Fluvial Geomorphological Assessment and Erosion Hazard Delineation

Sulphur Creek and Tributaries
159 and 163 Sulphur Springs Road
Ancaster, Ontario

Prepared For:
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GEO Morphix Project No. 24108

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Disclaimer

This report presents professional opinions and findings of a scientific and technical nature based on the knowledge and information available at the time of preparation. This document is prepared solely for the Client, and the data, interpretations, suggestions, recommendations, and opinions expressed in the report pertains only to the project being completed for the Client.

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1 Introduction

GEO Morphix Ltd. (GEO Morphix) was retained to complete a geomorphological assessment and erosion hazard delineation for a portion of Sulphur Creek and its tributaries to support a development at 159 & 163 Sulphur Springs Road in Ancaster, Ontario. The subject property is bounded by Sulphur Springs Road and residential properties to the south and west, natural heritage system to the east, and the provincially significant Sulphur Creek Valley Life Science Area of Natural and Scientific Interest (ANSI) to the north (**Appendix A**). Sulphur Creek flows generally west to east through a waterbody through the northern portion of the subject property. Additionally, a small pond and tributary to Sulphur Creek flows generally west to east through the southern portion of the subject property.

The geomorphological and erosion hazard delineation assessment will, in part, inform the limits of development. The following activities were completed to as part of the geomorphological and erosion hazard assessment:

- Review available background reports and mapping (e.g., watershed/subwatershed reporting, geology, and topography) related to channel form and function and controlling factors related to fluvial geomorphology
- Review recent and historical aerial photographs of the site to understand historical changes in channel form and function
- Delineate watercourse reaches based on a desktop assessment and field confirmation
- Conduct field reconnaissance using standard, industry-accepted tools such as the rapid geomorphic assessment (RGA) (MOE, 2003) and rapid stream assessment technique (RSAT) (Galli, 1996) to evaluate existing instream and riparian conditions (i.e., evidence of ongoing channel processes, active erosion/deposition, or potential channel instability)
- Delineate limits of the meander belt width/erosion hazard on a reach basis using the results of the desktop and field assessments

This report provides a summary of existing geomorphologic conditions and the approach and methodology for erosion hazard delineation. The findings outlined herein should be considered in conjunction with the results of other studies to inform development opportunities and constraints and the overall limit of development (e.g., geotechnical stable slope analyses, floodline analysis and environmental constraints).

2 Background Review and Desktop Assessment

2.1 Site Overview

The subject property is situated within the headwaters of the Sulphur Creek subwatershed, which ultimately drains to Lake Ontario. The Sulphur Creek watershed has a drainage area of approximately 17 km^2, including the catchments Slote Road, Rifle Range, Jerseyville Road, Mineral Spring Road, Hermitage Ruins, Sulphur Springs Road, and Lower Sulphur Creek. Land use within the watershed predominantly consists of open space (5.33 km^2), residential lands (4.66 km^2), and agricultural (2.58 km^2). Forest cover accounts for 62.2%, meadows cover 1.2%, and wetlands are <1% of the subwatershed cover (Hamilton Conservation Authority, 2010).

A review of publicly available 2021 LiDAR data was conducted using hillside imagery derived at 0.5 m resolution. The subject lands appear relatively flat near Sulphur Springs Road, with topographic relief occurring to the north. In the northern portion of the site, a relatively steep valley and large online pond feature are present. Figure 1 in **Appendix A** demonstrates the extent of the subject property; and the Figure 2 includes hillshade imagery, for reference. A series of small drainage features, including a small pond feature are also present in the southern portion of the subject property. Waterbodies and drainage features are also depicted in Figure 1 (**Appendix A**).

Generally, the surficial geology within the subject property and surrounding area is predominately composed of coarse textured glaciolacustrine deposits comprised of sand, gravel, with some silt and clay (OGS, 2010). A small pocket of Paleozoic bedrock is present along the northeast portion of the subject property and surrounding area. The southern portion of the subject property is located within

the Norfolk Sand Plain physiographic region while the northern portion of the subject property is located within the Niagara Escarpment (Chapman and Putnam, 1984).

2.2 Historical Assessment

A series of historical aerial photographs were reviewed to determine changes to channels or drainage features on site and surrounding land use and land cover. This information, in part, provides an understanding of the historical factors that have contributed to current channel morphodynamics. Various aerial photographs and satellite images from 1934 to 2023 were retrieved to complete the historical assessment and inform the erosion hazard delineation. Specifically, aerial photographs for the years 1934 (1:20,000), 1945 (1:20,000), 1965 (1:20,000), and 1986 (1:25,000) were retrieved from the National Air Photo Library; 1954 (1:17,000) and 1959 (1:30,000) were retrieved from McMaster University Library (Historical Hamilton Portal); 1995 (1:30,000) was retrieved from The Ministry of Natural Resources and Forestry; and 2005, 2014, 2017, 2021, and 2023 were retrieved from Google Earth Pro. All historical aerial photographs are provided in **Appendix B** for reference.

In 1934, the subject property consisted of a residential dwelling, manicured grasses, and immature trees and hedgerows. The watercourse tributary through the northern portion of the property flowed south-west to north-east, exhibiting a straightened channel planform. Surrounding land use included residential development to the south, and agricultural lands with fragmented forests to the north, east, and west. No other drainage features were visible on site in 1934.

Between 1934 and 1945, the northern watercourse planform is no longer identifiable due to tree cover. A small wetland or pond feature is present along the northern tributary. Little to no changes are present in the surrounding land use. Through to 1959, a large pond appears constructed within the northern portion of the subject lands, replacing the previous wetland/pond feature. A trail is present along the edge of the pond. A new access road or driveway is constructed within the subject property, connecting Sulphur Springs Road to the pond. There are no visible changes to the planform of the tributary due to tree cover. Residential development continues to expand to the south.

By 1986, tree cover has matured surrounding the pond, extensively to the north, as well as within the subject property. The upstream tributary (**Reach SCT3**) is visible and exhibits a straight channel planform through a densely vegetated riparian corridor. Residential development expands to just south of Sulphur Springs Road. Surrounding land use changes from agricultural land to predominantly mature forests to the north.

Between 1995 and 2005, tree cover has continued to mature, and density increases around the large pond. With higher resolution aerials, the channel planform downstream of the pond is identifiable. This channel (**Reach SCT1**) exhibits a straight channel planform. The surrounding land use is comprised of residential dwellings to the east, south and west, along with denser forested areas to the north. Less agricultural land is present. Between 2005 and 2023, little to no changes are present within the subject property. The planform of the tributary downstream of the pond (**Reach SCT1**) remains straight. The tributary upstream of the pond (**Reach SCT3**) is still not visible due to dense tree cover.

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 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
- Certain types of channel modifications by humans

This follows scientifically defensible methodology proposed by Montgomery and Buffington (1997), Richards et al. (1997), and the Toronto and Region Conservation Authority (2004). Reaches are first delineated as a desktop exercise using available data and information such as aerial photography, topographic maps, geology information and physiography maps. The results are then verified in the field.

Several reaches were delineated in association with the subject lands based on the MNR Ontario Hydro Network and the criteria outlined above. Ultimately, reaches were finalized based on field verification and mapping and include **Reaches SCT1, SCT2, SCT3, SCT4, SCT1-2, SCT1-3** and **SCT1-4**, and **SCT1-5**. It should be noted that reach verification was only completed on features within the subject property. For example, only a short section of **SCT-6** and **SC1** were observed within the property. General descriptions of all reaches are provided below, and mapped extents of the reaches are provided in **Appendix A**.

3.2 General Reach Observations

Field investigations were completed on October 21, 2024, and included the following:

- Descriptions of riparian conditions
- Estimates of bankfull channel dimensions
- Determination of bed and bank material composition and structure
- Observations of erosion, scour, or deposition
- Collection of photographs to document the watercourses, riparian areas and/or valley, surrounding land use, and channel disturbances such as crossing structures

Only portions of reaches within parcel boundaries were assessed in the field. These observations and measurements are summarized **Table 1**. The field descriptions are supported with representative photographs, which are included in **Appendix C**. Field sheets, including those completed for rapid assessments, are provided in **Appendix D**.

Table 1: Summary of general reach characteristics

Reach	Average Bankfull Width (m)	Average Bankfull Depth (m)	Substrate		Riparian Vegetation	Notes
			Riffles	Pools		
SCT1	2.10	0.26	[1]Clay/silt, sand, and gravel		Continuous, wide riparian buffer of mature trees and shrubs	Sinuous single channel through confined valley. Perched culvert and scour pool was present at the outlet of the waterbody upstream.
SCT2 (Pond Feature)	*N/A*	*N/A*	*N/A* *Pond not wadable*		Continuous, wide riparian buffer of mature trees and shrubs	Reach contained large, online waterbody with wide, dense riparian buffer.
SCT3	1.04	0.15	Sand, Gravel and cobble	Clay/silt, and sand	Continuous; mature trees and some grasses	Narrow, single channel enters waterbody downstream; knick points present; established riparian vegetation.

Reach	Average Bankfull Width (m)	Average Bankfull Depth (m)	Substrate		Riparian Vegetation	Notes
			Riffles	Pools		
SCT6 (Drainage Feature)	[2]0.94	[2]0.03	[1]Clay/silt, and sand		Continuous; mature trees and grasses	No defined bed and banks; standing water; approaches manicured lawn west of property line.
SCT1-3 (Piped Drainage Feature)	*N/A*	*N/A*	*N/A*		Continuous immature grasses	Feature is piped from small pond to access road driveway and eastern property line.
SCT1-4 (Pond Feature)	*N/A*	*N/A*	*N/A*		Continuous; immature grasses with a few shrubs and trees	Small pond feature with; riparian buffer contains manicured lawn and sparse trees.
SCT1-5 (Drainage Feature)	*N/A*	*N/A*	*N/A*		Continuous immature grasses with a few trees	Poorly defined overland flow path from pipe flow on adjacent property south of pond.

N/A – Not applicable for reaches that were observed to be waterbodies or poorly defined drainage feature or ditch

[1] Uniform channel bed morphology

[2] Average wetted width and depth as flow path did not display defined bed or banks. Observations were limited due to site access restrictions

Reach SCT1 was a sinuous single channel that outlets a waterbody before flowing through a confined valley system. The reach begins at the outlet of a waterbody where it flows through a piped system that discharges from a man-made berm. The piped outfall is perched approximately 0.83 metres above the channel bed with a scour pool observed immediately downstream of the outfall. The channel continues to flow through a dense riparian buffer consisting of a continuous coverage of mature trees and shrubs that moderately encroaches the reach. Riffle-pool morphology was absent with runs dominating the geomorphic units. The bed substrates ranged from clay and silt to gravel, whilst the bank substrates were comprised of clay, silt, and sand. The average bankfull width and depth were 2.10 m and 0.26 m, respectively. Bank angles ranged between 60° to 90° and moderate erosion was observed along the channel banks (i.e., approximately 30-60% of the reach). It should be noted that approximately 40-50 metres of this reach was observed due to site access restrictions.

Reach SCT2 was a waterbody along the Sulphur Creek tributary. A wide dense forested buffer was observed around the waterbody. Generally, erosion was not observed around the waterbody however, other observations were limited as the depth of the waterbody was too deep to wade.

Reach SCT3 was a relatively straight channel through a partially confined valley system. The riparian vegetation consisted of trees and grasses minimally encroaching the channel. Localized phragmites were identified at the inlet to the waterbody and a portion of reach furthest downstream. Diverse geomorphic units were identified throughout the reach including riffles, runs, pools, a chute, and a small cascade. The substrate in riffles ranged from sand to cobbles, whilst the pool substrates were comprised of clay, silt, and sand. The average bankfull width and depth were 1.04 m and 0.15 m, respectively. Bank angles ranged between 0° to 30° and minimal undercutting or erosion was observed. Small knickpoints were also observed along the bed.

Reach SCT6 was characterized as a poorly defined feature with a low gradient. Approximately 20 metres of the feature was on the subject property within a pocket of trees. Additional length of the feature was visible from the property line as it crossed a manicured lawn. The feature was characteristic of a headwater drainage feature lacking defined bed and banks. Bankfull measurements were not collected, as there was no discernible, formed channel. Although, standing water was present in one location, and a wetted width and depth were measured at 0.94 m and 0.03 m, respectively.

Reach SCT1-3 was characterized as a piped drainage feature. The feature carries water from the pond at Reach SCT1-4 to the access road culvert, ultimately discharging flows to the eastern extent of the property. Water was not observed on the day at the culverts or downstream (east) of the property line and access road.

Reach SCT1-4 is a small pond in the southern portion of the subject property. The riparian buffer was observed to generally consist of shrubs that were present along the banks, however, immature grasses and some trees were also observed surrounding the waterbody. Generally, erosion was not observed around the waterbody however, other observations were limited as the depth of the waterbody was too deep to wade into.

Reach SCT1-5 was characterized as a poorly defined, artificial drainage feature with a low gradient. The feature is associated with overland flow from an existing pipe from the rear yard of the southern, adjacent property. There was no discernible channel feature, but it was assumed that overland flow ultimately drains to the small pond feature (**Reach SCT1-4**).

3.3 Rapid Geomorphological Assessment Tools

Rapid assessments were completed to identify dominant geomorphic processes, document stream health, and to identify any areas of concern regarding erosion or instability. Channel instability was objectively quantified through the application of the Ontario Ministry of the Environment's (2003) Rapid Geomorphic Assessment (RGA). Observations were quantified using an index that identifies channel sensitivity based on evidence of aggradation, degradation, channel widening, and planimetric adjustment. The index produces values that indicate whether a channel is stable/in regime (score <0.20), stressed/transitional (score 0.21-0.40), or adjusting (score >0.41).

The Rapid Stream Assessment Technique (RSAT) was also employed to provide a broader view of the system as it considers the ecological function of the watercourse (Galli, 1996). Observations were made of channel stability, channel scouring or sediment deposition, instream and riparian habitats, and water quality. The RSAT score ranks the channel as maintaining a poor (<13), fair (13-24), good (25-34), or excellent (35-42) degree of stream health.

Reaches were also classified according to a modified Downs (1995) Channel Evolution Model. The Downs (1995) model describes successional stages of a channel because of perturbation, namely hydromodification. Understanding the current stage of the system is beneficial as this allows one to predict how the channel will continue to evolve or respond to an alteration to the system. The results of these assessments are summarized below.

The RGA score of **Reach SCT1** was 0.188, indicating that the reach was in regime. The dominant geomorphic process shaping the channel was determined to be degradation, largely due to the elevated outlet and scouring that is occurring as a result. The RSAT score was 25, indicating that the reach was in good condition. The limiting feature was the physical instream habitat due to the lack of diverse habitat and generally shallow depth of the channel. Under the Downs (1995) model, the channel was determined to be laterally migrating due to the widening that was also occurring as result of leaning and fallen trees and increase in erosion along the channel. Although, overall, observations showed a generally straight channel.

The RGA score of **Reach SCT3** was 0.273, indicating that the reach was in transition. The dominant geomorphic process shaping the channel was determined to be degradation, largely due to the presence of knick points. The RSAT score was 26, indicating that the reach was in good condition. The limiting feature was the physical instream habitat due to the shallow depth of the channel and lack of deep pools. Under the Downs (1995) model, the channel was determined to be in a depositional condition due to the presence of a low flow channel between outer banks.

The rapid assessment tools were not applied on the remaining reaches as they consisted of waterbodies, piped features, or small poorly defined drainage features.

4 Erosion Hazard Assessment

4.1 Methodology

Most watercourses in southern Ontario have a natural tendency to develop and maintain a meandering planform, provided there are no spatial constraints. A meander belt width or erosion hazard assessment estimates the lateral extent that a meandering channel has historically occupied and will likely occupy in the future. This assessment is therefore useful for determining the potential hazard to proposed activities in the vicinity of a watercourse.

When defining the erosion hazard for a watercourse, Ministry of Natural Resources (MNR, 2002) guidelines treat unconfined and confined systems differently. Confined systems are those where the watercourse is contained within a defined valley, where valley wall contact is possible. In contrast, unconfined systems are those with poorly defined valleys or slopes well outside where the channel could realistically migrate. Unconfined systems are generally found within glaciated plains with flat or gently rolling topography. Partially confined systems are those where meander bends or the channel are adjacent to only one valley wall and the watercourse is therefore restricted in migration and floodplain occupation on one side of the valley system.

In unconfined systems, a meander belt width can be applied, at minimum, based on 20 times the bankfull channel width. Alternatively, the meander belt width can be determined through a detailed geomorphological study that examines the largest channel meanders observed through historical and recent aerial photograph interpretation. The meander belt width can then be graphically defined using orthorectified aerial imagery by determining the channel centerline and the channel's central tendency (i.e., meander belt axis). In cases where the channel is not discernible in aerial photographs or the channel has been substantially modified, empirical models can be used to estimate the meander belt width.

The Ontario Ministry of Natural Resources (MNR) outlines an approach for establishing the erosion hazard where watercourses are confined by valley walls. This approach defines an appropriate erosion setback or toe erosion allowance from a channel bank where the creek is within 15 m of the toe of the valley slope. A toe erosion allowance can be determined in several ways: use of an average annual recession rate; application of a 15 m toe erosion allowance in areas where the channel is within 15 m of the toe of slope; or use of soil information and field observations of geomorphic processes (MNR, 2002). In partially confined systems, a hybrid approach can be used to delineate the erosion hazard whereby an appropriate meander belt width is applied to unconfined portions of a given reach and where the channel is within 15 m of the valley toe, a toe erosion allowance and stable slope allowance are applied.

Through field reconnaissance, it was determined that **Reach SCT1** was confined. Therefore, the erosion hazard limit was defined based on a toe erosion allowance. **Reach SCT3** was partially confined, and therefore both a meander belt width and an appropriate toe erosion allowance were delineated to establish the erosion hazard limit.

As noted previously in this Report, the remaining reaches are characterized as low-order drainage features with limited feature definition or pond features. Meander belt widths have not been delineated for these features as they have limited erosion/migration potential due to their ephemeral/intermittent flow regimes and relatively small drainage areas.

4.2 Reach SCT1 (Confined)

Reach SCT1 was identified as confined within the study area. It is a relatively small tributary situated downstream of the large online pond feature. The reach is densely vegetated and poorly visible through aerial photograph interpretation. Given the poor aerial coverage and limited channel definition observed in the historical and recent aerials, meander migration analysis was not possible to determine an average annual recession rate. As such, we have developed a recommendation below for an appropriate toe erosion allowance based on a combination of reach-level observations of existing geomorphic conditions and guidance outlined by MNR in their technical guide for defining riverine erosion hazards (MNR, 2002).

The erosion hazard in this location consists of the toe erosion allowance (where the channel is within 15 m of the toe of valley slope), stable slope allowance (completed by others) and an erosion access allowance. Channel bank materials consisted of clay and silt. Given the relatively small size of the feature, a 5 m toe erosion allowance is recommended and is to be applied from the valley toe of slope where the channel is within 15 m of the valley toe. This is consistent with Table 3 of MNR (2002) guidelines for stiff/hard cohesive soil (clays, clay silt) and coarse granular (gravels) till.

It should be noted that only a short section of **Reach SCT1** (30-40 m length) was observed within the subject property due to access limitations. As such, the toe erosion allowance may be subject to refinement depending on downstream channel conditions. Although, the channel appears to be a significant distance from the existing valley slope situated on the south side of the large online pond. The hillshade imagery in Figure 2 of **Appendix A** shows that the section of **SCT1** within the subject property is in the range of 50-60 m from the southern valley slope.

Reach SCT2 consisted of an online pond feature with an adjacent valley wall to the south. Although the pond does not represent a typical erosion hazard due to a lack of channel processes, a 5 m toe erosion allowance is also recommended for this Reach and should be applied from the slope toe.

The erosion hazard extent in confined systems is to also include a stable slope allowance. The stable slope allowance should be determined through a valid geotechnical study and should be reviewed in tandem with the above toe erosion allowance recommendations.

4.3 Reach SCT3 (Partially Confined)

Reach SCT3 was assessed as partially confined. A review of recent and historical aerial imagery was completed but did not indicate the presence of significant meanders along **Reach SCT3** due to mature tree coverage. Given the lack of defined meanders, an empirical modelling approach was used to determine a range of potential meander belt widths and support the definition of the erosion hazard for the unconfined reach through the subject property.

The empirical relations from Williams (1986) were modified to include channel area and width, and applied using the bankfull channel dimensions such that:

$$B_w = 18A^{0.65} + W_b \quad \text{[Eq. 1]}$$

$$B_w = 4.3{W_b}^{1.12} + W_b \quad \text{[Eq. 2]}$$

where *Bw* is meander belt width (m), *A* is bankfull cross-sectional area (m^2), and W_b is bankfull channel width (m). An additional 20% buffer, or factor of safety, was applied to the computed belt width values. This addresses issues of under prediction.

The Ward et al. (2002) bankfull width model was also used to determine a meander belt width (ft), *Bw*:

$$B_w = 6{W_b}^{1.12} \quad \text{[Eq. 3]}$$

The resulting value was then converted to the metric system (m). A 20% factor of safety was not applied to this value due to the approach used in the modelling (i.e., hazard envelope rather than a linear relationship).

The empirical modeling exercise resulted in meander belt widths ranging from 7 m to 8 m for **SCT3**. To be conservative, we recommend a nominal meander belt width of 10 m for **Reach SCT3.** This is an appropriate approach as it is based on site-specific conditions and is considered a conservative value as this reach functions as a straight channel with limited evidence of planform adjustment or active erosion. The final meander belt width is graphically displayed in **Appendix E**.

In partially confined systems where one side of the channel is within 15 m of the slope toe, a toe erosion allowance should also be applied, in combination with a stable slope allowance (completed by others) and an erosion access allowance. Reach SCT3 is partially confined along the eastern side of the channel. The valley slope is visible in the hillshade imagery provided in Figure 2 (**Appendix A**). Channel bank materials consisted of clay and silt. Given the relatively small size of the feature, a 5 m

toe erosion allowance is recommended and is to be applied from the valley toe of slope where the channel is within 15 m of the valley toe. This is consistent with Table 3 of MNR (2002) guidelines for stiff/hard cohesive soil (clays, clay silt) and coarse granular (gravels) till.

5 Summary

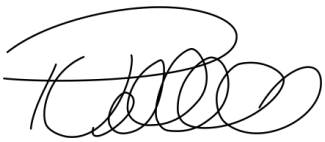
GEO Morphix was retained to complete a fluvial geomorphological assessment and erosion hazard delineation for tributaries of Sulphur Creek in support of a proposed development at 159 & 163 Sulphur Springs Road in Ancaster, Ontario.

GEO Morphix completed a desktop assessment and field investigation to understand existing fluvial geomorphological conditions for the subject property. This included a desktop review of historical and recent aerial photographs, existing geology and topographic mapping, and reach delineation. A tributary of Sulphur Creek is situated along the northern portion of the subject property and includes a large online pond, likely constructed in the late 1950s. Due to heavy tree cover, the tributary upstream and downstream of this pond are not visible in aerial imagery. Several small drainage features are also present in the southern portion of the subject property, but these features displayed limited form or definition or were piped.

Erosion hazard delineation was completed for the main tributary through the northern portion of the subject property. **Reach SCT1** was considered confined within an existing valley system, and a 5 m toe erosion allowance is recommended where the channel is within 15 m of the toe of valley slope. Although, **Reach SCT2** was a large online pond and does not represent a typical erosion hazard due to a lack of channel processes, a 5 m toe erosion allowance is also recommended and should be applied from the toe of slope. Reach SCT3 was classified as partially confined. A meander belt width of 10 m is recommended based on an empirical modelling exercise. On the eastern side of the channel, where there is a defined valley slope, a toe erosion allowance of 5 m is recommended for any locations where the channel is within 15 m of the toe of slope. It should be noted that a stable slope allowance is also required in addition to a toe erosion allowance is applied. The stable slope allowance should be delineated through a valid geotechnical study.

We trust this report meets your current requirements. Should you have any questions, please contact the undersigned.

Respectfully submitted,



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Director, Principal Geomorphologist

Kat Woodrow, M.Sc.
Manager of Watershed Studies

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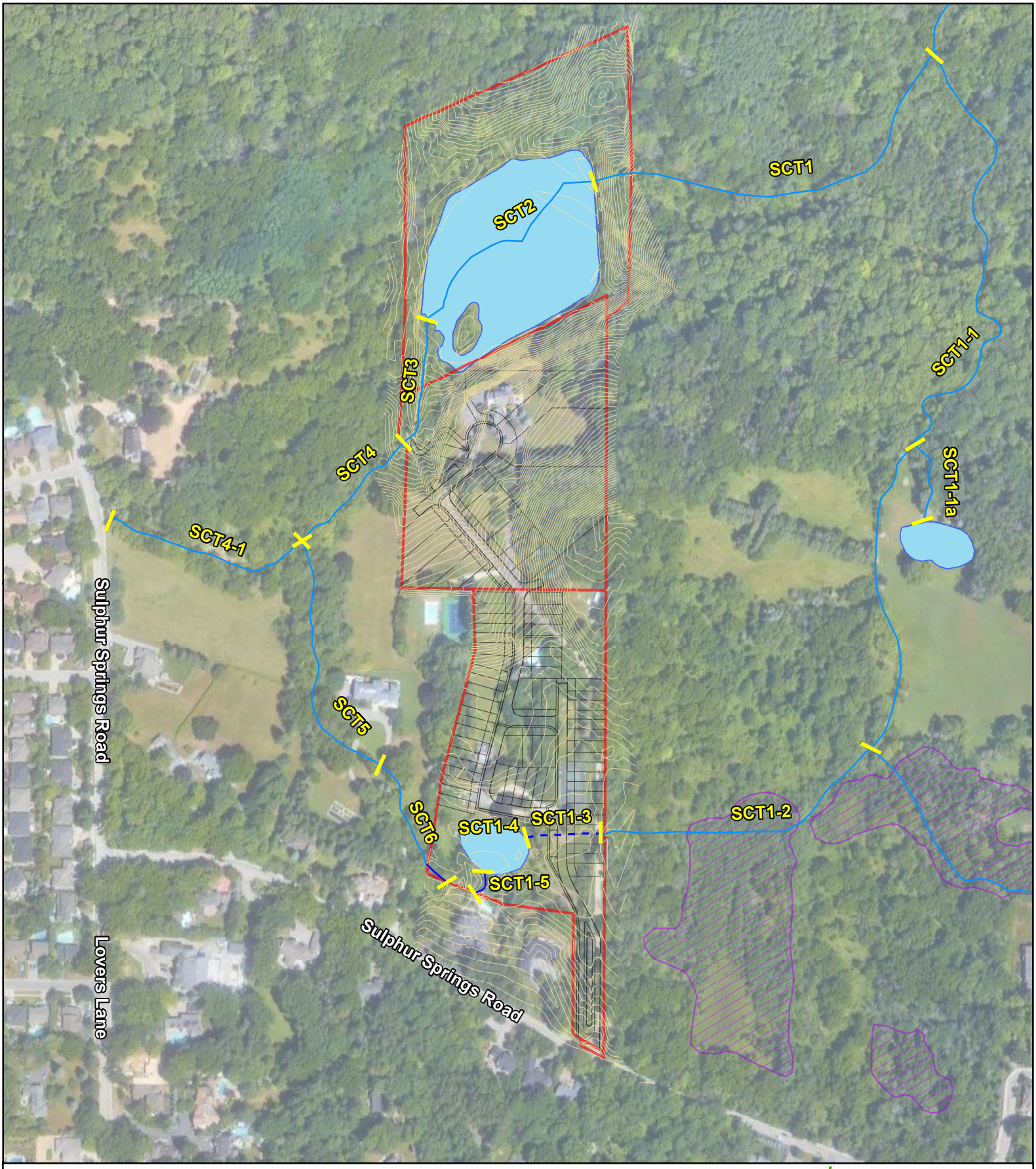
Appendix A:
Study Area and Reach Delineation



Legend

- Reach Break and ID
- Watercourse
- Drainage Feature
- Piped Feature
- 0.5 m Contour
- Development Fabric
- Subject Lands
- MNR Mapped Wetland
- OHN Waterbody

Figure 1

Study Area and Reach Delineation

Sulphur Creek

Ancaster, Ontario

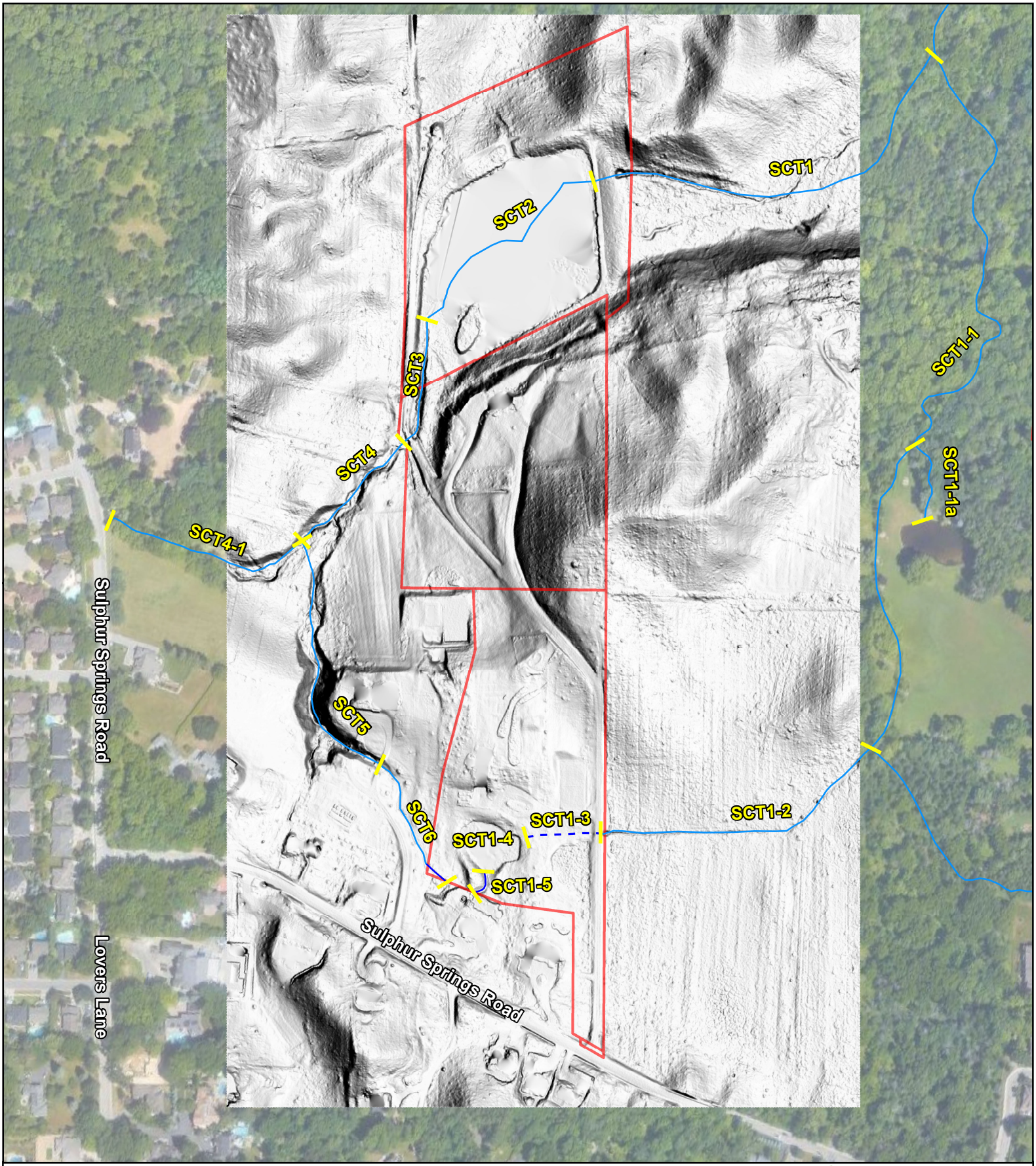
GEO MORPHIX™

N

0 60 120

Metres

Imagery: Google Earth, 2023. Watercourse: Hamilton, 2024.
Waterbody, Watercourse (OHN), Wetland: MNRF, 2024.
Subject Lands, Development Fabric: Crozier, 2024.
Print Date: October 2024. PN24108. Drawn By: R.A., M.O., K.W.



Legend

- Reach Break and ID
- Watercourse
- Drainage Feature
- Piped Feature
- Subject Lands

Figure 2

Terrain Analysis

Sulphur Creek

Ancaster, Ontario

GEO MORPHIX™

N

0 60 120

Metres

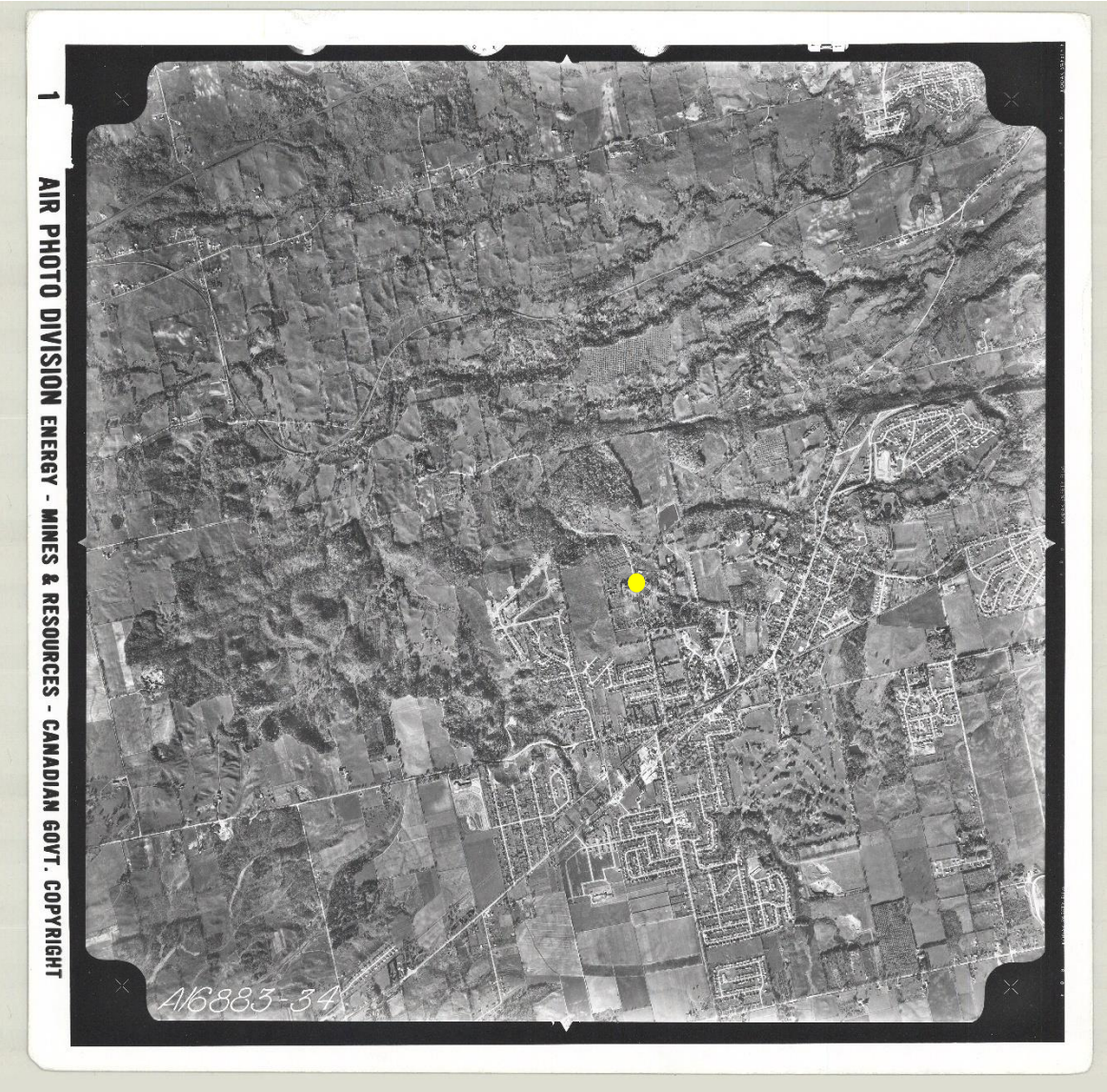
Hillshade: MNRF, 2021. Watercourse: Hamilton, 2024.
Watercourse (OHN): MNRF, 2024. Subject Lands: Crozier, 2024.
Print Date: November 2024. PN24108. Drawn By: R.A., M.O., K.W.

Appendix B:
Historical Aerial Photographs

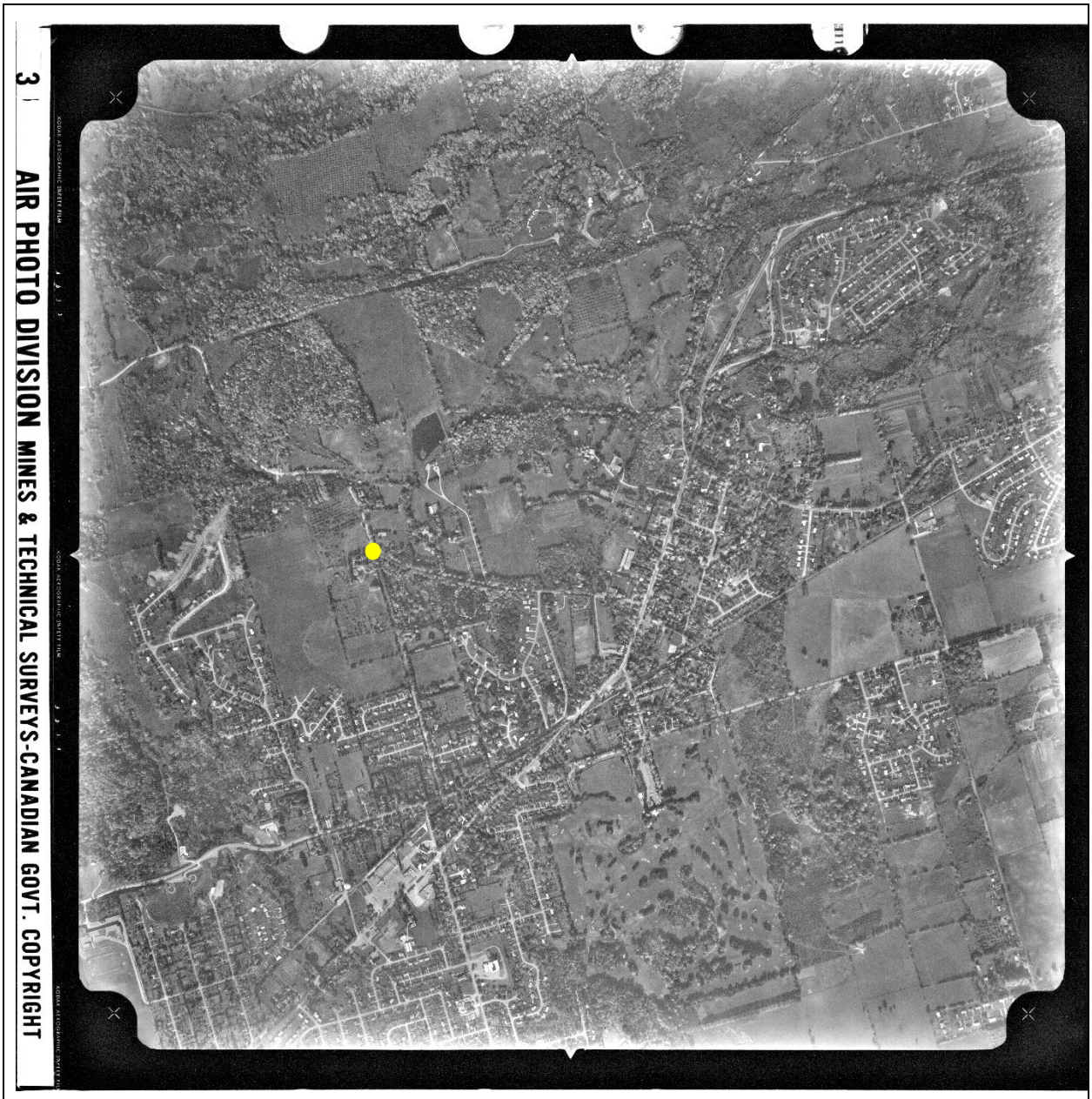
Location: Ancaster, ON
Year: 1934
Scale: 1:20,000
Source: National Air Photo Library
Yellow Point: Intersection of Sulphur Springs Road and Lovers Lane

Location: Ancaster, ON
Year: 1945
Scale: 1:20,000
Source: National Air Photo Library
Yellow Point: Intersection of Sulphur Springs Road and Lovers Lane

Location: Ancaster, ON
Year: 1954
Scale: 1:17,000
Source: McMaster University Library (Historical Hamilton Portal)
Yellow Point: Intersection of Sulphur Springs Road and Lovers Lane

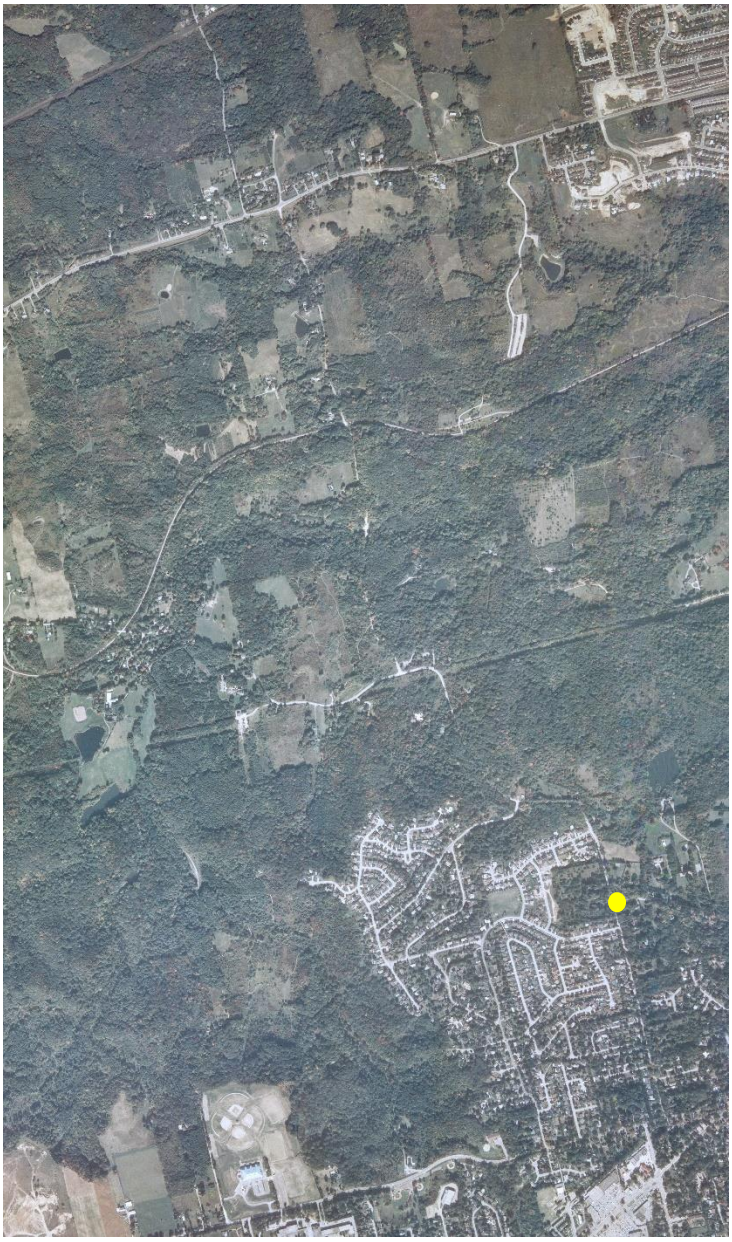


Location: Ancaster, ON
Year: 1959
Scale: 1:30,000
Source: McMaster University Library (Historical Hamilton Portal)
Yellow Point: Intersection of Sulphur Springs Road and Lovers Lane

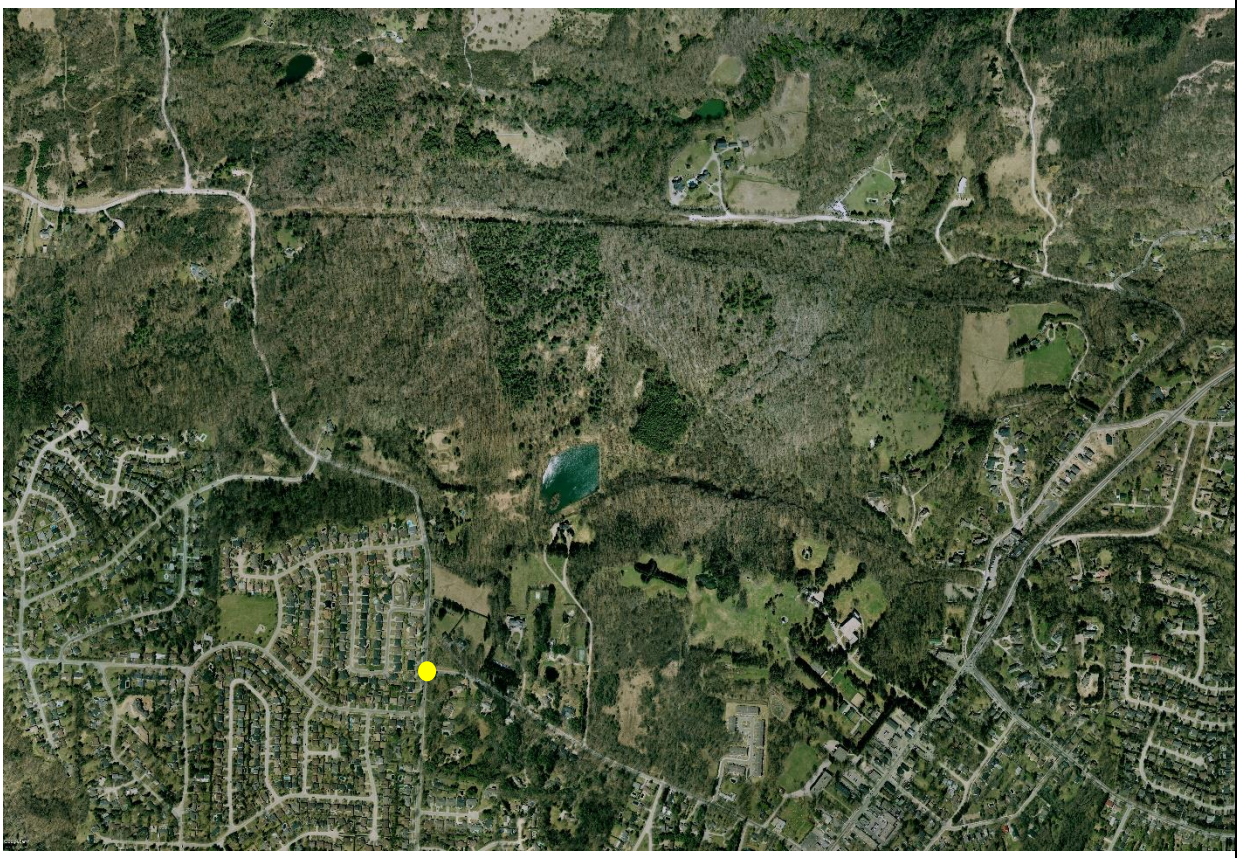


Location: Ancaster, ON
Year: 1965
Scale: 1:20,000
Source: National Air Photo Library
Yellow Point: Intersection of Sulphur Springs Road and Lovers Lane

Location: Ancaster, ON
Year: 1986
Scale: 1:25,000
Source: National Air Photo Library
Yellow Point: Intersection of Sulphur Springs Road and Lovers Lane

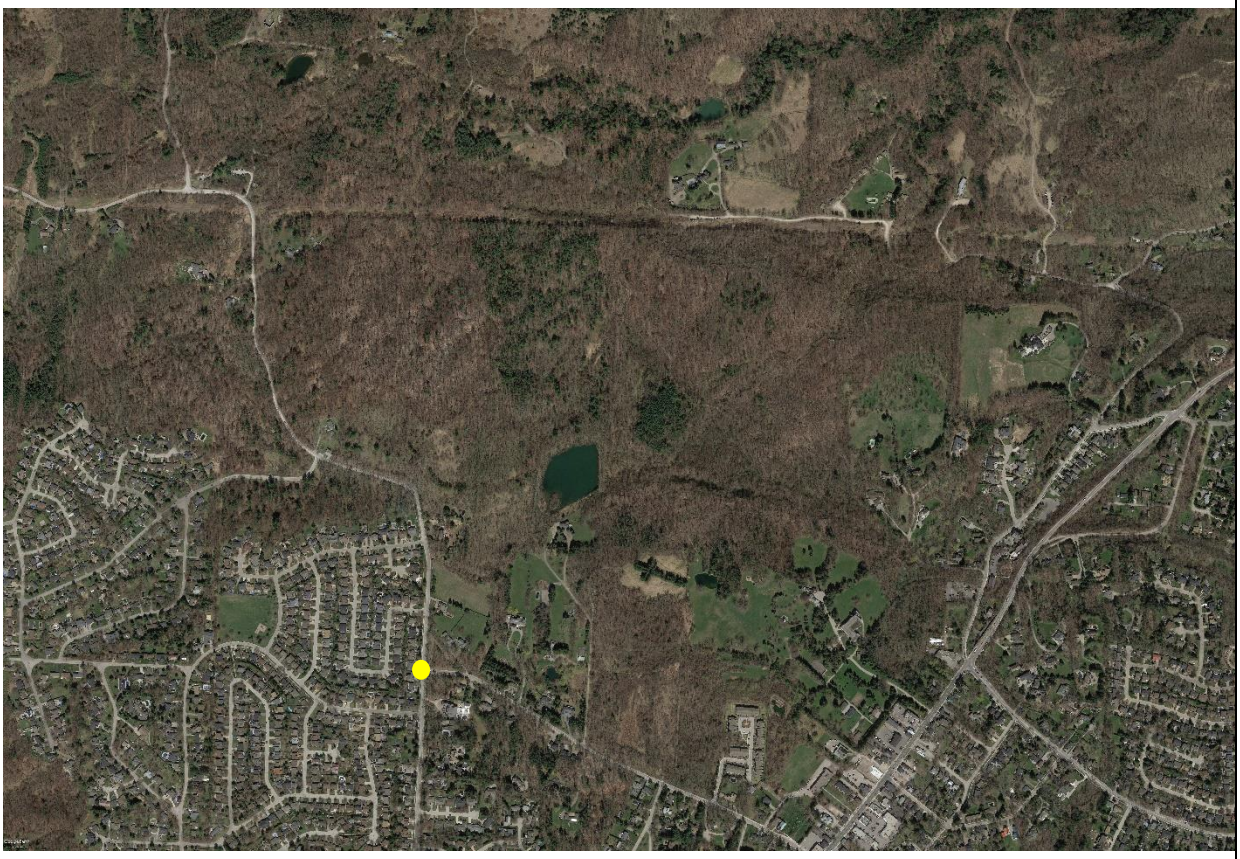


Location: Ancaster, ON
Year: 1995
Scale: 1:30,000
Source: Ministry of Natural Resources and Forestry
Yellow Point: Intersection of Sulphur Springs Road and Lovers Lane

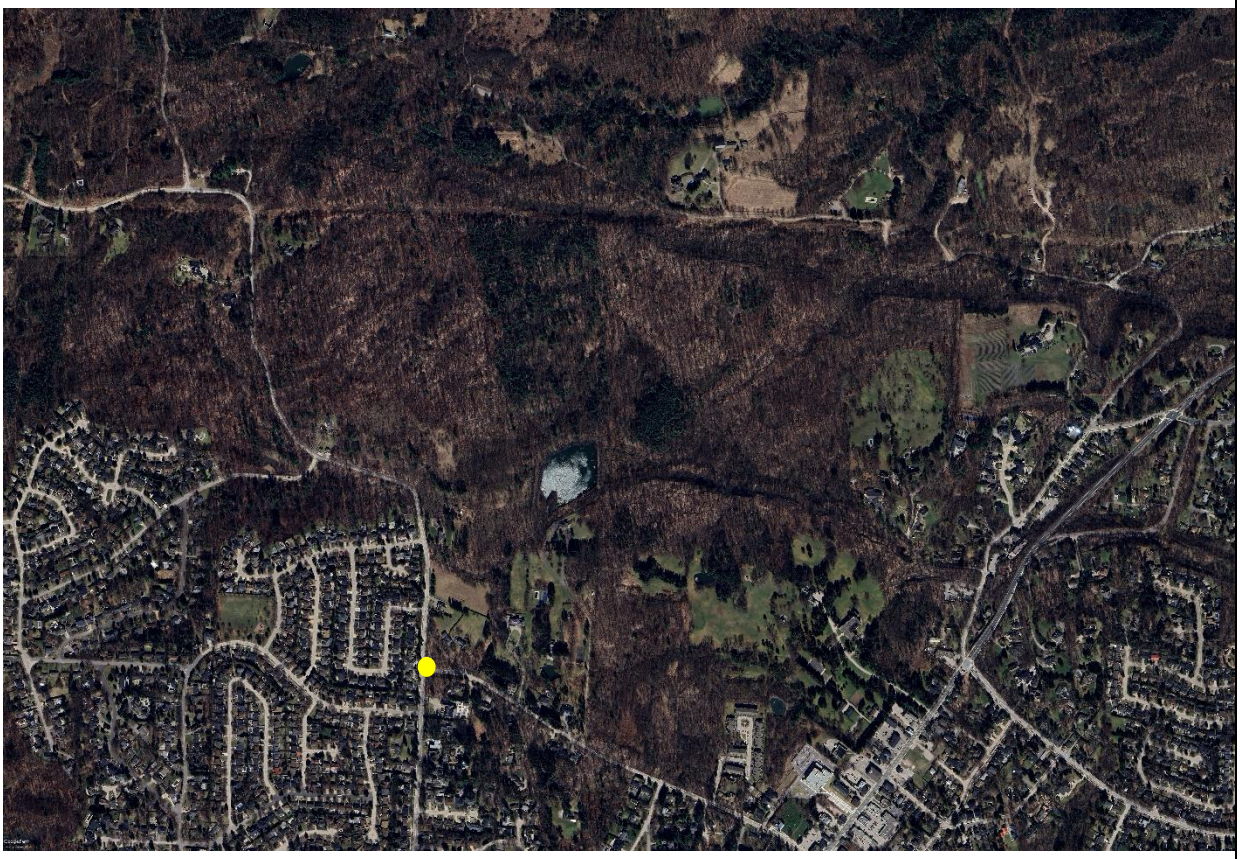


Location: Ancaster, ON
Year: 2005
Scale: Digital Orthoimagery
Source: Google Earth Pro
Yellow Point: Intersection of Sulphur Springs Road and Lovers Lane

Location: Ancaster, ON
Year: 2014
Scale: Digital Orthoimagery
Source: Google Earth Pro
Yellow Point: Intersection of Sulphur Springs Road and Lovers Lane



Location: Ancaster, ON
Year: 2017
Scale: Digital Orthoimagery
Source: Google Earth Pro
Yellow Point: Intersection of Sulphur Springs Road and Lovers Lane



Location: Ancaster, ON
Year: 2023
Scale: Digital Orthoimagery
Source: Google Earth Pro
Yellow Point: Intersection of Sulphur Springs Road and Lovers Lane

Appendix C:
Photographic Record

Photo 1
Tributary of Sulphur Creek - Reach SCT1
Ancaster, Ontario

A perched outfall was present in the most upstream section of the reach with a scour pool present measuring up to 0.83 metres deep.

Photo 2
Tributary of Sulphur Creek - Reach SCT1
Ancaster, Ontario

The reach had many exposed roots with some woody debris throughout the reach.

Photo 3
Tributary of Sulphur Creek - Reach SCT1
Ancaster, Ontario

Some erosion was observed along the channel as well as in the scour pool (yellow arrow – general bank erosion).

Photo 4
Tributary of Sulphur Creek - Reach SCT1
Ancaster, Ontario

Bed substrate (as shown in photograph 4) consisted of clay, silt, sand, and gravel whilst the bank substrate was observed to consist of clay, silt, and sand.

Photo 5
Tributary of Sulphur Creek - Reach SCT2
Ancaster, Ontario

This reach consisted of a waterbody with a dense forested buffer surrounding it.

Photo 6
Tributary of Sulphur Creek - Reach SCT3
Ancaster, Ontario

Generally, the banks of the low flow channel were well vegetated with grass and some trees. Some localized phragmites were observed at the most downstream portion of the reach.

Photo 7
Tributary of Sulphur Creek - Reach SCT3
Ancaster, Ontario

The bed substrate was observed to consist of sand, gravel, and cobbles generally through riffles.

Photo 8
Tributary of Sulphur Creek - Reach SCT3
Ancaster, Ontario

A couple of knickpoints were present in this reach. In these regions the channel has worn into the undisturbed overburden (yellow arrow).

Photo 9
Tributary of Sulphur Creek - Reach SCT3
Ancaster, Ontario

Erosion throughout the reach was generally observed along the outer banks of the channel, whilst minimal erosion was observed through the low flow channel.

Photo 10
Tributary of Sulphur Creek - Reach SCT6
Ancaster, Ontario

Approximately 20 metres of this reach was present on the subject property. The feature was characteristic of a low order headwater drainage feature with a lack of definition and erosion present. The remainder of the reach was not accessed due to access restrictions.

Photo 11
Tributary of Sulphur Creek - Reach SCT1-3
Ancaster, Ontario

The feature consisted of a tile drain that was identified through the presence of an open grate where a pipe and flowing water was observed.

Photo 12
Tributary of Sulphur Creek - Reach SCT1-4
Ancaster, Ontario

This reach consisted of a waterbody with grass and trees within the riparian area. Algae was also observed on the pond water surface.

Photo 13
Drainage feature - Reach SCT1-5
Ancaster, Ontario

The drainage feature was observed to enter the pond via overland flow over a concrete slab.

Photo 14
Drainage feature - Reach SCT1-5
Ancaster, Ontario

The drainage feature was observed to be flowing with a lack of defined bed or banks. As a result the bed and bank substrate was observed to consist primarily of rootlets, silt, and sand.

Photo 15
Drainage feature - Reach SCT1-5
Ancaster, Ontario

The source of the flows was observed to be from piped flows discharging from the adjacent properties.

Appendix D:
Field Observations

GEO MORPHIX

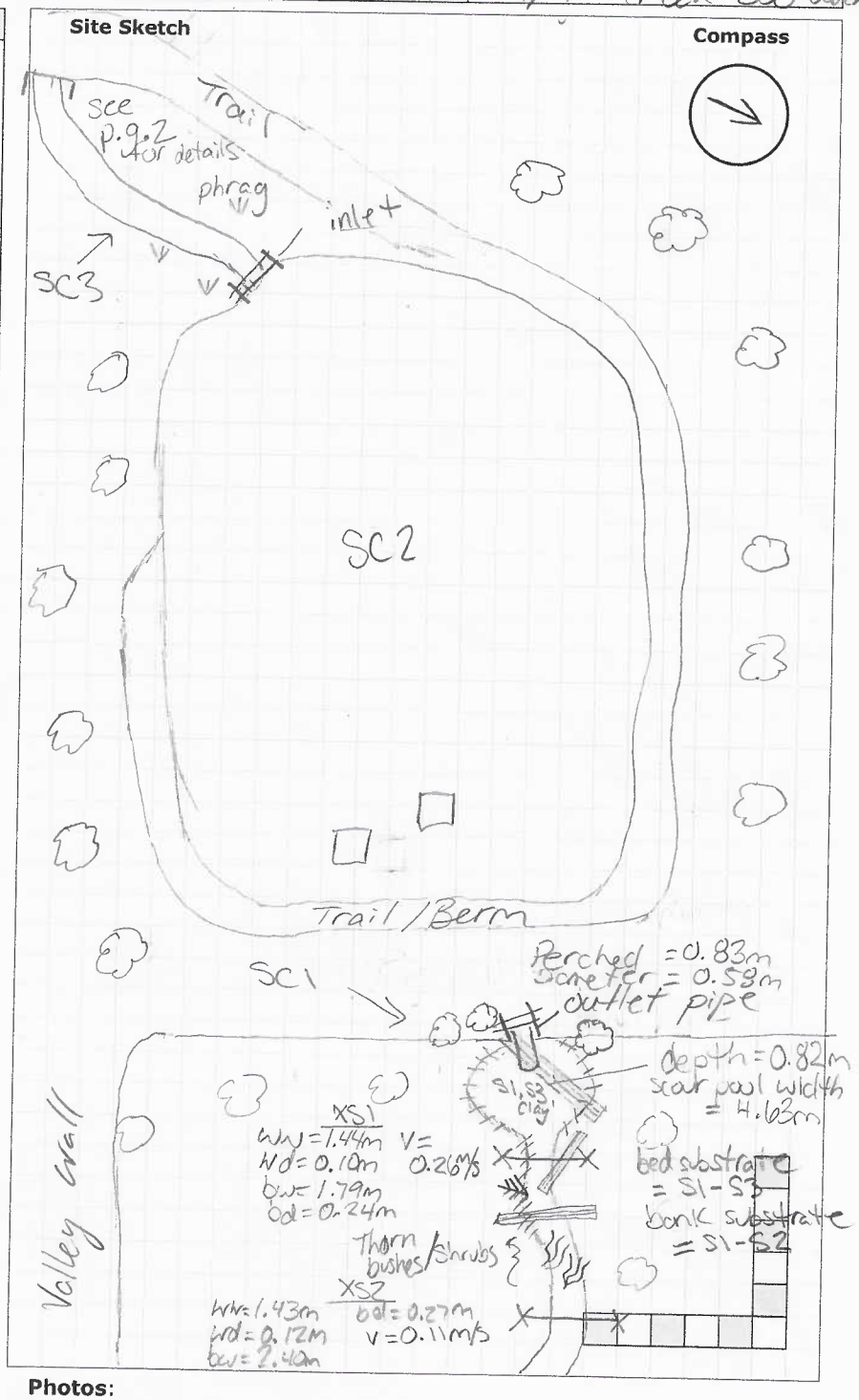
General Site Characteristics

Project Number: 24108

Date:	2024-10-21	**Stream:**	Sulphur Creek
Time:	11:00 AM	**Reach:**	SCT1, SCT2
Weather:	sunny, 20°c	**Location:**	159/163 Sulphur Springs rd.
Field Staff:	RA CM	**Watershed/Subwatershed:**	Sulphur Creek Subwatershed

Features	Monitoring
Reach break	Long-profile
Station location	Monumented XS
Cross-section	Monumented photo
Flow direction	Monumented photo direction
Riffle	Sediment sampling
Pool	Erosion pins
Sediment bar	Scour chains
Eroded bank/slope	**Additional Symbols**
Undercut bank	
Bank stabilization	
Leaning tree	
Fence	
Culvert/outfall	
Swamp/wetland	
Grasses	
Tree	
Instream log/tree	
Woody debris	
Beaver dam	
Vegetated island	

Site Sketch



Flow Type

H1	Standing water	**H1A**	Back 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	**H9A**	Dissipates below 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

Photos:

Notes: Perched height from bottom of pipe to depth of scour pool (scour pool deepest at centre). Pipe observed to be degrading. Banks 1.5m high.

Version #4
Last edited: 21/02/2023

Senior staff sign-off (if required): _____ Checked by: KW Completed by: RA

GEO MORPHIX

Rapid Geomorphic Assessment **Project Number:** PN24108

Date:	2024-10-21	**Stream:**	Sulphur Creek
Time:	11:00 AM	**Reach:**	SCT1
Weather:	Sunny, 20°C	**Location:**	159/163 Sulphur Springs rd.
Field Staff:	RA AM	**Watershed/Subwatershed:**	Sulphur Creek Subwatershed

Process	No.	Geomorphological Indicator: Description	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		✓	0/7
	2	Coarse materials in riffles embedded		✓	
	3	Siltation in pools		✓	
	4	Medial bars		✓	
	5	Accretion on point bars		✓	
	6	Poor longitudinal sorting of bed materials		✓	
	7	Deposition in the overbank zone		✓	
		Sum of indices =	0	7	0.0
Evidence of Degradation (DI)	1	Exposed bridge footing(s)	N/A		3/8
	2	Exposed sanitary / storm sewer / pipeline / etc.	✓		
	3	Elevated storm sewer outfall(s)	✓		
	4	Undermined gabion baskets / concrete aprons / etc.	N/A		
	5	Scour pools downstream of culverts / storm sewer outlets	✓		
	6	Cut face on bar forms		✓	
	7	Head cutting due to knickpoint migration		✓	
	8	Terrace cut through older bar material		✓	
	9	Suspended armour layer visible in bank		✓	
	10	Channel worn into undisturbed overburden / bedrock		✓	
		Sum of indices =	3	5	0.375
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	✓		3/8
	2	Occurrence of large organic debris		✓	
	3	Exposed tree roots	✓		
	4	Basal scour on inside meander bends		✓	
	5	Basal scour on both sides of channel through riffle		✓	
	6	Outflanked gabion baskets / concrete walls / etc.	N/A		
	7	Length of basal scour >50% through subject reach (full reach not assessed)	✓		
	8	Exposed length of previously buried pipe / cable / etc.		✓	
	9	Fracture lines along top of bank		✓	
	10	Exposed building foundation	N/A		
		Sum of indices =	3	5	0.375
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		✓	0/7
	2	Single thread channel to multiple channel		✓	
	3	Evolution of pool-riffle form to low bed relief form		✓	
	4	Cut-off channel(s)		✓	
	5	Formation of island(s)		✓	
	6	Thalweg alignment out of phase with meander form		✓	
	7	Bar forms poorly formed / reworked / removed		✓	
		Sum of indices =	0	7	0.0

Notes: * RGA completed along approx. 40-50m length of reach on property; no field access further downstream

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.188

In Regime	In Transition/Stress	In Adjustment
☒ 0.00 - 0.20	☐ 0.21 - 0.40	☐ 0.41

Version #3
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: KW Completed by: RA

GEO MORPHIX

Rapid Stream Assessment Technique Project Number: 24108

Date:	2024-10-21	**Stream:**	Sulphur Creek
Time:	11:00 AM	**Reach:**	SCT1
Weather:	sunny, 20°c	**Location:**	159/163 Sulphur Springs rd.
Field Staff:	RA CM	**Watershed/Subwatershed:**	Sulphur Creek Subwatershed

Category	Poor	Fair	Good	Excellent
Channel Stability	• < 50% of bank network stable • Recent bank sloughing, slumping or failure frequently observed	• 50-70% of bank network stable • Recent signs of bank sloughing, slumping or failure fairly common	• 71-80% of bank network stable • Infrequent signs of bank sloughing, slumping or failure	• > 80% of bank network stable • No evidence of bank sloughing, slumping or failure
	• Stream bend areas highly unstable • Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) • Bank overhang > 0.8-1.0 m	• Stream bend areas unstable • Outer bank height 0.9-1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) • Bank overhang 0.8-0.9m	• Stream bend areas stable • Outer bank height 0.6-0.9 m above stream bank (1.2-1.5 m above stream bank for large mainstem areas) • Bank overhang 0.6-0.8 m	• Stream bend areas very stable • Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) • Bank overhang < 0.6 m
	• Young exposed tree roots abundant • > 6 recent large tree falls per stream mile	• Young exposed tree roots common • 4-5 recent large tree falls per stream mile	• Exposed tree roots predominantly old and large, smaller young roots scarce • 2-3 recent large tree falls per stream mile	• Exposed tree roots old, large and woody • Generally 0-1 recent large tree falls per stream mile
	• Bottom 1/3 of bank is highly erodible material • Plant/soil matrix severely compromised	• Bottom 1/3 of bank is generally highly erodible material • Plant/soil matrix compromised	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material
	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally V- or U-shaped	• Channel cross-section is generally V- or U-shaped
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4 ☒ 5	☐ 6 ☐ 7 ☐ 8	☐ 9 ☐ 10 ☐ 11
Channel Scouring/ Sediment Deposition	• > 75% embedded (> 85% embedded for large mainstem areas)	• 50-75% embedded (60-85% embedded for large mainstem areas)	• 25-49% embedded (35-59% embedded for large mainstem areas)	• Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas)
	• Few, if any, deep pools • Pool substrate composition >81% sand-silt	• Low to moderate number of deep pools • Pool substrate composition 60-80% sand-silt	• Moderate number of deep pools • Pool substrate composition 30-59% sand-silt	• High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas) • Pool substrate composition <30% sand-silt
	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits uncommon	• Streambed streak marks and/or "banana"-shaped sediment deposits absent
	• Fresh, large sand deposits very common in channel • Moderate to heavy sand deposition along major portion of overbank area	• Fresh, large sand deposits common in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits uncommon in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits rare or absent from channel • No evidence of fresh sediment deposition on overbank
	• Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand	• Point bars common, moderate to large and unstable with high amount of fresh sand	• Point bars small and stable, well-vegetated and/or armoured with little or no fresh sand	• Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☐ 5 ☐ 6	☒ 7 ☐ 8

Only deep scour pool

Version #2
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: _____

GEO MORPHIX

Date:	2024-10-21	PN:	PN24108	Location:	159/163 Sulphur Springs rd.

Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	• Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	• Wetted perimeter 40-60% of bottom channel width (45-65% for large mainstem areas)	• Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas)	• Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)
	• Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low)	• Few pools present, riffles and runs dominant. • Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate)	• Good mix between riffles, runs and pools • Relatively diverse velocity and depth of flow	• Riffles, runs and pool habitat present • Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water)
	• ~~Riffle~~ substrate composition: predominantly gravel with high amount of sand • < 5% cobble	• Riffle substrate composition: predominantly small cobble, gravel and sand • 5-24% cobble	• Riffle substrate composition: good mix of gravel, cobble, and rubble material • 25-49% cobble	• Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand • > 50% cobble
	• ~~Riffle~~ depth < 10 cm for large mainstem areas	• ~~Riffle~~ depth 10-15 cm for large mainstem areas	• Riffle depth 15-20 cm for large mainstem areas	• Riffle depth > 20 cm for large mainstem areas
	• Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure	• Large pools generally 30-46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structure	• Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure	• Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure
	• Extensive channel alteration and/or point bar formation/enlargement	• Moderate amount of channel alteration and/or moderate increase in point bar formation/enlargement	• Slight amount of channel alteration and/or slight increase in point bar formation/enlargement	• No channel alteration or significant point bar formation/enlargement
	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	• Riffle/Pool ratio 0.5-0.69:1 ; 1.31-1.5:1	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	• Riffle/Pool ratio 0.9-1.1:1
	• Summer afternoon water temperature > 27°C	• Summer afternoon water temperature 24-27°C	• Summer afternoon water temperature 20-24°C	• Summer afternoon water temperature < 20°C
Point range	☐ 0 ☐ 1 ☒ 2	☐ 3 ☐ 4	☐ 5 ☐ 6	☐ 7 ☐ 8
Water Quality	• Substrate fouling level: High (> 50%)	• Substrate fouling level: Moderate (21-50%)	• Substrate fouling level: Very light (11-20%)	• Substrate fouling level: Rock underside (0-10%)
	• Brown colour • TDS: > 150 mg/L	• Grey colour • TDS: 101-150 mg/L	• Slightly grey colour • TDS: 50-100 mg/L	• Clear flow • TDS: < 50 mg/L
	• Objects visible to depth < 0.15m below surface	• Objects visible to depth 0.15-0.5m below surface	• Objects visible to depth 0.5-1.0m below surface	• Objects visible to depth > 1.0m below surface
	• Moderate to strong organic odour	• Slight to moderate organic odour	• Slight organic odour	• No odour
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☒ 5 ☐ 6	☐ 7 ☐ 8
Riparian Habitat Conditions	• Narrow riparian area of mostly non-woody vegetation	• Riparian area predominantly wooded but with major localized gaps	• Forested buffer generally > 31 m wide along major portion of both banks	• Wide (> 60 m) mature forested buffer along both banks
	• Canopy coverage: <50% shading (30% for large mainstem areas)	• Canopy coverage: 50-60% shading (30-44% for large mainstem areas)	• Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	• Canopy coverage: >80% shading (> 60% for large mainstem areas)
Point range	☐ 0 ☐ 1	☐ 2 ☐ 3	☐ 4 ☐ 5	☒ 6 ☐ 7

Total overall score (0–42) = 25	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Version #2
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: KW Completed by: RA

*RSAT completed along approx. 40-50m length of reach on property; no field access further downstream

GEO MORPHIX

Reach Characteristics

Project Number: PN24108

Date:	2024-10-21	**Field Staff:**	RA CM	**Watershed/Subwatershed:**	Sulphur Creek
Time:	11:00AM	**Stream:**	Sulphur Creek	**UTM (Upstream):**	
Weather:	Sunny, 20°C	**Reach:**	SCT1	**UTM (Downstream):**	

Land Use (Table 1): 1 | **Valley Type** (Table 2): 2 | **Channel Type** (Table 3): 12 | **Channel Zone** (Table 4): 1 | **Flow Type** (Table 5): 1 | ☐ Evidence of Groundwater Location: n/a Photo: _____

Riparian Vegetation

Dominant Type (Table 6): 1/2

Encroachment (Table 7): 3

Coverage: ☐ None; ☐ Fragmented; ☒ Continuous

Channel Widths: ☐ 1 - 4; ☐ 4 - 10; ☒ > 10

Age (yrs): ☐ Immature (<5); ☐ Established (5-30); ☒ Mature (>30)

Aquatic & Instream Vegetation

Type (Table 8): N/A

Reach Coverage %: /

Woody Debris: ☐ In Cutbank; ☒ In Channel; ☐ Not Present

WD Density: ☒ Low; ☐ Mod; ☐ High

WDJ/50m: 0

Water Quality

Odour (Table 16): 1

Turbidity (Table 17): 2

Channel Characteristics

Sinuosity Type (Table 9): 1

Gradient (Table 11): 1

Entrenchment (Table 13): 2

Down's Model (Table 15): m

Sed Sorting (Table 20): Mod.

Transport Mode (Table 21): 3

Geomorphic Units (Table 22): 8

Riffle-Pool Spacing (m): /

Sinuosity Degree (Table 10): 1

# of Channels (Table 12): 1

Bank Failure (Table 14): 1

Bankfull Indicators (Table 18): 3/5

Sediment Transport Observed? ☐ Yes ☒ No ☐ Not Visible

% of Bed Active: /

Mass Movement (Table 23): /

% Riffles: 0 **% Pools:** 0 **% Pars** 100

Bank Angle: ☐ 0 – 30; ☐ 30 – 60; ☒ 60 – 90; ☐ Undercut

Bank Erosion: ☐ < 5%; ☐ 5 – 30%; ☒ 30 – 60%; ☐ 60 – 100%

(Table 19)	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Bank	☒	☒	☐	☐	☐	☐	☐
Riffle	☐	☐	☐	☐	☐	☐	☐
Pool	☐	☐	☐	☐	☐	☐	☐
Bed (if no riffle-pool morphology)	☒	☒	☒	☐	☐	☐	☐

Bankfull Width (m)	1.79	2.40	/	**Wetted Width (m)**	1.44	1.43	/
Bankfull Depth (m)	0.24	0.27	/	**Wetted Depth (m)**	0.10	0.12	/
Undercuts (m)	—	—	—	**Velocity (m/s)**	0.26	0.11	/
Pool Depth (m)	0.82	—	—	**Velocity Estimate Method**	Wade	to	ll
Riffle Length (m)	—	—	—	**Meander Amplitude (m)**	—	—	—

Notes:
→ May be riffle pool morphology further downstream (where accessibility was not available)
→ Down's Model could also be reassessed if entire reach is accessed.
→ Only portion of the reach walked up to property line. No access past property boundary.

Photos:

Version #4
Last edited: 04/04/2023

Senior staff sign-off (if required): _____ Checked by: KW Completed by: KA

GEO MORPHIX™

Reach Characteristics

Project Number: PN24108

Date:	2024-10-21	**Field Staff:**	RA CM	**Watershed/Subwatershed:**	Sulphur Creek Subwatershed
Time:	11:00 AM	**Stream:**	Sulphur Creek	**UTM (Upstream):**	
Weather:	Sunny, 20°C	**Reach:**	SCT2	**UTM (Downstream):**	

Land Use (Table 1): 1 | **Valley Type** (Table 2): 2 | **Channel Type** (Table 3): / | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 1 | ☐ Evidence of Groundwater Location:_____ Photo:_____

Riparian Vegetation

Dominant Type (Table 6): 1

Encroachment (Table 7): 1

Coverage	Channel Widths	Age (yrs)
☐ None	☐ 1 - 4	☐ Immature (<5)
☐ Fragmented	☒ 4 - 10	☐ Established (5-30)
☒ Continuous	☐ > 10	☒ Mature (>30)

Aquatic & Instream Vegetation

Type (Table 8): /

Reach Coverage %: /

Woody Debris	WD Density
☐ In Cutbank	☐ Low
☐ In Channel	☐ Mod
☒ Not Present	☐ High

WDJ/50m: 0

Water Quality

Odour (Table 16): 1

Turbidity (Table 17): 2

Channel Characteristics

Sinuosity Type (Table 9): 1

Gradient (Table 11): 1

Entrenchment (Table 13): /

Down's Model (Table 15): /

Sed Sorting (Table 20): /

Transport Mode (Table 21): /

Geomorphic Units (Table 22): /

Riffle-Pool Spacing (m): /

Sinuosity Degree (Table 10): 1

# of Channels (Table 12): 1

Bank Failure (Table 14): /

Bankfull Indicators (Table 18): /

Sediment Transport Observed? ☐ Yes ☒ No ☐ Not Visible

% of Bed Active: /

Mass Movement (Table 23): /

% Riffles: /

% Pools: /

Bank Angle	Bank Erosion
☒ 0 - 30	☒ < 5%
☐ 30 - 60	☐ 5 - 30%
☐ 60 - 90	☐ 30 - 60%
☐ Undercut	☐ 60 - 100%

(Table 19)

	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Bank	☒	☒	☐	☐	☐	☐	☐
Riffle	☐	☐	☐	☐	☐	☐	☐
Pool	☐	☐	☐	☐	☐	☐	☐
Bed (if no riffle-pool morphology)	☒	☒	☐	☐	☐	☐	☐

Bankfull Width (m)			**Wetted Width (m)**
Bankfull Depth (m)			**Wetted Depth (m)**
Undercuts (m)			**Velocity (m/s)**
Pool Depth (m)			**Velocity Estimate Method**
Riffle Length (m)			**Meander Amplitude (m)**

Notes:
→ waterbody with dense riparian buffer around the lake.
→ inlet and outlet walled. See reach mapping

Photos:

Version #4
Last edited: 04/04/2023

Senior staff sign-off (if required): _____ Checked by: KW Completed by: RA

GEO MORPHIX™

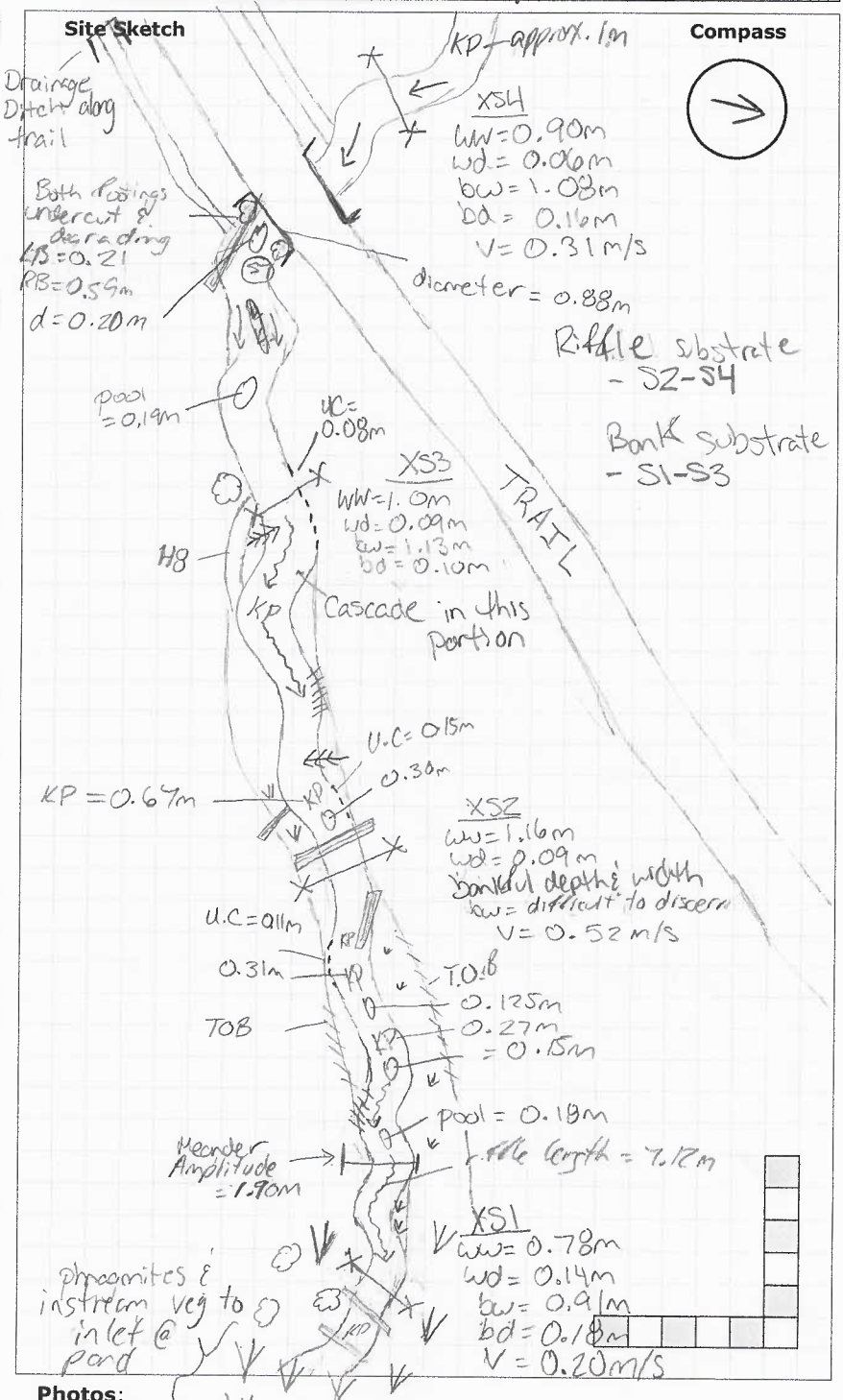
General Site Characteristics

Project Number: PW24108

Date:	2024-10-21	**Stream:**	Sulphur Creek
Time:	12:00 pm	**Reach:**	SCT3
Weather:	Sunny, 20°	**Location:**	159/163 Sulphur Springs Rd.
Field Staff:	KA CM	**Watershed/Subwatershed:**	Sulphur Creek Subwatershed

Features	Monitoring
Reach break	Long-profile
Station location	Monumented XS
Cross-section	Monumented photo
Flow direction	Monumented photo direction
Riffle	Sediment sampling
Pool	Erosion pins
Sediment bar	Scour chains
Eroded bank/slope	**Additional Symbols**
Undercut bank	
Bank stabilization	
Leaning tree	
Fence	
Culvert/outfall	
Swamp/wetland	
Grasses	
Tree	
Instream log/tree	
Woody debris	
Beaver dam	
Vegetated island	

Site Sketch



Photos:

Notes:

See pg 1 for connection to pond.

Flow Type

H1	Standing water	**H1A**	Back 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	**H9A**	Dissipates below 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

GEO MORPHIX

Rapid Geomorphic Assessment

Project Number: PW24108

Date:	2024-10-21	**Stream:**	Sulphur Creek
Time:	12:00 pm	**Reach:**	SCT3
Weather:	Sunny, 20°C	**Location:**	159/163 Sulphur Springs Rd
Field Staff:	RA CM	**Watershed/Subwatershed:**	Sulphur Creek Subwatershed

Process	No.	Geomorphological Indicator: Description	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		✓	0/7
	2	Coarse materials in riffles embedded		✓	
	3	Siltation in pools		✓	
	4	Medial bars		✓	
	5	Accretion on point bars		✓	
	6	Poor longitudinal sorting of bed materials		✓	
	7	Deposition in the overbank zone		✓	
		Sum of indices =	0	7	0.0
Evidence of Degradation (DI)	1	Exposed bridge footing(s)	✓		3/7
	2	Exposed sanitary / storm sewer / pipeline / etc.	N/A		
	3	Elevated storm sewer outfall(s)	N/A		
	4	Undermined gabion baskets / concrete aprons / etc.	N/A		
	5	Scour pools downstream of culverts / storm sewer outlets		✓	
	6	Cut face on bar forms		✓	
	7	Head cutting due to knickpoint migration	✓		
	8	Terrace cut through older bar material		✓	
	9	Suspended armour layer visible in bank		✓	
	10	Channel worn into undisturbed overburden / bedrock	✓		
		Sum of indices =	3	4	0.429
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	✓		3/8
	2	Occurrence of large organic debris		✓	
	3	Exposed tree roots	✓		
	4	Basal scour on inside meander bends		✓	
	5	Basal scour on both sides of channel through riffle		✓	
	6	Outflanked gabion baskets / concrete walls / etc.	N/A		
	7	Length of basal scour >50% through subject reach	✓		
	8	Exposed length of previously buried pipe / cable / etc.		✓	
	9	Fracture lines along top of bank		✓	
	10	Exposed building foundation	N/A		
		Sum of indices =	3	5	0.375
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s) (one chute)	✓		2/7
	2	Single thread channel to multiple channel		✓	
	3	Evolution of pool-riffle form to low bed relief form		✓	
	4	Cut-off channel(s)		✓	
	5	Formation of island(s)		✓	
	6	Thalweg alignment out of phase with meander form		✓	
	7	Bar forms poorly formed / reworked / removed	✓		
		Sum of indices =	2	5	0.286

Notes:

*approx. 90-100m walked of reach due to u/s access restrictions

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.273

In Regime	In Transition/Stress	In Adjustment
☐ 0.00 - 0.20	☒ 0.21 - 0.40	☐ 0.41

Version #3
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: KW Completed by: RA

GEO MORPHIX

Rapid Stream Assessment Technique Project Number: PR4108

Date:	2024-10-21	**Stream:**	Sulphur Creek
Time:	12:00 pm	**Reach:**	SCT3
Weather:	Sunny, 20°C	**Location:**	159/163 Sulphur Springs rd
Field Staff:	RA CM	**Watershed/Subwatershed:**	Sulphur Creek Subwatershed

Category	Poor	Fair	Good	Excellent
Channel Stability	• < 50% of bank network stable • Recent bank sloughing, slumping or failure frequently observed	• 50-70% of bank network stable • Recent signs of bank sloughing, slumping or failure fairly common	• 71-80% of bank network stable • Infrequent signs of bank sloughing, slumping or failure	• > 80% of bank network stable • No evidence of bank sloughing, slumping or failure
	• Stream bend areas highly unstable • Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) • Bank overhang > 0.8-1.0 m	• Stream bend areas unstable • Outer bank height 0.9-1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) • Bank overhang 0.8-0.9m	• Stream bend areas stable • Outer bank height 0.6-0.9 m above stream bank (1.2-1.5 m above stream bank for large mainstem areas) • Bank overhang 0.6-0.8 m	• Stream bend areas very stable • Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) • Bank overhang < 0.6 m
	• Young exposed tree roots abundant • > 6 recent large tree falls per stream mile	• Young exposed tree roots common • 4-5 recent large tree falls per stream mile	• Exposed tree roots predominantly old and large, smaller young roots scarce • 2-3 recent large tree falls per stream mile	• Exposed tree roots old, large and woody • Generally 0-1 recent large tree falls per stream mile
	• Bottom 1/3 of bank is highly erodible material • Plant/soil matrix severely compromised	• Bottom 1/3 of bank is generally highly erodible material • Plant/soil matrix compromised	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material
	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally V- or U-shaped	• Channel cross-section is generally V- or U-shaped
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4 ☐ 5	☒ 6 ☐ 7 ☐ 8	☐ 9 ☐ 10 ☐ 11
Channel Scouring/ Sediment Deposition	• > 75% embedded (> 85% embedded for large mainstem areas)	• 50-75% embedded (60-85% embedded for large mainstem areas)	• 25-49% embedded (35-59% embedded for large mainstem areas)	• Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas)
	• Few, if any, deep pools • Pool substrate composition >81% sand-silt	• Low to moderate number of deep pools • Pool substrate composition 60-80% sand-silt	• Moderate number of deep pools • Pool substrate composition 30-59% sand-silt	• High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas) • Pool substrate composition <30% sand-silt
	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits uncommon	• Streambed streak marks and/or "banana"-shaped sediment deposits absent
	• Fresh, large sand deposits very common in channel • Moderate to heavy sand deposition along major portion of overbank area	• Fresh, large sand deposits common in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits uncommon in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits rare or absent from channel • No evidence of fresh sediment deposition on overbank
	• Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand	• Point bars common, moderate to large and unstable with high amount of fresh sand	• Point bars small and stable, well-vegetated and/or armoured with little or no fresh sand	• Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☐ 5 ☒ 6	☐ 7 ☐ 8

Version #2
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: KW Completed by: RA

GEO MORPHIX

Date:	2024-10-21	PN:	24108	Location:	159/163 Sulphur Springs rd

Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	• Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	• Wetted perimeter 40-60% of bottom channel width (45-65% for large mainstem areas)	• Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas)	• Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)
	• Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low)	• Few pools present, riffles and runs dominant. • Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate)	• Good mix between riffles, runs and pools • Relatively diverse velocity and depth of flow	• Riffles, runs and pool habitat present • Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water)
	• Riffle substrate composition: predominantly gravel with high amount of sand • < 5% cobble	• Riffle substrate composition: predominantly small cobble, gravel and sand • 5-24% cobble	• Riffle substrate composition: good mix of gravel, cobble, and rubble material • 25-49% cobble	• Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand • > 50% cobble
	• Riffle depth < 10 cm for large mainstem areas	• Riffle depth 10-15 cm for large mainstem areas	• Riffle depth 15-20 cm for large mainstem areas	• Riffle depth > 20 cm for large mainstem areas
	• Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure	• Large pools generally 30-46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structure	• Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure	• Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure
	• Extensive channel alteration and/or point bar formation/enlargement	• Moderate amount of channel alteration and/or moderate increase in point bar formation/enlargement	• Slight amount of channel alteration and/or slight increase in point bar formation/enlargement	• No channel alteration or significant point bar formation/enlargement
	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	• Riffle/Pool ratio 0.5-0.69:1 ; 1.31-1.5:1	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	• Riffle/Pool ratio 0.9-1.1:1
N/A	• Summer afternoon water temperature > 27°C	• Summer afternoon water temperature 24-27°C	• Summer afternoon water temperature 20-24°C	• Summer afternoon water temperature < 20°C
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☒ 4	☐ 5 ☐ 6	☐ 7 ☐ 8
Water Quality	• Substrate fouling level: High (> 50%)	• Substrate fouling level: Moderate (21-50%)	• Substrate fouling level: Very light (11-20%)	• Substrate fouling level: Rock underside (0-10%)
	• Brown colour • TDS: > 150 mg/L	• Grey colour • TDS: 101-150 mg/L	• Slightly grey colour • TDS: 50-100 mg/L	• Clear flow • TDS: < 50 mg/L
	• Objects visible to depth < 0.15m below surface	• Objects visible to depth 0.15-0.5m below surface	• Objects visible to depth 0.5-1.0m below surface	• Objects visible to depth > 1.0m below surface
	• Moderate to strong organic odour	• Slight to moderate organic odour	• Slight organic odour	• No odour
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☐ 5 ☒ 6	☐ 7 ☐ 8
Riparian Habitat Conditions	• Narrow riparian area of mostly non-woody vegetation	• Riparian area predominantly wooded but with major localized gaps	• Forested buffer generally > 31 m wide along major portion of both banks	• Wide (> 60 m) mature forested buffer along both banks
	• Canopy coverage: <50% shading (30% for large mainstem areas)	• Canopy coverage: 50-60% shading (30-44% for large mainstem areas)	• Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	• Canopy coverage: >80% shading (> 60% for large mainstem areas)
Point range	☐ 0 ☐ 1	☐ 2 ☐ 3	☒ 4 ☐ 5	☐ 6 ☐ 7

Total overall score (0–42) = 26	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Version #2
Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: KW Completed by: RA

* approx 90-100m of reach accessible on property; Reid access not permitted U/S.

GEO MORPHIX

Reach Characteristics

Project Number: PN24108

Date:	2024-10-21	**Field Staff:**	RA CM	**Watershed/Subwatershed:**	Sulphur Creek
Time:	12:00 pm	**Stream:**	Sulphur Creek	**UTM (Upstream):**	
Weather:	sunny, 20°c	**Reach:**	SCT3	**UTM (Downstream):**	

Land Use (Table 1): 1 | **Valley Type** (Table 2): 1 | **Channel Type** (Table 3): 12 | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 1 | ☐ Evidence of Groundwater Location: n/a Photo:

Riparian Vegetation

Dominant Type (Table 6): 1/3

Coverage: ☐ None ☒ Fragmented ☐ Continuous

Channel Widths: ☐ 1 - 4 ☒ 4 - 10 ☐ > 10

Age (yrs): ☐ Immature (<5) ☐ Established (5-30) ☒ Mature (>30)

Encroachment (Table 7): 2

Aquatic & Instream Vegetation

Type (Table 8): 6

Reach Coverage %: 5 localized

Woody Debris: ☐ In Cutbank ☒ In Channel ☐ Not Present

WD Density: ☒ Low ☐ Mod ☐ High

WDJ/50m: 0.25

Water Quality

Odour (Table 16): 1

Turbidity (Table 17): 2

Channel Characteristics

Sinuosity Type (Table 9): 2

Sinuosity Degree (Table 10): 2

Gradient (Table 11): 1

# of Channels (Table 12): 1

Entrenchment (Table 13): 1

Bank Failure (Table 14): 2

Down's Model (Table 15): d

Bankfull Indicators (Table 18): 3/5

Sed Sorting (Table 20): Mod

Sediment Transport Observed?: ☐ Yes ☒ No ☐ Not Visible

Transport Mode (Table 21): 2/3

% of Bed Active: /

Geomorphic Units (Table 22): 2/3/5/6/8

Mass Movement (Table 23): / % rms 65

Riffle-Pool Spacing (m): approx. 2

% Riffles: 15 **% Pools**: 20

Bank Angle: ☒ 0 – 30 ☐ 30 – 60 ☐ 60 – 90 ☒ Undercut

Bank Erosion: ☐ < 5% ☒ 5 – 30% ☐ 30 – 60% ☐ 60 – 100%

(Table 19)	Clay/Silt	Sand	Gravel	Cobble (small)	Boulder	Parent	Rootlets
Bank	☒	☒	☒	☐	☐	☐	☐
Riffle	☐	☒	☒	☒	☐	☐	☐
Pool	☒	☒	☐	☐	☐	☐	☐
Bed (if no riffle-pool morphology)	☐	☐	☐	☐	☐	☐	☐

Bankfull Width (m)	0.91	/	1.13	**Wetted Width (m)**	0.78	1.16	1.0
Bankfull Depth (m)	0.18	/	0.10	**Wetted Depth (m)**	0.14	0.09	0.09
Undercuts (m)	0.15	0.11	0.08	**Velocity (m/s)**	0.20	0.52	/
Pool Depth (m)	0.18	0.15	0.30	**Velocity Estimate Method**	Wade	Ball	
Riffle Length (m)	7.12	/	/	**Meander Amplitude (m)**	1.90	/	/

Notes: XS4
- OW: 1.08
- bd: 0.16
- WW: 0.90
- wd: 0.06
- V: 0.31 m/s

→ phragmites at downstream portion where inlet is to the pond
→ Some erosion was present along outer banks.
→ Banks generally well vegetated with grasses & trees.
→ Footing of crossing was observed to be failing along both banks.

Photos:

Version #4
Last edited: 04/04/2023

Senior staff sign-off (if required): _____ Checked by: KW Completed by: RA

GEO MORPHIX

General Site Characteristics

Project Number: PN24108

Date:	2024-10-21	**Stream:**	Trib. of Sulphur Creek
Time:	1:00 pm	**Reach:**	SCT1-4, SCT1-3
Weather:	sunny, 20°c	**Location:**	159/163 Sulphur Springs rd
Field Staff:	RA CM	**Watershed/Subwatershed:**	Sulphur Creek Subwatershed

Features

- Reach break
- Station location
- Cross-section
- Flow direction
- Riffle
- Pool
- Sediment bar
- Eroded bank/slope
- Undercut bank
- Bank stabilization
- Leaning tree
- Fence
- Culvert/outfall
- Swamp/wetland
- Grasses
- Tree
- Instream log/tree
- Woody debris
- Beaver dam
- Vegetated island

Monitoring

- Long-profile
- Monumented XS
- Monumented photo
- Monumented photo direction
- Sediment sampling
- Erosion pins
- Scour chains

Additional Symbols

V = wetland veg.

= bat house

Flow Type

H1	Standing water	**H1A**	Back 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	**H9A**	Dissipates below free fall

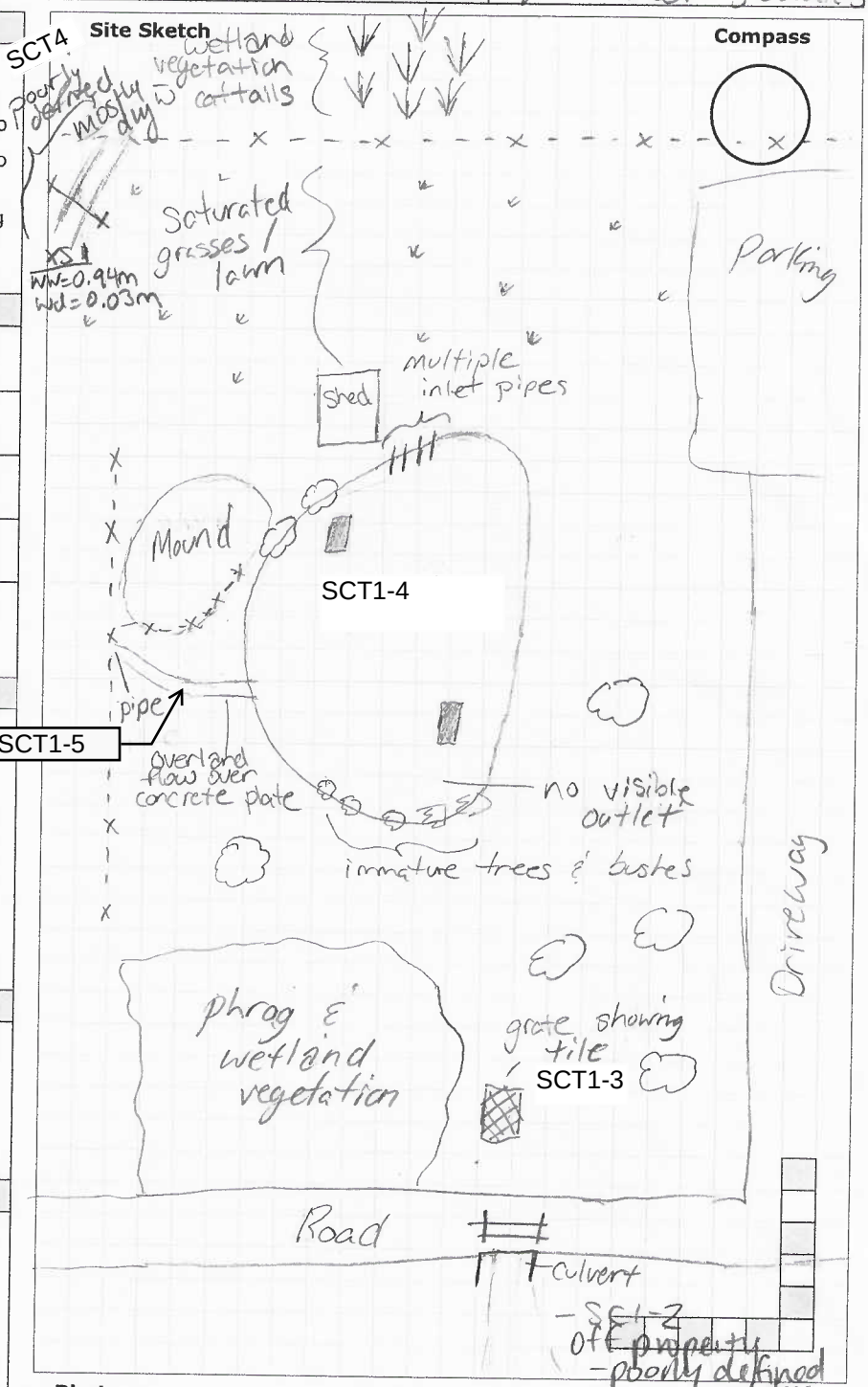
Substrate

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



Compass

Photos:

Notes: Algae on pond and pond is green.

Reach SCT1-3 tiled up to property boundary.

Reach SCT1-4 Pond

~20m of SCT6 observed in SW corner of property's poorly defined, limited water: no flow N/A

SCT6 Characteristic of low-order HDF; no erosion overland flow path.

Version #4
Last edited: 21/02/2023

Senior staff sign-off (if required): _____ Checked by: KW Completed by: _____

GEO MORPHIX

Reach Characteristics

Project Number: PN24108

Date:	2024-10-21	**Field Staff:**	RA CM	**Watershed/Subwatershed:**	Sulphur Creek
Time:	1:00 pm	**Stream:**	Sulphur Creek trib	**UTM (Upstream):**	
Weather:	Sunny, 20°C	**Reach:**	SCT1-3	**UTM (Downstream):**	

Land Use (Table 1): 7 | **Valley Type** (Table 2): 1 | **Channel Type** (Table 3): N/A | **Channel Zone** (Table 4): 1 | **Flow Type** (Table 5): 1 | ☐ Evidence of Groundwater Location: n/a Photo: ____

Riparian Vegetation

Tile Drain

Dominant Type (Table 6): 3

Encroachment (Table 7): N/A

Coverage	Channel Widths	Age (yrs)
☐ None	☐ 1 - 4	☐ Immature (<5)
☐ Fragmented	☐ 4 - 10	☒ Established (5-30)
☒ Continuous	☒ > 10	☐ Mature (>30)

Aquatic & Instream Vegetation

Type (Table 8): /

Reach Coverage %: /

Woody Debris	WD Density
☐ In Cutbank	☐ Low
☐ In Channel	☐ Mod
☒ Not Present	☐ High

WDJ/50m: /

Water Quality

Odour (Table 16): 1

Turbidity (Table 17): 2/6 (Green)

Channel Characteristics

Sinuosity Type (Table 9): 1

Gradient (Table 11): 1

Entrenchment (Table 13): /

Down's Model (Table 15): /

Sed Sorting (Table 20): /

Transport Mode (Table 21): 3

Geomorphic Units (Table 22): /

Riffle-Pool Spacing (m): /

Sinuosity Degree (Table 10): 1

# of Channels (Table 12): 1

Bank Failure (Table 14): /

Bankfull Indicators (Table 18): /

Sediment Transport Observed? ☐ Yes ☐ No ☒ Not Visible

% of Bed Active: /

Mass Movement (Table 23): /

% Riffles: /

% Pools: /

Bank Angle
☐ 0 – 30
☐ 30 – 60
☐ 60 – 90
☐ Undercut
N/A

Bank Erosion
☐ < 5%
☐ 5 – 30%
☐ 30 – 60%
☐ 60 – 100%
N/A

(Table 19)

	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Bank	☐	☐	☐ N/A	☐	☐	☐	☐
Riffle	☐	☐	☐	☐	☐	☐	☐
Pool	☐	☐	☐	☐	☐	☐	☐
Bed (if no riffle-pool morphology)	☐	☐	☐	☐	☐	☐	☐

Bankfull Width (m)			**Wetted Width (m)**		
Bankfull Depth (m)			**Wetted Depth (m)**		
Undercuts (m)			**Velocity (m/s)**		
Pool Depth (m)			**Velocity Estimate Method**		
Riffle Length (m)			**Meander Amplitude (m)**		

Notes:
→ Tiled feature from the pond to the driveway.
→ Open grate observed near driveway showing the drain with flowing water.
→ Across driveway a culvert was present that was dry. Based on these observations it is possible tile drain continues or that higher flows utilize that culvert.
→ Overall, no visible or surface connection between pond and OIS SC1-2 (off site)

Photos:

Version #4
Last edited: 04/04/2023

Senior staff sign-off (if required): _____ Checked by: KW Completed by: RA

GEO MORPHIX™

Reach Characteristics

Project Number: PN24108

Date:	2024-10-21	**Field Staff:**	RA CM	**Watershed/Subwatershed:**	Sulphur Creek
Time:	1:00 pm	**Stream:**	Sulphur Creek	**UTM (Upstream):**	
Weather:	Sunny, 20°C	**Reach:**	SCT1-4	**UTM (Downstream):**	

Land Use (Table 1): 7 | **Valley Type** (Table 2): 1 | **Channel Type** (Table 3): N/A | **Channel Zone** (Table 4): 1 | **Flow Type** (Table 5): 1 | ☐ Evidence of Groundwater Location: n/a Photo:

Riparian Vegetation

Dominant Type (Table 6): 3

Encroachment (Table 7): 2

Coverage: ☐ None; ☒ Fragmented; ☒ Continuous

Channel Widths: ☒ 1 - 4; ☐ 4 - 10; ☐ > 10

Age (yrs): ☐ Immature (<5); ☒ Established (5-30); ☐ Mature (>30)

Aquatic & Instream Vegetation

Type (Table 8):

Reach Coverage %: 0

Woody Debris: ☐ In Cutbank; ☐ In Channel; ☒ Not Present

WD Density: ☐ Low; ☐ Mod; ☐ High

WDJ/50m:

Water Quality

Odour (Table 16): 1

Turbidity (Table 17): 2/6 (Green)

Channel Characteristics

Sinuosity Type (Table 9): 1

Gradient (Table 11): 1

Entrenchment (Table 13):

Down's Model (Table 15):

Sed Sorting (Table 20):

Transport Mode (Table 21):

Geomorphic Units (Table 22):

Riffle-Pool Spacing (m):

Sinuosity Degree (Table 10): 1

# of Channels (Table 12):

Bank Failure (Table 14):

Bankfull Indicators (Table 18):

Sediment Transport Observed? ☐ Yes ☒ No ☐ Not Visible

% of Bed Active

Mass Movement (Table 23):

% Riffles:

% Pools:

Bank Angle: ☒ 0 – 30; ☐ 30 – 60; ☐ 60 – 90; ☐ Undercut

Bank Erosion: ☒ < 5%; ☐ 5 – 30%; ☐ 30 – 60%; ☐ 60 – 100%

(Table 19)	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Bank	☒	☒	☐	☐	☐	☐	☐
Riffle	☐	☐	☐	☐	☐	☐	☐
Pool	☐	☐	☐	☐	☐	☐	☐
Bed (if no riffle-pool morphology)	☒	☒	☐	☐	☐	☐	☐

Bankfull Width (m)

Bankfull Depth (m)

Undercuts (m)

Pool Depth (m)

Riffle Length (m)

Wetted Width (m)

Wetted Depth (m)

Velocity (m/s)

Velocity Estimate Method

Meander Amplitude (m)

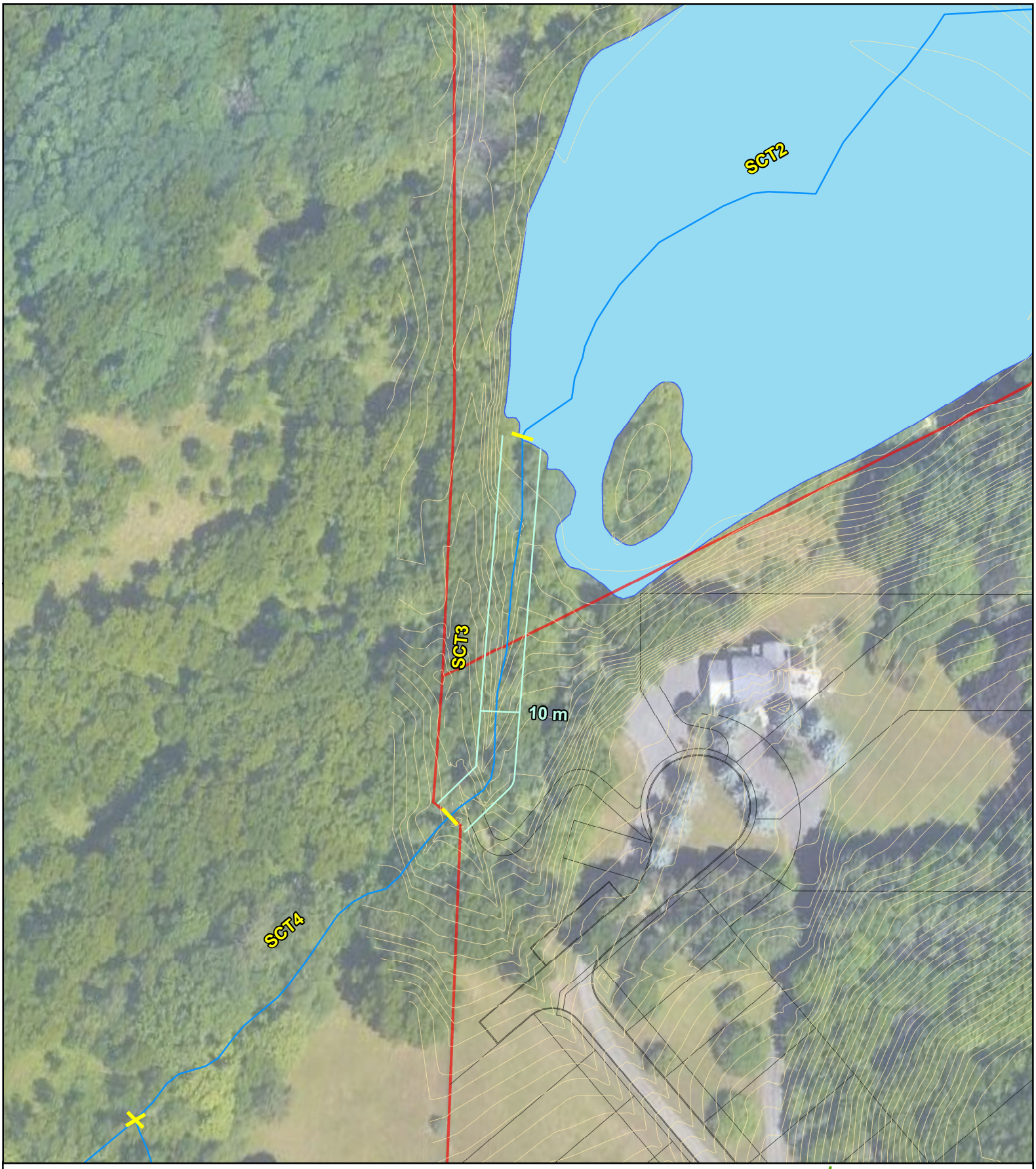
Notes:
→ This reach is a waterbody.
→ The riparian vegetation consists primarily of manicured lawn with some herbaceous veg. and shrubs surrounding the pond.
→ Two pipes were present along the west side of the pond at the inlet.
→ An overflow pathway was also present along the southern side of pond collecting drainage from southern properties.
→ An outlet was not observed however a the drain west of the pond was present & is likely the outlet.

Photos:

Version #4
Last edited: 04/04/2023

Senior staff sign-off (if required): _____ Checked by: KW Completed by: RA

Appendix E:
Meander Belt Width Delineation



Legend

- Reach Break and ID
- Meander Belt Width
- Watercourse
- Drainage Feature
- Piped Feature
- 0.5 m Contour
- Development Fabric
- Subject Lands
- OHN Waterbody

Figure 3

Erosion Hazard Delineation

Sulphur Creek

Ancaster, Ontario

GEO MORPHIX™

N

0 20 40

Metres

Imagery: Google Earth, 2023. Watercourse: Hamilton, 2024.
Waterbody, Watercourse (OHN), Wetland: MNRF, 2024.
Subject Lands, Development Fabric: Crozier, 2024.
Meander Belt Width: GEO Morphix Ltd., 2024.
Print Date: November 2024. PN24108. Drawn By: R.A., M.O., K.W.