|ID= 1 DT=15.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .48

     Unit Hyd Qpeak  (cms)=    .449

     PEAK FLOW       (cms)=    .780 (i)
     TIME TO PEAK    (hrs)=   6.250
     RUNOFF VOLUME    (mm)=  88.552
     TOTAL RAINFALL   (mm)= 111.321
     RUNOFF COEFFICIENT   =    .795

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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  ****************************
  ** SIMULATION NUMBER:   7 **
  ****************************

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| MASS STORM       |    Filename: M:\PROJECTS\DRAFT\08\089020 WATMP
|                  |              Phases 3 & 4\Water Resources\Dillon Models\
|                  |              VO2 modeling\SCS12HII 15min.mst
| Ptotal= 25.00 mm |    Comments: SCS 12 HOUR TYPE II STORM DISTRIBUTION
--------------------
                       Duration of storm    = 12.00 hrs
                       Mass curve time step = 30.00 min
                       New Storm time step  = 15.00 min

                TIME    RAIN |  TIME    RAIN |  TIME    RAIN |  TIME    RAIN
                 hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr
                 .25     .25 |  3.25    1.00 |  6.25   13.50 |  9.25    1.00
                 .50     .50 |  3.50    1.00 |  6.50    4.50 |  9.50    1.00
                 .75     .50 |  3.75    1.00 |  6.75    3.25 |  9.75     .75
                1.00     .50 |  4.00    1.00 |  7.00    2.00 | 10.00     .50
                1.25     .50 |  4.25    1.25 |  7.25    1.75 | 10.25     .50
                1.50     .50 |  4.50    1.50 |  7.50    1.50 | 10.50     .50
                1.75     .50 |  4.75    1.75 |  7.75    1.50 | 10.75     .50
                2.00     .50 |  5.00    2.00 |  8.00    1.50 | 11.00     .50
                2.25     .75 |  5.25    2.50 |  8.25    1.25 | 11.25     .50
                2.50    1.00 |  5.50    3.00 |  8.50    1.00 | 11.50     .50
                2.75    1.00 |  5.75   12.75 |  8.75    1.00 | 11.75     .50
                3.00    1.00 |  6.00   22.50 |  9.00    1.00 | 12.00     .50

---------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD    (0029) |   Area    (ha)=   7.53   Curve Number   (CN)= 88.3
|ID= 1 DT=15.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .35

         NOTE:  RAINFALL WAS TRANSFORMED TO  15.0 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
                .250     .25 | 3.250    1.00 | 6.250   13.50 |  9.25    1.00
                .500     .50 | 3.500    1.00 | 6.500    4.50 |  9.50    1.00
                .750     .50 | 3.750    1.00 | 6.750    3.25 |  9.75     .75
               1.000     .50 | 4.000    1.00 | 7.000    2.00 | 10.00     .50
               1.250     .50 | 4.250    1.25 | 7.250    1.75 | 10.25     .50
               1.500     .50 | 4.500    1.50 | 7.500    1.50 | 10.50     .50
               1.750     .50 | 4.750    1.75 | 7.750    1.50 | 10.75     .50
               2.000     .50 | 5.000    2.00 | 8.000    1.50 | 11.00     .50
               2.250     .75 | 5.250    2.50 | 8.250    1.25 | 11.25     .50
               2.500    1.00 | 5.500    3.00 | 8.500    1.00 | 11.50     .50
               2.750    1.00 | 5.750   12.75 | 8.750    1.00 | 11.75     .50
               3.000    1.00 | 6.000   22.50 | 9.000    1.00 | 12.00     .50

     Unit Hyd Qpeak  (cms)=    .830

     PEAK FLOW       (cms)=    .099 (i)
     TIME TO PEAK    (hrs)=   6.250
     RUNOFF VOLUME    (mm)=   7.293
     TOTAL RAINFALL   (mm)=  24.938
     RUNOFF COEFFICIENT   =    .292

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.
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--------------------
| CALIB            |
| NASHYD    (0030) |   Area    (ha)=   2.38   Curve Number   (CN)= 91.1
|ID= 1 DT=15.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .16

     Unit Hyd Qpeak  (cms)=    .586

     PEAK FLOW       (cms)=    .039 (i)
     TIME TO PEAK    (hrs)=   6.000
     RUNOFF VOLUME    (mm)=   6.949
     TOTAL RAINFALL   (mm)=  24.938
     RUNOFF COEFFICIENT   =    .279

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0031) |   Area    (ha)=   5.68   Curve Number   (CN)= 92.4
|ID= 1 DT=15.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .48

     Unit Hyd Qpeak  (cms)=    .449

     PEAK FLOW       (cms)=    .083 (i)
     TIME TO PEAK    (hrs)=   6.500
     RUNOFF VOLUME    (mm)=   9.721
     TOTAL RAINFALL   (mm)=  24.938
     RUNOFF COEFFICIENT   =    .390

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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 FINISH
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Simulation No.	Design Event
1	Regional (Hazel)

NASHYD ID	Outlet ID
29	W3
30	W4
31	W5

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       V    V   I    SSSSS  U   U    A    L
       V    V   I    SS     U   U   A A   L
        V  V    I     SS    U   U  AAAAA  L
        V  V    I      SS   U   U  A   A  L
         VV     I    SSSSS  UUUUU  A   A  LLLLL

        OOO   TTTTT  TTTTT  H   H  Y   Y  M   M   OOO    TM, Version 2.0
       O   O    T      T    H   H   Y Y   MM MM  O   O
       O   O    T      T    H   H    Y    M   M  O   O   Licensed To: Dillon Consulting Ltd

        OOO     T      T    H   H    Y    M   M   OOO                 vo2-0082

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                    *****  D E T A I L E D   O U T P U T *****


  Input   filename: C:\Program Files\Visual OTTHYMO v2.0\voin.dat

  Output  filename: M:\PROJECTS\DRAFT\08\089020~1\WATERR~1\DILLON~1\VO2MOD~1\STORMW~2\SWM090~1\Future regional
storms.out
  Summary filename: M:\PROJECTS\DRAFT\08\089020~1\WATERR~1\DILLON~1\VO2MOD~1\STORMW~2\SWM090~1\Future regional
storms.sum


DATE: 1/25/2010                              TIME: 3:44:05 PM

USER:


COMMENTS: _____________________________________________________________


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  ****************************
  ** SIMULATION NUMBER:   1 **
  ****************************


--------------------
|    READ STORM    |    Filename: M:\PROJECTS\DRAFT\08\089020 WATMP
|                  |              Phases 3 & 4\Water Resources\Dillon Models\
|                  |              VO2 modeling\HAZEL.STM
| Ptotal=212.00 mm |    Comments: 12-Hour Hurricane Hazel
--------------------
                TIME    RAIN |  TIME    RAIN |  TIME    RAIN |  TIME    RAIN
                 hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr
                 .25    6.00 |  3.25   13.00 |  6.25   23.00 |  9.25   53.00
                 .50    6.00 |  3.50   13.00 |  6.50   23.00 |  9.50   53.00
                 .75    6.00 |  3.75   13.00 |  6.75   23.00 |  9.75   53.00
                1.00    6.00 |  4.00   13.00 |  7.00   23.00 | 10.00   53.00
                1.25    4.00 |  4.25   17.00 |  7.25   13.00 | 10.25   38.00
                1.50    4.00 |  4.50   17.00 |  7.50   13.00 | 10.50   38.00
                1.75    4.00 |  4.75   17.00 |  7.75   13.00 | 10.75   38.00
                2.00    4.00 |  5.00   17.00 |  8.00   13.00 | 11.00   38.00
                2.25    6.00 |  5.25   13.00 |  8.25   13.00 | 11.25   13.00
                2.50    6.00 |  5.50   13.00 |  8.50   13.00 | 11.50   13.00
                2.75    6.00 |  5.75   13.00 |  8.75   13.00 | 11.75   13.00
                3.00    6.00 |  6.00   13.00 |  9.00   13.00 | 12.00   13.00

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--------------------
| CALIB            |
| NASHYD    (0029) |   Area    (ha)=   7.53   Curve Number   (CN)= 95.0
|ID= 1 DT=15.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .35

     Unit Hyd Qpeak  (cms)=    .830

     PEAK FLOW       (cms)=   1.049 (i)
     TIME TO PEAK    (hrs)=  10.000
     RUNOFF VOLUME    (mm)= 191.462
     TOTAL RAINFALL   (mm)= 212.000
     RUNOFF COEFFICIENT   =    .903

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

---------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0030) |   Area    (ha)=   2.38   Curve Number   (CN)= 96.0
|ID= 1 DT=15.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .16
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```
     Unit Hyd Qpeak  (cms)=    .586

     PEAK FLOW       (cms)=    .273 (i)
     TIME TO PEAK    (hrs)=  10.000
     RUNOFF VOLUME    (mm)= 154.163
     TOTAL RAINFALL   (mm)= 212.000
     RUNOFF COEFFICIENT   =    .727

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0031) |   Area    (ha)=   5.68   Curve Number   (CN)= 97.0
|ID= 1 DT=15.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    .48

     Unit Hyd Qpeak  (cms)=    .449

     PEAK FLOW       (cms)=    .736 (i)
     TIME TO PEAK    (hrs)=  10.250
     RUNOFF VOLUME    (mm)= 198.554
     TOTAL RAINFALL   (mm)= 212.000
     RUNOFF COEFFICIENT   =    .937

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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 FINISH
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