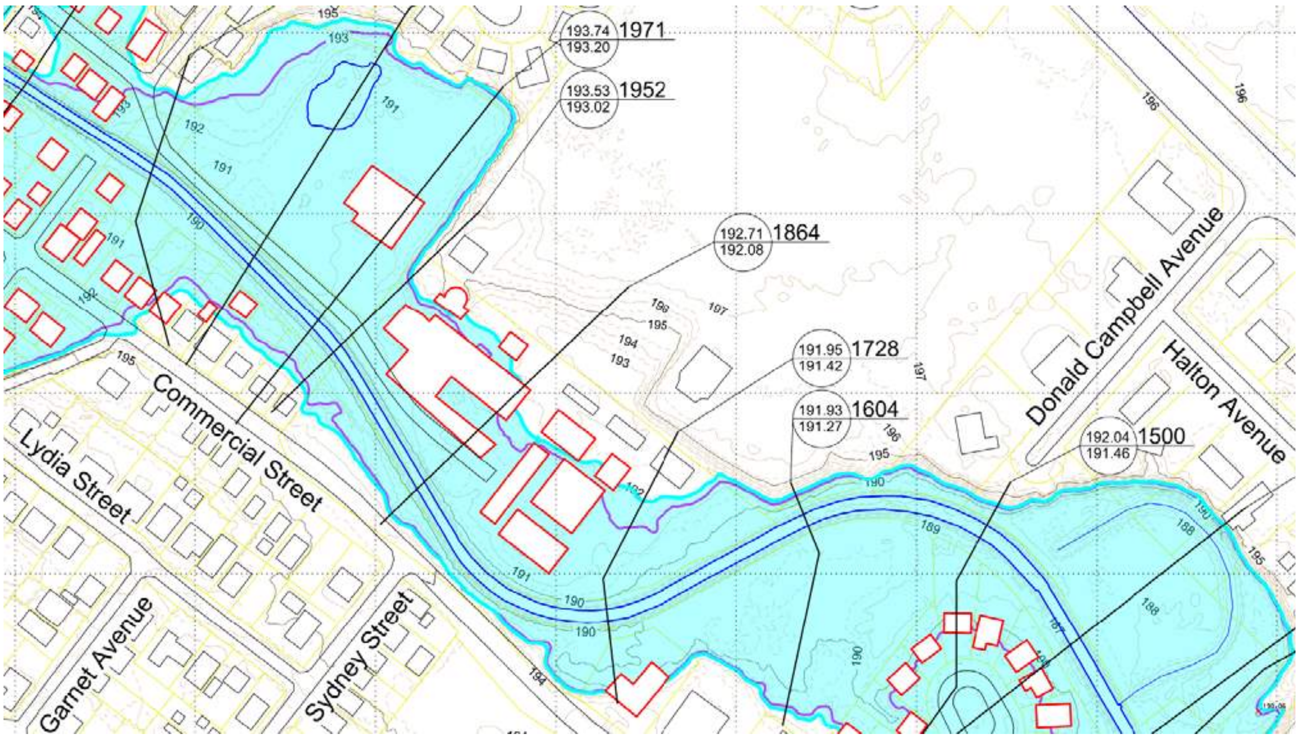
FLOOD HAZARD MAPPING – URBAN MILTON FINAL REPORT

SIXTEEN MILE CREEK

JULY 11, 2023

PROJECT 20-693



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EXECUTIVE SUMMARY

In recent years, the Town of Milton has undergone considerable growth, resulting in a larger population and significant increases in land and property value. This growth has taken place based on the watershed wide floodplain mapping completed in 1988, with various sub-watershed analyses completed to support individual projects of land-use change throughout Milton. Additionally, floodplain mapping was completed on a site-specific basis through detailed project specific studies. Conservation Halton (CH) recognizes the need to update regulatory flood hazard models and flood hazard mapping on a broader basis using the latest technology and approaches. As part of this study, mapping has been updated for major tributaries of the West Branch of Sixteen Mile Creek, primarily within the existing and planned urban areas within the Town of Milton.

This report presents the work completed to update Regulatory flood hazard mapping within a portion of urbanized lands in the Town of Milton, Ontario and a localized area of Halton Hills. The study was completed following a process that included guidance and review by a Technical Advisory Committee (TAC), and public consultation. The TAC included representation from Conservation Halton and the Towns of Milton and Halton Hills and Halton Region. To support their full participation on the TAC, the Town of Milton retained a consultant, WSP (formerly John Wood Group PLC) who provided peer review services throughout the lifespan of the project. Public consultation was provided through three Public Information Centres (PIC). Of particular value was the detailed review and contributions provided by the Town of Milton, as they could provide site specific context to their legacy knowledge and understanding of stormwater management practices and approvals for development projects completed throughout the Town.

The key products of this study include:

1. A new hydrologic model
2. A new hydraulic model
3. Inventory and hydraulic details for all major watercourse crossings
4. 16 digitally georeferenced flood hazard map sheets
5. Study report

The updated flood hazard mapping prepared as part of this study will be used to establish regulation limits within the study area in accordance with provincial standards enforced by Conservation Halton. In addition to informing regulation, the models developed as part of this study may be used for many purposes, including flood forecasting and warning, emergency planning and response, prioritization of flood mitigation efforts, etc.

Hydrologic analyses were completed for portions of the Sixteen Mile Creek watershed to determine peak flow rates for the 100-year event and the Regional Storm (Hurricane Hazel). The hydrologic analyses were completed through the development of a new deterministic hydrologic simulation model. Hydrologic analyses were prepared for existing land-use conditions and calibrated to observed flow data.

The hydrology of the watershed was found to have many complex features, associated with the presence of wetlands, reservoirs, intra/inter basin spills, stormwater management facilities and land cover changes, coupled with the focused scope of this study and lack of recent extreme rainfall events which has limited the potential extent of calibration.

Subsequent to calibration and validation of the hydrologic model, peak flows were determined for future land-use conditions as per the Town of Milton's Official Plan as provided by the Town of Milton. The 100-year and Regional storm event flows were used in the hydraulic model to establish flood hazard limits.

A new detailed, one-dimensional hydraulic computer simulation model, was prepared for the study area. In total, approximately 26 kilometers of watercourse was modelled. Hydraulic conditions were found to be particularly complicated at select locations due to:

- The presence of several existing watercourse crossings structures (bridges and or culverts) that have limited capacity to adequately convey flood flows,
- Former watercourse crossings, resulting in sudden confinement of the valley,
- Historical fill placed within the valley, resulting in frequent expansion/contraction of the valley lands, and
- The relocation of low flow channels from their historical floodplain locations.

To determine flood hazard limits, an extensive field program was completed to survey all pertinent watercourse crossings throughout the area to be mapped. The survey recorded culvert and bridge geometries to determine conveyance capacity through watercourse crossings. A total of 81 watercourse crossings were investigated. Sensitivity analyses were completed for both the hydrologic and hydraulic modelling to quantify the level of certainty and establish a level of confidence with assumptions and use of standard parameters.

The results of the hydraulic analyses were mapped on full size drawing sheets. The maps show floodlines for both the Regional and 100-year storm flood events. Generally, the main tributaries that receive flows from the extensive undeveloped lands north and west of the Town have their Regulatory flood hazards defined by the Regional storm event. Urbanized areas that receive most of their flow from smaller urbanized areas typically have their floodlines defined by the 100-year storm.

A report supporting the draft flood hazard mapping presented at PIC 2 was completed in March 2020. The following revisions to the hydrologic and hydraulic modelling have been completed since that time:

- Incorporation of several municipally operated stormwater management facilities for flood control purposes in the 100-year event scenario only
- Use of 100-year storm areal reduction factors
- Further refinement of hydrologic parameters
- Further refinement of hydraulic modelling

This study has been prepared specifically for Regulatory floodline mapping purposes and not for the use in establishing or evaluating stormwater management criteria and system performance.

This study received support through the National Disaster Mitigation Program. The views expressed in this material are the views of Greck and do not necessarily reflect the views of the Province of Ontario or the Government of Canada.

The modelling and mapping are appropriate for use in the administration of Ontario Regulation 162/06 and land-use decision making subject to any additional refinements made by Conservation Halton.

1.0 INTRODUCTION

Greck was retained by Conservation Halton (CH) to prepare updated, comprehensive regulatory hazard mapping for portions of the West Branch of Sixteen Mile Creek, through the urban portion of Milton, Ontario and a localized area of Halton Hills. The hazard mapping is supported by extensive hydrologic and hydraulic modelling as outlined throughout this report.

As part of this study, a Technical Advisory Committee (TAC) was assembled from various key stakeholders within the area. The purpose of the TAC Committee is to oversee the study and provide technical feedback throughout the study timeline. The TAC committee included representatives from the following municipal authorities and consultants:

- Conservation Halton,
- Town of Milton (the Town),
    - WSP (formerly Wood) as a Peer reviewer retained by the Town.
- Town of Halton Hills, and
- Region of Halton (the Region).

This study received support through the National Disaster Mitigation Program. The views expressed in this material are the views of Greck and Associates Limited and do not necessarily reflect the views of the Province of Ontario or the Government of Canada.

1.1 SCOPE OF WORK

The goals of this study are to prepare the following key deliverables:

1. The development of a calibrated hydrologic model (supporting development of flood hazard mapping), using current topographic, land-use and soils information.
2. New, fully georeferenced hydraulic model in HEC-RAS to identify flood hazards associated with key tributaries of the West Branch of Sixteen Mile Creek within the urban portion of the Town of Milton and a localized area of Halton Hills.
3. Detailed technical report of work completed.
4. Georeferenced flood hazard mapping.

1.2 LIMITATIONS OF THIS STUDY

This study has been prepared specifically for Regulatory floodline mapping purposes and not for the use in establishing or evaluating stormwater management criteria and system performance. Results in this study are an estimate of anticipated Regulatory flood hazards. Regulatory flood elevations can be further refined using site specific studies, topographic survey etc.

1.3 STUDY METHODOLOGY

Several steps were involved to complete the flood hazard mapping within Urban Milton study area. The overall study methodology is described briefly below:

1. Review of Background Information: Review previous studies to get a better understanding of watershed hydrology and hydraulics.
2. Data Collection and Processing: Survey hydraulic structures to confirm culvert and bridge sizes throughout the mapping study area & LiDAR validation.
3. Hydrologic Modelling: Develop a hydrologic model to quantify peak flows through the study area.
4. Model Calibration: Calibrate the hydrologic model to known, monitored events through the study area.
5. Hydraulic Modeling: Generate a hydraulic model to determine flood elevations to develop flood hazard mapping through the study area.
6. Flood Hazard Mapping: Results of the hydraulic and hydrologic model were incorporated into digital flood hazard mapping, overlaying the overall floodline to identify flood hazards associated with major tributaries of the Sixteen Mile Creek West Branch primarily within the developed and urbanizing portions of the Town of Milton, and localized sections of Halton Hills.

A series of memorandums and draft reports have been prepared throughout this process and have been submitted and reviewed by the TAC Committee for feedback and input. Comments and contributions from the TAC was an essential process that occurred throughout the study. The TAC generally provided comments on technical memorandums, draft reports, modelling methodologies and materials presented.

As part of Greck's QA/QC process, the project manager was responsible for overseeing and reviewing all analyses completed by the study team to ensure a quality and defendable product is completed. This water resources engineer was not involved in the main development and analyses of the study, but rather, to simulate a peer review by a qualified professional upon completion of all analyses and report writing. Additional peer reviews were completed by WSP (formerly Wood)on behalf of the Town of Milton. Feedback was received from WSP (formerly Wood) and were incorporated into this report.

This report outlines the summary of analyses, calculations and modelling procedures completed in an effort to meet the study goals of establishing Regulatory Flood Hazard mapping for reaches of the West Branch of Sixteen Mile Creek through the existing urban Town of Milton, and localized portions of Halton Hills.

1.4 STUDY AREA

The study area is shown in **Figure 1.1.** While the Sixteen Mile Creek watershed continues southerly through Oakville and to its ultimate location of discharge into Lake Ontario, the scope of this study is to assess flood hazards associated with select tributaries of the West Branch of Sixteen Mile Creek within the urban portion of the Town of Milton, generally mapping regulatory floodplain limits between Campbellville Road (5^{th} Sideroad) to Britannia Road. The study area was expanded slightly, however, to consider and map a known spill from the upper reaches of the Middle Branch of Sixteen Mile Creek to the West Branch of Sixteen Mile Creek, and as such, mapping has also been developed for a localized area in Halton Hills. To support this assessment, the hydrology of all flow contributions which go through Milton within the West Branch of Sixteen Mile Creek, including drainage areas within the Town of Halton Hills, which contribute flow to both the West and Middle Branches of Sixteen Mile Creek was modelled.

The study area consists of two distinct branches of Sixteen Mile Creek, referred to as the West Branch and the Middle Branch. Several tributaries of the Middle Branch and the West Branch are located within the urban portion of the Town of Milton; some of these tributaries, however, were not included in mapping developed through this study as they are the subject of ongoing or recently finalized studies.

The West Branch study area is 11,817 ha to Britannia Road, while the Middle Branch study area is 4,109 ha to the Railway crossing upstream of the intersection of Boston Church Sideroad and 5^{th} Sideroad (the spill point identified by the FDRP study). The majority of the contributing area to the West Branch consists of agricultural, wetland, forested and rural land-uses within the headwaters, primarily north of Highway 401, and urban areas south of 401. Over the past 30 years, there has been significant industrial development immediately north of Highway 401. Within the study limits, the Middle Branch is almost entirely undeveloped (wetland and forests), rural, agricultural lands.

Sixteen Mile Creek primarily functions as a natural channel system throughout the watershed; however, a concrete lined engineered channel exists within urban Milton. The West Branch watershed features two reservoirs (Kelso and Hilton Falls Reservoirs), which function as recreational facilities, provide low flow augmentation and some degree of flood control (i.e., the reservoirs are operated to provide attenuation during the annual melt, and to a lesser degree, the attenuation for storms occurring during other times of the year). The Middle Branch features one reservoir (Scotch Block Reservoir) that similarly provides low flow augmentation and minor flood control functions.

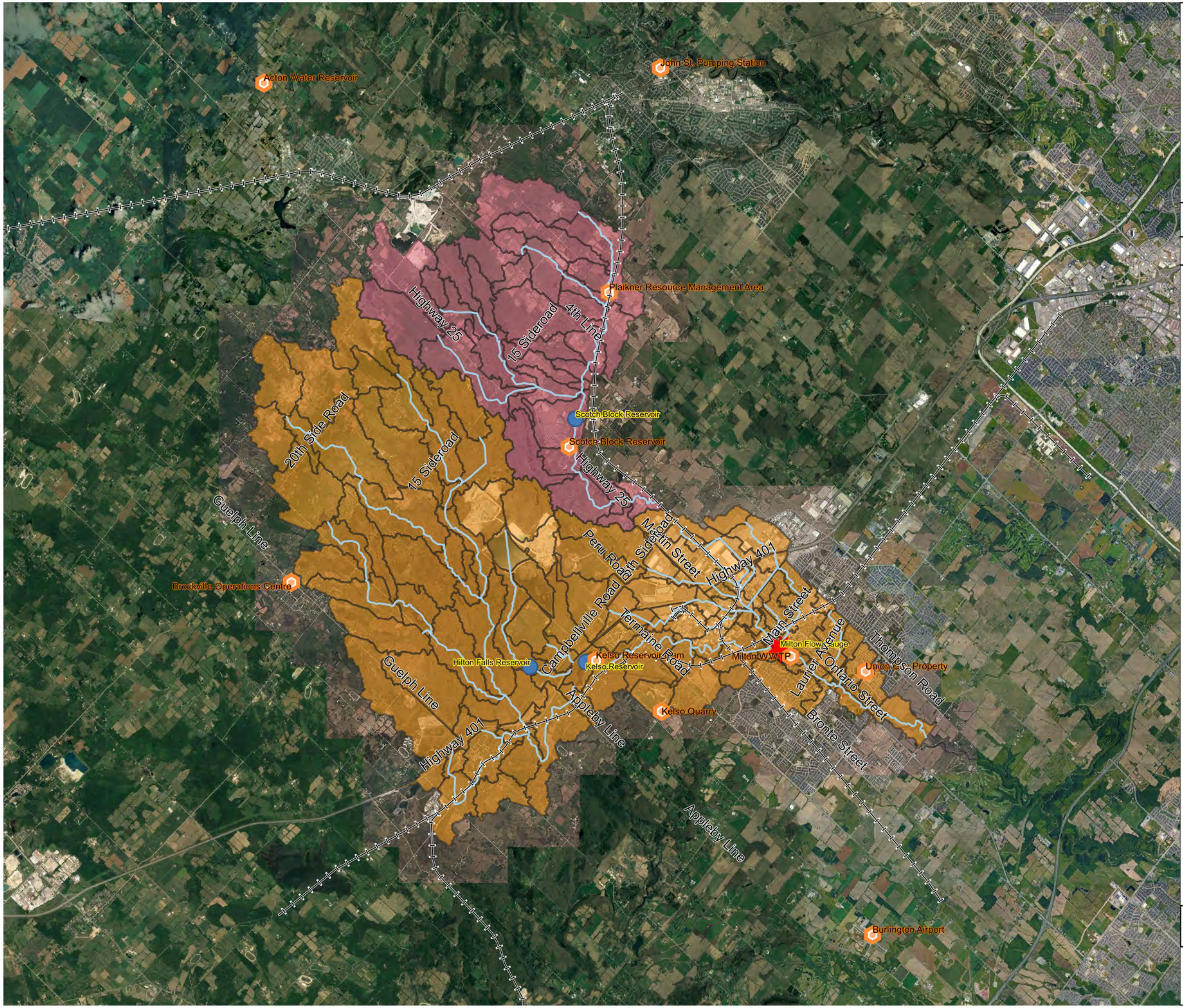


Figure 1.1: Study Area

Flood Hazard Mapping - Urban Milton
Sixteen Mile Creek
Project No.19-609

0 2,000 4,000 m

NAD 1983 UTM Zone 17N

Legend

- West Branch
- Middle Branch
- Railway Lines
- Reservoir
- Flow Gauge
- Watercourse
- Inter-Watershed Spill
- Weather Stations

Greck

March 2020

Basemap Image Google Maps 2019 & Airborne Imaging, 2019

Catchments delineated via PCSWMM by Greck and Associates Limited, January 2020

Within the study area, several stormwater management facilities (SWMFs), primarily surface detention ponds, are located within the urban Town of Milton and at least one private SWMF is located within the drainage-shed associated with the Town of Halton Hills.

Significant wetland features are identified via both orthophotography and available land-use information within both the West Branch and Middle Branch watersheds of Sixteen Mile Creek. Wetlands can greatly influence runoff throughout the watershed due to their flat topography, ability to retain/detain surface flows and enhance infiltration and evapotranspiration. Large bodies of wetlands were noted upstream (north) of Highway 401 within the West Branch, with smaller more sparse wetlands noted within the Middle Branch. Wetlands are identified in **Figure 4.2**

1.5 PREVIOUS STUDIES

Several studies have been completed in the past to define the watershed hydrology and river hydraulics within the area. These studies were prepared for several different purposes. The key studies are listed below with a brief description and summary of key elements relative to the work completed as part of this report.

Floodline Mapping Study of Sixteen Mile Creek: Technical Report, Proctor and Redfern Ltd., 1988

As part of the 1988 Flood Study, referred to as the FDRP study, a new watershed wide HYMO hydrological model was developed. The purpose of this study was to provide flood hazard mapping throughout the Sixteen Mile Creek watershed. The model identified major spill from the Middle Branch at a Canadian National Railway (CNR) watercourse crossing. The model included 75 unique catchments and encompassed the entire Sixteen Mile Creek watershed. The study considered data from two (2) Water Survey of Canada (WSC) flow gauges within the watershed in effort to calibrate the hydrologic model, referred to as the Milton Gauge (02HB005) and Omagh Gauge (02HB004).

The 1988 study concluded that the use of the Water Survey of Canada Milton Gauge (02HB005) for calibration of the hydrologic model was not feasible, as calibration plots were not in very good agreement, and as flows in upstream reservoirs stored and delayed flows for days. Active reservoir operations further complicated evaluation of the modelled watershed response.

A HEC-2 hydraulic model was subsequently developed to define the flood hazard limits, and mapping was developed using 1m contour data.

Sixteen Mile Creek Watershed Plan, Prepared in Support of the Sixteen Mile Creek Watershed Plan and Halton Urban Structure Plan & Technical Report 1 Model Calibration, Gore & Storrie Ltd. Et. Al 1995

A watershed wide model update was completed on behalf of the Region of Halton in 1995 to evaluate the impact of planned growth within the Sixteen Mile Creek watershed. The 1988 HYMO model was converted into a QUALHYMO model, and the study concluded that development would not negatively impact flooding within Sixteen Mile Creek. No updated mapping was completed as part of this study.

Sixteen Mile Creek Subwatershed Planning Study, Areas 2 & 7, Town of Milton, (Technical Appendix Stormwater Management), Phillips Planning & Engineering et. Al., January 2000

The purpose of this study was to evaluate the impact of proposed land-use changes to the hydrologic and water quality processes within the sub-watershed and watershed and to evaluate the effectiveness of various SWM techniques to mitigate these impacts.

All areas upstream of the Kelso Reservoir were combined into one single catchment, referred to as Subarea 1. Subarea 2 represented an area downstream of Kelso Reservoir. The model was created in HSP-F and made note that all drainage areas contributing to the Kelso Reservoir had, "*…limitations in the subcatchment model parameterization under extreme rainfall events. Under such conditions, the available soil moisture storage would be exceeded, and significant runoff would occur. This suggests that under extreme rainfall events, the HSP-F parameter suite (selected for Subwatershed 1 to represent the swamp wetland storage) would likely be beyond the range where it provides reasonable results.*"

To address the above issue, Regional flows were simulated under Antecedent Moisture Condition (AMC) III conditions using the last 12 hours of Hurricane Hazel.

Functional Stormwater and Environmental Management Strategy – Highway 401 Industrial/Business Park Secondary Plan Area, Town of Milton, Phillips Engineering Ltd., July 2000

The above study evaluated flow contributions within the industrial zone centred around Highway 401. The purposes of this report were two-fold: 1) to identify aquatic and terrestrial resources, and outline where these proved to be a constraint to certain types of land-use and 2) to develop SWM strategies for proposed development. The study re-discretized catchments, generating 17 flow nodes within the industrial study area. The study assessed existing culverts under Highway 401 and provided catchment data and flows for tributary areas above the Niagara Escarpment.

Storage and Operations Optimization Study Hilton Falls Reservoir, Phillips Engineering Ltd., April 2005

This report was prepared to quantify the flows routed through a diversion structure in addition to establishing/evaluating requisite pumping rates from a quarry to the Hilton Falls Reservoir. The study assessed the operating characteristics over the Hilton Falls Reservoir noting an inter-basin spill at a diversion structure located northwest of the Hilton Falls Reservoir. Spills from an adjacent tributary of Sixteen Mile Creek were noted to occur during low flow conditions towards the Hilton Falls Reservoir based on a diversion structure consisting of a concrete weir. The diversion of flows was also impacted by upstream beaver dams that were surveyed in order to develop a rating curve. Phillips Engineering observed approximately 27-47% of flows were diverted towards this branch based on two field investigations in the fall of 2003.

The study also recognized the presence of the upstream Dufferin Quarry, whereby flows are discharge towards the dam at a regular basis. Best efforts were made to calibrate the existing HSPF model under a continuous simulation; however, did not produce modelled/fitted curve, particularly during the spring freshet. The report, however, was accepted by CH.

Scotch Block Dam Spill Assessment, Conservation Halton, Phillips Engineering Ltd. December 2005

The purpose of this study was to conduct a dam break analysis for the Scotch Block Reservoir to determine what flooding and erosion effects would occur throughout the watershed, and at the area of spill between the Middle and West Branch of Sixteen Mile Creek. This work was completed to support a dam safety review which was being completed by others. The study established peak regional inflows and outflows at the Scotch Block Reservoir, while also establishing the probable maximum flood flow and dam break flows.

Functional Servicing Report, Escarpment Business Community (West), MGM Consulting Inc. May 2007

This study provided details related to servicing, grading and SWM for proposed development with the Milton 401 Industrial Business Park area. A SWMF was designed to provide erosion, flood and water quality control for the upstream lands. The SWMF design indicates that a portion of the development area is to drain towards the west SWMF, where its outlets towards a tributary to the south. A second portion drains towards an eastern facility, where drainage is conveyed to another tributary of Sixteen Mile Creek.

Sixteen Mile Creek, Areas 2 & 7 Subwatershed Update Study (SUS), AMEC Environment &Infrastructure et. al., November 2015.

This study included further model refinements to support a range of studies, including the Highway 401 Industrial Business Park Report and two studies within the area, referred to as the *Indian Creek / Sixteen Mile Creek Sherwood Survey Subwatershed Management Study,* Town of Milton and *Hilton Falls Reservoir Operations Optimization Study*, Phillips Engineering Ltd., 2005.

The study's goals were to provide management strategies, including sub-watershed management and SWM, and to outline opportunities for restoration/rehabilitation of terrestrial and aquatic resources.

2.0 PUBLIC CONSULTATION

Public consultation was an important process throughout the study, as it allowed for the study team to receive feedback from local residents, business owners and authorities regarding the watershed.

Public feedback was sought through three (3) Public Information Centres (PIC's). The first PIC was held shortly after project initiation, to notify the public of the on-going study, share the Study Team's understanding of the Watershed, solicit public input and local knowledge to support validation analysis, and raise awareness of personal emergency preparedness and planning. The second PIC was held as an on-line release due to concerns over public gatherings during the global COVID-19 Pandemic. This information was released as the study neared completion to share draft study results, solicit public feedback, and continue to raise awareness of flood risks and personal emergency preparedness and planning. A third PIC was held February 22, 2023 to provide the public an opportunity to review the revised draft final mapping and reporting.

To maximize study awareness among the general public, Conservation Halton applied multiple notification methods including:

- Ads in the local newspapers
- Social media posts (e.g., CH Facebook and Twitter)
- Direct e-mail notification to identified stakeholders, requesting they share notice with others,
- An update on CH's website, and
- Coordination with the Town of Milton to include information on the Town's website.

The materials shared with the public are included in **Appendix A**.

3.0 FIELD PROGRAM AND DATA COLLECTION

The following section details the methodology utilized in the collection and processing of data from the field to validate the LiDAR topography data and build the hydraulic model of Sixteen Mile Creek. Topographic survey is essential in hydraulic modelling, as watercourse crossing details need to be field verified via site visit to confirm culvert information, such as geometry, inlet/outlet configuration, etc. The use of LiDAR elevation data alone cannot capture specific items that may restrict the conveyance capacity across a bridge or culvert, such as concrete barriers.

The collection of data involved a field inspection of watercourse crossing structures and a GPS survey of channel cross-sections and inverts at selected locations. An additional survey was completed to map and confirm the spill crest from the Middle Branch to the West Branch. Inspection and survey methodology, equipment used, and the scope of the field program are detailed below.

Most of the field work was completed from late June through to the end of July 2019 by a two person team. This work involved collecting data for watercourse crossings and at selected channel cross-sections as predetermined by Conservation Halton, and through a desktop review of the study area. A total of 81 crossing structures were surveyed, 79 of which were identified by Conservation Halton, with two additional crossings of importance identified by Greck.

At each crossing site, access to the crossing was gained by walking down the bank adjacent to the crossing. If the channel was gated, a key provided by Conservation Halton was used to gain access. Structural measurements were taken and recorded by one person, while the survey was completed by the other person. The respective methodology and equipment used for each task is outlined below. Access to private lands was secured by obtaining permission from the landowners.

Crossing Measurements

Measurement and recording equipment included a Bosch laser distance measurement tool with +/-1.5mm accuracy within 50m, tape measure, survey rod and tablet with a built-in camera. For distance measurements, the laser measuring tool was used wherever possible as it provided the greatest accuracy.

Photos and measurements taken at each crossing were recorded via the tablet and placed on crossing specific field sheets. The "Stream Crossing Field Inventory Sheet," was identified by the original numbering provided by Conservation Halton. Measurements differed depending on the type of structure; however, a brief explanation of the fields on the crossing inventory forms and their modes of inspection are provided below. Inventory Sheets are provided in **Appendix B**.

Structure Type – Shape and classification of structure, i.e., arch bridge, box culvert, etc.

# of Spans – Number of openings for water to pass through. Two for twin culverts, four for bridges with three sets of piers, etc.

Span or Diameter – Width of the structure's opening(s). Multiple spans are provided for bridges with two or more piers. Measurements were primarily obtained with a hand laser measuring tool.

Rise – Vertical measurement of the structure's opening from invert to obvert (or the lowest point on a bridge profile). This does not include sediment accumulation for closed bottom footings. The survey rod was held vertically to clear the water and the laser measuring tool was held at the 1m mark, pointing upwards to measure to the obvert. The total rise recorded included the laser reading added to the 1m survey rod. Two measurements were taken, one at the upstream inlet and one at the downstream outlet.

Length – Horizontal measurements from inlet to outlet of structure. Measured by hand laser measuring tool for short distances and derived from GPS survey data for longer distances.

Material – The primary material(s) composing the structure, in most cases concrete or galvanized corrugated steel.

Open Footing – "No" if the structure has a floor, "Yes" if it does not have a floor, but rather a natural channel bottom. "Expected" if the concrete base is not visible but expected (i.e., a box culvert partially buried in sediment).

Skew Angle – The plan view angle of the structure from a reference line perpendicular to the road centre. Approximated from pictures and aerial imagery.

Sediment Depth – Depth of accumulated sediment if the channel does not have an open footing. Measured with survey rod or derived from two GPS readings at the top and bottom of sediment.

Barrier – Height and type of the barrier reaching the highest elevation on the structure. Measured with hand laser measuring tool.

Upstream (US) / Downstream (DS) Invert Elevation – The elevation of either the footing or the bottom of the channel at the inlet and outlet of the structure. Recorded by GPS survey.

US/DS Obvert Elevation – Derived from the rise added to the invert elevation or measured via measuring tape from deck and a point of reference recorded by GPS survey.

Inlet/Outlet Type – In the case of culverts, an indication of wingwalls, retaining walls or headwalls.

High Water Mark Depth – Height of a visible watermark line from thalweg of channel. “Not Observed” if a watermark line was not visible. Measured with a survey rod.

Piers – An indication if the structure had piers (only for bridges).

Pier Width – Width of pier face to incoming flow. A diameter is provided for round-nose piers. Measured by measuring tape.

Low Point in Deck Elevation – Lowest elevation of deck profile, or the location where over-topping would first occur. Note that for roads with curbs, this is a curb elevation instead of a road elevation since the space between the top of curb and top of road is ineffective flow area. Recorded by GPS survey.

Water Depth – Upstream water depth from channel bottom to water surface. Measured by survey rod.

Additional Notes – Provided if there are notable or unusual elements to the structure.

Topographic Survey

Equipment used for the topographic survey included a Trimble R2 RTK Rover GPS with +/-1cm accuracy under a clear signal. To gauge the consistency of the equipment, a survey point of a catchbasin was taken at the GO Park and Ride Station in the southeast corner of Highway 401 and Regional Road 25 each day at the same time before visiting any sites, see **Figure 3.1**.

FIGURE 3.1: CONTROL POINT FOR SURVEY AT GO PARK AND RIDE

Table 3.1 summarizes the elevations recorded at the control point each day of the survey.

TABLE 3.1: SURVEYED CONTROL POINT ELEVATIONS

Date	Surveyed Elevation (m above MSL)
June 28, 2019	209.521
July 2, 2019	209.534
July 3, 2019	209.515
July 8, 2019	209.490
July 10, 2019	209.496
July 11, 2019	209.492
July 12, 2019	209.516
July 15, 2019	209.522
July 18, 2019	209.511
July 23, 2019	209.505

Note: Elevations reported in Geoid CGG2013.

This catchbasin survey point was used as the control point for the survey for the entire day. The consistency proved to be within 4cm over the course of the entire surveying period. Permanent benchmarks were discovered on various culverts as the survey progressed, see **Figure 3.2**. These benchmarks were surveyed and compared to published elevations, see **Table 3.2**. It should be noted that the catchbasin control point was not used to adjust daily surveyed values.

FIGURE 3.2: MNRF BENCHMARKS 00820080015 (LEFT) AND 00820080018 (RIGHT).

TABLE 3.2: PERMANENT BENCHMARK ELEVATIONS

Benchmark	Benchmark Location	Benchmark Elevation (m)	Surveyed Elevation (m)
MNRF Station No. 00820080015	586243.682 E 4819430.728 N	219.020	219.020
MNRF Station No. 00820080018	588694.009 E 4820235.577 N	207.261	207.265

Note: All elevations in table are reported in Geoid HT2_2010 (NAD83-CSRS V6). Benchmarks retrieved from Ontario Ministry of Natural Resources, 2015. Surveyed elevations from July 18, 2019.

As per **Table 3.2,** excellent accuracy was obtained with the survey equipment.

Each crossing profile was surveyed to an extent determined by reference to previous floodplain mapping delineations. The points surveyed at each site included the road edges or curbs on the deck of both the upstream and downstream sides, the upstream and downstream inverts, the ends of each headwall and parapet wall, the top of any retaining or wingwalls, and some ground points to characterize any slopes or tapers around the inlet/outlet. Cross-sections were surveyed upstream or downstream of the crossing as needed to further characterize the channel.

Additional points were taken on either side of the deck, either close to the railing or on the headwall/top of culvert to serve as points of reference. These reference points were used to derive the obvert elevations, as some locations had excessive tree cover that prevented a clear GPS signal at the invert. Instead of adding the rise to the invert for these locations, the distance between the reference point and the obvert was measured and subtracted from the point of reference. The rise was then subtracted from the obvert to obtain an invert elevation. This method was also used if the invert elevation proved to have significant inaccuracy (+/- 10cm), again due to a weak GPS signal from excessive tree cover.

The topographic survey was also performed at specific locations to verify the LiDAR data and map the northern spill area. Ten (10) points were taken along the spill crest, another ten (10) points on asphalt in the Park and Ride Go Station next to Highway401 and Regional Road 25, and another ten (10) points on bare earth/low grass in Brian Best Park, see **Figure 3.3.**

FIGURE 3.3: TERRAIN OF THE NORTHERN SPILL CREST AREA (TOP), PARK AND RIDE GO STATION (MIDDLE), AND BRIAN BEST PARK (BOTTOM).

3.1 LIDAR ACCURACY ASSESSMENT

A Vertical and Horizontal Accuracy Assessment was completed as part of the original LiDAR survey by Airborne Imaging Inc. to determine the accuracy of the LiDAR survey. This was assessed during the LiDAR acquisition process, outlined in **Section 4.3.1**, by having a GPS mounted truck collecting topographic survey of the road. The accuracy assessment concluded that with a 95% confidence interval the data has a horizontal accuracy of 30cm, and a vertical accuracy of 6.6 cm on flat hard surfaces. Further details outlining the vertical accuracy assessment and summary reports of the LiDAR topographic survey by Airborne Imaging Inc. are provided in **Appendix C**.

Greck completed a separate Vertical Accuracy assessment as part of the field program, where field surveyed points were compared to LiDAR survey points. In additional to surveying watercourse crossings, Greck obtained additional topographic data at various locations on a variety of land covers. A summary of the vertical accuracy assessment by Greck is provided below in **Table 3.3**.

TABLE 3.3: SPOT CHECK VERTICAL ACCURACY ASSESSMENT

Land Cover	Number of Points	95% Confidence Interval
Agricultural/Hydro corridor	10	0.03m
Open field/Park	10	0.03m
Floodplain	18	0.09m
Impervious Surface	10	0.02m

As expected, the results concluded that the LiDAR topographic survey had a higher level of accuracy on flat impervious surfaces and open fields with limited vegetation, and a lower level of accuracy in highly vegetated areas, such as a floodplain. The above discrepancies are within acceptable ranges as per the Federal Airborne LiDAR Data Acquisition Guidelines (Natural Resources Canada, 2022), which indicate that topographic data that has a non-vegetated vertical accuracy of +/- 10 to 15cm is appropriate for use in flood hazard mapping even in high risk areas.

As such, a 95% vertical confidence interval of 6.6cm on smooth hard surfaces and closer to 9 cm in floodplain areas is considered appropriate for the use of Flood Hazard Mapping, as it represents a reasonable level of accuracy and falls within typical levels of freeboard and setbacks associated with floodplain mapping.

4.0 HYDROLOGICAL MODELLING

Flood hazard mapping was prepared based on gradually varied, steady state flows throughout the study area. This means only peak flows were required at selected locations for the hydraulic model. To obtain the required peak flow input data, a deterministic hydrologic model of the watershed was developed. Deterministic models use analytical methods to calculate peak flows based on actual or design storm precipitation events. Deterministic modelling tools are particularly useful in estimating peak flows for events that have not occurred within the watershed.

The hydrological model was created to quantify the runoff for the West Branch of Sixteen Mile Creek. A small portion of the Middle Branch of Sixteen Mile Creek was included to quantify the level of inter-basin spill which occurs upstream of the CNR Embankment located north of the intersection of 5th Side Road and Martin Street (Highway 25). This spill was quantified by creating a 1D non-steady state HEC-RAS hydraulic model. The following section describes the development of the hydrologic model, its calibration and verification, and the results obtained.

4.1 MODEL SELECTION

All hydrologic modelling was completed using Visual OTTHYMO Version 5.1.2006 (VO) hydrologic modelling software. VO is commonly applied by industry professionals within southern Ontario and has been approved for use in flood hazard mapping projects as per the 2019 Federal Flood Mapping Guidelines (NRC, 2019). CH has recently invested in the use of this software for several recent and ongoing flood hazard studies and to support development of a predictive flood forecasting and warning model that is integrated with the watershed monitoring system throughout Conservation Halton's jurisdiction.

VO is maintained by Civica Infrastructure, located within Vaughan Ontario. Civica can provide ongoing support based on their experience with the software directly in southern Ontario.

VO is noted to have strengths in representing the physical watershed properties of both urban and rural watersheds; an important consideration for the Sixteen Mile Creek watershed. The NasHYD command uses the Soil Conservation Service (SCS) Curve Number Method (SCS Method) for losses and the unit hydrograph method to determine runoff rates. These methods have been proven useful to describe runoff from pervious land-uses within rural areas. Use of the VO model platform and SCS Curve Number Method maintain consistency with the previous FDRP modelling and mapping.

The SCS Method allows for a wide range of Curve Numbers to be applied for varying land-use types in comparison to alternative methods, which rely on simpler runoff coefficients based on a level of imperviousness. For example, while a variety of undeveloped lands may all have a very low percent impervious (<2%), varying types of agricultural land can have significantly different hydrologic characteristics. A specific example is that while both are100% pervious, heavily treed, forested areas would produce less runoff in comparison to an agricultural field, and, as such, the SCS Method proves useful to describe these differences in hydrologic responses.

VO also allows one to model urban areas using the StandHYD command. With the StandHYD command, the pervious and impervious areas within urban land-uses can be separately modelled, then convoluted to create a single runoff hydrograph. The benefits of this are while the hydrologic response is typically governed by percent impervious and catchment slope, considerations for how open space exists in an urban area can be adequately accounted separately.

4.2 HYDROLOGIC MODEL ELEMENTS NAMING CONVENTION

The watershed was subdivided into distinct reaches. Each reach had multiple subatchments. Each reach was numbered and this number was used as the prefix to numbering subcatchments as outlined in **Table 4.1.**

TABLE 4.1: HYDROLOGIC AND HYDRAULIC MODELLING NAMING CONVENTION

Reach	Subcatchments in Hydrologic Model	Flow Nodes	Route Channels	Route Pipe
100	110 120 130	11 12 13	911 912 913	811 812 813
200	210 220 230	21 22 23	921 922 923	821 822 823
300	310 320 330	31 32 33	931 932 933	831 831 823
1000*	1010 1020 1030	101 102 103	9101 9102 9103	8101 8102 8103

This naming convention allows one to discretize catchments further for any future analyses. For example, should a future development be considered within a portion of subcatchment 110, subcatchment 110 can be further divided into 111, 112, 113 etc.

A flow node was inserted at a point of confluence between two reaches and will be labelled as the starting flow node for the next downstream reach. For example, at a point of confluence, if Reaches 10 and 200 flow into Reach 300, the point of confluence would be labeled as 301.

Flows are routed through a reach using the RouteChannel command. RouteChannels have a prefix of “9” to differentiate them from a flow node or subcatchment. A sample of the watershed schematic used in VO5 is illustrated in **Figure 4.1**.

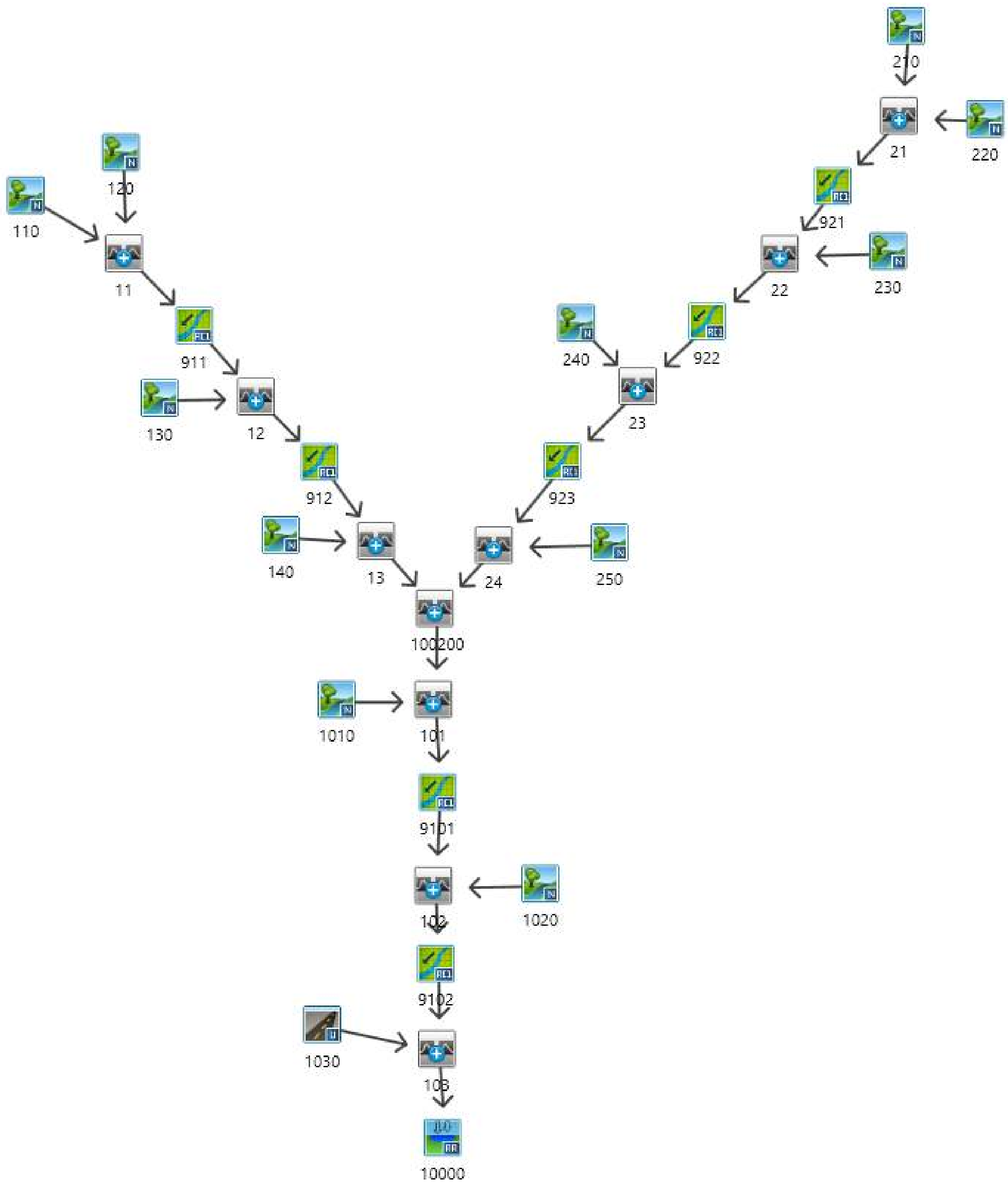


FIGURE 4.1: HYDROLOGIC MODELLING NAMING CONVENTION

4.3 DATA SOURCES

To develop a working hydrological model, several sources of information were required to define the watershed characteristics.

4.3.1 LIDAR TOPOGRAPHIC SURVEY

A Light Detection and Ranging (LiDAR) topographic survey of the study area was key in developing the hydrologic and hydraulic model for this study. This technology provides high resolution digital topographic information, which was essential to the definition of drainage areas, watercourses and identifying areas inundated by flood water.

The LiDAR survey used in this study was completed in 2018 by Airborne Imaging Inc. LiDAR topographic surveys typically feature a laser targeted to the ground attached to an aircraft, where a sensor records the reflected light from the laser in order to determine the ground elevation. The ground surface is georeferenced by the GPS satellite tracking of the aircraft. The date of the survey was completed between March 19th, 2018, and May 9th, 2018. Elevations were assessed based on a point density of 10.4 points per square meter.

A LiDAR digital elevation model (DEM) was created based on the topographic survey and a Digital Terrain Model (DTM) was created to filter vegetation and buildings, thereby creating a “Bare Earth” model. The model was completed using the CGVD2013 vertical datum and NAD83 CSRS Horizontal Datum, UTM Zone 17.

4.3.2 LAND COVER

A Hydrologic model was completed to determine peak flows under two land-use scenarios: existing and future. Existing conditions were required to facilitate the model calibration and validation process. Future land-use conditions were required to assess how peak flows might change to ensure flood hazard mapping was accurate for the land-use scenario that produced the greatest potential risks for flooding.

Land cover information is a critical component in deterministic hydrologic modelling, as it is the foundation in establishing watershed parameters, such as percent impervious, infiltration parameters, etc.

GIS land cover information was received from CH and the Town of Milton. The existing land-use represents the land cover as of 2019 and was amalgamated by Greck based on the following sources:

- Conservation Halton, 2012
- Town of Milton Official Plan, 2008; and
- Aerial orthophotography, 2019

A desktop review was conducted using aerial orthophotography to revise or update land cover as needed.

4.3.2.1 EXISTING LAND COVER

A summary of the distribution of existing land cover is provided below in **Table 4.2** and in

Figure 4.2. Only land covers with percent cover greater than 1% are noted in this table. All remaining land covers were designated as "Other."

TABLE 4.2: EXISTING LAND COVER DISTRIBUTION OF SIXTEEN MILE CREEK

Land Cover	% Cover (West Branch)	% Cover (Middle Branch)
Agricultural	13%	38%
Commercial/Industrial	3%	<1%
Extraction	3%	<1%
Field	9%	5%
Forest / Treed / Natural Area	26%	37%
Golf Course, Cemetery, Recreational	<1%	<1%
Grass	2%	<1%
Hedge Row	<1%	<1%
Impervious	4%	<1%
Parking Lot	<1%	<1%
Pasture	3%	3%
Plantation	2%	<1%
Rural Residential	5%	4%
Transportation	3%	<1%
Urban Residential	5%	<1%
Water	3%	2%
Wetland	17%	6%
Other	<1%	<1%

In general, land cover associated with the West Branch of Sixteen Mile Creek catchment area upstream of the Kelso reservoir is predominantly forested/treed, agricultural and rural containing significant wetland features north of Highway 401.

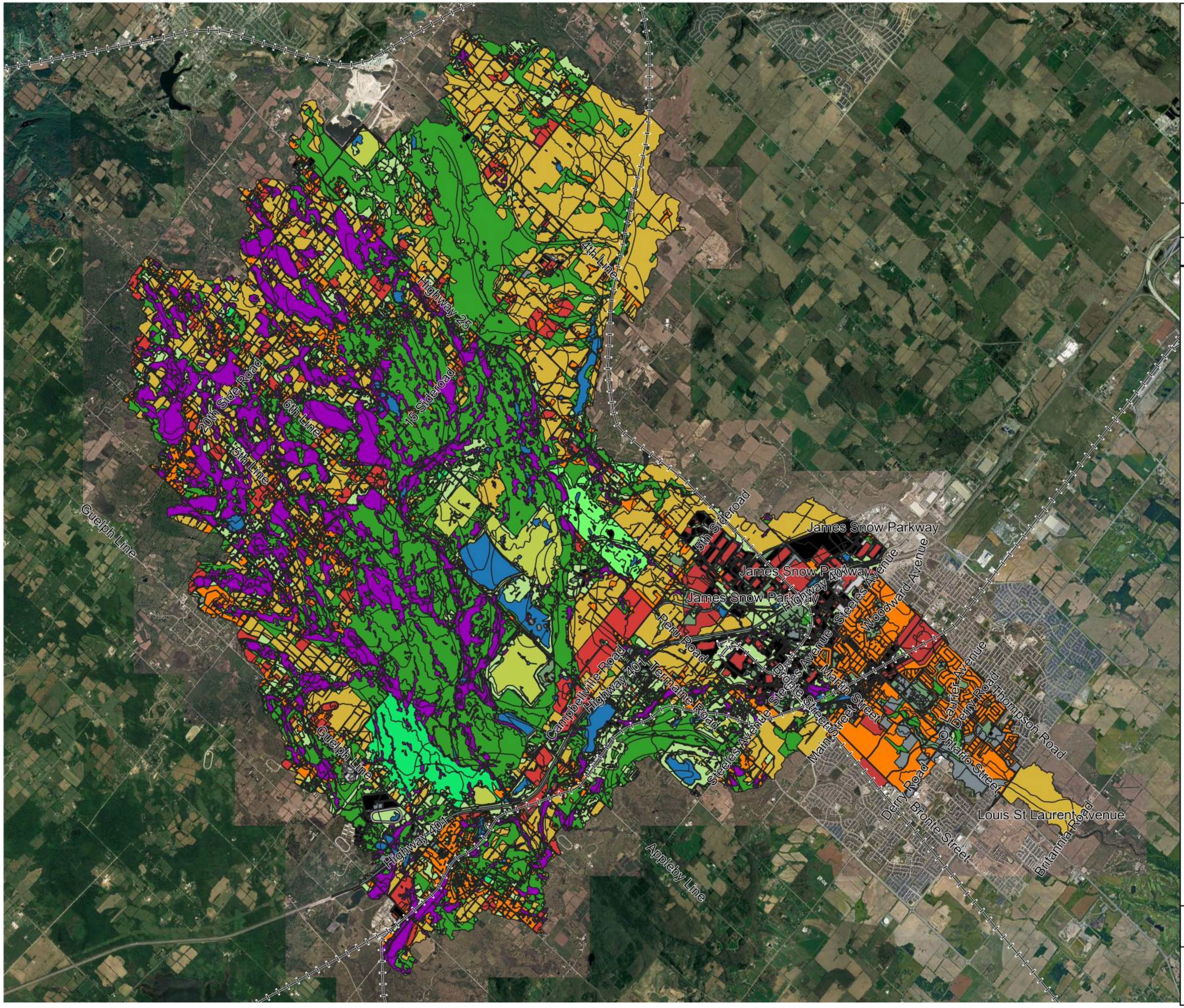


Figure 4.2: Existing Landuse

Flood Hazard Maping - Urban Miton
Sixteen Miile Creek
Project No.20-693

0 2,000 4,000 m

NAD 1983 UTM Zone 17N

Legend

- Agricultural
- Other
- Commercial/Industrial
- Extraction
- Field
- Forest / Treed
- Golf Course
- Grass
- Hedge Row
- Impervious
- Parking Lot
- Pasture
- Plantation
- Residential
- Water
- Wetland
- Other
- Railway Lines

Greck

October 2022

Basemap Image Google Maps 201 & Airborne Imaging, 2019
Land-use as per Conservation Halton, 2012, Town of Milton Official Plan, 2008 and Aerial orthophotography, 2019

The Middle and West Branch of Sixteen Mile Creek both feature significant wetlands. Wetlands are important features in hydrologic modelling, as they can provide significant attenuation and lag in peak flows through the storage of flows, resulting in reduced rates of discharge. As such, wetlands have a compounding effect on watershed hydrology when considered with other features which cause attenuation and lag in peak flows. The relative impact of the wetland features on local hydrology can be complex as it is dependent on multiple factors including location within the watershed; size; storage potential (as determined by both topography and groundwater levels); etc. The impacts of a wetland may also vary based on the size of the rainfall event and on seasonal conditions (i.e., winter vs. summer). During minor storm events, wetlands may provide permanent retention storage or act as a sponge where little to no runoff /discharge occurs. During these events, most stored water is conveyed to groundwater or lost through evaporation and evapotranspiration. For large events, stored runoff is retained and or detained until the available storage is filled. As the full potential storage capacity of the wetland is reached, the impact of the wetland may be more muted, limited to routing impacts associated with flatter topography.

While there is no single, major wetland feature within the watershed, wetlands are distributed throughout the study area and primarily located above the brow of the escarpment. To ensure the impacts of wetland storage were appropriately considered under Regulatory Storm conditions, Conservation Halton completed a separate analysis of runoff volumes and peak flows using a HEC RAS 2D rain on grid model, which is discussed in greater detail under Section 4.6.5. Greck also examined the use of alternative methods for determining Time of Concentration and Time to Peak for routing flows through wetland areas, see Section 4.7.1.2.

A dense industrial area is located immediately north of Highway 401. South of Highway 401, land-use is predominantly residential and commercial. The interaction of the rural and wetland features within the headwaters and urbanized areas of Milton both contribute to the flood hazards throughout the study area.

4.3.2.2 FUTURE SCENARIO LAND COVER

A future land-use condition was considered based on the Town of Milton’s Official Plan. Further intensification is expected, north of Highway 401, where the industrial area is anticipated to expand, bounded by 5th Sideroad to the north, Tremaine Road to the west and Highway 401 to the south. Further residential development is also expected, particularly to the west, bounded by Peru Road to the west, Tremaine Road to the east, and Steeles Avenue/existing railway to the south. Additional residential development is anticipated at the downstream limit of the study area, bounded by Britannia Avenue to the south and Louis St. Laurent Avenue to the North.

As per the Official Plan, the main areas of expected development (located within the study area), are highlighted below in **Figure 4.3**. It should be noted that there are additional areas that while anticipated to be developed as per the Official Plan have been considered as "existing" land-use for hydrologic modelling purposes, as they are anticipated to include Regional stormwater management controls, resulting in no net increases in downstream flows.

4.3.3 SURFICIAL SOILS

GIS surficial soils information was received from CH and the Town of Milton. The surficial soils were defined by Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA, 2015) **Figure 4.4**. Surficial soils information is a critical component in deterministic hydrologic modelling, as it is paired with land cover information to further establish watershed parameters, such as Curve Numbers (losses due to infiltration). Soils can be defined into four (4) distinct hydrologic soil groups:

<u>Type A</u> soils consist of sandy soils, where they have low runoff potential when thoroughly wet. Type A soils generally have less than 10% clay and more than 90% sand or gravel.

<u>Type B</u> soils have moderately low runoff potential when thoroughly wet. Type B soils generally have between 10% and 20% clay, and 50 to 90% loamy sand or sandy loam textures.

<u>Type C</u> soils have moderately high runoff potential when thoroughly wet, and are between 20% and 40% clay, while being less than 50% sand.

<u>Type D</u> soils have high runoff potential when thoroughly wet and are greater than 40% clay.

A small portion of the hydrologic soils groups were noted as "other." This "other" is further categorized as escarpment or water. For hydrological modelling purposes, it was assumed that "other" soils groups are best represented by the same infiltration parameters as a Type D soil.

A summary of the distribution of hydrologic soils is provided below in Table 4.3

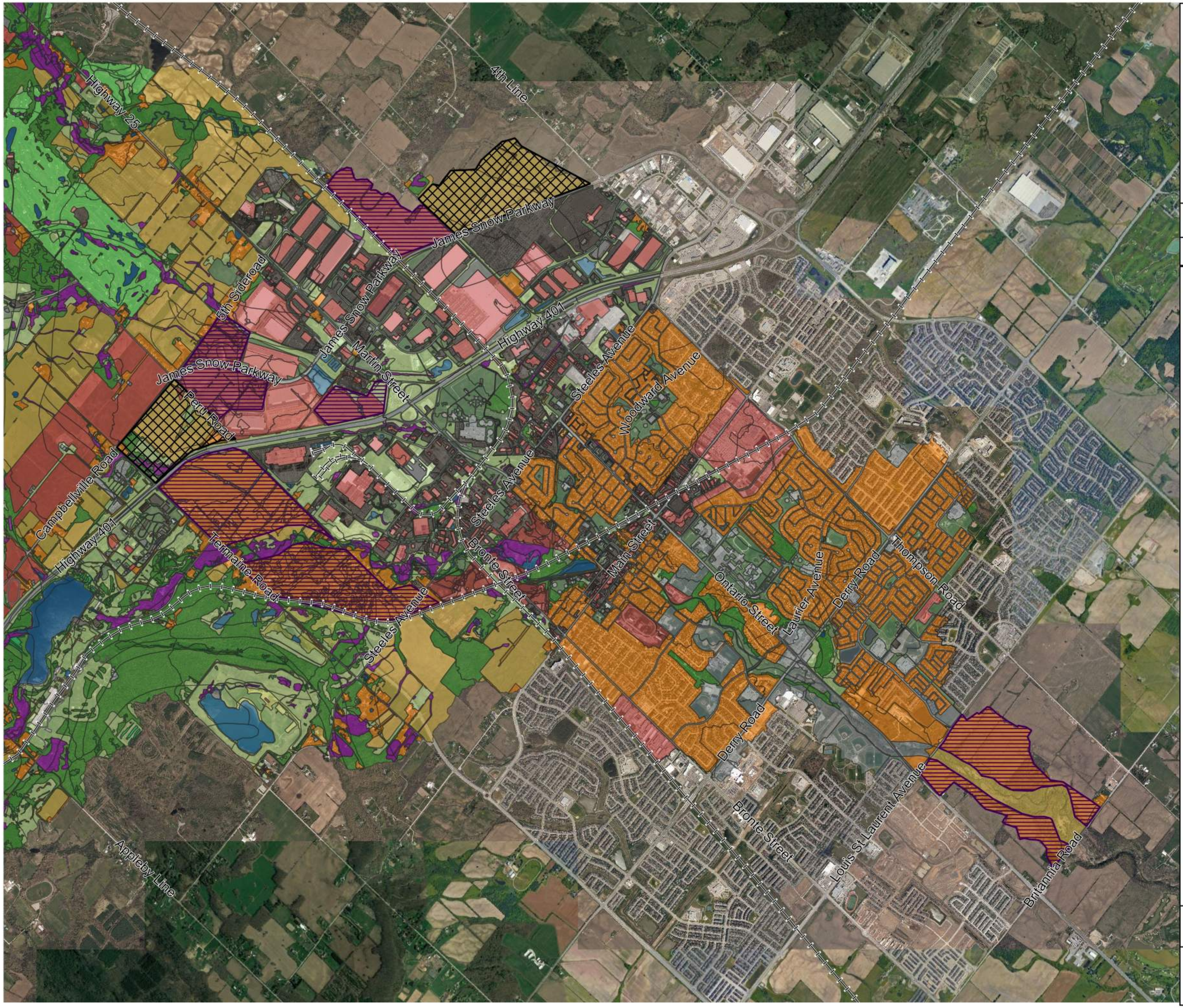


Figure 4.3: Future Landuse

Flood Hazard Maping - Urban Miton
Sixteen Miile Creek
Project No.20-693

0 1,000 2,000 m

NAD 1983 UTM Zone 17N

Legend

- Railway Lines
- Agricultural
- Other
- Commercial/Industrial
- Extraction
- Field
- Forest / Treed
- Golf Course
- Grass
- Hedge Row
- Impervious
- Parking Lot
- Pasture
- Plantation
- Residential
- Water
- Wetland
- Other
- OP Future Development
- OP Future Development*
  *Landuse to Remain as "Existing"

Greck

October 2022

Basemap Image Google Maps 201 & Airborne Imaging, 2019
Land-use as per Conservation Halton, 2012, Town of Milton Official Plan, 2008 and Aerial orthophotography, 2019

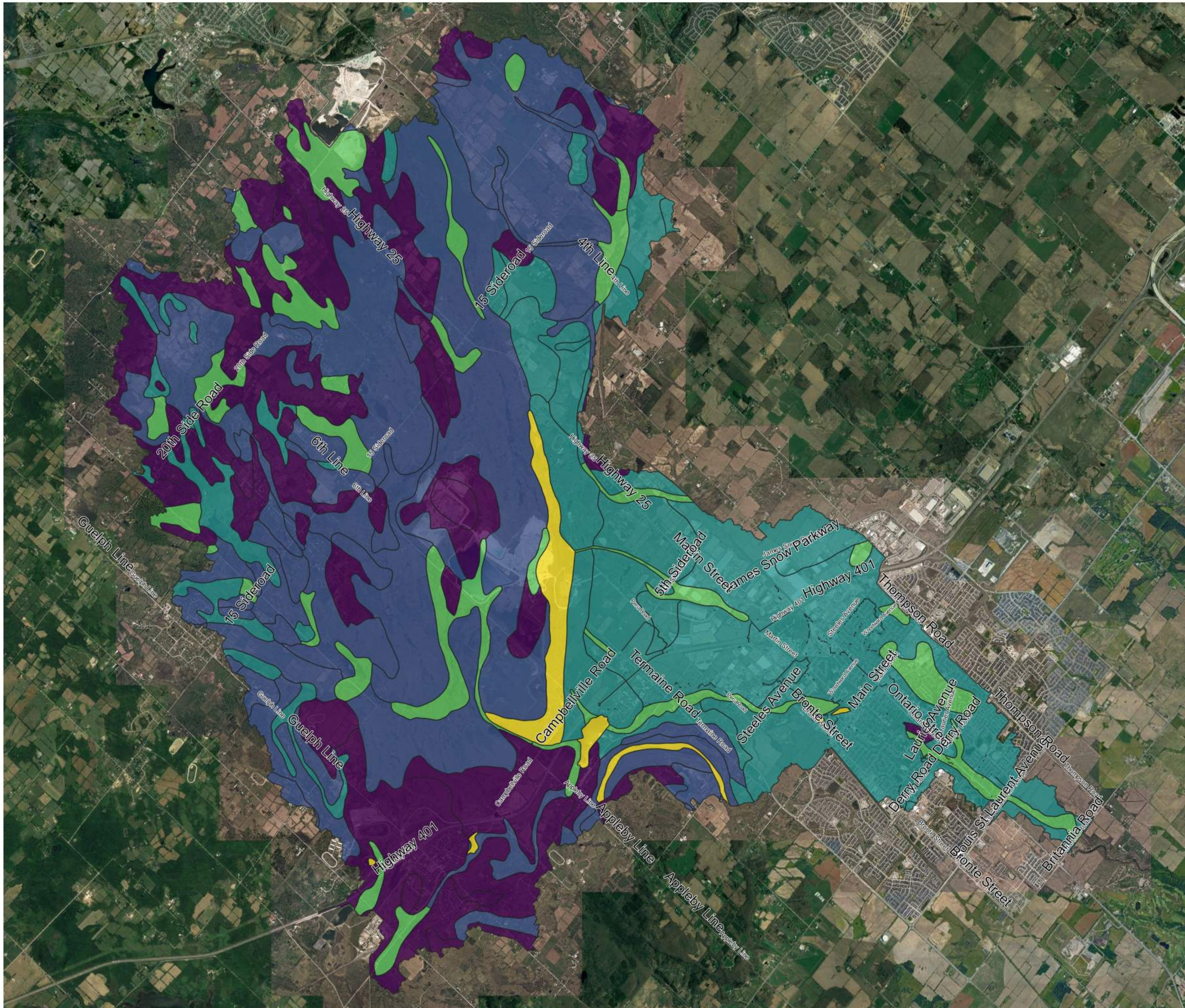


Figure 4.4: Surficial Soils

Flood Hazard Maping - Urban Miton
Sixteen Miile Creek
Project No.19-609

0 2000 4000 m

NAD 1983 UTM Zone 17N

Legend

- Hydrologic Soils Group A
- Hydrologic Soils Group B
- Hydrologic Soils Group C
- Hydrologic Soils Group D
- Other (Water/Escarpment)

Greck January 2020

Basemap Image Google Maps 2019.

Catchments delineated via PCSWMM by Greck and Associates Limited, January 2020

TABLE 4.3: HYDROLOGIC SOILS GROUP DISTRIBUTION OF SIXTEEN MILE CREEK

Hydrologic Soils Group	% (West Branch)	% (Middle Branch)
A	25	18
B	34	50
C	30	23
D	9	8
Other	2	1

The majority of type A and B soils are noted to be above the Niagara Escarpment - within the headwaters of the watershed, while Type C and D soils are generally located south of the escarpment within Urban Milton.

4.3.4 PRECIPITATION DATA AND MODELLING TIME STEP

Precipitation data was provided by CH for several weather stations within the area. Precipitation data was applied in efforts to calibrate the hydrologic model when coupled with known flow data within the watercourse. The rainfall records provided begin in 1989, and, as such, only contain rainfall events from 1989 onwards. A summary of each weather station and their rainfall record are provided below in **Table 4.4.** Locations of each weather station are indicated in **Figure 1.1**.

For calibration purposes, more recent rain events were preferred, primarily due to the availability of precipitation data with smaller intervals. Five-minute rainfall data is available from 2004 onwards, and, therefore storm events since 2004 were preferred due to more discrete data. More recent storm events also reflect existing land-use conditions, as calibrating to historical land-use conditions would not provide appropriate results.

A five-minute rainfall was also consistent with the desired modelling time step of five (5) minutes. A five-minute time step was preferred as it would ensure capture of peak runoff rates from the urbanized portions of the watershed. A longer timestep could result in underestimating the peak flow.

TABLE 4.4: PRECIPITATION GAUGE SUMMARY

Date	Years on Record	Record Interval
Brookville OPS Yard	April 30, 2018, to June 3, 2019	5-minute
Burlington Airport	May 31, 2017, to July 3 2019	5-minute
John St. Pump Station	August 31, 2007, to July 3 2019	5-minute
Kelso Rainfall	January 1, 1992, to January 31 2017	1-hour from 1992 to 2018 1-minute from 2016 onwards
Kelso Quarry	September 24, 2015, to July 6 2019	5-minute
Kelso Reservoir	January 5, 1992, to July 9 2019	1-hour (January1992 to May 2016) 15-minute (May 2016 to November 2016) 5-minute (November 2016 to July 9, 2019)
Milton WWTP	July 31, 2004, to July 2 2019	5-minute
Plaikner	May 12, 2016, to June 13 2019	15-minute (May 2016 to August 2018) 5-minute (August 2018 to June 2019)
Scotch Block Rainfall	January 1, 1992, to January 31 2017	1-hour (January 1992 to July 2019) 5-minute (July 2019 to January 2017)
Scotch Block Reservoir	January 1, 1989, to July 9 2019	1-hour (January 1989 to July 1999) 5-minute (July 2016 to July 2019)
Union Gas Property	May 1, 2015, to July 2 2019	5-minute

4.3.5 FLOW DATA

When coupled with precipitation data, flow gauge data can be used to calibrate and validate hydrologic models. Flow data was available throughout the watershed at each of the three reservoirs (Kelso, Hilton Falls and Scotch Block), in addition to the Milton Flow Gauge. The Milton Flow gauge (water Survey of Canada Gauge Station – Sixteen Mile Creek at Milton – 02HB005) is located near Fulton Street and Pine Street. The flow gauge is located approximately 180m downstream of a confluence of two reaches of Sixteen Mile Creek (**Figure 4.5**).

FIGURE 4.5: 02HB005 FLOW GAUGE LOCATION

The western reach (Tributary W1) runoff is sourced from primarily rural and agricultural land-use within the upper portions of the watershed, along with a smaller, urbanized portion within the lower portion of this sub-watershed. An important feature of this reach is the presence of two (2) dams, referred to as the Kelso Reservoir and Hilton Falls Reservoir. It is important to note that operating conditions of the reservoirs are digitally available from 2008 onwards. Furthermore, flow records are only available for the discharge from the reservoirs, which has been back calculated based on the reservoir's water surface elevation and corresponding gate and valve settings. To determine flow rates into the reservoirs it was necessary to complete further back calculations based on rate of change in storage within the reservoir.

The eastern reach peak runoff (Tributary M1) is sourced from predominately urban drainage, including a largely residential area within the lower portion and a significant industrial area within the upper portion of this sub-watershed. The watershed also includes drainage from rural areas north of 5th Sideroad/Campbellvile Road. A review of aerial imagery via Google Earth dating back to 2004 suggests that the industrial portion of the watershed has experienced on-going development. This industrial portion is bounded by Highway 401 to the south, James Snow Parkway/5th side road to the north, James Snow Parkway to the east and Tremaine Road to the west. This industrial area is approximately 655 ha in size and is primarily impervious land-use.

4.4 SUBCATCHMENT DISCRETIZATION

Catchments were discretized using LiDAR digital elevation model (DEM) provided by CH. The LiDAR DEM is noted as a bare-earth model, or often referred to as a Digital Terrain Model (DTM). A DTM is a category of DEM where buildings and vegetation have been filtered, thus providing a "bare-earth" elevation model.

A stream-burn-in layer was created based on available LiDAR generated watercourse mappings provided by CH, as well as a review of aerial orthophotography. Airborne LiDAR does not typically penetrate through hydraulic structures or water; therefore, a stream-burn-in layer is applied to a DEM to modify the DEM in the z-coordinate only to ensure the DEM is hydrologically corrected to account for watercourses that convey flow through hydraulic structures. Provided below in **Figure 4.6** is a schematic outlining the stream burn-in concept. Without the use of a stream-burn in layer, catchments would be delineated differently in order to be conveyed around the subject watercourse crossing.

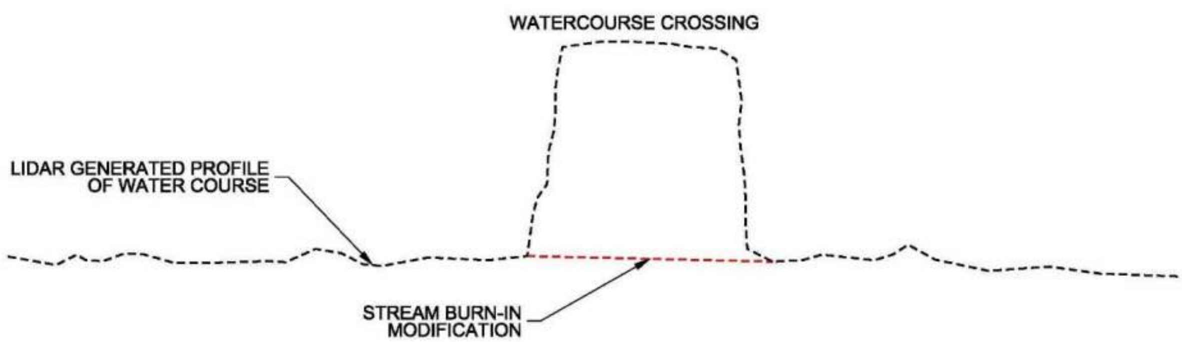


FIGURE 4.6: STREAM BURN-IN SCHEMATIC

Catchments were delineated using the Watershed Delineation Tool (WDT) in the PCSWMM software. This software, often used for sewer network analyses, has a friendly user interface tool specifically for hydrologic analyses. It should be noted that PCSWMM was only used to define the overall catchments, flow nodes, and layout of routing, and was not used in any hydrologic analyses. Flow nodes are automatically generated at points of confluence, or manually inserted points based on engineering judgment (i.e., at reservoirs, points of interest, etc.). A target catchment area of 25 ha was initially provided to deliver a higher resolution to minimize larger catchments with a variety of land cover. Smaller, adjacent subcatchments with similar land-use properties were combined to simplify the modelling and remove unnecessary flow nodes, with a goal to ensure regulatory flow values do not exceed a 10% flow difference between flow nodes.

A total of 161 subcatchments were delineated. From this total, 126 catchments were part of the West Branch of Sixteen Mile Creek watershed, and 35 were part of the Middle Branch of Sixteen Mile Creek watershed. Highlighted in Error! Reference source not found. are the individual subcatchments for both watersheds. A full-sized drawing (Arch D) of the overall catchment schematic is provided in **Appendix D**.

Subcatchments draining towards existing stormwater management facilities were reviewed any compared to historical drainage plans (where ponds were included in the hydrologic model). Overall, contributing drainage areas were relatively in conformance with one another. However, it should be recognized that discretization from older reports were not always maintained, due to more accurate delineation via available LiDAR information.

The level of catchment discretization was significantly greater than completed in previous hydrologic studies of the watershed. Different level of discretization influences the parameters which may be adjusted for suitable model calibration and validation.

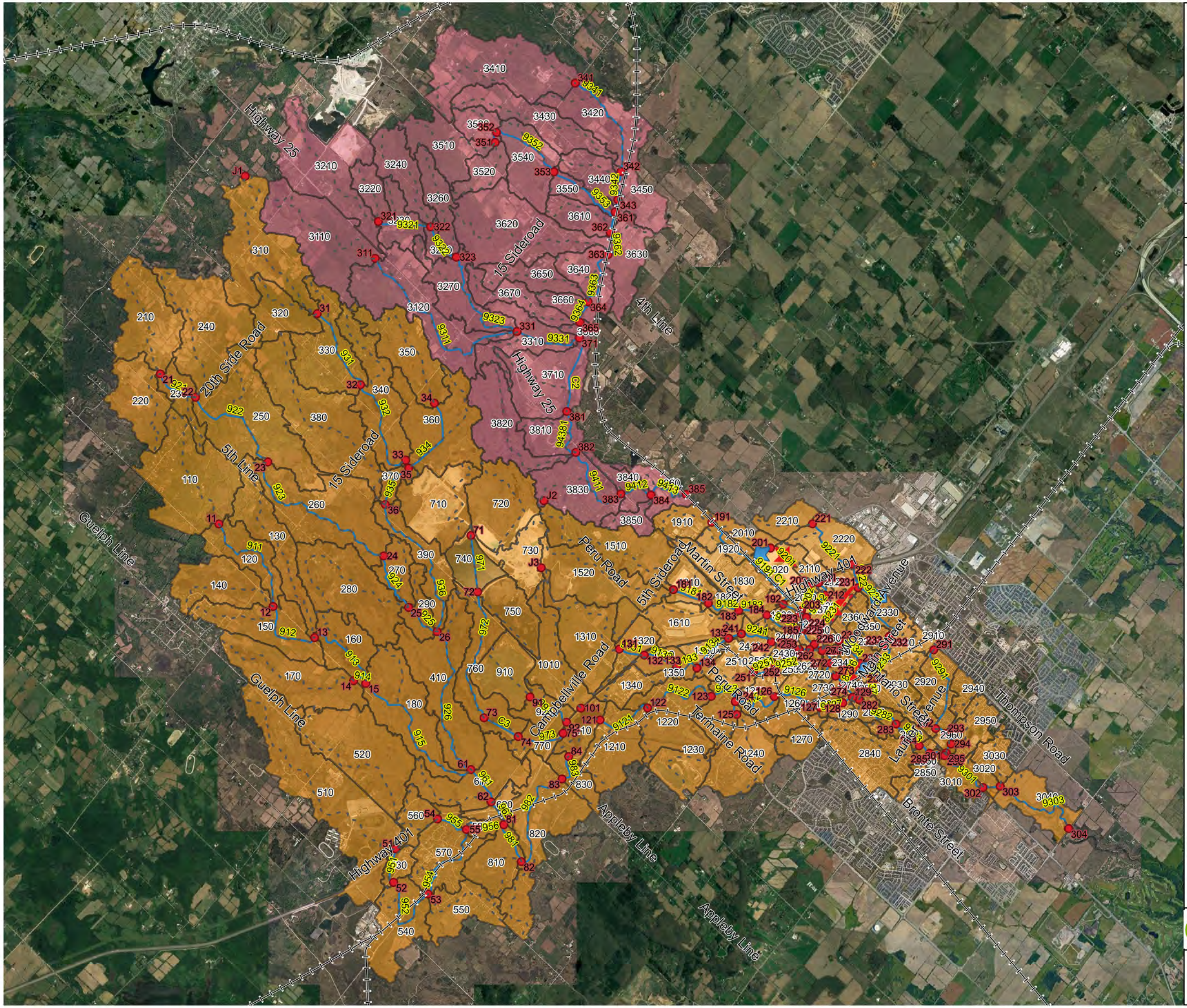
4.5 FLOW ROUTING ELEMENTS

Channel routing is an important feature in hydrologic modelling, as it accounts for the storage of flows within the channel and adjacent floodplain area. This storage results in the attenuation and subsequent lagging of peak flows between flow nodes. The number of flow routing elements required in a hydrologic model is a function of the level of catchment discretization.

Channel routing between flow nodes was delineated using the PCSWMM WDT tool, with slopes and lengths derived from the DEM via GIS software. Channel routing cross sections were determined by an overall average cross section, rather than selecting a single representative cross section. PCSWMM can determine an average cross section by cutting cross sections at a specific interval (e.g., every 100m) and combining all cross sections into a single cross-sectional profile. This average cross section accounts for geometric variability, as a single cut cross section may not be representative of the entire reach. The average cross section features a QA/QC feature integrated in PCSWMM that removes any outlier cross sections that may not be representative of the length of watercourse. It filters out sections based on a created rating curve, and any section with an outlying rating curve is ignored as part of the average cross section calculation. All routing cross sections were then reviewed and filtered based on engineering judgement.

Figure 4.7: Hydrlogic Routing

Flood Hazard Mapping - Urban Milton
Sixteen Mile Creek
Project No.19-609



0 2,000 4,000 m

NAD 1983 UTM Zone 17N

Legend

- Inter-Watershed Spill
- Railway Lines
- Flow Nodes
- West Branch
- Middle Branch
- RoutePipe
- RouteChannel

Greck

March 2020

Basemap Image Google Maps 2019 & Airborne Imaging, 2019

Catchments delineated via PCSWMM by Greck and Associates Limited, January 2020

The cross-sectional profile was used for each ChannelRoute command in the VO hydrologic model. For simplicity, all channel routes were applied with a Manning's n of 0.035 within the channel banks, 0.05 for grassed/agricultural or manicured overbank areas and 0.08 within treed/forested areas, unless there is a noticeably unique watercourse (i.e., engineered, concrete channel within the urban core). Applying a roughness of 0.08 typically accounts for the potential of vegetation growth within municipal channel blocks. In general, Manning roughness coefficients were chosen to be consistent with HEC-RAS modelling.

The cross-sectional profile was used for each ChannelRoute command in the VO hydrologic model. For simplicity, all channel routes were applied with a Manning's n of 0.035 within the channel banks, 0.05 for grassed/agricultural or manicured overbank areas and 0.08 within treed/forested areas, unless there is a noticeably unique watercourse (i.e., engineered, concrete channel within the urban core). Applying a roughness of 0.08 typically accounts for the potential of vegetation growth within municipal channel blocks. In general, Manning roughness coefficients were chosen to be consistent with HEC-RAS modelling. The cross-sectional profile was used for each ChannelRoute command in the VO hydrologic model. For simplicity, all channel routes were applied with a Manning's n of 0.035 within the channel banks, 0.05 for grassed/agricultural or manicured overbank areas and 0.08 within treed/forested areas, unless there is a noticeably unique watercourse (i.e., engineered, concrete channel within the urban core). Applying a roughness of 0.08 typically accounts for the potential of vegetation growth within municipal channel blocks. In general, Manning roughness coefficients were chosen to be consistent with HEC-RAS modelling.

Concrete channels, particularly those in the urban core of Milton, used a value of 0.015. While there are several grade-control structures in the channelized sections, a uniform grade was used as these structures are typically fully submerged during the critical Regional storm and/or the 100-year storm events (typically used to define the regulatory flood plain).

Flow diversions were modeled using the DuHYD command. Flow diversions were required at selected locations to represent significant major/minor systems. Minor systems were conveyed with the RoutePipe command, based on the capacity of the minimum pipe size and slope through that length of pipe. Flows exceeding the pipe capacity would therefore be diverted towards the major system.

Major overland flow paths were modelled using the ChannelRoute command where applicable. A flat bottom channel with a roughness of 0.015 was applied to represent the asphalt base, with overbanks at using a roughness of 0.05 to represent the sidewalk and boulevards.

4.5.1 BRIDGE / CULVERT ATTENUATION

Watercourse crossings, such as bridges and culverts can often provide significant storage that results in the attenuation and lag in peak flows during significant, infrequent rainfall events. During these larger storm events, earth fill embankments for roads and railways can be at their maximum capacity, resulting in a backwater effect and flood storage.

The effects of any attenuation of flows behind watercourse crossings were not considered for the purposes of this study. This approach is consistent with the Technical Guide - River and Stream Systems: Flooding Hazard Limit (MNRF, 2002). Typically, this attenuation of flows is not considered throughout southern Ontario for several reasons:

- Embankment or fill used to construct the watercourse crossing may not withstand all impacts from extreme storm events and have potential to washout.
- Potential for blockage due to debris etc.
- No guarantee that the watercourse crossings will remain in place. For example, a culvert may be replaced with a larger culvert in the future, as permitted under riparian law.

While it is standard practice to not include watercourse crossings for flood hazard purposes, incorporating these structures into a hydrologic model would have effects on calibrating a model. One typically will notice a more gradual falling limb and some attenuation of flows when comparing an observed hydrograph to a simulated hydrograph. This is an important feature in watershed hydrology that will be discussed further in **Section 4.10** to explain discrepancies between observed and simulated hydrographs.

4.6 STORMWATER MANAGEMENT PONDS / DAMS & RESERVOIRS / WETLANDS

SWMFs, dams/reservoirs and wetlands within the study area provide significant storage during some storm events. The study's approach to storage varies, in accordance with the Technical Guide for River and Stream Systems: Flooding Hazard Limit (MNRF, 2002) and standard practices.

4.6.1 STORMWATER MANAGEMENT FACILITIES

SWMFs can have a substantial effect on peak flow reduction for more frequent storm events, especially within intensively developed and highly impervious areas. The effect of SWMFs was noticed during attempts to calibrate the hydrologic model based on the WSC Gauge (02HB005).

The impact of SWMFs are sometimes included when developing hydrologic models for regulatory flood hazard mapping where there is confidence in the degree of routing expected under a regulatory storm and a low risk of failure based on current standards/guidance. Where these rigorous conditions cannot be met, the impacts of SWMF are excluded from the regulatory modeling.

Early in the study process, a desktop review of the number and location of SWMFs was completed to understand the potential for SWMFs to influence peak flows within the study area. The desktop assessment relied on aerial imagery, and through this review, Greck could not confirm whether SWMFs functions included quantity or flood control. This desktop review also could not identify some types of lot-level SWMF, such as underground storage chambers, roof top storage, parking lot storage, infiltration galleries, etc., which, with the exception of infiltration galleries, are common features in small industrial or commercial developments.

The desktop review estimated there are seventeen (17) SWM ponds within the study area. Eleven (11) of these facilities were noted to be upstream of the Milton Flow Gauge (02HB005).

Further research into SWMFs was undertaken by CH and Town of Milton staff and their Consultant, WSP (formerly Wood). It was determined that the flood control benefits of some 100-year SWMFs were included in the hydrologic modelling supporting the definition of the flood hazard in previous studies. None of these facilities, however, were purposely built to control the Regional Storm, as the supporting Subwatershed Studies, Subwatershed Impact Studies and/or Functional Servicing and Environmental Management Studies guiding development in this area did not establish Regional Storm control targets for SWMFs.

During an extreme event, the degree of routing and risk of failure of older SWMFs not designed specifically for Regional Storm controls is difficult to determine or predict and as such, this study has assumed the complete absence of all SWMFs under Regional Storm conditions.

In this study, select stormwater management facilities are included in the hydrologic modelling for the 100-year return period storm. A total of four (4) stormwater management facilities were included, as they met the following criteria:

- They Stormwater management facility is municipally owned, operated and maintained.
- There is sufficient background information readily available (i.e., pond rating curves, as-built drawings, reporting etc.).
- New information from this study did not indicate any new or additional risk of failure.

Appendix E documents the location of these ponds, the discharge-storage curves considered in the design event hydrology and the reference reports defining the rating curve information applied.

While this study has not modelled the effect of all stormwater management facilities within the watershed, the impact of excluding these facilities when defining the regulatory flood hazards is expected to be localized, as the Regional Storm is typically the regulatory storm within the mapped area and past studies did not identify the need for Regional Storm flood controls.

4.6.2 DAMS/RESERVOIRS

While the potential impacts of dams/reservoirs are acknowledged, it is standard practice to ignore the impacts of such structures when developing flood hazard limits, as per the Technical Guide - River and Stream Systems: Flooding Hazard Limit, MNRF, 2002, Section B.4.1.1. There can be substantial uncertainty in the function of these facilities during major storm events, such as Hurricane Hazel. During such an event, runoff volumes are substantial enough that the peak flow reduction of dams/reservoirs are often insignificant, and there can be no guarantee on the operating condition of each individual facility during the flood event. For these reasons, dams/reservoirs are not considered for peak flow determination as part of this flood hazard mapping study. Descriptions of Conservation Halton's dams/reservoirs within the study area are provided below.

Kelso Reservoir

The Kelso Reservoir is the largest reservoir within the area, as it receives drainage from approximate 7994 ha (67%) of the West Branch of the Sixteen Mile Creek watershed within the study area. Among the main roles of the Kelso Reservoir, it provides low flow augmentation essential to the assimilation of sewage treatment discharges in the lower reaches of the study area. The reservoir also provides some flood control and recreational values. Historically, the Kelso reservoir is maintained at a "summer" level for recreational purposes, and used for low flow augmentation into September, followed by a lowering of the reservoir in October to provide additional flood control during hurricane season and in anticipation of the spring freshet. The Kelso reservoir receives runoff from almost entirely agricultural/rural lands, with wetlands throughout.

The Kelso Reservoir features several outlet-control structures, including a valve, two gates and six stoplog sluiceways.

Limited historical operating characteristics were made available for the Kelso Reservoir, with hourly records from the year 2008 to 2013. The records include the hourly setting of each control structure, water levels, inflows and outflows.

Hilton Falls Reservoir

The Hilton Falls Reservoir is located upstream of the Kelso Reservoir, approximately 1 km northwest. The Hilton Falls Reservoir collects drainage from approximately 791 ha (7%) of the West Branch of Sixteen Mile Creek watershed. The Hilton Falls Reservoir primarily captures pumped discharges and gravity drainage from an upstream quarry, referred to as the Dufferin Quarry.

Hilton Falls Reservoir receives significant inflows from an adjacent diversion structure along a tributary of Sixteen Mile Creek. This diversion structure is located northwest of the Hilton Falls Reservoir, where spills from the adjacent branch drain towards Hilton Falls. This diversion structure consists of an adjacent weir, running parallel to “Beaver Dam Trail,” where upstream beaver dams are noted to obstruct the weir structure. It was observed that approximately 27%-47% of flows were diverted towards this branch based on two field investigations in the Fall of 2003 (Phillips, 2005).

In keeping with recommendations from past Dam Safety Studies, construction commenced in 2020/2021 to eliminate potential spill from the Sixteen Mile Creek Tributary. As such, a DuHYD command to represent potential split flow was not incorporated into the hydrologic modelling.

The quarry is to discharge towards the Hilton Falls Reservoir at a maximum rate of 700,000 m^3/day as agreed upon between CH and the Dufferin Quarry (Phillips, 2005).

Outflows from the Hilton Falls Reservoir are controlled by three valves, where the dam operates as a flood control structure from January to March. From March to April, the reservoir is filled with snowmelt and runoff, where the excess water is stored and released to maintain a minimum flow to assimilate the Milton Wastewater Treatment plant effluent.

Scotch Block Reservoir

The Scotch Block reservoir provides flood control from October until March, while providing low flow augmentation of Sixteen Mile Creek from April until October. Similar to the Hilton Falls Reservoir, the Scotch Block Reservoir collects snowmelt and runoff in the spring, where it provides low flows throughout the summer.

The Scotch Block Reservoir is located within the Middle Branch of the Sixteen Mile Creek watershed. Approximately 3,545 ha of drainage is conveyed through the Scotch Block reservoir (approximately 86% of the total contributing area to the CN Rail embankment, the identified point of inter-basin spill).

All dams within Conservation Halton’s jurisdiction are operated to provide flood control year-round; however, as each dam is operated to support multiple functions, the degree of flood control available during the summer months is limited when reservoirs are maintained at a higher elevation to support other uses including low flow augmentation/water quality and recreational uses.

4.6.3 WETLAND INFLUENCE AND IMPACT ON REGULATORY STORM EVENT

Wetlands provide valuable functions and support flood attenuation. Unlike dams and SWMFs, wetlands are typically explicitly incorporated into the hydrologic model where their size and position in the watershed results in potential for substantial peak flow reduction for a broad range of storm events, not only for smaller, frequent events. Even when wetlands are not directly represented in hydrology models, their hydrologic influence is often represented by way of parameter adjustments through model calibration and/or back-calibration of representative routing elements rather than explicit/quantified parameterization.

To determine whether wetland storage needed to be specifically represented through route-reservoir model routines within the mapped flood hazard models in this study, CH completed a high-level modelling exercise to develop an understanding of the potential impacts of wetlands within the headwaters of the West Branch of Sixteen Mile Creek in 2020. The supporting memorandum by CH is attached in Appendix I.

A 2D HEC-RAS model was created, with rainfall for the Regional Storm event distributed evenly across the watershed over a 2D grid, referred to as a rain-on-grid analysis. The 2D grid was prepared using the available LiDAR information. Potential storage volumes within the wetland areas therefore can be determined by depth of ponding within depressions via this LiDAR based grid. The intent of the model was to assess the depression storage potential, in relation to large storm events similar to the Regional event. The analysis included several assumptions that impact the flow and storage potential throughout the watershed:

- Rain-on-grid analysis does not incorporate any infiltration or initial abstraction and as such, would overestimate the runoff volume throughout the watershed.
- Storage potential is overestimated as this high-level model did not incorporate bridge/culvert crossings associated with roadways. The roadway crown would restrict flows until the roadway is overtopped, or ponding levels increase, and an alternate outlet is accessed. Ponded flows would not leave the system and as such, the rain-on-grid analysis would overestimate storage potential.
- No areal reduction factors were applied for the 2D rain-on-grid HEC-RAS analysis.

Therefore, storage potential of the wetlands in the 2D rain-on-grid HEC-RAS analysis would be conservative.

The resulting analysis concluded that 10,814,000 m^3 of rainfall occurred during the Hurricane Hazel 12-hour event, resulting in 8,402,000 m^3 of runoff. This equates to a total storage of 2,412,000 m^3, or a 47 mm rainfall event. This volume is equivalent to a 2-year 24-hour rainfall event (48 mm) as per Town IDF information from the Town of Milton Engineering and Parks Standards Manual, 2008 over the catchment area.

Considering the above noted assumptions, such as no infiltration, increase in storage due to roadways, and no areal reduction factors, it would be anticipated that the actual storage potential of the wetlands would be significantly lower. As such, it can be assumed that within the study area, the upstream wetlands would have little impact on peak flow reduction associated with the Regional Storm Event (Hurricane Hazel), which is the storm that predominately defines the regulated flood hazard within the study area.

Therefore, for the purposes of this study, wetlands have been represented in selecting catchment and channel routing parameters, but specific route reservoir commands have not been incorporated into the model to account for additional storage functions. This is supportable as:

- The Regional Storm represents the Regulatory Storm for mapped watercourses that have significant wetland coverage within their respective drainage catchments
- Only the last 12 hours of the Hurricane Hazel Storm are being modelled and it is expected that the initial 73 mm of rainfall would be sufficient to substantially fill the 47 mm of storage identified across the watershed by the rain on grid analysis.

4.7 CATCHMENT PARAMETERS

Prior to any calibration, catchment parameters were established to represent the hydrologic properties of each catchment throughout the watershed. Catchment parameters were established based on CH, Town of Milton and provincial standards, and professional judgement. These catchment parameters were then further refined as part of the calibration process. Catchment areas were automatically calculated using GIS software. All catchment input parameters are provided in detail in **Appendix E**.

4.7.1 NASHYD PARAMETERS

NasHYD is the name of the subroutine within the VO software which determines peak runoff in rural catchments. NasHYDs were applied to all catchments where the overall percent impervious was less than 20%. When using the NasHYD command, peak runoff can be determined based on the following catchment parameters.

4.7.1.1 CURVE NUMBER AND INITIAL ABSTRACTION

The Soil Conservation Service (SCS) Curve Number (CN) is used to determine runoff from rural catchments. The CN is an empirical parameter used to predict runoff and infiltration from rainfall excess. Curve numbers were established based on a combination of the land cover and surficial soils group for each catchment. Rainfall excess is the rainfall depth available after accounting for the Initial Abstraction.

An area weighted calculated CN was determined for all catchments within the study area based on Antecedent Moisture Conditions (AMC). AMC I conditions represent a dry soil, AMC II represent average moisture conditions, while AMC III represent wet moisture conditions. For all calibration simulations, only AMC II and/or AMC III conditions were considered.

CN was calculated under AMC II and AMC III conditions. AMC III conditions were applied for the simulation of Hurricane Hazel only, to account for the saturated soil conditions that occurred during this historical rainfall event. All other design storm events applied AMC II conditions.

For Ontario, it is standard procedure to apply the modified Curve Number Method, also referred to as CN*. The CN* method was developed based on research and monitoring of rural and urban catchments in Canada. The CN* method is an accepted method for approximating infiltration, however various other infiltration methods are accepted by Conservation Halton, such as Horton, Green-Ampt etc. For the CN* conversion, a rainfall volume of 122.4mm was used, based on the 100-year rainfall volume. IA* values were derived based on the following, as per the VO manual:

- CN<=70: IA* = 0.075 S
- 70 < CN <=80 IA* = 0.1S
- 80 < CN <= 90 IA* = 0.15S
- 90> CN: IA* = 0.2S

Initial Abstraction is a parameter that accounts for all losses prior to runoff and consists of mainly interception, infiltration, evaporation and surface depression storage. Initial abstractions for CN* conversions were based on an area weighted calculation based on land-use, using industry standard and CH standard parameters based on land-use.

4.7.1.2 TIME OF CONCENTRATION AND TIME TO PEAK

The VO software requires a value for the flow time to peak. The time to peak was derived from the flow time of concentration. Time of concentration is the time required for runoff to travel from the most hydraulically distant point in a watershed (or catchment) to its outlet. This refers to the point with the longest travel time, not necessarily longest travel length.

Time of concentration can often be broken down into three types:

1. **Overland flow** (sheet flow) is the shallow mass of runoff with a uniform depth across a sloping surface, typically occurring within the headwaters of a catchment over short distances (maximum of 130m). Flow depths typically reach a maximum of 20-30mm for overland sheet flow.
2. **Shallow concentrated flow** occurs following overland flow, at depths between 40-100mm where runoff accumulates in rills and/or gullies
3. **Channelized Flow** occurs when flow accumulates significantly, forming larger/deeper flow depths of a typical open channel (such as a ditch or watercourse).

Due to the limited amount of input parameters associated with the NASHYD command in Visual OTTYHMO, peak runoff is very sensitive to this parameter and as such, the hydrologic modeler must determine an appropriate time of concentration by factoring land cover/surface roughness, watershed slope, rainfall intensity, watershed length and shape.

Several methods for computing the time of concentration of a watershed have been developed and can often produce significantly different results. Typically, in Ontario, the two primary methods are described as the Airport Method and the Bransby-Williams method. As per Ministry of Transportation (MTO) guidelines, the Airport Method is to be used for watersheds with a runoff coefficient less than 0.4, and Bransby Williams Equation elsewhere. A summary of the two formulas is provided below:

Bransby William Equation

$$T_c = \frac{0.057\,L}{{S_w}^{0.2} A^{0.1}}$$

Airport Equation

$$T_c = \frac{3.26\,(1.1 - C) L^{0.5}}{{S_w}^{0.33}}$$

Where:

- L = catchment length (m)
- S_w = catchment slope (%)
- A = catchment area (ha)
- C = runoff coefficient

The above two methods are generally more applicable to smaller catchments with a uniform cover. Both of the above methods however do not adequately account for the type of land cover throughout the watershed. While the Airport method does account for land cover via a runoff coefficient, the runoff coefficient is predominantly used as a simplification to define the runoff volumes, rather than flow velocities and surface roughness.

Surface roughness is a significant factor in establishing a time of concentration, as urban areas typically provide less retardance of flow due to smoother more consistent drainage paths associated with streets, sewers etc. in comparison to an undeveloped agricultural or wooded area. For example, when applying the Bransby Williams equation (for a watershed with a runoff coefficient greater than 0.4), there would be no difference between the time of concertation of a paved catchment compared (C = 0.95) and a wooded clayey catchment (C = 0.45). The above Airport and Bransby Williams methods also do not account for the three varying types of overland flow (overland, shallow concentrated and channelized).

As such, Greck has computed the time of concertation of each catchment using the Shallow Concentrated Flow formula as outlined below:

Shallow Concentrated Flow

$$V = k\, S_w^{0.5} \qquad\qquad T_c = \frac{L}{60\,V}$$

Where:

- V = velocity (m/s)
- k = Intercept coefficient
- L = catchment length (m)
- S_w = catchment slope (%)

K is defined based on land cover as follows:

Land Cover	K
Forest with heavy ground litter; hay meadow	0.076
Trash fallow or minimum tillage cultivation; contour or strip cropped; woodland	0.152
Short grass pasture	0.213
Cultivated straight row	0.274
Nearly bare and untilled; alluvial fans in western regions	0.305
Grassed waterway	0.457
Unpaved	0.491
Paved	0.619

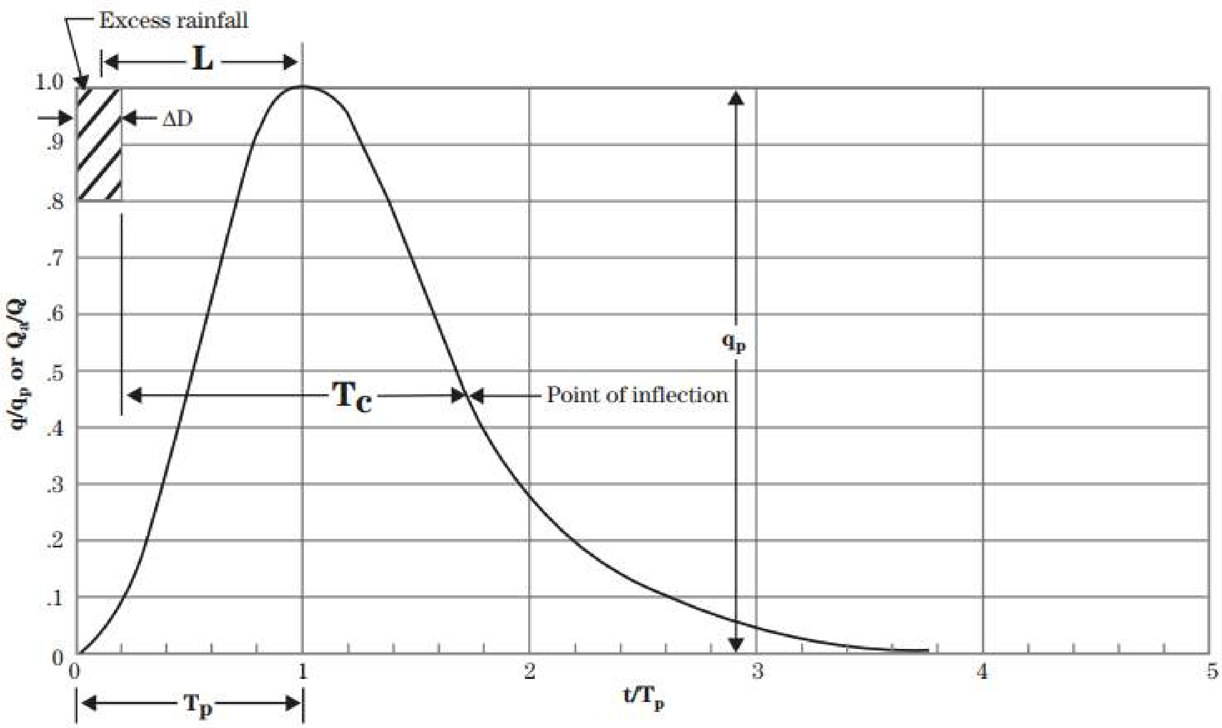
Source: City of Pickering Stormwater Management Guidelines, July 2019
United States Department of Agricultural: Part 630 Hydrology – Natural Engineering Handbook Chapter 15: Time of Concentration, May 2010

As seen from the above table, the intercept coefficient accounts for the slower runoff velocity through a forested area in comparison to a paved or grassed land-use.

Greck applied an area-weighted methodology to determine an overall intercept coefficient for each catchment using provided land-use information from Conservation Halton. The upland, small, overland flow portion (<130m) is considered insignificant at a watershed scale, where catchment lengths range from 500m to 5,400m. Channelized flow was not considered for simplification purposes – as quantifying channelized time of concentration is an iterative process that requires establishing bankfull cross-sectional areas of the channelized portion. The bankfull cross-sectional area can vary significantly throughout the watershed and as such, only shallow concentrated flow was applied. Any lag or attenuation of flows between catchments was modelled separately with the channel flow routing command.

Generally, shallow concentrated flow methodology resulted in larger time of concentration values in comparison to the traditional Airport or Bransby Williams equations. This will result in lower peak flows from these traditionally used equations.

While the time of concentration is the time for water to travel through the watershed, the time to peak represents time of peak flow through the watershed. A graphical representation of the time to peak and time of concentration is provided below in **Figure 4.8**. Time to peak was calculated based on 2/3 of the time of concentration, as standard procedure within Ontario. While time of concentration calculations were completed for all catchments, the parameter is only utilized in rural / undeveloped lands within the NasHYD command.



where:

- L = Lag, h
- T_c = time of concentration, h
- T_p = time to peak, h
- ΔD = duration of excess rainfall, h
- t/T_p = dimensionless ratio of any time to time to peak
- q = discharge rate at time t, ft^3/s
- q_p = peak discharge rate at time T_p, ft^3/s
- Q_a = runoff volume up to t, in
- Q = total runoff volume, in

FIGURE 4.8: TIME OF CONCENTRATION & TIME TO PEAK UNIT HYDROGRAPH METHOD (USDA NRCS, 2010)

4.7.2 STANDHYD PARAMETERS

The Standard hydrograph or StandHYD command was applied for urban areas with pervious and impervious contributions. When using the StandHYD command, pervious and impervious runoff are calculated separately, then combined for a total peak runoff.

Total impervious area (TIMP) represents total percent of imperviousness of each catchment. TIMP was calculated using an area weighted function based on standard CH and Town of Milton parameters for various land-uses.

Total directly connected impervious (XIMP) area represents a percentage of impervious surfaces directly connected to a storm sewer system. XIMP is calculated using an area weighted function based on standard CH and Town of Milton parameters based on land-uses.

Infiltration losses within the pervious areas applied the SCS Infiltration losses to be consistent with the NasHYD infiltration methodology. Within StandHYDs, pervious infiltration losses were determined based on a grassed surface land cover and calculated using an area weighted function based on the surficial soil types.

Pervious flow lengths were visually determined for each catchment via aerial orthophotography. A pervious length of 40m was applied in catchments where residential land-use was predominant, as it generally represents the lot length from the rear property to the curb line. A pervious flow length of 20m was applied in any commercial/industrial catchments, as this incorporates typical 40m catchbasin spacing that would be applied within these areas.

For the purposes of this study, the hydrologic model default impervious flow length was used. This method was considered reasonable given the size of the subcatchment areas and purposes of the hydrologic analyses. The size of the areas often included a combination of open and various types of impervious surfaces. More detailed estimates of the impervious length are typically necessary when examining urban watersheds in greater detail, particularly for local stormwater management purposes.

The default method estimates the overland travel length for impervious area as a function of the total subcatchment drainage area and not just the portion of impervious area. As such this method does not take into consideration the level of imperviousness within a subcatchment. In other words, two urban subcatchments of equal size but at different level of imperviousness will have the same travel length for impervious flow. This may result in an over or under estimation of the runoff length for a given subcatchment area.

To better define the impervious length for this study would require further discretization of the subcatchment areas to better isolate the more concentrated and uniform areas of imperviousness. This would add unnecessary complexity to the model, as the influence of impervious length is not anticipated to have hydrologic significance for the purposes of flood hazard mapping.

The remaining parameters associated with the STANDHYD command were set to default or standard parameters. These parameters include:

- Impervious length (derived in VO),
- Pervious Manning roughness of 0.25,

- Impervious Manning roughness of 0.015,
- Pervious Slope (2%),
- Impervious Slope (1%),
- Impervious Depression storage (2mm),
- Pervious area storage coefficient (0 hours), and
- Impervious area storage coefficient (0 hours).

4.8 STORM EVENTS

Provincial Guidelines, such as the Technical Guide - River and Stream Systems: Flooding Hazard Limit (MNRF, 2002) have defined Regulatory Flood Hazard as the greater of the areas inundated by water from a rainfall experienced event or by the 100-year (1% annual probability of occurrence) flow event. In Ontario Hurricane Hazel is a regionally experienced storm event which generally produces flows in excess of the 100-year flood. The 100-year flood can be determined based on long term flow records (flood frequency analyses) or modelled based on what would occur from a rainfall event which has a 100-year or 1% annual probability of occurring.

The lower return period storm events (2-year through 50-year storm events) were modelled but are not explicitly reported on in this study, as the purpose of this assessment is for flood hazard delineation only. Both the hydrologic and hydraulic modelling were prepared with a focus on large storm events (100-year and Regional) and are expected to represent lower return frequency events (i.e. 2-year through 50-year) with less accuracy. Presented below is information for the Regional, and 100-year design storm events.

4.8.1 REGIONAL

Within Conservation Halton's jurisdiction, the Regional Storm is defined as the Hurricane Hazel storm event. Hurricane Hazel was a historical event that occurred in October 1954 and resulted in significant property damage and loss of life throughout southern Ontario.

Hurricane Hazel was a tropical storm that resulted in significant rainfall within southern Ontario. Prior to Hurricane Hazel, the Greater Toronto Area received above average rainfall for 36 hours, where approximately 73 mm of rainfall occurred. Hurricane Hazel resulted in an additional 212 mm of rainfall within 12 hours, for a total rainfall depth of 285 mm over the span of 48 hours.

Provincial guidance documents mandate simulation of anticipated flooding levels associated with the Hurricane Hazel storm be applied at any location within southern Ontario.

4.8.2 DESIGN STORM EVENTS

Design storms are described by their volume, duration and temporal distribution. The volume and duration are typically obtained from statistical records of rainfall intensities for various durations. This information is presented in the form of an Intensity Duration Frequency (IDF) chart. The temporal distribution can vary by region and theoretical distribution. In Ontario, a few distributions such as the SCS, Chicago and AES are commonly used.

For this study the Chicago 24-hour storm distributions were applied for the 100-year storm event. The Chicago 24-hour storm is the standard storm distribution applied for SWM design within the Town of Milton and as such, was considered for all 100-year floodline mapping.

The design storms were generated from the Town of Milton engineering standards Intensity Duration Frequency (IDF) parameters as outlined below in **Table 4.5**. All IDF parameters were derived based on the Toronto Pearson International Airport weather station.

The rainfall hyetographs for Chicago design storms are provided in **Appendix E**.

TABLE 4.5: TOWN OF MILTON IDF PARAMETERS (TOWN OF MILTON, 2019)

Storm Event	A	B	C	12-Hour Rainfall Volume (mm)	24-Hour Rainfall Volume (mm)
2-year	779	6.0	0.8206	42.0	48.0
5-year	959	5.7	0.8024	58.8	67.2
10-year	1089	5.7	0.7955	70.8	79.2
25-year	1234	5.5	0.7863	85.2	96.0
50-year	1323	5.3	0.7786	94.8	110.4
100-year	1435	5.2	0.7721	105.6	122.4

4.8.3 AREAL REDUCTION FACTORS

In large watersheds, the rainfall intensity for a given event is typically not uniform across the entire watershed. To account for this spatial variability, areal reduction factors are applied.

The total area of the West Branch and Middle Branch of Sixteen Mile Creek is approximately 15,922 ha, or 159 km^2 (through the study area only). As per the Technical Guide – River and Stream Systems: Flooding Hazard Limit (MNRF, 2002), for flow points with a contributing area greater than 25 km^2, an areal adjustment factor should be applied to the Regional Storm depth based on the equivalent circular area method. This is completed by calculating the area of a circle based on the longest flow path of the watershed.

Within the hydrologic model, a variety of Hurricane Hazel storm events were simulated based on the area reduction factors mandated in O.Reg 162/06 (which are also included in MTO and MNRF Manuals and Guidelines). The appropriate version of Hurricane Hazel was be applied throughout the watershed based on a subcatchment's upstream equivalent circular area. Area reduction factors are typically not applied within the headwaters of the watersheds due to their lack of total area but will be applied as the total contributing area increases downstream.

For the 100-year return period, an areal reduction factor was applied based on the WMO curve as per the Technical Guide – River and Stream Systems: Flooding Hazard Limit (MNRF, 2002), which is also a function of the contributing watershed.

A note has been included within each flow node within the hydrologic model to indicate the applicable reduction factor applied. All areal reduction factors for the 100-year and Hurricane Hazel rainfall are provided in **Appendix E**.

Typically, small highly impervious urban areas will produce peak flows which exceed the peak flow from the Regional storm event. This is largely attributed to the sensitivity of the runoff surface to high intensity short durations rainfall events characterized by the design storm.

4.9 FLOOD FREQUENCY ANALYSIS

For comparison purposes a Flood Frequency Analysis (FFA) was performed with available flow records. A FFA was completed based on a Gumbel Distribution, **Figure** 4.9. The analyses were completed using a Microsoft Excel spreadsheet.

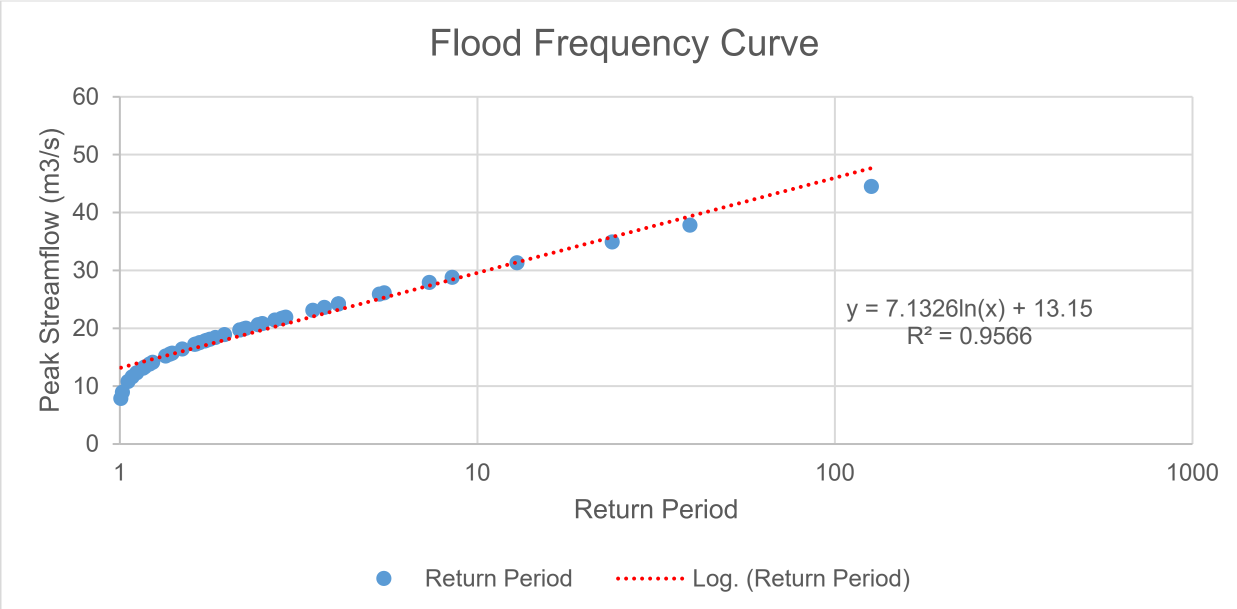


FIGURE 4.9: FLOOD FREQUENCY CURVE – FLOW GAUGE 02HB005

The FFA incorporated annual peak flow data from the 02HB005 Flow Gauge, where records are available from 1957 to 2019. The Kelso Reservoir and Hilton Falls reservoir were constructed in 1962 and 1966, respectively. As such, only records from 1967 through 2019 were considered.

It should be noted that peak annual flow data were not available for

- 2002, 2004, 2005, 2006, 2007, 2009, 2010, 2011, 2013, 2014

Applying a logarithmic best-fit curve, the following peak flows were estimated for each frequency flow, **Table 4.6**. Further details of the flood frequency analysis are provided in **Appendix G**.

TABLE 4.6: FLOOD FREQUENCY RESULTS AT WSC FLOW GAUGE HB02005

Return Period	FFA Peak Flow (m^3/s)
2-year	18.1
5-year	24.6
10-year	29.6
25-year	36.1
50-year	41.1
100-year	46.0

The FFA describes the return frequency from actual flow records. Event based deterministic modelling methods rely on the statistical analyses of rainfall records to define a return period hyetograph, which is then applied to generate a return period flow. Return frequency flows from FFA are typically lower than return period flows produced through deterministic modelling methods. A key reason for this is, deterministic models assume the return period rainfall event occurs with a uniform distribution over the entire watershed, subwatershed or subcatchment area. This is in contrast to stochastic or FFA methods which represent the actual spatial variability of a rainfall event which has occurred over the watershed, subwatershed or subcatchment area.

The FFA is also expected to produce lower flows in comparison to deterministic modelling due to the presence of anthropogenic storage (such as the Hilton Falls and Kelso Reservoirs, storage behind crossing embankments, and select SWMF features). These factors were not accounted for within the hydrologic modelling for the reasons outlined in Section 4.6. Due to the differences described above, deterministic models using synthetic storms distributions typically generate greater flows than those derived from the FFA methodology, even where long-term flow data (monitored or simulated) is available.

Furthermore, statistical analyses of flows may be influenced by significant changes in land-use, modern technology allowing for an increased frequency of data collection which may better capture instantaneous peaks, rating curve improvements over time (recognizing the challenge associated with capturing high flow data) and other factors.

4.10 MODEL CALIBRATION

The flow gauge, referred to as 02HB005 by Water Survey Canada (WSC), is located near Fulton Street and Pine Street. Calibration was first attempted at this flow gauge due to the large period of record, the significant portion of study area captured and the accuracy of available flow information. This contrasts with the reservoir inflow and outflow records for Kelso, Scotch Block and Hilton Falls where the periods of record are more limited, data has been archived using different timesteps, and inflow and outflow rates are back-calculated based on change in reservoir WSEL, resulting in greater potential for reduced precision and accuracy in quoted flows.

4.10.1 LIMITATIONS OF MODEL CALIBRATION

The Sixteen Mile Creek features many complexities that influence the ability to create a fully calibrated hydrological model. Some influencing factors include the presences of large areas of wetlands within the upper limits of the watershed which would have very different hydrologic responses at different times of the year for storm events of different scales, variable split flows from the Sixteen Mile Creek towards Hilton Falls, active operation of gates and valves at each of the reservoirs in advance of and in response to rainfall, unknown SWMF characteristics and changing land-use over time.

With respect to dam operations, Conservation Halton's dam operations are guided by dam rule curves but may be determined on a case-by-case basis by trained Flood Duty Officers. While this allows flexibility to respond to naturally varying flow, this may result in application of multiple unique control conditions over the period covering the watershed response to a specific storm event. These operating procedures add complexity to the model calibration and validation process.

As previously mentioned, significant industrial development over the past 30 years has occurred north of Highway 401 within the Town of Milton. Provided in **Figure 4.10** is an aerial image of the land cover dating back to 2004.

In 2008, the industrial area was undergoing development. Several SWMF were built and/or modified to provide flood control due to intensification (See **Figure 4.11**, received from Google Earth and dated August 14, 2009).

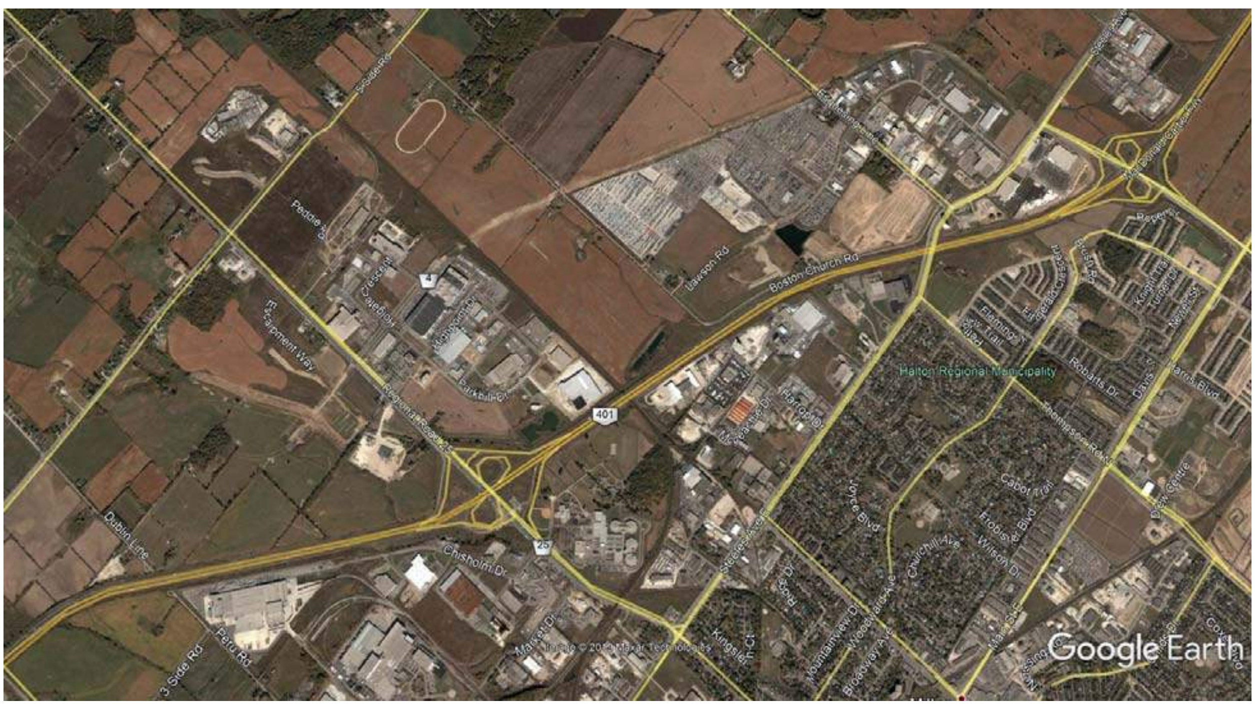


FIGURE 4.10: HISTORICAL COVER THROUGH INDUSTRIAL AREA (NOVEMBER 6, 2004)

FIGURE 4.11: APPROXIMATE LAND-USE DURING AUGUST 5, 2008, EVENT (AUGUST 14, 2009)

Further development occurred within the industrial area as identified through comparison to the 2011 conditions Figure 4.12**.** Of particular interest, an industrial building was constructed west of the intersection of Lawson Road and Boston Church Road (highlighted in yellow). Historically, a drainage feature intersected this property, however development has resulted in upstream drainage being conveyed through a ditch inlet catchbasin immediately south of James Snow Parkway, where it is diverted through a series of concrete pipes and box culverts through Boston Church Road, to a SWMF located just north of Highway 401.

FIGURE 4.12: APPROXIMATE LAND-USE DURING MAY 18-19, 2011, EVENT (AUGUST 25, 2012)

In 2013, the industrial area was still undergoing development, but featuring several SWMF to provide flood control (See **Figure 4.13**, received from Google Earth and dated September 4, 2013).

Calibration was first attempted at the WSC Milton Gauge, as measured flows would seemingly be more representative of the overall watershed. However, active operation of the upstream reservoirs in response to larger precipitation events and changes in land-use over the recent years limits the ability to calibrate the hydrologic response at the Milton WSC Gauge.

As such, the Milton WSC Gauge has only been applied as a validation gauge relative to runoff volume for recent events only, to reflect “existing conditions” as much as possible. It is understood that calibrating to peak flow rates is not feasible due to the presence of reservoirs, SWMFs, etc., and the focus of validation will be on total volumes only.

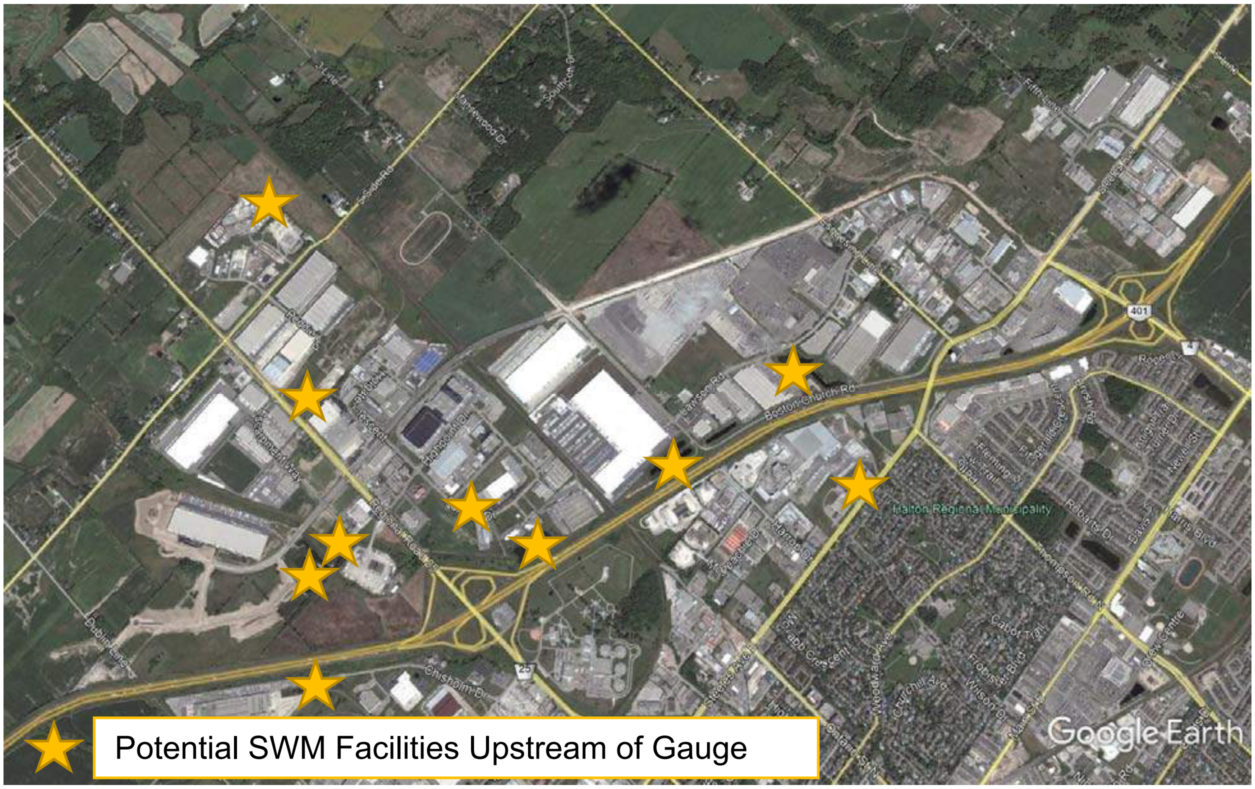


FIGURE 4.13: APPROXIMATE LAND-USE (SEPTEMBER 4, 2013)

An attempt to calibrate the hydrologic model was then made using the Kelso Reservoir flow data, however, calibrating Kelso Reservoir inflows was not deemed practical due to high degrees of oscillation in water levels noted at the flow gauge, coupled with the influence of the upstream Hilton Falls Reservoir and recognized potential for variation in the proportion of inter-basin spill from Sixteen Mile Creek towards Hilton Falls reservoir, along with variation in wetland response. For example, the proportion of inter-basin spill was impacted by the presence of beaver dams, while the filling, spilling and release of flows between wetland features may vary seasonally due to groundwater level fluctuations or as a result of inter-event times and could bring about variability in downstream flow rates. The location of this diversion structure is indicated below in **Figure 4.14.**

As part of the 2007 Hilton Falls Dam Safety Review, concern was expressed over the potential for diverted flows over and above flows controlled through the inlet gate structure to overwhelm the dam, and in 2020 and 2021 construction was advanced to eliminate uncontrolled spill flows for all events up to and including the Probable Maximum Flood. Therefore, it was not necessary to consider the potential impact of this spill as part of this study.

FIGURE 4.14: SIXTEEN MILE CREEK / HILTON FALLS SPILL DIVERSION

The Hilton Falls Reservoir is also greatly influenced by pumped discharge rates from the adjacent quarries, which would further skew the inflow hydrographs through the Hilton Falls Reservoir and immediately downstream of the Kelso Reservoir. It was noted that the observed hydrologic response differed greatly from the modeled, simulated hydrologic response. The quarrying within these subcatchments likely resulted in a delayed and highly dampened response, which would be characteristic of pumping runoff out of the quarry pits.

Due to the circumstances listed above, Greck has elected to conduct a sensitivity analyses performed on hydrologic parameters (**Section 4.14**) and calibration/validation based on information available for the Scotch Block Reservoir. Best efforts were made to calibrate the model, with a focus on the rural areas within the headwaters of the watershed relative to significant rainfall events as runoff from the rural area is the most significant factor influencing regulatory peak flood flows for a major portion of the study area.

4.10.2 DAM OPERATING CHARACTERISTICS

At each of the Hilton Falls, Scotch Block and Kelso Reservoirs, peak inflows at dams/reservoirs are calculated based on the recorded reservoir water surface elevation, as such, slight changes in water surface elevation can greatly affect calculated inflow and outflows. Slight changes could be due to wind/wave effects, loss of steady state conditions during operation, jarring of equipment, recording near or beyond limit of instrument tolerances, etc.

Reservoir outflows are calculated based on rating curves associated with each unique control condition, and inflows are back calculated based on a combination of outflows and any identified changes in reservoir storage.

There are challenges in modelling reservoir operations over the course of a particular event, as the dams are all operated in accordance with the standard rule curve, which results in the need to perform multiple operations over the course of larger storm events. This is exacerbated at Kelso Reservoir given the need to model operations through the event at both the Kelso Reservoir and the Hilton Falls Reservoir.

4.10.3 SELECTION OF CALIBRATION AND VALIDATION STORMS

A variety of storm events were reviewed for calibration purposes. Storm events were initially selected based on their peak flow at the 02HB005 flow gauge. Storm events that generate higher peak flows are preferred to calibrate to, as they can be more representative of a significant storm event such as Hurricane Hazel or a 100-year event.

More recent rain events were preferred, primarily due to the availability of precipitation data with smaller intervals. Five (5)-minute rainfall data is available from 2004 onwards and therefore storm events since 2004 were preferred.

Initially, several storm events were considered and selected to calibrate the hydrological model. However, a more applicable storm event occurred on January 10, 2020. The January 10, 2020, event occurred over a very long period under presumably saturated and frozen ground conditions. Prior to this storm event, little to no snow cover was present within the catchment, and the cold January temperatures would cause the soils to exhibit more of an AMC III condition, more similar to conditions which could occur during a Regional storm event. This storm event was a longer duration event with low rainfall intensities, also similar to the Hurricane Hazel type of event. For these reasons, this event was considered as the primary storm event for calibration purposes.

A secondary event, occurred on May 18, 2011, exhibiting an AMC II condition. This event was applied as a secondary calibration/validation storm event. This event is more representative of existing land-use conditions as opposed to earlier events, as the watershed has undergone significant intensification, especially within newly developed industrial areas.

A summary of these two calibration/validation storm events is provided in **Table 4.7**.

TABLE 4.7: CALIBRATION/VALIDATION STORM EVENT SUMMARY

Year	Assumed AMC Condition	Rainfall Depth (mm)	Storm Duration (hours)
January 10th, 2020	AMC iii	75	54
May 18th, 2011	AMC ii	33.8	8

The importance of these events can be illustrated in **Figure 4.15** which plots both observed flows and rainfall distributions for the January 10, 2020, and the May 11, 2011, events. In this figure the lower intensity event in January produced peak flows which exceed the peak flow for a much greater intensity rainfall event. This suggests that the importance of calibrating to events where the losses due to infiltration are less significant.

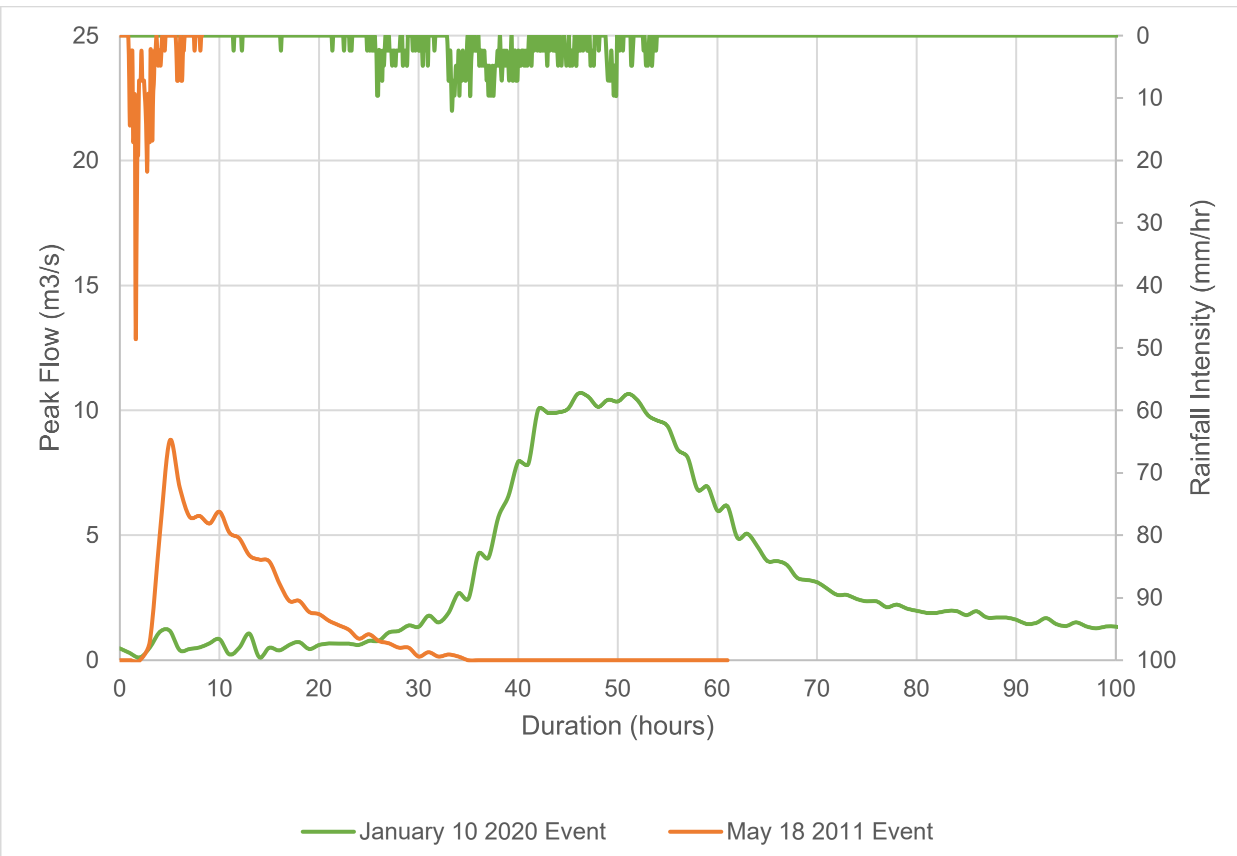


FIGURE 4.15: RAINFALL INTENSITY EFFECTS (SCOTCH BLOCK RESERVOIR)

4.10.4 HYDROLOGICAL MODEL CALIBRATION

As outlined above, the January 10, 2020, storm event is the primary storm event to be applied for calibration purposes. Due to complexities of wetland features, multiple reservoirs operating at unknown conditions, rainfall variability, Antecedent Soil Moisture Conditions (AMC) within rural areas, and interbasin spill from Sixteen Mile Creek to Hilton Falls Reservoir, calibrating the hydrologic model was completed using inflow data at the Scotch Block Reservoir as opposed to the Milton Flow Gauge. Details on the wetland features and rainfall variability are provided in **Appendix I**.

The initial modelled and observed hydrograph at the Scotch Block reservoir is provided below in **Figure 4.16**. This scenario assumed AMC III conditions. All precipitation data is from the Scotch Block reservoir rainfall gauge.

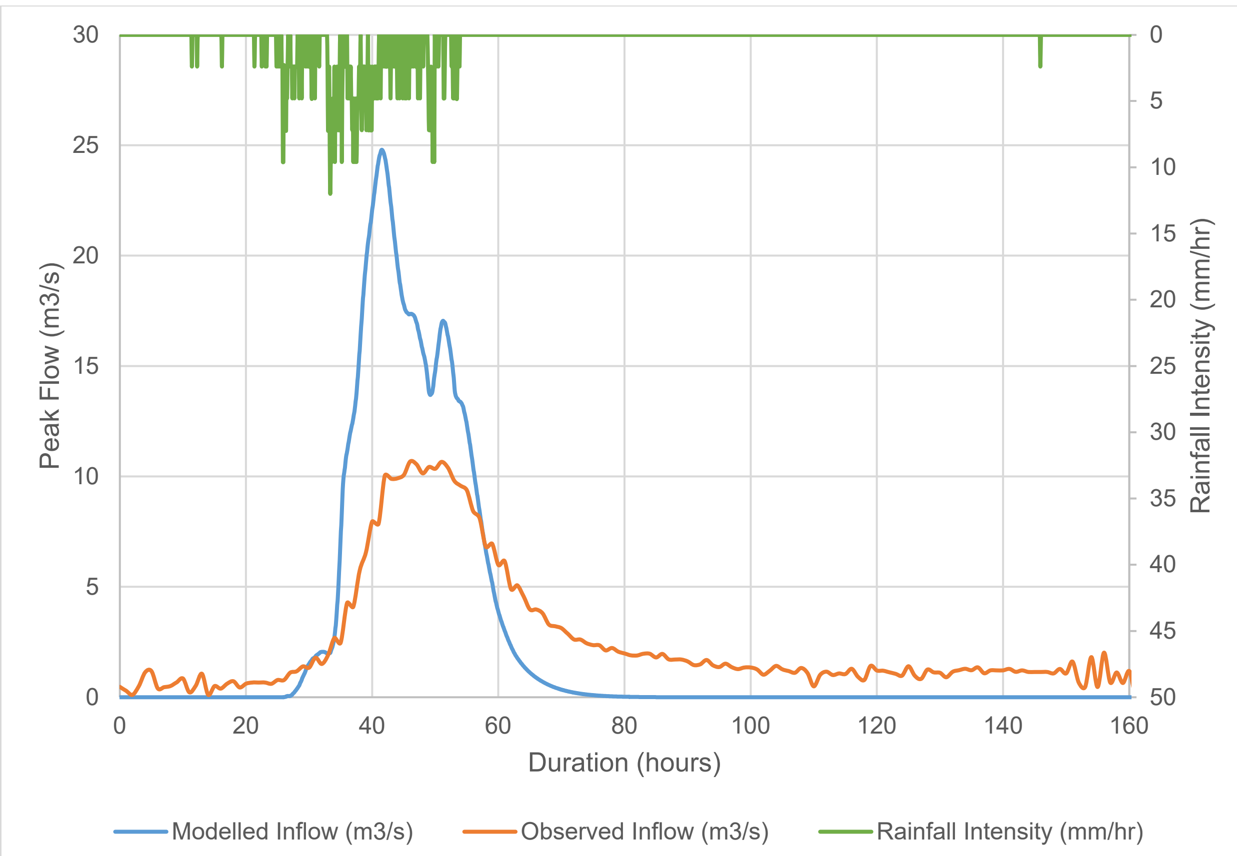


FIGURE 4.16: JANUARY 10, 2020, SCOTCH BLOCK HYDROGRAPH (NON-CALIBRATED)

A summary of the observed peak flows and volumes are provided below in **Table 4.8.**

TABLE 4.8: JANUARY 10, 2020, SCOTCH BLOCK – SUMMARY (NON-CALIBRATED)

Year	Peak Flow (m^3/s)	Volume (m^3)
Observed	10.67	1,500,852
Modelled	24.8	1,471,761
% Difference	+132%	-2%

From the above table, it can be determined that the AMC III assumption is likely valid, as overall volumes were nearly equivalent. However, there is a significant difference in the overall peak flow noted at Scotch Block reservoir. This difference is largely attributed to the presence of wetland features located upstream of the Scotch Block Reservoir, which may be anticipated to have more than typical attenuation capabilities available during this event, given typical seasonal groundwater fluctuations and few precipitation events resulting in surface runoff. Wetland impacts are expected to have a larger impact on the low volume January event, as opposed to the Hurricane Hazel storm event which resulted in 285mm vs the 75mm from the January 2020 event.

To properly calibrate the hydrologic model, the wetlands require detailed assessments and the creation of stage-storage-discharge relationships of each wetland. Such a detailed assessment is outside of the scope of this study. As discussed in Section 4.6.4, the majority of wetland features within the study are expected to be fully inundated during a significant storm event such as Hurricane Hazel, however, may have even further attenuating abilities due to flat wetlands upstream of a road crossing. Therefore, a detailed wetland assessment is not necessary as part of this flood hazard mapping study.

However, it is noted that these wetland features can be accounted for within the NasHYD command by varying the Number of Linear Reservoirs parameter. In efforts to fit a modeled hydrograph to the observed flow, a range of linear reservoir values was examined. The best fit was found with the number of linear reservoirs reduced to 1.15, see **Figure 4.17**.

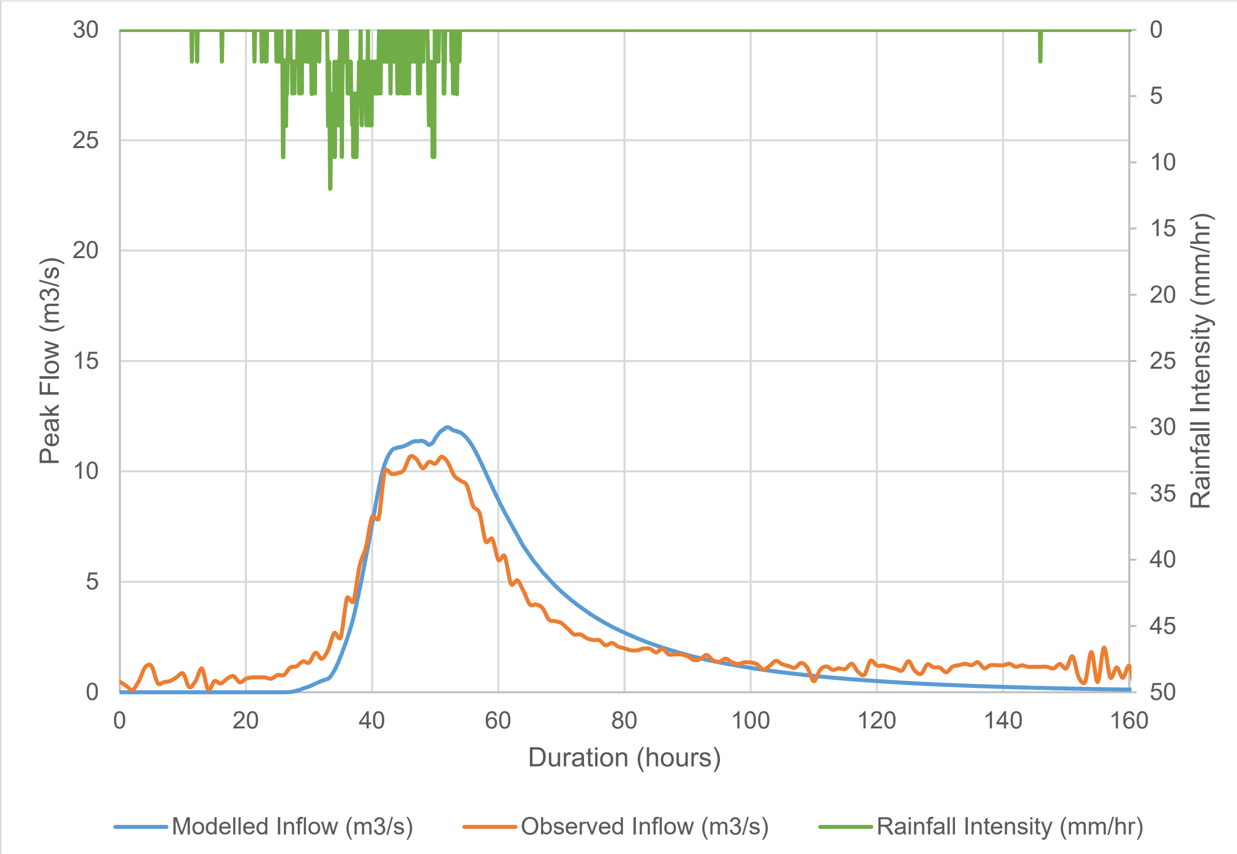


FIGURE 4.17: JANUARY 10, 2020, SCOTCH BLOCK HYDROGRAPH N = 1.15)

The resulting curve generates a modelled hydrograph more in line with the observed inflow, as volumes and peak flows are within acceptable ranges, with a more appropriate time to peak and falling limb. Provided below in **Table 4.9** is a summary of the calibrated peak flows and volume for the January 10, 2020, event.

TABLE 4.9: JANUARY 10, 2020, SCOTCH BLOCK SUMMARY (N=1.15)

Year	Peak Flow (m^3/s)	Volume (m^3)
Observed	10.67	1,500,852
Modelled	12.00	1,449,885
% Difference	+12%	-3%

However, it is important to note that the volume of this storm event (75mm) is not comparable to an event such as the Hurricane Hazel storm event, where 212mm of rainfall occurred following 73mm of previous rainfall. As such, forcing the number of linear reservoirs to 1.15 would show a bias towards a smaller, insignificant event and would likely produce unrealistic flows during the Hurricane Hazel event.

As such, it is Greck's opinion that the number of linear reservoirs be limited to 2, as it represents a reasonable level wetland attenuation without underestimating peak flows for a regional or 100-year event.

Provided in **Figure 4.18** is the updated calibration plot, assuming N = 2.0.

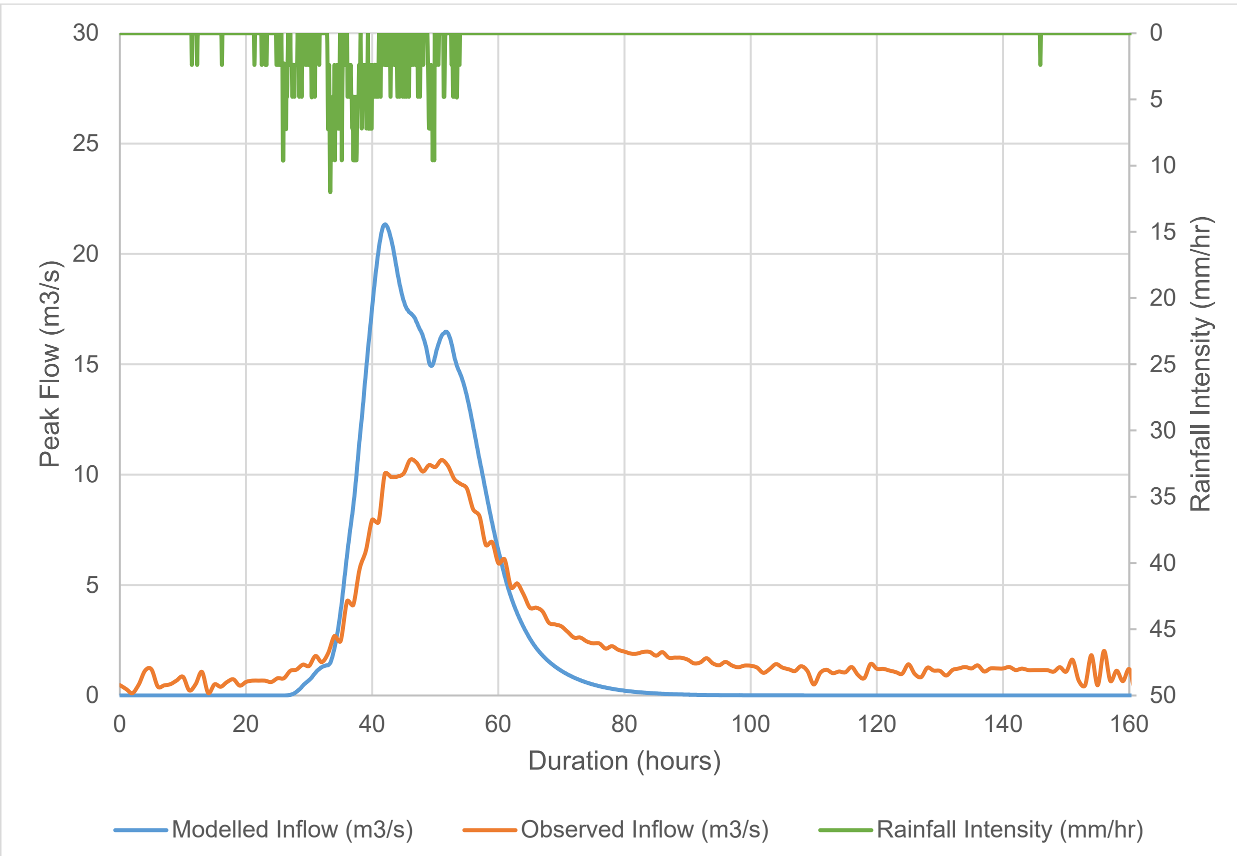


FIGURE 4.18: JANUARY 10, 2020, SCOTCH BLOCK HYDROGRAPH (N = 2.0)

While the peak flows are significantly different, the overall volumes are approximate which is more appropriate and avoids skewing the model to smaller storm events. Provided below in **Table 4.10** is a summary of the calibrated peak flows and volume for the January 10, 2020, event with an N = 2.0.

TABLE 4.10: JANUARY 10, 2020, SCOTCH BLOCK –SUMMARY (N=2.0)

Year	Peak Flow (m^3/s)	Volume (m^3)
Observed	10.67	1,500,852
Modelled	21.34	1,462,209
% Difference	+100%	-3%

4.10.5 HYDROLOGICAL MODEL VALIDATION

To validate the hydrological model, additional storm events were reviewed under AMC II conditions.

May 18, 2011, Event

The May 18, 2011, event was used to validate/calibrate the hydrologic model under AMC II conditions. This event incorporates precipitation data from the Kelso Reservoir. Rainfall record from the Kelso Reservoir were noted to represent the median rainfall condition when comparing across various gauges.

The observed and modelled inflow hydrographs are provided below in **Figure 4.19**. The modelled hydrograph does not exhibit the flashier response associated with the observed peak. This flashier peak is likely attributed to a somewhat "urban" response directly on the reservoir itself. The Scotch Block reservoir features an approximate 35 ha flat, waterbody surrounded by adjacent roads. To account for this flashy response, further discretization of the watershed could be applied, however this will have little to no effect on the downstream flows at the railway crossing, as this peak would subside as flows are routed downstream.

While the timing of the peaks and overall peaks do not match precisely, the overall volumes are similar. Provided below in **Table 4.11** is a summary of the validated peak flows and volume for the May 18, 2011, with an N = 2.0.

TABLE 4.11: MAY 18, 2011, SCOTCH BLOCK –SUMMARY (N=2.0)

Year	Peak Flow (m^3/s)	Volume (m^3)
Observed	8.79	315,989
Modelled	8.68	271,607
% Difference	-1%	-14%

The above validation implies that volumes were underestimated, however, peak flows were relatively inline with each other and as such, another iteration of calibrating both the January 10, 2020 event and May 18, 2011 event was completed by increasing the curve number through rural type land-covers portions by 5%, such as wetlands, agricultural, open fields, grassed areas etc. which were in turn adjusted for all catchments (including pervious portions of urban areas), see **Figure 4.20.**

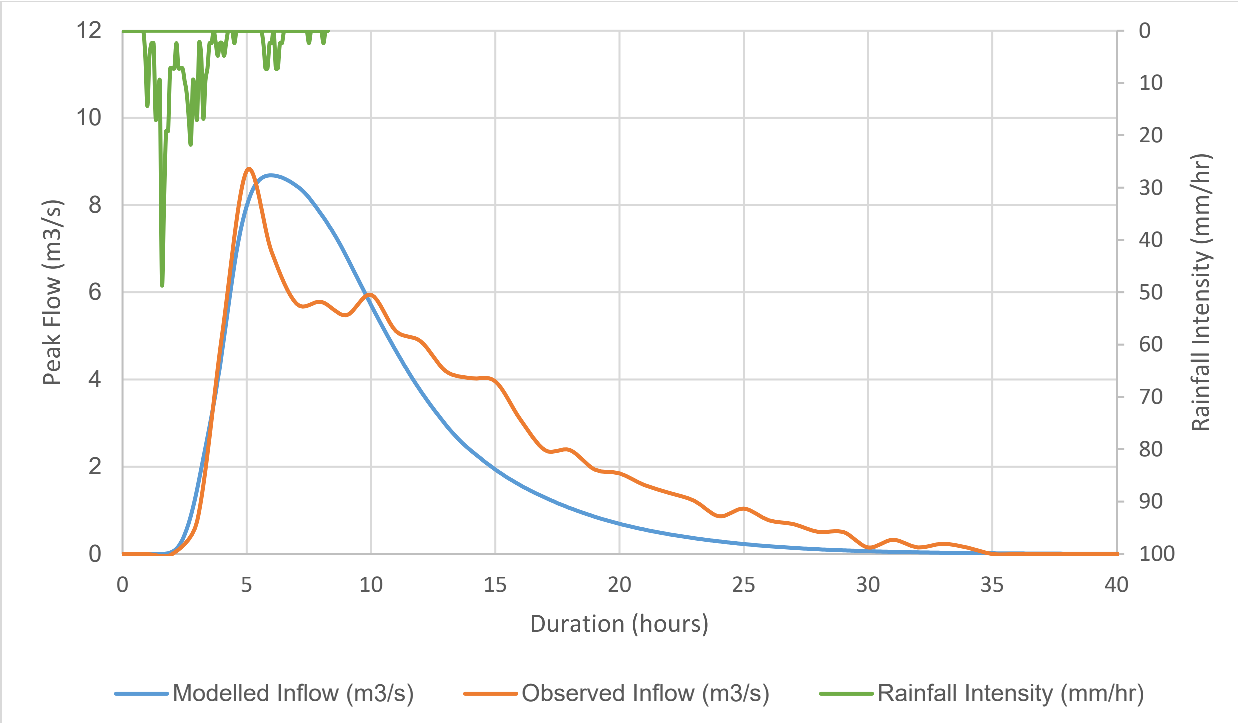


FIGURE 4.19: MAY 18, 2011, SCOTCH BLOCK HYDROGRAPH (CALIBRATED – N = 2.0)

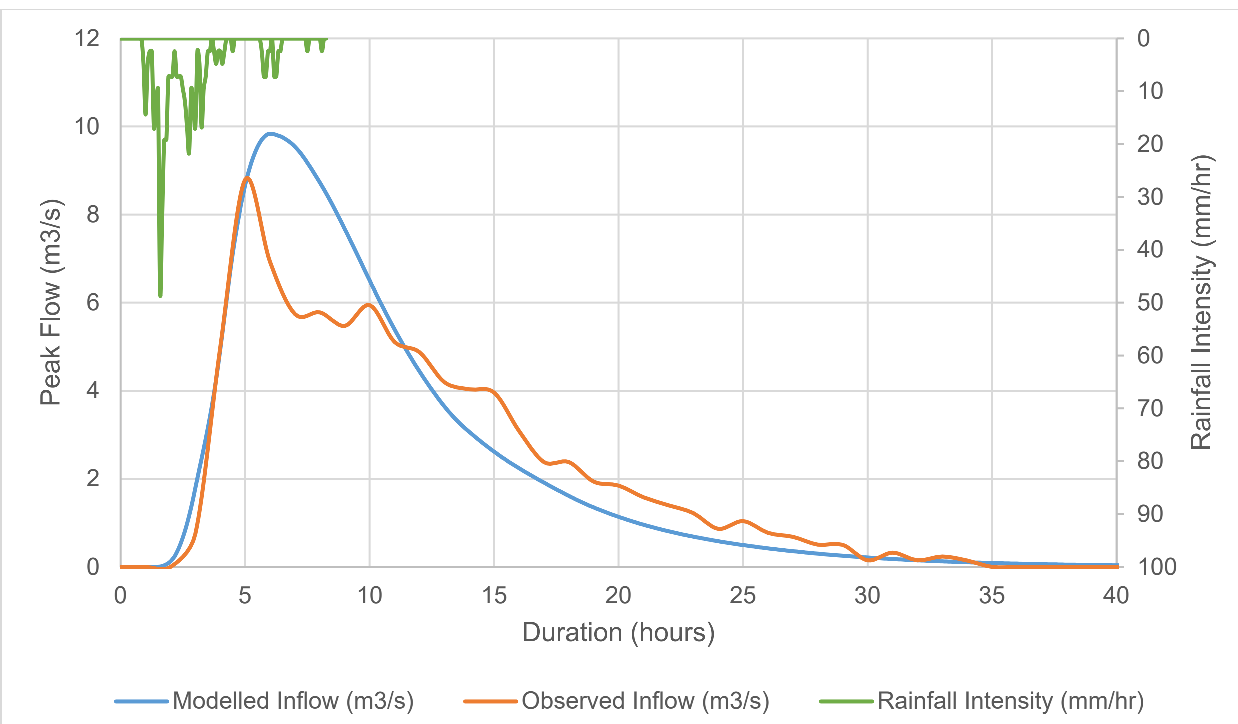


FIGURE 4.20: MAY 18, 2011, SCOTCH BLOCK HYDROGRAPH (N = 2.0, RURAL CN+5%)

Revising the rural CN values resulted in a more appropriate curve, with volumes and peaks more inline. Peak volumes and overall curve are more in line, with the exception of the flashy peak as outlined above. Provided below in **Table 4.12** is a summary of the validated peak flows and volume for the May 18, 2011, with an N = 2.0 and rural CN values +5%.

TABLE 4.12: MAY 18, 2011, SCOTCH BLOCK –SUMMARY (N=2.0, RURAL CN+5%)

Year	Peak Flow (m^3/s)	Volume (m^3)
Observed	8.79	315,989
Modelled	9.84	329,160
% Difference	+12%	+4%

May 18, 2011, at Milton Flow Gauge

The inflow hydrographs during the May 18, 2011, event at the Milton flow gauge was then reviewed as another means of calibration/validation. As previously mentioned, exact timing and peaks cannot be 100% calibrated due to the presence of upstream reservoirs, wetlands, and SWMF, however achieving a relative equivalent modelled and observed overall volume of the system provides further validation of the hydrologic model.

The May 18, 2011, event is an applicable storm event as it represents a time when the industrial area was most developed and therefore more representative of existing conditions, while also providing a significant hydrologic response in both the Scotch Block and Milton Flow gauge. Provided in **Figure 4.21** is the observed and modelled flow hydrographs at the Milton Flow Gauge. As expected, the modelled hydrograph is peakier due to underestimating the effects of upstream reservoirs and wetlands, which may provide more substantial attenuation for this smaller event, along with the flashy peak flows from the industrial area were SWMF are present. Provided below in **Table 4.13** is a summary of the validated peak flows and volume at the Milton Flow Gauge under this scenario.

TABLE 4.13: MAY 18, 2011, MILTON GAUGE –CALIBRATED SUMMARY (N=2.0, RURAL CN+5%)

Year	Peak Flow (m^3/s)	Volume (m^3)
Observed	18.10	1,134,796
Modelled	36.72	929,262
% Difference	103%	-18%

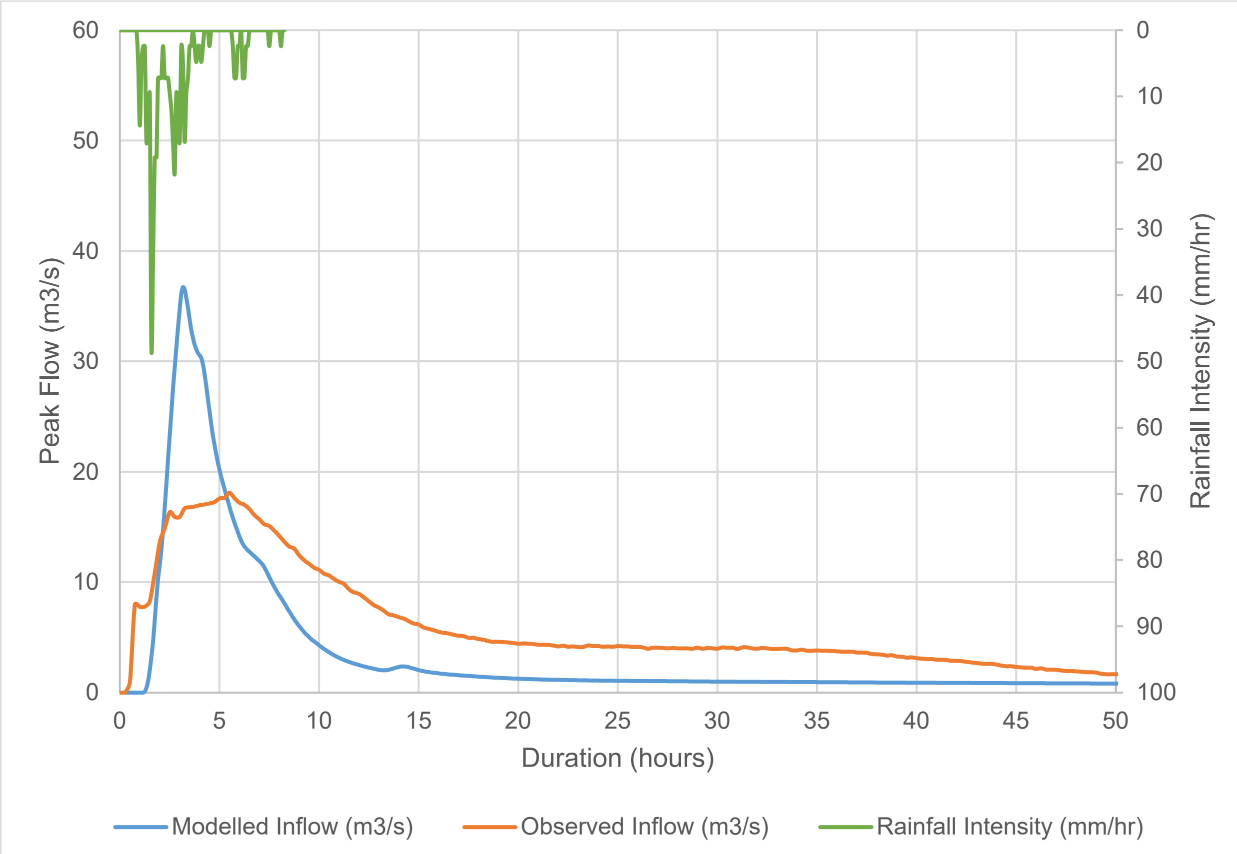


FIGURE 4.21: MAY 18, 2011, MILTON GAUGE HYDROGRAPH (N = 2.0, RURAL CN+5%)

Modelled peak flows are significantly higher than observed flows, however, given the presence of upstream reservoirs, SWMFs, and wetlands (which may play a significant role in attenuating smaller storms but not large storms), this was expected.

In contrast, the modelled volumes are lower than observed values. Potential reasons for the model's lower volume at the Milton Flow Gauge could be spatial variability in rainfall data, soil conditions, base flow conditions, saturated soils leading up to the storm, active storage volumes remaining within the upper watershed, etc. Calibrating the parameters used for urban catchments is not appropriate due to the insufficient information on SWM controls and active operation of upstream reservoirs resulting in variable storage-discharge relationships. Without knowing the exact form and function of the wetlands and SWMF, and degree of attenuation provided by Kelso/Hilton Falls, it is not feasible to calibrate the urban catchment parameters to achieve a modelled hydrograph with more similar values.

Table 4.14 presents a comparison of simulated Regional Storm flow values from this study with simulated values from the Town of Milton's calibrated HSP-F model and from Conservation Halton's calibrated HYMO model (1988 Floodline Mapping Study).

TABLE 4.14: REGIONAL STORM PEAK FLOW COMPARISON TO PAST CALIBRATED MODELS

Flow Gauge Station	Flow (m3/s)		
	Greck 2023 VO Model – Existing/Future	Proctor & Redfern 1988 HYMO Model1	WSP (formerly Philips) 2000 HSP-F Model 2
WSC HB02005 (Pine Street)	**383/387**	**436**	**386**

[1] Values from Table 5 – 16 Mile Creek Flows Future Land Use Without Reservoir Routing per The Proctor & Redfern Group, 1988, Floodline Mapping Study of the Sixteen Mile Creek – Technical Report

[2] Values from Table 2.12 – Summary of Regional Storm Flow Rates (m^3/s) for Existing Land Use Conditions (No Reservoirs) per Philips Planning and Engineering Ltd., 2000, Sixteen Mile Creek Subwatershed Planning Study Areas 2 and 7, Town of Milton – Technical Appendix Stormwater Management

There is very close agreement between the HSP-F and VO models at the Milton Flow Gauge near Pine Street, with simulated Regional peak flows within 1%. The VO simulated Regional flows at the WSC Gauge are 11% lower than the calibrated values determined from the 1988 floodline mapping study.

While some calibration simulations may suggest the VO model produces greater peak flows, the comparison of previous regional storm peaks flows and the similarity between modeled and observed peak flows and runoff volumes at the Scotch Block reservoir (during the May 18, 2011 storm event), indicate that the VO model does not generate overly conservative flows for regulatory storm.

Re-Calibration of January 10, 2020, Event

The effect of increasing the rural CN by 5% was then re-applied to the AMCIII calibrated model for the January 10, 2020, storm event. This generated a similar curve (in comparison to simply N =2.0), however slightly increased the overall modelled volumes and peaks, see **Figure 4.22 and Table 4.15.**

All pre and post calibrated standard parameters are provided in **Appendix E**, but in summary were adjusted as follows:

- CN for pervious surfaces only were increased by 5%
- Linear Reservoirs decrease from standard value of 3 to 2

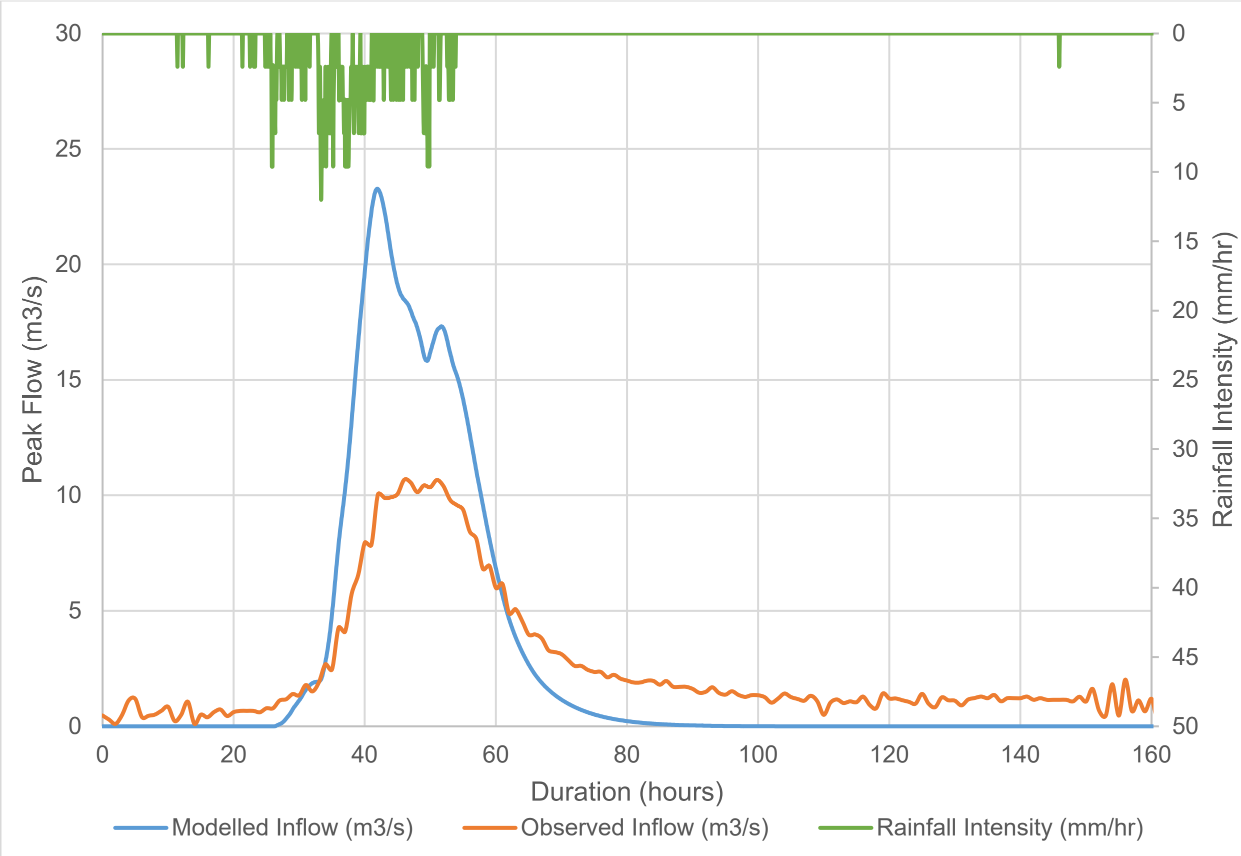


FIGURE 4.22: JANUARY 10, 2020, SCOTCH BLOCK HYDROGRAPH (N = 2.0, RURAL CN+5%)

TABLE 4.15: JANUARY 10, 2020, SCOTCH BLOCK – CALIBRATED SUMMARY (N=2.0, RURAL CN+5%)

Year	Peak Flow (m^3/s)	Volume (m^3)
Observed	10.67	1,500,852
Modelled	23.28	1,582,467
% Difference	+118%	5%

Table 4.16 presents a comparison of simulated Regional Storm flow values from this study relative to the simulated values from the 1988 Floodline Mapping Study. This study predicts 11% lower peak flows than the 1988 study at the inlet to the Scotch Block Reservoir.

TABLE 4.16: PEAK FLOW COMPARISON AT SCOTCH BLOCK RESERVOIR – CURRENT AND PAST STUDIES

Flow (m^3/s)	
Greck 2023 VO Model – Existing/Future	Proctor & Redfern Group 1988 HYMO Model
192.4	216.7

[1] Values from Table 5 – 16 Mile Creek Flows Future Land Use Without Reservoir Routing per The Proctor & Redfern Group, 1988, Floodline Mapping Study of the Sixteen Mile Creek – Technical Report

Further model refinements to achieve a more appropriate continuity between modelled and observed flows were not made for a number of reasons, including but not limited to:

- Avoid bias/skewing model to smaller storm events in comparison to a regional event (i.e., a 75 mm rainfall event such as the January 2020 event that is not representative of the 285 mm rainfall event from Hurricane Hazel),
- Uncertainty related to antecedent conditions (including available wetland storage), the effect of which may be more apparent during smaller storms, as evidenced the variability between simulated and observed watershed response between the May 18, 2011 and January 10, 2020 rainfall events,
- The similarities of modelled Regional flows relative to other calibrated models, i.e., 11% reduction in Regional flows as compared to the 1988 HYMO model and 1% change relative to the 2000 HSP-F model, and
- Further attenuation of storms upstream of watercourse crossings.

As such, differences between observed and modelled conditions (as demonstrated in Figures 4.21 and 4.22 and Tables 4.13 and 4.15) should not be interpreted as an indication that the study model generates overly conservative flows for the purposes of flood hazard mapping. The calibration was focused on AMC III conditions, recognizing that the Hurricane Hazel Regional Storm typically defines the extent of the regulated flood hazard within the study area and how this storm is defined in O.Reg. 162/06. The calibrated model is representative for larger or more extreme storm events and is deemed an appropriate tool to support definition of the flood hazard.

4.11 SPILL CONSIDERATION FROM MIDDLE BRANCH

Previous studies have made note of the potential for intra-watershed spill from the Middle Branch to the West Branch. This spill is located northwest of 5th Side Road, upstream of a rail crossing as indicated in **Figure 4.23**. The location of the watershed divide was used to determine the extents of the spill crest and was confirmed via topographic survey.

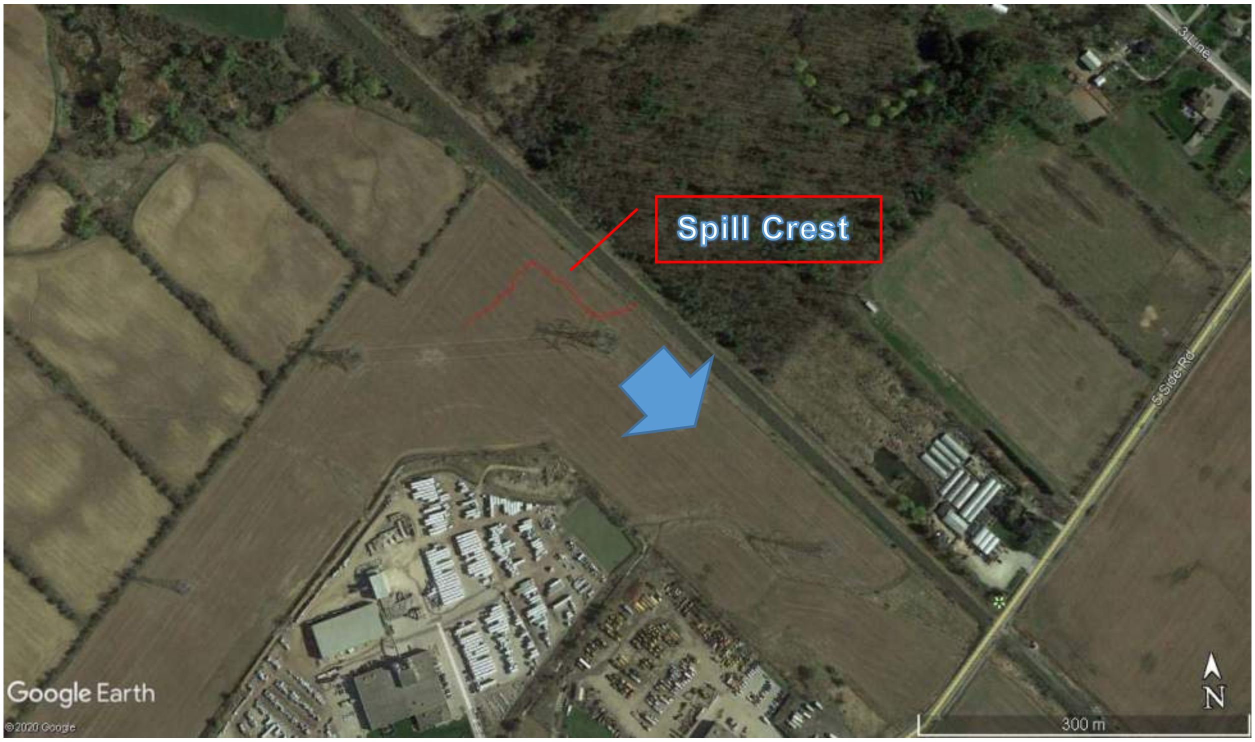


FIGURE 4.23: MIDDLE TO WEST BRANCH SPILL LOCATION

Spills from the Middle Branch are captured by a drainage swale along a hydro corridor, where flows are conveyed towards the West Branch near Highway 401, through the correctional facility.

The calibrated model mentioned above was then incorporated into a non-steady state HEC-RAS hydraulic model, by inserting the flow hydrograph at the CN rail crossing. The spill crest was modelled as a lateral structure, digitally cut from the LiDAR DTM.

The non-steady state flow model resulted in an outflow hydrograph, with a peak outflow of 29 m^3/s at the spill crest. The outflow hydrograph was then incorporated into the overall hydrological model in order to quantify the spill through the corridor and assess its effects through Sixteen Mile Creek.

This spill significantly increases the peak flow through the hydro corridor and near the correctional facility. The peak flow in this tributary is primarily governed by the spill. This spill has minimal to no effect throughout the remainder of the model, as peak flows from the West Branch of Sixteen Mile Creek have primarily subsided by the time this spill occurs.

Provided in **Figure 4.24** are the flow hydrographs through the drainage swale along the eastern rail crossing and through the Maplehurst Correctional Complex and eventually, to Steeles Avenue.

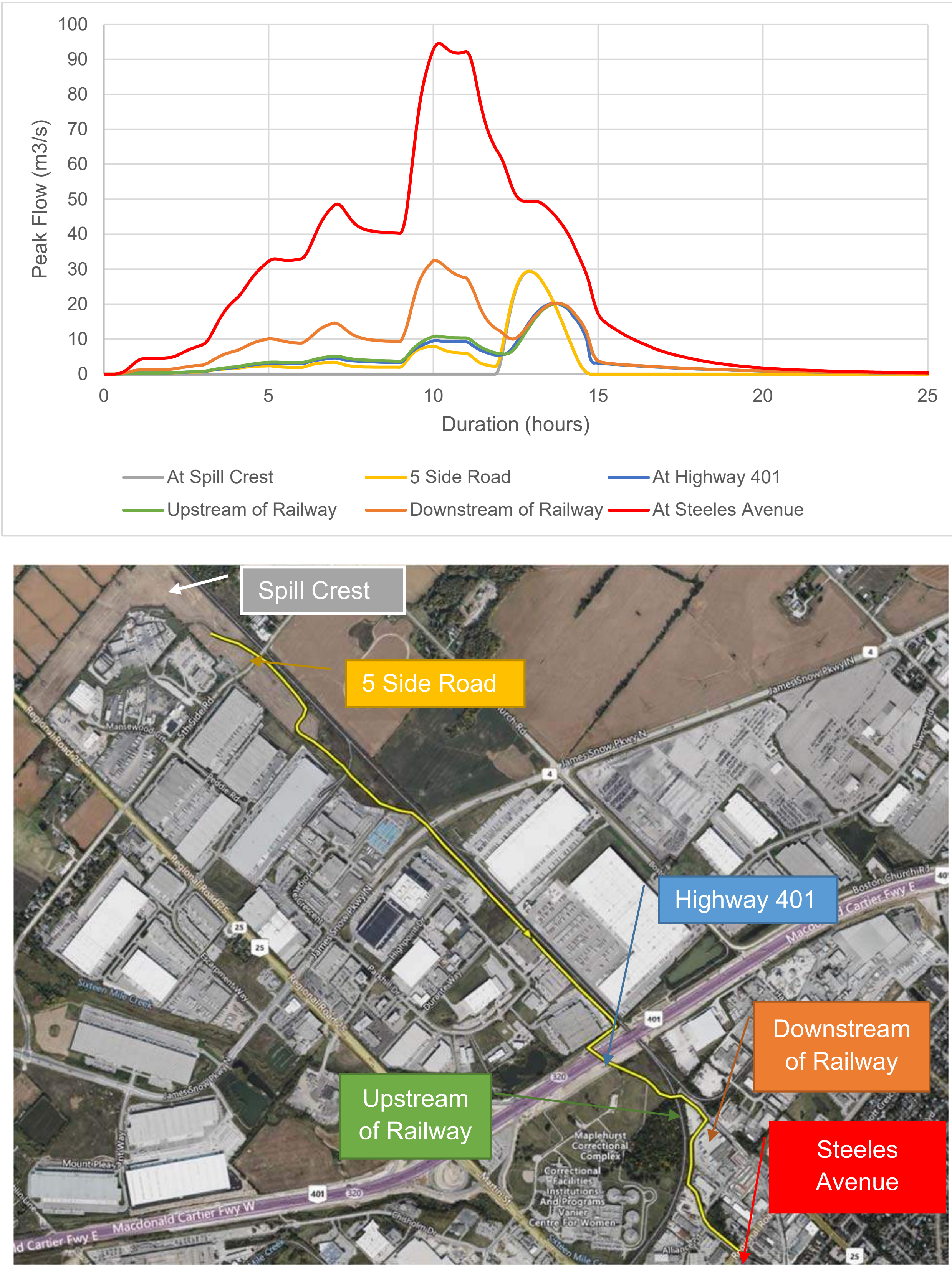


FIGURE 4.24: PROPAGATION OF SPILL HYDROGRAPH (TOP) AND PLAN VIEW (BOTTOM)

This figure illustrates how the spill from the Middle Branch progressively has a lesser impact on downstream flows of the West Branch, this is primarily due to the fact that the peak of the spill from the Middle Branch occurs approximately three (3) hours after the peak of the Western Branch.

An additional scenario was considered in order to quantify the level of spill, crediting the peak flow reduction of the Scotch Block Reservoir. Under this scenario, standard reservoir operation conditions were assumed, which resulted in no flows spiling from the Middle Branch to the Western Branch. A standard operating rating curve of the Scotch Block Reservoir was obtained from CH on January 14, 2020, provided in **Appendix E**.

Two further scenarios were investigated, to assess the amount of spill, should the culvert crossing be removed and assuming normal flow conditions through the valley lands. One scenario included the Scotch Block Reservoir, and one without. Both scenarios concluded that no spill would occur between the Middle and West Branch if the rail crossing were removed.

A summary of the spill flow rate for each condition is provided in **Table 4.17**. Spill was not encountered during the 100-year storm events.

TABLE 4.17: REGIONAL PEAK FLOWS AT KEY LOCATIONS (m^3/s)

Scenario	Peak flow at Rail (m^3/s)	Peak flow leaving the system (m^3/s)
Regional	199.76	29.37
Regional with Scotch Block	156.33	0.0
Regional – CN Rail Removed	199.76	0.0
Regional – CN Rail Removed & No Scotch Block Consideration	199.76	0.0

From the above, it can be seen that the Scotch Block Reservoir provides a significant impact to downstream spills, as incorporating the Scotch Block Reservoir eliminates all spills between the Middle and West Branch. The inclusion of the railway has a significant impact as well, due to its limited conveyance capacity and consequential substantial backwater effects.

4.12 HYDROLOGIC MODELLING SCENARIOS

Several hydrologic modelling scenarios were incorporated into the final hydrologic model. Details outlining each scenario are summarized below in **Table 4.18**.

Further scenarios were included, as summarized below in **Table 4.19**. All calibration scenarios applied existing land-use conditions.

TABLE 4.18: HYDROLOGY MODEL SCENARIOS

Scenario	Land-use	Storm Events	AMC Conditions	Reservoir Consideration
Ex. Regional AMCiii	Existing Conditions	Regional (Hurricane Hazel)	AMC III	None
Ex.100yrARF_AMCii (SWMF)	Existing Conditions	24-hour Chicago Storm	AMC II	Four SWMF only
Ex.100yrARF-CC_AMCii (SWMF)	Existing Conditions (and Climate Change)	24-hour Chicago Storm	AMC II	Four SWMF Only
Fu.Regional_AMCiii	Future Conditions	Regional (Hurricane Hazel)	AMC III	None
Fu.100yrARF_AMCii (SWMF)	Future Conditions	24-hour Chicago Storm	AMC II	Four SWMF Only
Fu.100yrARF-CC_AMCii (SWMF)	Future Conditions (and Climate Change)	24-hour Chicago Storm	AMC II	Four SWMF Only

TABLE 4.19: CALIBRATION HYDROLOGY MODEL SCENARIOS

Scenario	Storm Events	AMC Conditions	Calibrated Parameters
Calib-Jan2020-AMCiii	January 10, 2020, Rainfall at Scotch Block	AMC iii	Non-calibrated model
Calib-Jan2020-AMCiii N=1.15	January 10, 2020, Rainfall at Scotch Block	AMC iii	N = 1.15
Calib-Jan2020-AMCiii N=2.0	January 10, 2020, Rainfall at Scotch Block	AMC iii	N = 2.0
Calib-Jan2020-AMCiii N=2.0 CN+5%	January 10, 2020, Rainfall at Scotch Block	AMC iii	**N = 2.0 CN (pervious only) +5%**
Calib-May2011-AMCii N = 2.0	May 18, 2011, Rainfall at Kelso Reservoir	AMC ii	N = 2.0
Calib-May2011-AMCii N = 2.0 +5%	May 18, 2011, Rainfall at Kelso Reservoir	AMC ii	**N = 2.0 CN (pervious only) +5%**

Note: Bolded parameters represent the final calibration adjustments applied to all model scenarios listed in Table 4.16.

4.13 HYDROLOGIC MODELLING RESULTS

The calibrated hydrological model was used to determine the peak flows using the design storm and regional storm events. Peak flows for the Regional Storm at various key locations are summarized below in **Table 4.20**. Flows provided below assume all reservoirs and SWMF do not provide any form of flood control as typically required by MNRF guidelines and are under AMC III conditions. More detailed output tables are available in **Appendix F**.

The watershed wide hydrologic modeling has limitations, as modeling the full details of the urban drainage systems was outside of the study scope. As such the attenuation, storage and conveyance potential associated with the urban minor and major drainages have not been fully accounted for.

TABLE 4.20: EXISTING CONDITION REGIONAL PEAK FLOWS AT KEY LOCATIONS (m^3/s)

Location	Contributing Area (ha)	Areal Reduction Factor	Flow Node	Regional Peak Flow (m^3/s)
Kelso Reservoir	7994	95.40%	121	244.2
At Mill Pond	8845	93.50%	129	261.2
Milton Flow Gauge	11458	93.50%	282	383.4
CNR Embankment East of Martin Street	2354	99.20%	274	172.2
Confluence North of WI Dick Middle School	2220	99.20%	272	159.1
West Stream through Correctional facility	555	100.00%	243	52.4
Bridge at Laurier Avenue	11696	92.00%	284	391.1
Crossing at 25	12112	89.40%	302	405.5
Britannia Road	12298	89.40%	304	413.5

Peak flows for the 100-year 24-hour Chicago design storm event are provided below in **Table 4.21**. These flows assume all reservoirs do not provide flood control functions, however several SWMF were considered. Soils were simulated under AMC II conditions. More detailed output tables are available in **Appendix F**.

TABLE 4.21: EXISTING CONDITION 100-YEAR PEAK FLOWS AT KEY LOCATIONS (M^3/S)

Location	Contributing Area (ha)	Areal Reduction Factor	Flow Node	100-year Peak Flow (m^3/s)
Kelso Reservoir	7994	94.50%	121	63.8
At Mill Pond	8845	93.25%	128	67.3
Milton Flow Gauge	10979	93.25%	282	208.6
NR Embankment East of Martin Street	1940	98.50%	274	139.7
Confluence North of WI Dick Middle School	1816	98.50%	272	124.1
West Stream through Correctional facility	555	100.00%	243	36.1
Bridge at Laurier Avenue	11215	92.75%	284	221.4
Crossing at 25	11631	91.00%	302	219.3
Britannia Road	11817	91.00%	304	200.3

4.13.1 FUTURE LAND-USE SCENARIO

As outlined in Section 4.3.2, future land-use scenarios were investigated based on the 2008 Town of Milton Official Plan. **Table 4.22** compares the predicted existing and future 100-year and Regional Storm peak flow rates.

In general, an increase in peak flows is predicted throughout the study area, but future Regional Storm peak flows vary from existing conditions by less than 3%. There was a reduction in peak flows through the reach adjacent to the Mill Pond, near the intersection of Mill Street and Martin Street. This reduction in peak flows is due to development of upstream lands, particularly catchments 1220 through 1260. The conversion of these lands from agricultural/rural land-use to residential effects the overall timing of the hydrologic response, resulting in a much quicker/faster time to peak as opposed to a rural catchment.

TABLE 4.22: EXISTING AND FUTURE LAND-USE PEAK FLOWS

Location	Flow Node	Existing		Future Land-Use	
		Regional Peak Flow (m^3/s)	100-year (m^3/s)	Regional Peak Flow (m^3/s)	100-year (m^3/s)
Kelso Reservoir	121	244.2	63.8	244.5	63.8
At Mill Pond	129	261.2	67.2	254.0	67.1
Milton Flow Gauge	282	383.4	208.6	387.0	220.3
NR Embankment East of Martin Street	274	172.2	139.7	175.6	147.2
Confluence North of WI Dick Middle School	272	159.1	124.1	162.5	131.8
West Stream through Correctional facility	243	52.4	36.1	53.0	45.7
Bridge at Laurier Avenue	284	391.1	221.4	395.1	231.7
Crossing at 25	302	405.5	219.3	411.4	230.0.
Britannia Road	304	413.5	200.3	420.4	215.0

4.13.2 CLIMATE CHANGE

The climate change scenario has been modelled to support an understanding of relative risk. In this study, flood hazard mapping has been generated on the basis of current municipal IDF information as opposed to climate adjusted IDF information.

In southern Ontario, there has been an upward trend in the maximum daily precipitation due to climate change (Fadhel et al. 2017) and as such, peak flows generated from the hydrologic model may not be representative of the watershed in the future.

Future IDF curves were estimated using the IDF Climate Change Tool (IDF CC Tool), assuming the Representative Concentration Pathway (RCP) 8.5 climate change model for future climate year 2100. Due to the nature of uncertainty with climate change, the RCP 8.5 was the chosen model selection for climate change estimates, as it represents the most conservative estimates of climate change effects compared to other models, such as RCP 2.6, 4.5 or 6.0).

The effects of climate change based on future land-use are provided below in **Table 4.23**.

TABLE 4.23: CLIMATE CHANGE EFFECTS ON EXISTING LAND-USE

Location	Flow Node	Regional	100-year	
			Existing Land-use	2100 Climate Change
Kelso Reservoir	121	244.2	63.8	78.9
At Mill Pond	129	261.2	67.3	83.1
Milton Flow Gauge	282	383.4	208.6	240.4
NR Embankment East of Martin Street	274	172.2	139.7	158.6
Confluence North of WI Dick Middle School	272	159.1	124.1	142.5
West Stream through Correctional facility	243	52.4	36.1	42.8
Bridge at Laurier Avenue	284	391.1	221.4	256.7
Crossing at 25	302	405.5	219.3	253.5
Britannia Road	304	413.5	200.3	235.5

Throughout the watershed, flood hazard limits are generally governed by the Regional storm event (Hurricane Hazel). However, with the effects of climate change, the peak flows are trending towards convergence with Regional peak flows. In almost all instances however, the Regional storm remains as the governing storm event.

The effects of climate change based on future land-use are provided below in **Table 4.24**

TABLE 4.24: CLIMATE CHANGE EFFECTS ON FUTURE LAND-USE

Location	Flow Node	Regional	100-year	
			Future Land-use	2100 Climate Change
Kelso Reservoir	122	244.5	63.8	78.9
At Mill Pond	129	254.0	67.1	82.84
Milton Flow Gauge	282	387.0	220.3	253.2
NR Embankment East of Martin Street	274	175.6	147.2	166.4
Confluence North of WI Dick Middle School	272	162.5	131.8	153.6
West Stream through Correctional facility	**243**	**53.0**	**45.7**	**53.8**
Bridge at Laurier Avenue	284	395.1	231.7	269.5
Crossing at 25	302	411.4	230.0.	269.1
Britannia Road	304	420.4	215.0	251.3

With the exception of flows at Node 243, the results of the climate change analyses generally suggest the dominating flood flow events (Regional vs 100-year storms) is consistent with current climatic conditions. Where flood hazards are defined by the Regional Storm they will generally continue to be defined by this event, even when considering the effects of climate change. Where flood hazard lands are defined by the 100-year storm they will continue to be defined by this event when considering climate change. The severity of flooding caused by the 100-year storm would increase in a climate change scenario.

4.13.3 COMPARISON TO PAST STUDIES

Provided in this section is a comparison of flow rates determined in this study to the FDRP, as outlined in **Table 4.25**.

TABLE 4.25: FLOW RATE COMPARISON TO FDRP

Reach	Location	Urban Milton Update (2023)			FDRP (1988)	
		HEC-RAS Section	Regional (m^3/s)	100-year (m^3/s)	Regional (m^3/s)	100-year (m^3/s)
M1	At Confluence (south of Steeles)	1313	162.5	131.78	129.5	46.3
M2	Milton Flow Gauge (02HB005)	2180	385.01	221.57	436.1	82.4
M2	Derry Road	315	383.14	217.19	465.8	95.5
N3	Highway 401	698	57.9	41.01	52.5	18.1
W1	Kelso Road (DS of Reservoir)	5721	252.69	65.13	337.4	63.8
W1	Steeles Avenue	1849	253.56	66.81	339.9	63.3

Flow rates can change due to several factors, including updated modeling software and approaches, higher levels of catchment discretization using higher resolution topographical information, changes in land-use, differences in model calculation time steps, etc.. Most notable changes in peak flow reduction occurred within rural catchments when compared to the FDRP study. This is expected due to the transition using shallow concentrated flow, rather than methodologies such as Bransby Williams or Airport equations, which resulted in higher peak flows during previous draft versions of the hydrologic modelling.

4.14 SENSITIVITY ANALYSES

In lieu of further model calibration, a sensitivity analyses was completed to determine the impact of changing model parameters on calculated flows. Sensitivity Analyses (SA) helps identify the parameters that have a strong impact on the model output and hence include the model response. In addition, the SA assists in assessing the interaction between parameters, its preferable range and spatial variability which in turn influence the modelling outcomes and interpretation of the accuracy of results.

Provided below in **Table 4.26** is a summary of the Sensitivity Analyses scenarios.

TABLE 4.26: SENSITIVITY ANALYSIS HYDROLOGY MODEL SCENARIOS:

Scenario	Sensitivity Varied Parameter
CN+10%	NasHYD Curve numbers increased by 10%*
CN-10%	NasHYD Curve numbers decreased by 10%
TP+10%	Time to peak increased by 10%
TP-10%	Time to peak decreased by 10%
IA+50%	Initial abstraction increased by 10%
IA-50%	Initial abstraction decreased by 10%
NL+20%	Number of linear reservoirs increased by 20%
NL-20%	Number of linear reservoirs decreased by 20%
TIMP/XIMP+20%	Percent impervious increased by 20%**
TIMP/XIMP-20%	Percent impervious decreased by 20%
Slope+20%	Impervious/pervious slope increased by 20%
Slope-20%	Impervious/pervious slope decreased by 20%
P Len+50%	Pervious flow length increased by 50%
P Len-50%	Pervious flow length increased by 50%
sCN+10%	StandHYD Curve number increased by 10%
sCN-10%	StandHYD Curve number decreased by 10%
Length+20%	RouteChannel length increased by 20%
Length-20%	RouteChannel length decreased by 20%
n+20%	RouteChannel Manning roughness increased by 20%
n-20%	RouteChannel Manning roughness decreased by 20%

*To a maximum of 98
**To a maximum of 99%

4.14.1 SENSITIVITY ANALYSES RESULT

Sensitivity analyses were completed for the Regional storm event based on the above parameters are provided below in **Table 4.27** and **Table 4.28.** Sensitivity analysis results for the 100-year event are provided in **Table 4.29** and **Table 4.30.**

TABLE 4.27: SENSITIVITY ANALYSIS–- PEAK FLOW RESULTS – REGIONAL EVENT (M3/S)

Location	Flow Node	Base	CN		Tp		IA		N		% Impervious		Slope		Perv Length		Stand CN		RC Length		RC n	
			10%	-10%	20%	-20%	50%	-50%	20%	-20%	20%	-20%	20%	-20%	50%	-50%	10%	-10%	20%	-20%	20%	-20%
Kelso Reservoir	122	247	276	218	220	283	242	252	268	212	247	247	247	247	247	247	262	247	234	262	247	260
At Mill Pond	129	254	285	222	226	290	248	260	272	220	254	254	254	254	254	254	274	254	236	274	254	269
Milton Flow Gauge	282	387	417	355	356	430	379	395	407	355	386	388	386	389	388	386	419	387	360	419	389	409
CNR Embankment East of Martin Street	274	176	177	172	173	179	176	176	176	173	176	175	176	175	175	176	180	176	171	180	177	182
Confluence North of WI Dick Middle School	272	163	164	159	160	166	162	163	163	160	163	162	163	162	162	163	167	163	158	167	164	169
West Stream through Correctional facility	243	53	53	52	52	55	53	53	54	52	53	53	53	53	53	53	55	53	52	55	53	55
Bridge at Laurier Avenue	284	395	424	365	366	437	388	402	413	365	395	396	394	397	396	395	428	395	368	428	397	419
Crossing at 25	302	411	438	383	386	448	405	417	426	387	410	412	409	412	412	411	439	411	385	439	413	436
Britannia Road	304	420	447	394	398	455	414	427	435	398	420	421	420	421	421	420	452	420	392	452	423	447

TABLE 4.28: SENSITIVITY ANALYSIS – PERCENT VARIANCE–- REGIONAL EVENT

Location	Flow Node	CN		Tp		IA		N		% Impervious		Slope		Perv Length		Stand CN		RC Length		RC n	
		10%	-10%	20%	-20%	50%	-50%	20%	-20%	20%	-20%	20%	-20%	50%	-50%	10%	-10%	20%	-20%	20%	-20%
Kelso Reservoir	122	12%	-12%	-11%	15%	-2%	2%	9%	-14%	0%	0%	0%	0%	0%	0%	6%	0%	-5%	6%	0%	5%
At Mill Pond	129	12%	-13%	-11%	14%	-2%	2%	7%	-13%	0%	0%	0%	0%	0%	0%	8%	0%	-7%	8%	0%	6%
Milton Flow Gauge	282	8%	-8%	-8%	11%	-2%	2%	5%	-8%	0%	0%	0%	0%	0%	0%	8%	0%	-7%	8%	1%	6%
CNR Embankment East of Martin Street	274	1%	-2%	-1%	2%	0%	0%	0%	-1%	0%	0%	0%	0%	-1%	0%	3%	0%	-2%	3%	1%	4%
Confluence North of WI Dick Middle School	272	1%	-2%	-1%	2%	0%	0%	1%	-2%	0%	0%	0%	0%	-1%	0%	3%	0%	-3%	3%	1%	4%
West Stream through Correctional facility	243	0%	-3%	-2%	3%	0%	0%	2%	-3%	0%	0%	0%	0%	0%	0%	3%	0%	-2%	3%	0%	3%
Bridge at Laurier Avenue	284	7%	-8%	-7%	11%	-2%	2%	5%	-8%	0%	0%	0%	0%	0%	0%	8%	0%	-7%	8%	1%	6%
Crossing at 25	302	6%	-7%	-6%	9%	-1%	1%	4%	-6%	0%	0%	-1%	0%	0%	0%	7%	0%	-6%	7%	0%	6%
Britannia Road	304	6%	-6%	-5%	8%	-1%	2%	3%	-5%	0%	0%	0%	0%	0%	0%	7%	0%	-7%	7%	1%	6%

TABLE 4.29: SENSITIVITY ANALYSIS–- PEAK FLOW RESULTS – 100-YEAR EVENT (M3/S)

Location	Flow Node	Base	CN		Tp		IA		N		% Impervious		Slope		Perv Length		Stand CN		RC Length		RC n	
			10%	-10%	20%	-20%	50%	-50%	20%	-20%	20%	-20%	20%	-20%	50%	-50%	10%	-10%	20%	-20%	20%	-20%
Kelso Reservoir	122	64	75	54	58	72	60	68	70	54	64	64	64	64	64	64	64	64	61	67	67	67
At Mill Pond	129	67	79	56	61	75	63	71	73	58	67	67	67	67	67	67	67	67	64	71	71	70
Milton Flow Gauge	282	220	224	218	219	222	219	221	221	219	234	204	223	214	215	226	235	207	204	238	238	242
CNR Embankment East of Martin Street	274	147	150	146	147	148	147	148	148	147	155	137	150	142	145	151	156	139	137	160	160	163
Confluence North of WI Dick Middle School	272	132	134	131	131	132	131	132	132	131	139	123	133	128	130	135	141	124	122	144	144	147
West Stream through Correctional facility	243	46	47	45	45	46	45	46	46	45	49	42	46	45	45	46	49	43	40	52	52	51
Bridge at Laurier Avenue	284	232	236	230	231	233	231	233	232	231	247	218	235	227	227	237	251	217	213	257	257	261
Crossing at 25	302	230	234	228	229	232	229	231	230	229	244	217	230	227	227	232	250	213	206	262	262	260
Britannia Road	304	215	219	212	214	217	214	216	215	214	226	202	214	214	214	215	234	198	190	248	248	246

TABLE 4.30: SENSITIVITY ANALYSIS – PERCENT VARIANCE – 100-YEAR EVENT

Location	Flow Node	CN		Tp		IA		N		% Impervious		Slope		Perv Length		Stand CN		RC Length		RC n	
		10%	-10%	20%	-20%	50%	-50%	20%	-20%	20%	-20%	20%	-20%	50%	-50%	10%	-10%	20%	-20%	20%	-20%
Kelso Reservoir	122	18%	-16%	-10%	13%	-6%	6%	10%	-15%	0%	0%	0%	0%	0%	0%	0%	0%	-4%	5%	5%	4%
At Mill Pond	129	18%	-16%	-9%	12%	-6%	6%	9%	-13%	0%	0%	0%	0%	0%	0%	0%	0%	-5%	6%	6%	5%
Milton Flow Gauge	282	2%	-1%	0%	1%	0%	0%	0%	0%	6%	-7%	1%	-3%	-2%	2%	7%	-6%	-7%	8%	8%	10%
CNR Embankment East of Martin Street	274	2%	-1%	0%	1%	0%	0%	0%	0%	5%	-7%	2%	-4%	-2%	2%	6%	-6%	-7%	8%	8%	11%
Confluence North of WI Dick Middle School	272	2%	-1%	0%	1%	0%	0%	0%	0%	6%	-7%	1%	-3%	-1%	3%	7%	-6%	-7%	9%	9%	11%
West Stream through Correctional facility	243	3%	-1%	0%	1%	0%	0%	0%	0%	7%	-8%	1%	-2%	-2%	1%	8%	-6%	-12%	14%	14%	12%
Bridge at Laurier Avenue	284	2%	-1%	0%	1%	0%	0%	0%	0%	7%	-6%	2%	-2%	-2%	2%	8%	-6%	-8%	11%	11%	13%
Crossing at 25	302	2%	-1%	0%	1%	0%	1%	0%	0%	6%	-6%	0%	-1%	-1%	1%	9%	-7%	-10%	14%	14%	13%
Britannia Road	304	2%	-1%	-1%	1%	-1%	1%	0%	0%	5%	-6%	0%	-1%	-1%	0%	9%	-8%	-12%	15%	15%	14%

Varying the above-mentioned hydrologic parameters during the Regional storm event caused peak flows to vary at a maximum of 15%. This level of variability is expected when varying parameters from 10% to 20%.

During the Regional storm event, the hydrological model was most sensitive to catchment parameters associated with the NasHYD command, particularly Curve Number, Time to Peak and Number of Linear reservoirs. This is expected, as peak flows are primarily governed by the runoff from agricultural, forested and wetland catchments within the upper portions of the watershed. Initial abstraction has minimal impacts to peak flows throughout the model as depression storage would likely be filled and the underlying soils are almost fully saturated during the Hurricane Hazel event, limiting the ability for infiltration throughout the watershed.

Varying parameters associated with StandHYDs, such as slope, percent impervious and infiltration rates had little to no effect on the peak flows throughout the system, as peak runoff from the lower, urbanized catchments are generally less significant than the rural component from north of Highway 401.

The effects of varying the RouteChannel lengths and Manning roughness coefficient were somewhat sensitive throughout the system.

During the 100-year storm event, the hydrologic model was most sensitive to parameters such as Curve Number, time to peak, number of linear reservoirs, and slightly more sensitive to initial abstraction, as soil conditions are not fully saturated in comparison to the Regional storm event.

The 100-year storm event was more sensitive to StandHYD parameters such as infiltration rates, catchment slope etc. due to the nature of the Chicago Storm distribution being a more peaky, higher intensity event in comparison to the long duration, lower intensity hurricane Hazel event.

Of particular interest, urban catchments within the headwaters were noted to see a more significant impact to parameters due to their small catchment size and relative sensitivity due to the “flashiness” of the Chicago storm. The IND5 tributary was particularly sensitive (increase of 44%) due to adjustments to the StandHYD CN – this was due to the fact that the SWMF performance decreases significantly due to the increased volume, reducing the SWMF quantity control efficiency.

Overall, it can be concluded that the hydrologic model was within an acceptable range of sensitivity in response to varying parameters (maximum variation of 12% and 18% during Regional and 100-year event at key flow nodes). As such, no further detailed calibration is considered necessary.

5.0 HYDRAULIC ANALYSIS

The water surface elevations that will be used to define the flood elevations and limits of flooding within Urban Milton along Sixteen Mile Creek were determined using Civil Geo GeoHEC-RAS software (Version 4.0). GeoHEC-RAS utilizes the United States Army Corps of Engineers, Hydraulic Engineering Centre's River Analysis System, HEC-RAS software. This version of GeoHEC-RAS uses Version 6.2.0 of HEC-RAS.

HEC-RAS has the ability to perform one-dimensional (1-D) hydraulic calculations on a range of natural and constructed channels. It also has the ability to conduct a variety of analyses for structures at watercourse crossings. The newly created hydraulic model was used to determine the water surface elevations using the program's steady state analytical methods which are based on gradually varied flow within a subcritical flow regime.

All results provided in this section are based on the future land-use flow conditions, as flood hazard mapping is required for the protection of existing and future developed lands. Hydraulic modelling scenarios were also included for existing land-use conditions, as well as future land-use conditions (with climate change considerations) for assessment of potential impacts climate change may have on regulatory flood hazard limits.

The resultant water surface profiles are considered an accurate representation of the flood elevations during the Regional and 100-year storm events and appropriate for the purpose of Regulatory flood hazard mapping for Conservation Halton.

The following sections present details of the model setup, flood results and discussion at critical locations. This study has fulfilled the project scope and developed flood hazard mapping in accordance with the Provincial Technical Guide - River and Stream Systems: Flooding Hazard Limit (MNRF, 2002).

5.1 HYDRAULIC MODEL INPUT PARAMETERS

5.1.1 STREAM NETWORK

The delineated stream network provided by CH was prepared from 2018 LiDAR digital elevation models, topographic survey and aerial orthophotography. A total of 18 reaches were defined as significant tributaries within the area for flood hazard mapping. In total, mapping was prepared for ~26km of watercourse.

5.1.2 FLOW INPUT

Peak flows determined by the VO hydrologic model have been inputted directly into HECRAS at select locations along each reach. Essentially, a new flow was added where there was a significant flow change. Flow changes would occur either due to the addition of more drainage area or due to the application of an areal reduction factor. While all flow information for design storms and the Regional storm were included, the regulatory floodline is defined by the greater of the 100-year and Regional storm. In all instances, flows recorded at a downstream point of interest would be inserted through the upstream section of the reach. For example, in **Figure 5.1**, flows derived at the road crossing 677 would be inserted through the entire reach at section 878. Flows at points of confluence between major reaches or trunk sewers are incorporated directly at the point of confluence, as it would not be appropriate to convey flows at point of confluence further upstream.

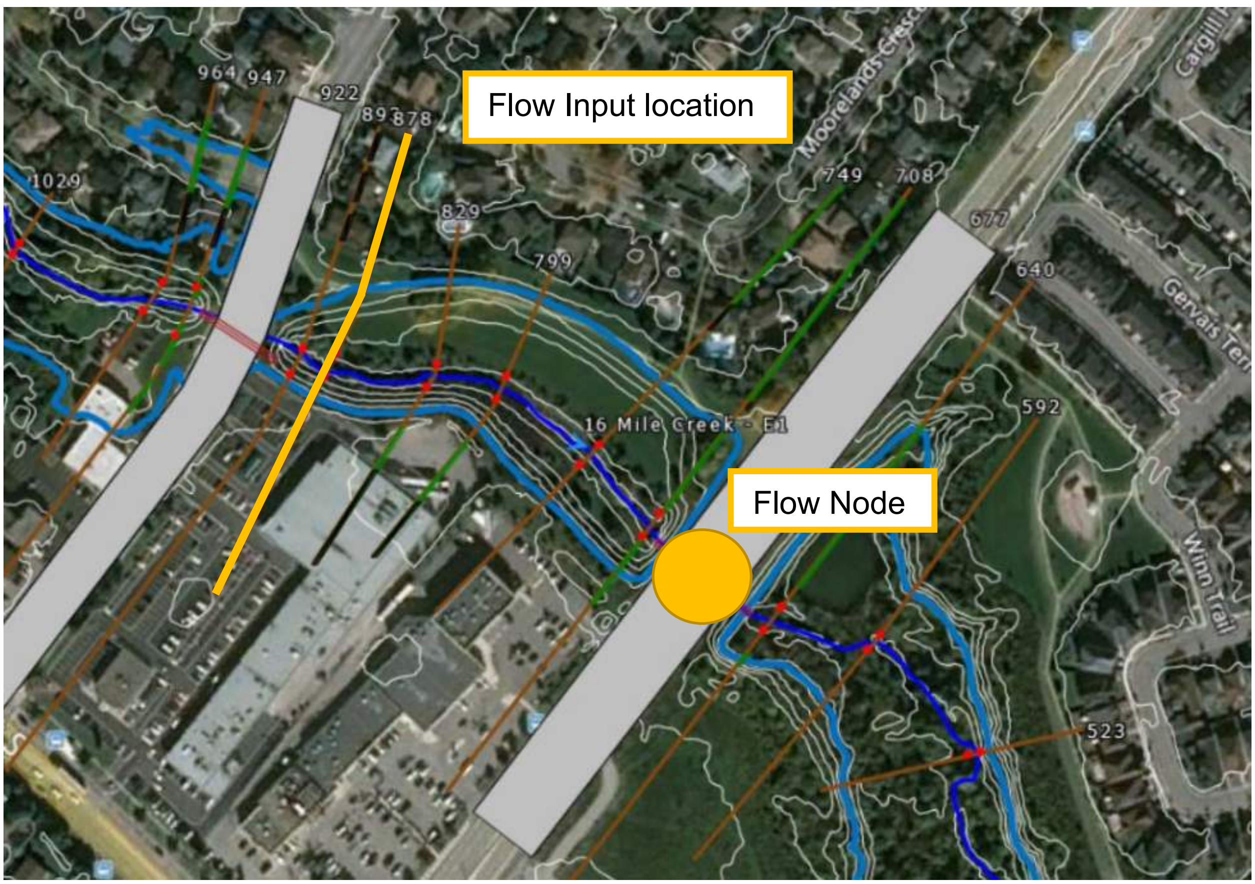


FIGURE 5.1: INCORPORATION OF FLOWS INTO HYDRAULIC MODEL

Best efforts were made to ensure flow node changes were less than 10% throughout the study reach, however, this is not always achievable at specific areas of confluences between reaches.

Provided in **Figure 5.2** is a layout of the reaches through the study area. The steady flow data contained in the model is presented in **Table 5.1** below**,** with the corresponding river station where the flow change occurs. The greater of the Regional and 100-year storm event is underlined. Due to the slight variability in peak flows caused by the application of aerial reduction factors and the routing of flows, not all nodes for a given reach were included in the hydraulic model. Generally, only flows which resulted in a positive increase while flowing downstream were used, however, an exception to this approach was made for the Sixteen Mile Creek spill, recognizing the greater routing potential and importance of timing differences.

5.1.3 FLOW REGIME AND LIMITATIONS

All hydraulic modeling was simulated under steady state and under subcritical flow conditions. Supercritical flow conditions were not examined. This procedure is consistent with MNRF, provincial and CH guidance, and recognizes the potential that super-critical flows may not be maintained under flood conditions due to potential for debris jams, etc.. Subcritical calculations within HEC-RAS are generally dominated by gravitational forces, while supercritical flow is based on momentum / inertia.

While conducting the subcritical flow analyses using backwater and standard step method, if a critical flow condition was encountered, the greater of the critical flow depth or downstream water surface elevation was reported as the flood elevation. This could indicate that the actual flow regime at these locations is more representative of supercritical flow, typically common in areas of shallow depth and high velocities and is often found in engineered channels.

Flood elevations determined by the hydraulic model are based on the assumption that during major flood events flow are in a subcritical regime. Subcritical flow is dominated by gravitational forces and behaves in a slow or stable way. Where the model assumes or forces conditions to a lower critical depth, its possible that the flow transitions to a supercritical regime. Where the transition is from supercritical to subcritical occurs, a hydraulic jump may occur. This will be seen as very localized change in surface water elevation. The use of a steady-state hydraulic model has limitations, as it can only determine the occurrence of a hydraulic jump as a static condition in both time and location. The reality is flow variability during a flood event will result in the transient occurrence and location of hydraulic jumps or when flows go from subcritical to supercritical and back to subcritical regimes. For this reason, the preference was to use subcritical flood elevations to define the limits of the flood hazard.

Figure 5.2: Reach Layout

Flood Hazard Mapping - Urban Milton
Sixteen Mile Creek
Project No.19-609

0 1,000 2,000 m

NAD 1983 UTM Zone 17N

Legend

Railway Lines
River Reaches

Greck

March 2020

Basemap Image Google Maps 2019.

Catchments delineated via PCSWMM by Greck and Associates Limited, January 2020

TABLE 5.1: SIXTEEN MILE CREEK PEAK FLOWS WITHIN HYDRAULIC MODEL

Reach	Location	HEC-RAS Section	Regional (m^3/s)	100-year (m^3/s)
E1	Ontario Street	1463	18.31	33.97
E1	Laurier Avenue	878	35.95	64.27
E1	Derry Road	592	46.88	78.33
IND1	North of 5 Side Road (at Spill Crest)	3299	29.47	12.01
IND1	5 Side Road	2924	20.24	11.06
IND1	Highway 401	443	20.16	11.27
IND12	Railway Crossing	309	32.88	21.21
IND5	Highway 401	730	16.34	7.00
IND9	Harrop Drive	527	5.49	5.53
M1	At Confluence (south of Steeles)	1313	162.50	131.78
M1	Highside Drive	958	164.54	135.90
M1	Woodward Avenue	593	175.63	147.21
M1	Railway Crossing	304	176.47	147.99
M2	Main Street	2438	387.03	220.30
M2	Pine Street	2180	385.01	221.57
M2	Parkway Drive	1282	395.12	231.74
M2	Laurier Avenue	606	396.35	226.74
M2	Derry Road	315	383.14	217.19
M3	West of Ontario Street (25)	9241	411.41	229.99
M3	Ontario Street (25)	8242	416.66	233.97
M3	Louis St. Laurent Avenue	7809	420.44	215.02
N1	5 Side Road	387	17.25	8.80
N2	5 Side Road	211	16.48	8.44

Reach	Location	HEC-RAS Section	Regional (m^3/s)	100-year (m^3/s)
N3	South of 5 Side Road	2941	41.07	27.01
N3	South of Pond Outlet	1719	40.95	21.07
N3	Ontario Street (25)	1355	55.74	42.31
N3	Highway 401	698	57.90	41.01
N4	Railway Crossing	524	94.14	66.61
N4	Steeles Avenue	172	94.51	67.29
NW1	Tremaine Road	3095	20.44	11.50
NW1	Highway 401	2459	29.93	25.79
NW1	3 Side Road	1942	31.17	24.11
NW1	Peru Road	1339	34.15	22.32
NW2	Pond Outlet	676	18.15	<u>33.20</u>
NW3	Downstream of Highway 401	1127	50.50	42.70
NW3	Martin Street	490	52.99	45.67
NW3	Railway Crossing	96	53.35	45.31
NW4	At confluence (north of Steeles Avenue)	397	66.22	63.61
NW4	At Steeles Avenue	207	67.66	64.45
NW6	Market Drive	1890	11.75	<u>18.77</u>
NW6	Railway Crossing	1400	13.82	<u>19.96</u>
W1	Kelso	6800	246.98	64.01
W1	Kelso Road	5721	252.69	65.13
W1	Upstream of Peru Road	3832	255.50	66.25
W1	Downstream of Peru Road	3124	255.34	66.53
W1	Steeles Avenue	1849	253.56	66.81
W1	Upstream of Mill Pond	675	253.99	67.08

The use of a steady-state hydraulic model has limitations when determining hydraulic jumps, as in reality, the riverine system does not undergo steady state conditions. In other words, when a lower supercritical flow condition is determined at a given location, this condition could result in a higher flood elevation as flows vary during the event and the regime transitions to subcritical.

A review of all HEC-RAS results was completed for the Regional and 100-year floodlines. At any instance where the computed flood elevation defaulted to critical depth, the flood elevation was reviewed to determine if the flood elevation was reasonable based on downstream flood elevations. In all cases, the assumption of critical depth was considered reasonable, as there were no significant changes in flood elevations from upstream to downstream sections.

5.1.4 BOUNDARY CONDITIONS

HEC-RAS requires the user to specify a downstream starting water surface elevation for the steady state, subcritical analysis. A normal flow depth boundary condition was applied at the downstream of the study limit (south of Britannia Road). A normal flow depth assumes there are no downstream backwater effects. Downstream of Britannia Avenue there is a considerable length of channel (over 3km) with no culvert or bridge obstruction and as such, a normal flow depth was considered reasonable. Normal flow depth boundary condition was determined via GeoHEC-RAS, which is derived based on the downstream 2 sections geometry and slope.

5.1.5 CROSS SECTIONS

The geometric data used for cross sections in the hydraulic model was extracted from the Digital Elevation Model (DEM) using tools in GeoHEC-RAS. Since LiDAR does not return laser points for any ground below the water surface, it was necessary to supplement these areas with surveyed data to create accurate river geometry. Bathymetric survey points were taken in various channels, up to the top of bank, throughout the study area.

The DEM is a crucial component in the development of cross sections. The use of GeoHEC-RAS ensures spatial reference of geometry data when imported into HEC-RAS. Cross sections were cut in the LiDAR-derived DEM.

Cross sections are cut at culvert crossings, bridges and other areas where flows may be restricted including abandoned structures and at locations of narrowing valley lands.

The location and orientation of the cross sections are chosen based on a combination of aerial photography and contour data, locations from past studies, site reconnaissance and general knowledge of the floodplain. Cross sections are generally located in areas that represent the average channel geometry within a reach, where there may be abrupt changes in geometry or slope and at the appropriate road crossing locations.

In several locations the cross-sectional geometries became complex and at times may appear to misrepresent the channel location. The complexity in the location of cross sections originates from two significant characteristics within the urban Milton study area. These characteristics include major historical realignment and channelization of the watercourses, and numerous railway crossings which result in significant obstructions to flood flows. Typically, sections were cut to represent the major flood flows and not to flows that might occur for minor storm events.

5.1.6 BANK STATIONS

Bank stations generally represent the top of a stream bank at a location where, if flow exceeded the bank elevation, it would spread within the floodplain. HEC-RAS uses bank stations to subdivide the cross section in channel and overbank flow areas and to identify the location where the roughness coefficient changes for the overbank area. HEC-RAS subdivides each cross section to determine the conveyance capability of the channel and within the left and right overbank areas. When the user chooses to use multiple Manning's "n" values for a section (e.g., more than three), the section is subdivided based on the horizontal change in roughness.

Bank station locations within the model are based on collected survey data, aerial photography and elevation data along with available pictures of the channel.

5.1.7 INEFFECTIVE FLOW AREAS

Ineffective flow areas were introduced at each culvert or bridge crossing and as needed at selected cross sections in accordance with recommendations contained in the HEC-RAS manual. The ineffective area was generally used where flood water will occur but was considered to not contribute to conveyance of flow.

For example, the upstream bounding cross section at a bridge/culvert crossing has ineffective flow area with an elevation at the top deck at locations left and right of the culvert entrance, as this accounts for low velocity, standing water located adjacent to the watercourse crossing. Ineffective flow areas at the downstream bounding cross section, were set to elevations midway between deck and culvert obvert elevations at locations left and right of the culvert opening. The ineffective area elevation at the downstream section was adjusted if it was considered necessary given the nature of the flood flow overtop the roadway.

Several ineffective flow areas were further incorporated into the hydraulic model to account for areas where water is typically not conveyed. For example, some pinch points or flow constrictions require upstream ineffective flow areas, as the conveyance capacity at these sections would be restricted by such a landform.

At selected locations, it was found that the typical indicators used for applying ineffective areas were inappropriate and as such they were removed or lowered. This was largely due to the nature of the significantly high flood flows conveyed through the section or the overtopping of a roadway crossing. This was typically found where a channel was no longer located in its historical floodplain. These historical floodplains became active channels during major flow events. This was considered when it was known that flood flows would be within the historical floodplain areas as determined by upstream flow conditions.

5.1.8 LEVEES

Levees were inserted into the model where needed to contain flows within a lower section of the channel. Without incorporating levees, HEC-RAS assumes water can go anywhere within a cross section. Levees were only inserted in locations where actual movement of water can occur from upstream to downstream when overtopping high ground.

5.1.9 EXPANSION/CONTRACTION COEFFICIENTS

Contraction and expansion coefficients were specified at each cross section to define the energy losses between two cross sections of varying geometry. Where there is minimal change in the geometry or shape of two cross sections, the energy losses will be minimal. If the transition in geometry is abrupt, such as at a bridge or culvert, energy losses will be high. Standard values for contraction and expansion coefficients, as specified in Table 3-3 of the “HEC-RAS River Analysis System Hydraulic Reference Manual” (2016) (HEC-RAS HRM), have been used throughout the current model. By default, all cross sections incorporate contraction/expansion coefficients of 0.1 and 0.3, except for culvert crossings or abrupt transitions. Expansion and contraction coefficients of 0.3 and 0.5 were applied at all culvert and bridge crossings.

In several instances, it was necessary to further modify contraction/expansion coefficients to values of 0.6/0.8, respectively. This was necessary to produce more acceptable results where the riverine valley suddenly increase or expands. This was common in the lower reaches (M1, M2 and M3) where a more natural valley was suddenly confined, typically due to historical fill within the valley.

5.1.10 MANNING'S ROUGHNESS COEFFICIENT

The value of Manning's "n" is highly variable and depends on several factors including surface roughness, vegetation, channel irregularities, channel alignment, scour and deposition, obstructions, size and shape of the channel, stage and discharge, seasonal changes, temperature and suspended material and bedload. The Manning's n values used in the HEC-RAS model were based on the recommendations and guidance from CH.

The main channel Manning's n values ranged from 0.015 to 0.035 and the overbank values ranged from 0.02 to 0.08. These values were determined for each cross section using a combination of a high resolution georeferenced aerial photograph, survey notes and photos. A Manning's n of 0.02 was applied for asphalt/concrete areas within the floodplain, to represent a mixture of asphalt and potential turf covered areas associated with boulevards, parks etc.

5.1.11 BUILDING OBSTRUCTIONS

The effect of a building within the floodplain can have a significant influence on the available conveyance area and energy losses immediately upstream and for a distance downstream of the actual building. Where a building may influence a cross section upstream or downstream, the obstruction has been projected onto the affected section. A significant number of buildings exist within the floodplain through the historical areas developed within Milton.

5.1.12 INLINE STRUCTURES

Inline structures were coded into the hydraulic model in instances where a former watercourse crossing was present, where the embankments of the crossing resulted in a sudden confinement of the valley. Utilizing an inline structure was found to better balance the energy within the model, rather than a new cross section (causing a sudden change in available conveyance area.

5.2 SPECIFIC AREAS OF MODELLING INTEREST

At several locations, special consideration was required to model site specific hydraulic situations. In some cases, the model was adjusted to represent channel hydraulics which at first may not seem consistent with conventional practices. A list of locations which required special modelling attention is provided in **Table 5.2.** This table notes modelling procedure used, with related comments.

Multiple Opening Analyses

At several instances, there were multiple locations where flows could be conveyed through a given stream crossing structure. This situation often occurred when a roadway dipped below the obvert of the adjacent culvert. This often originates from culvert being located away from their historical floodplain location. In other situations, culverts at railway crossing would cause flood waters to spill into an adjacent opening or culvert, providing additional opportunity for flood flow conveyance. Listed in **Table 5.2** are the crossing locations where multiple opening analyses were used.

TABLE 5.2: LOCATIONS OF HYDRAULIC MODELLING REQUIRING SPECIAL CONSIDERATION

Reach	Structure Number	Crossing Location	Notes
M3	8296	8267 to 9078	• Where the stream channel flows parallel and along Regional Road 25, typical culvert/bridge modelling procedures were used, however sections which may be suitable for low flow analyses were removed. • Multiple opening analysis was used at this location
M2	NA	1282 to 1251	• There is a reduction in the effective flow area caused by a loss of floodplain area. This has forced channel flows to reach supercritical flow conditions. Additional sections were included to confirm hydraulic operation of the channel in this reach.
M2	NA	1035, 1214, 1312 to 1353 1500 to 1728 1952, 2095	• Contraction/expansion coefficients of 0.6/0.8, respectively, were applied to account for valley constriction/expansion
M2	2222 and 2436	2180 to 2232	• The typical application of ineffective areas was modified to account for the interpreted occurrence of flood flows in the historic flood plain area at upstream sections. As such, this area will provide flood flow conveyance sooner than might be expected.
M1	NA	120, 958,1189	• Contraction/expansion coefficients of 0.6/0.8, respectively, were applied to account for valley constriction/expansion
M1	NA	120 to 204	• LiDAR data suggest a higher ground elevation upstream in the west floodplain area. The floodplain in this area includes an elevated parking structure which was assumed to have the ability to pass flood flows, based on images from Google Streetview showing multiple at-grade openings. The floodplain was manually adjusted in this area.

Reach	Structure Number	Crossing Location	Notes
W1	NA	Junction DS01 to Section 138	• No sections were provided from the junction until section 138 as this area is located within the floodplain of sections accounted for in Reach M2.
W1	1630, 1772, 5750		• Multiple opening analysis were used at these locations as the flood elevation was often below the obvert of the culvert or bridge. At section 1772 flood water will rise and spill though additional openings in the railway embankment.
NW4		53 to 293	• The floodplain for this portion of Reach NW4merges with the floodplain in Reach N4. A lateral structure was incorporated between the two reaches to account for spill between the reaches.
NW6	1460		• The culvert in the railway embank occurs at the confluence of two rail lines. In the space where they converge there is a break in the culvert where ponding is known to occur. This break in the culvert was not modelled due to limitations within modelling to accurately represent site conditions. A single length of culvert was used through the embankment. Since flood water rises significantly upstream of the railway embankment the section was extended to consider the potential for flood waters to pass through the opening in the embankment at Steeles Avenue. • Multiple opening analysis was used at this location.
NW3	185		• Due to several inflows and openings in the railway embankment a manual water balance was performed at this location. This was only performed to establish a uniform flood elevation upstream of the railway embankment. This required increasing the flow rate upstream of the railway embankment in Reach NW3. Downstream flow rates were not altered. Flow rates for storms less than the 100-year event were not altered. • Multiple opening analysis were used at this location.
NW1		1357 to 2635	• Reach requires further review and updating due to recent channel realignment through area. Works to be completed under a separate cover.

Reach	Structure Number	Crossing Location	Notes
NW1	1973		• Multiple opening analysis were used at this location.
NW1	2749		• Flood water spills to the adjacent eastern culvert under Highway 401. Flows are received by the same tributary downstream. No data is currently available for this culvert, and it cannot be addressed at this time. Flood elevations may be less than modelled, but will be updated at a later date to account for recent channel realignment, as outlined above.
N3	34		• Due to several inflows and openings in the railway embankment a manual water balance was performed at this location. This was only performed to establish a uniform flood elevation upstream of the railway embankment. This required decreasing the flow rate upstream of the railway embankment in Reach N3. Downstream flow rates were not altered. Flow rates for storms less than the 100-year event were not altered.
N4		65 to 249	• The floodplain for this portion of Reach N4 merges with the floodplain in Reach NW4. A lateral structure was incorporated between the two reaches to account for spill between the reaches.

6.0 RESULTS OF HYDRAULIC ANALYSIS

Summaries of the hydraulic analyses provided by the HEC-RAS program are provided in **Appendix H**. These results were used to prepare the flood hazard mapping. Presented below is a discussion on site specific findings of the hydraulic analyses. The locations of the structures are outlined in **Figure 6.1**.

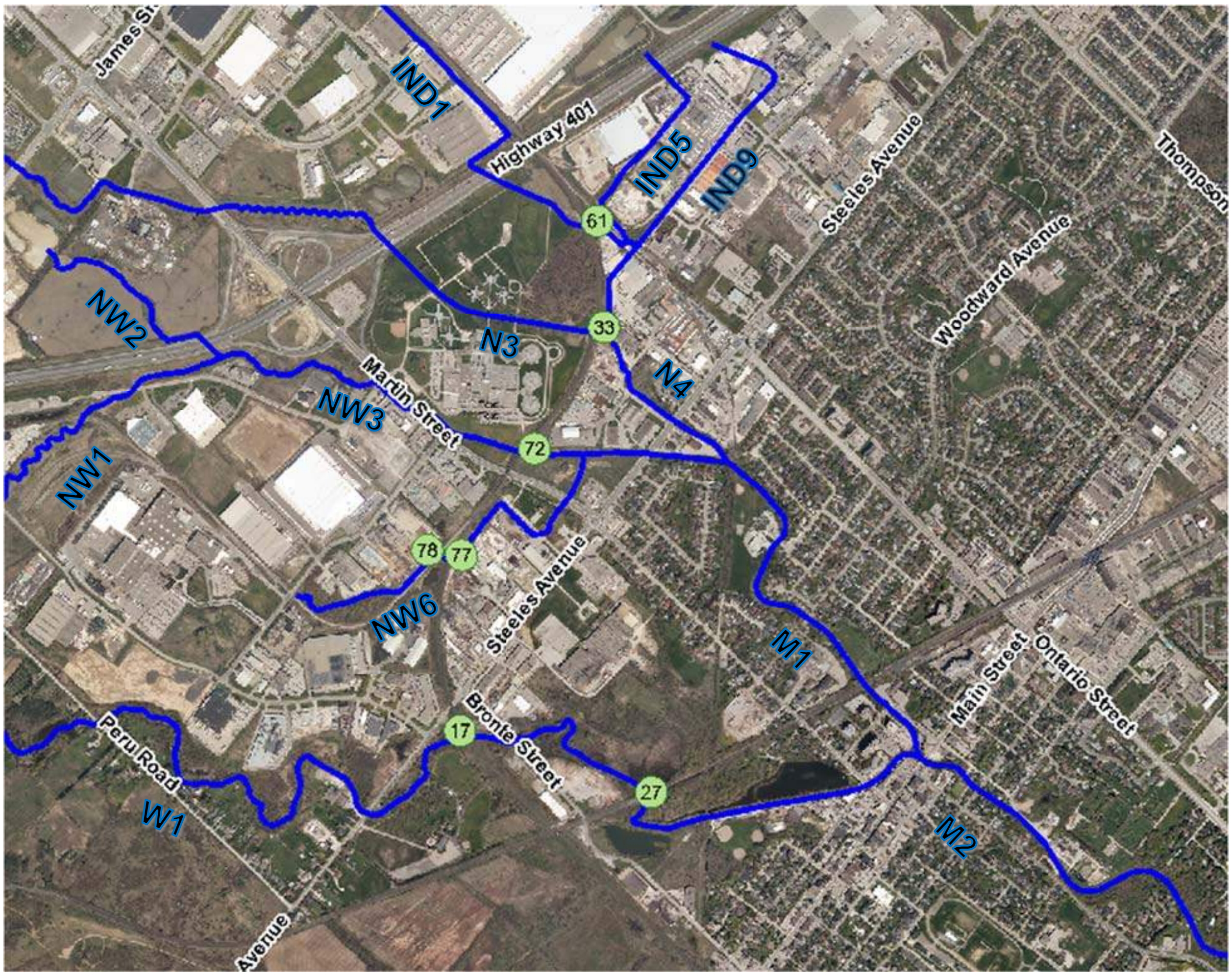


FIGURE 6.1: SIGNIFICANT STRUCTURE LOCATIONS

Reach M1 – (Structure #27) Railroad Crossing in between Martin St. and Ontario St. N

A culvert at this railway crossing causes a backwater effect. This backwater results in the further backwater conditions at upstream culvert crossings, which in-turn further impacts flood elevations upstream.

Reach N3, IND1 and NW3 – Structure #33 (N3), Structure #61 and Structure #72 (NW3) - Railroad Crossings

During the 100 year and the Regional event, the culverts under the railroad crossing at Reach N3, IND1 and NW3 cause backwater effects. The area becomes significantly inundated by flood waters, and spill occurs from Reach N3 to NW3 and IND1. Eventually flows will spill towards a railroad crossing on Martin Street. To model the relief flow provided by the railroad crossing, a multiple opening analysis was conducted for Reach NW3. A secondary hydraulic model was then created where flows at Reach N3, NW3 and IND1 were directed to one flow node, and the three crossings were modelled as one single structure. Reaches N3 and NW3 applied a consistent flood elevation, however, IND3 applied a higher flood elevation due to the difference in elevation between IND3 and the two other reaches.

Reach W1 – Structure #17 - Railroad Crossing

During the 100 year and the Regional event, the culverts under the railroad crossing at Reach W1 cause backwater effects. The area becomes inundated by flood waters, and eventually flows will spill towards railroad crossings located north of the culverts on Steeles Ave E and south of the culverts between Steeles and Bronte St. N. In order to model the relief flow provided by the railroad crossing, a multiple opening analysis was conducted for Structure 17 on Reach W1. Some spill of flood water can be anticipated to lands south of the two railway crossings.

Reach NW6 – Structure 77 and 78

Structure 77 and Structure 78 are located on Reach NW6. The two culverts are in series with Structure 78 located upstream of Structure 77 and are located on railroad tracks with steep embankments. The tracks converge as they approach Martin St. where there is a railroad crossing bridge. In between the tracks there is ponding water. Structure 77 is a smaller culvert than Structure 78 and during larger storm events it causes backwater effects, however the railroad crossing bridge on Martin St. provides relief flow. Relative to Reach NW6, the limits of the railroad crossing bridge are upstream of Structure 77 and downstream of Structure 78, therefore, to appropriately model the relief flow and produce an accurate floodline, Structure 77 and 78 were modelled as one structure.

7.0 FLOOD HAZARD MAPPING

Flood hazard maps prepared as part of this study have been created according to the Federal Geomatics Guidelines for Flood Mapping, Version 1.0 authored by Natural Resources Canada. A total of 16 map sheets are provided.

The floodlines were modelled on a DEM with a grid resolution of 1.0m. The DEM was created by Airborne Imaging using LIDAR data collected in Spring 2018. The contours are displayed in 0.5 m intervals and are generated from the DEM. Selected spot elevations have been added as surveyed by Greck in 2019.

The planimetric data on the map was acquired from CH in 2019. Within the scope of the study, all structures are labelled with the structure ID and the cross sections from the hydraulic model have been imported. The cross sections have been labelled with the river station number associated with the hydraulic model along with the respective water surface elevations during the 100 year and Regional storm events.

Buildings were identified and digitized based on orthoimages. The structures that encroached onto the floodline were identified and highlighted on the flood hazard maps as structures at risk. The extent of the floodlines was based on a combination of automated lines prepared by the Geo Hec Ras software. While automating floodline generation within GIS software can often provide a quick and efficient floodline mapping, they can often result in localized inaccuracies. As such, the floodlines have been manually drawn between each cross section where necessary to ensure floodlines follow contours and anticipated flow paths appropriately.

A floodline has been plotted for both the 100-year and Regional Storm events. The regulatory floodline is defined by the greater of the Regional and 100-year storm events and has been filled in with a colour shading. For each cross section, areas where the 100-year flood elevation exceeds the Regional have been indicated with a square box. Otherwise, a circle has been included for areas where the Regional Storm event is the governing event.

A total of 16 map sheets have been created in both PDF and CAD format. PDF drawings are available in both ARCH D and Tabloid (11x17) paper sizes. Map sheets are included in **Appendix H**.

7.1 STRUCTURES AT RISK OF FLOODING

Bridge and culvert crossings undergo flooding during various storm events. Provided in **Table 7.1** and **Table 7.2** is a summary of each watercourse crossing that undergoes flooding, outlining the specific storm event and the severity of flooding. Typically, a depth-velocity product that exceeds 0.4 m^2/s has sufficient shear forces to injure a small child (MNRF, 2002) and therefore, such structures cannot provide safe pedestrian ingress/egress. Depths in excess of 0.3 m provide difficulty for vehicular access.

Specific bridges that pose a risk to ingress/egress have been listed in **Table 7.1** and **Table 7.2**

While more significant storm events may produce higher depths of flooding, several of these structures are fully submerged and affected by downstream backwater effects, and therefore have lower velocities for the major storms. For these structures, a smaller storm event that may have no backwater effect can produce a higher velocity over the road.

7.2 LOCATIONS OF SPILLS

At selected locations it may not be possible to contain all flood flows within the natural floodplain of Sixteen Mile Creek. This can occur for a variety of reasons however the most common is associated with the limited conveyance of flood water past roadways and or naturally level terrain.

In other cases, the flood water from converging channels may spill into each others' floodplain. If the differences in the flood elevation were significant at converging channels a manual energy balance was performed.

For the purposes of this study the possible loss and or reduction in flow associated with a spill of flood water was not considered in the hydrologic and or hydraulic modelling. The amount of spill is generally minor. While the hydraulic conveyance of these flood flows may be exceeded, the LIDAR data was sufficient in most cases to indicate the area of spill and was typically based on catchment delineation (as per the hydrologic assessment).

Locations of spill are illustrated on all map sheets, where applicable.

TABLE 7.1: BRIDGES AT RISK OF FLOODING

Location	Reach-River Section	Storm Event	Max Depth of Flooding (m)	Velocity over Road (m/s)	Depth-Velocity Product (m^2/s)
Kelso Road	W1-5750	Regional	0.44	0.75	0.33
Tremaine Road	W1-5161	Regional 100-year	0.87 0.21	1.40 0.65	1.22 0.14
Peru Road	W1-3610	Regional 100-year	1.27 0.39	1.55 0.83	1.97 0.32
Steeles Avenue	W1-2227	Regional 100-year	5.36 0.46	NA 1.07	NA 0.50
Bronte Street	W1-1630	Regional 100-year	2.59 0.11	NA 0.40	NA 0.04
Trail off of Garden Lane	W1-607	Regional 100-year	1.79 1.12	NA 0.81	NA 0.91
Holy Rosary Elementary School	M1-510	Regional 100-year	5.50 4.42	NA NA	NA NA
Holy Rosary Elementary School	M1-445	Regional 100-year	5.64 4.36	NA NA	NA NA
Main Street East	M2-2426	Regional 100-year	1.48 0.83	1.56 1.31	2.31 1.09
Pine Street	M2-2222	Regional 100-year	2.78 2.01	1.21 0.90	3.36 1.81
Parkway Drive	M2-1322	Regional 100-year	3.14 1.90	2.04 1.88	6.40 3.58
Laurier Avenue	M2-651	Regional	0.31	0.85	0.26
Regional Road 25	M3-8296	Regional	0.10	NA	NA
Britannia Road	M3-5805	Regional	0.95	1.59	1.51

TABLE 7.2: CULVERTS AT RISK OF FLOODING

Location	Reach-River Section	Storm Event	Max Depth of Flooding (m)	Velocity over Road (m/s)	Depth-Velocity Product (m^2/s)
Harrop Drive	IND5-716	Regional	0.42	0.66	0.28
		100-year	0.18	0.68	0.12
Railroad Crossing	IND5-94	Regional	0.70	1.22	0.85
		100-year	0.41	0.85	0.35
Chris Hadfield Way	NW6-985	Regional	1.74	0.27	0.47
		100-year	1.82	0.52	0.96
Railway Crossing	NW6-840	Regional	0.20	0.62	0.12
		100-year	0.27	0.74	0.20
5 Side Road	IND1-2969	Regional	0.43	1.03	0.44
		100-year	0.27	0.82	0.22
Informal Crossing	IND1-2302	Regional	0.35	0.92	0.32
		100-year	0.26	0.79	0.21
Informal Crossing	IND1-997	Regional	1.11	1.46	1.62
		100-year	1.11	1.56	1.74
Railroad Crossing	IND1-191	Regional	0.19	0.64	0.12
		100-year	0.12	0.49	0.06
Railway Crossing	IND12-247	Regional	0.63	1.05	0.66
		100-year	0.46	0.83	0.38
Highway 401	NW1-2757	Regional	0.19	0.57	0.11
3rd Sideroad	NW1-1973	Regional	0.75	NA	NA
		100-year	0.72	NA	NA
Peru Road	NW1-1357	Regional	0.95	NA	NA
		100-year	0.80	NA	NA
Chisholm Drive	NW1-304	Regional	0.20	0.63	0.13
Highway 401	NW2-66	Regional	1.31	1.77	2.31
		100-year	1.31	1.77	2.31
Chisholm Drive	NW3-709	Regional	0.62	1.04	0.65
		100-year	0.51	1.11	1.08
Private Crossing	NW3-656	Regional	0.63	0.86	0.54
		100-year	0.52	0.91	0.47

Private Crossing	NW3-574	Regional	0.99	0.68	0.67
		100-year	0.69	0.44	0.30
Steeles Avenue	NW4-248	Regional	0.52	1.03	0.54
		100-year	0.43	1.14	0.49
James Snow Parkway	N3-2148	Regional	0.20	0.84	0.17
Private Driveway	N3-1686	Regional	0.29	0.81	0.24
Regional Road 25	N3-1411	Regional	0.38	0.88	0.26
SWM access Road	N3-943	Regional	2.30	0.57	1.31
		100-year	2.16	0.49	1.06
James Snow Parkway	N3-782	Regional	0.59	1.10	0.65
		100-year	0.45	0.99	0.44
Railroad Crossing	N3-34	Regional	0.40	0.95	0.38
		100-year	0.26	0.78	0.28
Wheelabrator Way	N4-444	Regional	1.13	1.67	1.89
		100-year	0.80	1.50	1.20
Steeles Avenue	N4-213	Regional	0.94	1.58	1.48
		100-year	0.67	1.30	0.87
Martin Street	W1-189	Regional	1.29	1.29	2.25
		100-year	0.94	0.78	0.73
W.I. Dickie Middle School	M1-989	Regional	3.06	0.57	1.74
		100-year	1.92	0.94	1.80
Woodward Avenue	M1-624	Regional	4.47	0.25	1.10
		100-year	3.19	0.32	1.01
Railway Crossing	M1-353	Regional	0.20	0.61	0.12
Laurier Avenue	E1-922	Regional	0.02	0.25	0.01
		100-year	0.49	1.06	0.52
Derry Road	E1-677	100-year	0.50	1.10	0.55
Regional Road 25	E1-65	Regional	0.54	1.37	1.25
		100-year	0.91	1.37	1.25

8.0 SUMMARY AND CONCLUSIONS

Greck and Associates Limited has provided updated hydrologic modelling for upper reaches of the West Branch and a portion of the Middle Brach of Sixteen Mile Creek and hydraulic modelling and flood hazard mapping for select reaches of the West Branch of Sixteen Mile Creek located primarily within the urban area of the Town of Milton. This is a product of technical analyses and has considered input from the Technical Advisory Committee and public consultation. Key aspect and results of this study are summarized below:

8.1 HYDROLOGY

1. Visual OTTHYMO was an applicable hydrologic model to quantify peak flows through the watershed. The hydrologic model was for 11,817 ha of the West Branch of 16 Mile Creek watershed and 4,109ha of the Middle Branch of Sixteen Mile Creek.

2. The hydrologic model was reasonably calibrated for existing land-use conditions to a low intensity, long duration rainfall event during AMC III like condition which reflects the level of saturation which may occur during a Hurricane Hazel event. The model was not calibrated relative to frequent storms.

3. Model calibration and validation were focused to the upper portion of the watershed where stormwater management facilities are generally not present. The lower portion of the watershed with urban flow contributions was used for model validation to volume only.

4. An inter-basin spill was assessed from the Middle Branch to the West Branch of Sixteen Mile Creek via an unsteady-state hydraulic model.

5. The calibrated hydrologic model was used to determine peak flows for flood hazard mapping purposes. Consideration for select municipally owned stormwater management facilities at low risk of failure was applied in the event-based modelling, but not for the Regional Storm. No dams were included for derivation of peak flood flows.

6. A sensitivity analysis was performed by varying hydrologic parameters to test the model sensitivity due to assumed or unknown parameters. This was used to understand potential model limitations that may arise given data limitations, making it difficult to fully calibrate the model. It was concluded that the model was within anticipated ranges of sensitivity.

7. A flood frequency analysis was completed at the Milton Flow gauge. The results of the flood frequency analysis were noted to be significantly lower than deterministic modelling, as is typical in such assessments.

8.2 HYDRAULICS

8. A new hydraulic model was developed using GeoHEC-RAS software for 26 km of watercourse and involving 81 crossing structure.

9. An inventory and survey of 81 crossing structures was completed and incorporated into the hydraulic model.

10. Several hydraulic structures/watercourse crossings were considered at risk to flooding for the 100-year and Regional events.

8.3 FLOOD HAZARD MAPPING

11. Sixteen flood hazard mapping sheets were prepared. The mapping base includes topographic information derived from LiDAR data, site specific topographic survey at stream crossing structures and planimetric information including roads, buildings and selected features.

12. Currently 327 buildings have been identified in the designated flood hazard area. It should be noted that these buildings vary from commercial, residential, industrial structures and include sheds, garages and/or permanent storage containers.

9.0 RECOMMENDATIONS

The modelling and mapping are appropriate for use in the administration of Ontario Regulation 162/06 and land-use decision making subject to any additional refinements made by Conservation Halton related to the relocated channel by Peru Road identified as being updated under a separate cover.

The flood hazard mapping is a reasonable estimate of the anticipated Regulatory flood hazard. The following recommendations identify areas where model refinements should be considered, as appropriate, in future studies to improve the understanding of flood hazards and risks. Other refinements may be undertaken at a subwatershed or site-specific level as new data and technical analysis become available.

1. <u>Subcatchment and Urban Routing Refinements:</u> As this was a watershed scale study, the delineation of subcatchments was performed utilizing a GIS based tool and refined based on local knowledge shared by members of the TAC. With TAC support, significant dual drainage outlets were also identified and included within

the model through the use of a DivertHYD command (i.e., at underpasses, and for the Escarpment Business Community SWMF, trunk sewers etc.). Overall, subcatchment delineation and routing was found to be reasonable; however, further refinement may be appropriate as part of a more detailed level of study. It is recommended that future studies consider further refinements to subcatchment delineations and urban routing, as necessary, to support the intended uses.

Catchment refinements apply to both:

a) Areas of low topographic relief such as wetlands and
b) Urban areas in which dual drainage systems and SWMF may have altered natural overland drainage routes.

Routing refinements should be considered particularly in urban headwater areas where the 100 year design storm defines the flood hazard limit, where it may be appropriate to include further assessment of the major and minor drainage systems (dual flow) and pipe flow routing in the hydrologic model to:

a) Consider more defined flow paths/outlet points,
b) Ensure attenuation of flows has been adequately accounted for, and
c) That the routing of flood flows via all storm trunk sewers has been included.

2. Inclusion of SWMF: The hydrologic modelling completed as part of this study did not include the operation of several existing and proposed future stormwater management facilities. These facilities may have included a variety of dry and or wet detention ponds, parking lot and roof top storage and or underground detention tanks. The full extent of these types of facilities is currently unknown. The approach used was intended to meet current provincial guidelines for regulatory flood plain mapping. Not including these detention facilities has limited the potential for calibration of the hydrologic model to more frequent storms. It is recommended that future hydrologic modelling assess the impacts and or benefits of all existing and any currently approved but not yet constructed SWMF if a more complete understanding of potential flood risks other than the regulatory flood hazard delineation is of interest.

3. Spill Areas – Areas for Future 2D Modelling: Additional assessment should be considered at locations where substantial spill, cross flow or combined flow occurs. There are several locations where hydraulic structures (i.e., Railway Embankments, Highway 401, etc.) have resulted in the spill of flows to adjacent watercourses within the same or adjacent subcatchment. This study uses manual adjustments of flows for energy balances, which provides a reasonable result for the purposes of supporting Conservation Halton's Approximate Regulation Limit mapping. To support site specific work proximate to such areas, consideration

should be given to the use of alternative computer modelling methods such as a 2D modelling which incorporate the use of unsteady flow analyses and the dynamic utilization of floodplain storage. If 2D modelling is pursued, the methodology applied must be adapted to ensure consistency with provincial direction related to the definition of the flood hazard.

4. Flow Monitoring Network: An expanded flow monitoring network is recommended, as funding permits, to improve the calibration of hydrologic and hydraulic models in future studies.

10.0 REFERENCES

City of Pickering Stormwater Management Guidelines, July 2019

Federal Geomatics Guidelines for Flood Mapping, Natural Resources Canada, 2019

Federal Hydrologic and Hydraulic Procedures for Flood Hazard Delineation, Natural Resources Canada, 2019

Federal Airborne LiDAR Data Acquisition Guideline, Natural Resources Canada, 2022

Floodline Mapping Study of Sixteen Mile Creek: Technical Report, Proctor and Redfern Ltd., 1988

Functional Servicing Report, Escarpment Business Community (West), MGM Consulting Inc. May 2007

Functional Stormwater and Environmental Management Strategy – Highway 401 Industrial/Business Park Secondary Plan Area, Town of Milton, Phillips Engineering Ltd., July 2000.

HEC-RAS River Analysis System – Hydraulic Reference Manual, Version 5.0 February 2016

Scotch Block Dam Spill Assessment, Conservation Halton, Phillips Engineering Ltd. December 2005

Sixteen Mile Creek Subwatershed Planning Study, Areas 2 & 7, Town of Milton, (Technical Appendix Stormwater Management), Phillips Planning & Engineering et. al., January 2000.

Sixteen Mile Creek Watershed Plan, Prepared in Support of the Sixteen Mile Creek Watershed Plan and Halton Urban Structure Plan & Technical Report 1 Model Calibration, Gore & Storrie Ltd. et. al 1995

Sixteen Mile Creek, Areas 2 & 7 Subwatershed Update Study (SUS), AMEC Environment &Infrastructure et. al., November 2015.

Storage and Operations Optimization Study Hilton Falls Reservoir, Phillips Engineering Ltd., April 2005

Technical Guide - River and Stream Systems: Flooding Hazard Limit, Ontario Ministry of Natural Resources, 2002

Town of Milton Official Plan, 2008

United States Department of Agricultural: Part 630 Hydrology – Natural Engineering Handbook Chapter 15: Time of Concentration, May 2010

United States Department of Agricultural: Part 630 Hydrology – Natural Engineering Handbook Chapter 15: Time of Concentration, May 2010

Visual OTTHYMO User's Manual Version 5.1, Civica Infrastructure Inc., July 2018

APPENDIX A: PUBLIC CONSULTATION

Summary of Public Consultation

Urban Milton Flood Hazard Mapping Study - PIC 1: October 1, 2019

Newspaper Ads:

- Ads ran September 19th and 26th, 2019 in the Milton Champion and Halton Hills IFP – See sample ad attached

Social Media:

- Notices for PIC 1 were placed on CH Twitter and Facebook feeds

Stakeholder Mailing:

- A targeted e-mail message was sent out to identified stakeholders September 20, 2019 (mailing list and e-mail are attached.

Response to Community Questions:

- E-mail Exchanges are attached
  - Marina Huissoon (October 12, 2019)
  - Jeff McColl (October 14, 2019)
  - Ken Armstrong (October 20, 2019)
  - Region of Halton (October 22, 2019)
  - Hydro One (November 18, 2019)

Website Content

- PIC 1 content was uploaded to Conservation Halton's website October 3, 2020 and remained available until March 25th 2020, when it was replaced with content from PIC 2.

PIC 1 Content:

- PIC 1 Technical Display Boards (attached)
- Sign-In Sheet (attached)
- Completed Comment Card (attached)

The PIC also included booths on Emergency Preparedness (Region of Halton) and Flood Forecasting and Warning (Conservation Halton)

... OPPORTUNITY ... RMERS

eggs from their own backyard as early as next spring.

Town staff were directed to report back to council in the spring regarding backyard chicken coops, at the Sept. 9 council meeting.

"Residents kept contacting me and asking about backyard chickens," Coun. Clark Somerville said.

A number of municipalities have given the go-ahead for urban farmers to install coops in their yard, and Halton Hills staff will look at what's already in practice regarding setbacks, required staffing and eligible yard sizes.

"To be realistic, if we said we didn't know people have them now, we'd be fooling ourselves," Somerville said.

However, Somerville said, there has been only a single complaint lodged regarding a chicken keeper, and it was because of a rooster.

"If you want eggs to eat, you're not going to have a rooster," Somerville said.

While there is certainly an interest in raising backyard chickens, Somerville said, residents do have concerns, ranging from predators, to cleanliness, to diseases.

Another concern is what residents will do with spent hens — hens no longer laying eggs.

"We are at the beginning of the process," Somerville said.

In municipalities that allow backyard chickens, a number of small businesses that essentially rent chickens and coops seasonally give would-be urban farmers a chance to experience the process without committing to a lifetime of fowl play.

In the coming months, Halton Hills staff will seek public consultation online at Let's Talk Halton Hills, regarding backyard chickens.

Metroland/Photo

A Cambridge committee has nixed the idea of allowing residents to keep backyard hens on their properties.

THE ISSUE: BACKYARD CHICKENS

LOCAL IMPACT: AS EARLY AS NEXT SPRING, RESIDENTS COULD BE RAISING LAYING HENS IN THEIR BACKYARDS THROUGHOUT HALTON HILLS.

STORY BEHIND THE STORY

A Halton Hills councillor raised the issue on social media sparking an ongoing discussion among residents. At town council a motion was passed for staff to report back on the logistics of allowing residents to keep chickens.

Stakeholder Consultation List for Urban Milton Flood Hazard Mapping Study

to Receive Notification of PICs, etc. through e-mail

Agencies				
	CAO	Hassaan Basit		
	Associate Director, Engineering	Janelle Weppler		
	Associate Director, People, Culture & Creative	Jill Ramseyer		
	Associate Director, Science & Partnerships	Kim Barrett		
	Director Parks & Recreation	Gene Matthews		
	Director, Planning & Watershed Management	Barb Veale		
	Senior Director, Coroporate & Strategic Initiatives	Lawerence Wagner		
	Chair, Conservation Halton Board of Directors	Gerry Smallegange Councillor		E-mail to Board of Directors sent out via Office of CAO
	Vice Chair, Conservation Halton Board of Directors	Moya Johnson Mayor		
	Board of Directors	Marianne Meed Ward		
	Board of Directors	Councillor Allan Elgar		
	Board of Directors	Councillor Cathy Duddeck		
Conservation Halton	Board of Directors	Councillor Dave Gittings		
	Board of Directors	Mayor Gordon Krantz		
	Board of Directors	Jean Williams		
	Board of Directors	Jim Sweetlove		
	Board of Directors	Councillor Bryan Lewis		
	Board of Directors	Joanne Di Maio		
	Board of Directors	Dr. Zobia Jawed		
	Board of Directors	Hamza Ansari		
	Board of Directors	Councillor Zeeshan Hamid		
	Board of Directors	Councilor Rick Di Lorenzo		
	Board of Directors	Councillor Mike Cluett		
	Board of Directors	Mayor Rob Burton Stephen		
	Board of Directors	Gilmour Councillor		
	Board of Directors	Rory Nisan		
Grand River Conservation Authority		Scott Robertson		
Credit Valley Conservation Authority	Director, Watershed Planning and Engineering	Rizwan Haq		
Niagara Escarpment Commission	Senior Strategic Advisor	Kim Peters	232 Guelph St, Georgetown, ON L7G 4B1	kim.peters@ontarioca
Municipalities				
	Regional Clerk	Graham Milne	1151 Bronte Road, Oakville L6M 3L1	Graham.Milne@halton.ca
	Chair, Halton Regional Council	Garry Carr	1151 Bronte Road, Oakville L6M 3L1	gary.carr@halton.ca
	Clerk			townclerk@milton.ca
	Regional Councillor Ward 1	Colin Best		colin.best@milton.ca
	Town Councillor Ward 1	Kristina Tesser Derksen		Kristina.TesserDerksen@milton.ca
Town of Milton	Regional Councillor Ward 2	Rick Malboef		rick.malboef@milton.ca
	Town Councillor Ward 2	John Challinor		john.challinorII@milton.ca
	Town Councillor Ward 4	Sameera Ali		Sameera.Ali@milton.ca
	Coordinator, Stormwater Management	Rachel Ellerman		Rachel.Ellerman@milton.ca
	Clerk	Suzanne Jones		Suzannej@haltonhills.ca
	Mayor	Rick Bonnette		mayor@haltonhills.ca
Town of Halton Hills	Regional Councillor Wards 1 & 2	Clark Somerville		clarks@haltonhills.ca
	Ward 2 Councillor	Ted Brown		tedb@haltonhills.ca
	Ward 2 Councillor	Bryan Lewis		bryanlewis@haltonhills.ca
		Steve Grace		SteveG@haltonhills.ca
School Boards				
Halton District School Board			Box 5005, STN LCD 1, Burlington, ON L7R 3Z2	contact@hdsb.ca
Halton Catholic District School Board			802 Dury Lane, Burlington, ON L7R 4L3	comments@hcdsb.org
Provincial Government				
	Administrative Assistant, Central Division			
Ministry of Transportation	Provinical Highways Management Division	Judy Cooling	Bldg D 2nd Flr, 159 Sir Wiliam Hearst Ave, Toronto, ON M3M 0B7	judy.cooling@ontario.ca
	Manager, Environmental Policy Office			
	Transportation Planning Branch	Dawn Irish	Garden City Tower 2nd Flr, 301 St. Paul St., St. Catherines, ON L2R 7R4	dawn.irish@ontario.ca
	Manager, (Acting) Program Services Section	Beth Brownson| 705-755-1278 | beth.brownson@ontario.ca		beth.brownson@ontario.ca
Ministry of Natural Resources and Forestry	Natural Herigate & Landuse Planning Advisor, Natural Heritage Section (Natural Resources and Forestry)	Susan Cooper	2nd Flr S, 300 Water St., Peterborough, ON K9J 3C7	susan.cooper@ontario.ca
	District Manager (Acting), Aurora	Brad Allan	50 Bloomington Rd., Aurora, ON L4G 0L8	brad.allan@ontario.ca
Ministry of Municipal Affairs and Housing	Executive Assistant (Acting), Local Government and Planning Policy Division	Bianca Cirella	College Park, 13th Floor, 777 Bay St., Toronto, ON M5G 2E5	Bianca.Cirella@ontario.ca
	Director, Provincial Planning Policy Branch	Laurie Miller	College Park, 13th Floor, 777 Bay St., Toronto, ON M5G 2E5	laurie.miller@ontario.ca
Infrastructure Ontario	Director (Acting), Realty Management Branch Realty Division	Trevor Bingler	College Park 2nd Flr, 777 Bay St., Toronto, ON M5G 2E5	trevor.bingler@ontario.ca
Federal				
Department of Fisheries and Oceans			304-3027 Harvester Road, Burlington, ON L7R 4K3	fisheriesprotection@dfo-mpo.gc.ca
Utilities				
Milton Hydro				customerservice@miltonhydro.com
Halton Hills Hydro				chrish@haltonhillshydro.com
Hydro One	Secondary Land Use Department			SecondaryLandUse@HydroOne.com
Enbridge?				ombudsman@enbridge.com
Union Gas	Lead Environmental Planner	Doug Schmidt		dschmidt@uniongas.com
Bell Canada				accessible@bell.ca
Railways / Transit				
CN				contact@cn.ca
Canadian Pacific Railway (CPR)	Area Manager Support	Josie Tomei	800-1290 Central Parkway West Mississauga, ON L5C 4R3	Josie_Tomei@cpr.ca
Environmental Groups				
Economic Development				
Milton Chamber of Commerce				info@miltonchamber.ca
Halton Hills Chamber of Commerce				generalmanager@haltonhillschamber.on.ca
BILD				info@bildgta.ca
Downtown Milton Business Owners Association				Cheryl Ciccarelli <cciccarelli@downtownmilton.com>
Hamilton-Halton Home Builders' Association				info@hhhba.ca
Agriculture				
Halton Agricultural Advisory Committee	Agricultural Liaison Officer	Anna DeMarchi-Meyers		anna.demarchi-meyers@halton.ca

24 Members of the Public Requesting to be added to Mailing List

Amy Mayes

From:	Amy Mayes
Sent:	September 20, 2019 1:01 PM
To:	Amy Mayes
Subject:	Urban Milton Flood Hazard Mapping Study - Please Join Us at PIC 1 to learn more.
Attachments:	Urban Milton Flood Control System PIC.PDF

Conservation Halton is undertaking a study to assess and map the flood hazard associated with the West Branch of Sixteen Mile Creek within Urban Milton. As part of this study we will be updating the hydrologic models for the upstream contributing drainage areas. On October 1st we'll be hosting a Public Information Centre to share details about the intended study process, answer questions, and seek public input - including local knowledge and any experiences of flooding within the watershed, which will help us to more accurately map and define the flood risk.

A drop in style PIC will take place from 6:30 to 8:30 at Conservation Halton's Administrative Office, where members of the Study Team will be available to meet with you and answer any questions you might have. Following the PIC, the information boards will be available through a project link accessible here: https://www.conservationhalton.ca/floodplainmapping

Floodplain Mapping — Conservation Halton

Why Floodplain Mapping is Important . In Canada, floods account for the largest portion of disaster recovery costs on an annual basis. The first step to reduce the cost of flood damage within a community is to have mapping that accurately shows flood hazards.

www.conservationhalton.ca

As the project nears completion in the spring of 2020, we will host a second PIC to share draft study results. We invite you to share this PIC Invitation with other partners and interested community members, and would welcome your feedback should you have any questions or information to share.

kind regards,
Amy Mayes, P.Eng.
Coordinator, Floodplain Mapping

Note: This message was sent to identified stakeholders that may have an interest in project outcomes, if you do not wish to receive further notices related to this study, please respond to this e-mail requesting to be removed from the project mailing list.

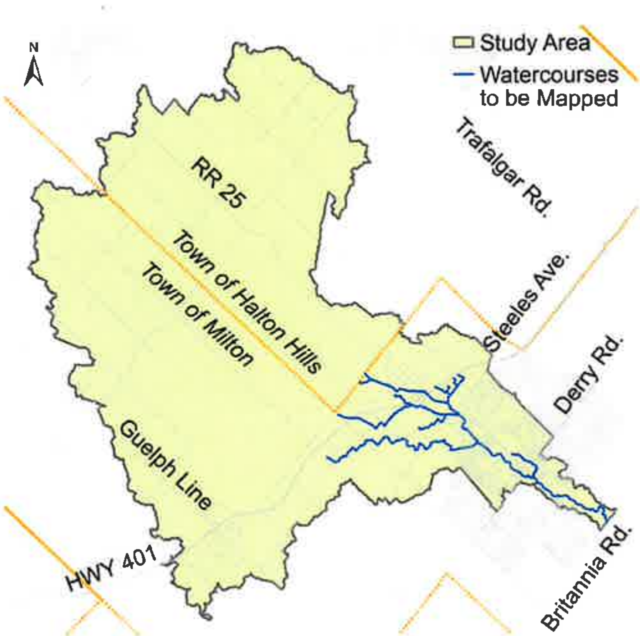
Amy Mayes, P.Eng.
Coordinator, Floodplain Mapping

Conservation Halton
2596 Britannia Road West, Burlington, ON L7P 0G3
905.336.1158 ext. 2302 | Cell 289.230.2656 | Fax 905.336.7014 | amayes@hrca.on.ca
conservationhalton.ca

JOIN US for a Public Information Centre

Urban Milton Flood Hazard Mapping

Conservation Halton



Project & Purpose

Conservation Halton has retained Greck and Associates Ltd. to generate flood hazard mapping for tributaries of 16 Mile Creek (West Branch) in Urban Milton. Floodplain mapping is used to identify areas that may be susceptible to flooding during large storm events.

Floodplain mapping is an important tool used by Conservation Halton to fulfill its role as a watershed management agency. Conservation Halton is focused on protecting our communities, conserving our natural environment, and supporting our partners in the creation of sustainable communities. New models and updated mapping generated through this project may be used by Conservation Halton, and municipal partners, for many purposes including:

- flood forecasting and warning,
- emergency planning and response,
- prioritizing future flood mitigation works,
- community planning and land use decision making,
- infrastructure renewal, and
- restoration works.

Updated floodplain mapping also allows landowners and residents to prepare for and respond to potential flooding, and to make informed decisions on personal emergency plans, property improvements, and insurance needs.

Public Consultation

Over the course of this project Conservation Halton will seek community feedback through two Public Information Centres (PICs). The first PIC will summarize the project scope, methodology, schedule, and anticipated study outcomes. The second PIC will be held in March 2020, and will present draft study findings. Please drop by at any time over the course of the PIC to find out more, and have your questions answered.

Public Information Centre 1

Tuesday, October 1, 2019
6:30–8:30 p.m.
Conservation Halton Administrative Office
2596 Britannia Road West, Burlington, ON

Get Involved

Your thoughts and observations are important to us. Members of the public, watershed residents, businesses, landowners, Indigenous Peoples, stakeholder groups, governmental agencies and other interested parties are encouraged to join us at the PIC or view materials on-line (available after the PIC at conservationhalton.ca/ floodplainmapping). To share your feedback, request additional information, or to be added to the project mailing list, please contact:

Amy Mayes, P.Eng.
Coordinator, Floodplain Mapping
Conservation Halton

905.336.1158 ext. 2302
amayes@hrca.on.ca

Amy Mayes

From: Amy Mayes
Sent: October 2, 2019 5:10 PM
To: Amy Mayes
Subject: Thank You for Attending the PIC for the Urban Milton Flood Hazard Mapping Study

Good Afternoon Everyone,

I wanted to take a moment to thank you all for coming out last night to learn more about the Urban Milton Flood Hazard Mapping Study that is currently underway. I've added all of you to the project contact list and expect to reach out to you all in a few months to invite you to attend the next public consultation, where we plan on sharing the draft study findings. I will also reach out to share details of any subsequent key project milestones.

The information shared on display boards at last night's meeting is now available on-line through the Urban Milton Flood Hazard link found here: https://www.conservationhalton.ca/floodplainmapping The link is located mid-way down the page under the heading 'How You Can Participate'.

I hope we were able to answer all of your questions last night, but please know I'm available and happy to answer any further questions you may have. If you have any comments on the materials presented last night, or would like to share local knowledge that may help us to 'truth' our models, please take a moment to complete and return the comment card provided, or simply respond to this e-mail. It would be greatly appreciated if all comments could be provided by October 15th. Once again, thank you for joining us last night and expressing an interest in this study.

kind regards,
Amy

Amy Mayes, P.Eng.
Coordinator, Floodplain Mapping

Conservation Halton
2596 Britannia Road West, Burlington, ON L7P 0G3
905.336.1158 ext. 2302 | Cell 289.230.2656 | Fax 905.336.7014 | amayes@hrca.on.ca
conservationhalton.ca

WELCOME

Urban Milton Flood Hazard Mapping Study

The purpose of this Open House is to:

1. Provide an overview of flood hazard mapping practices and procedures in Ontario
2. Notify the public and interested parties of the nature of the ongoing study
3. Obtain public input regarding known flooding issues to assist with the study


Source: Greck and Associates, Upstream of Britannia Rd, July 2019


Source: Greck and Associates, Downstream of Main Street, west of Martin Street, July 2019


Source: Greck and Associates, Upstream of Derry Road, west of Ontario Street , July 2019


Source: Greck and Associates, Downstream of Wheelabrator Way, north of Steeles Ave , July 2019


Source: Greck and Associates, Downstream of Louis St Laurent Ave, July 2019


Source: Greck and Associates, Upstream of Laurier Ave, near Milton District High School, July 2019

If you would like to be included on the project mailing list, please sign in!

Conservation Halton

Greck

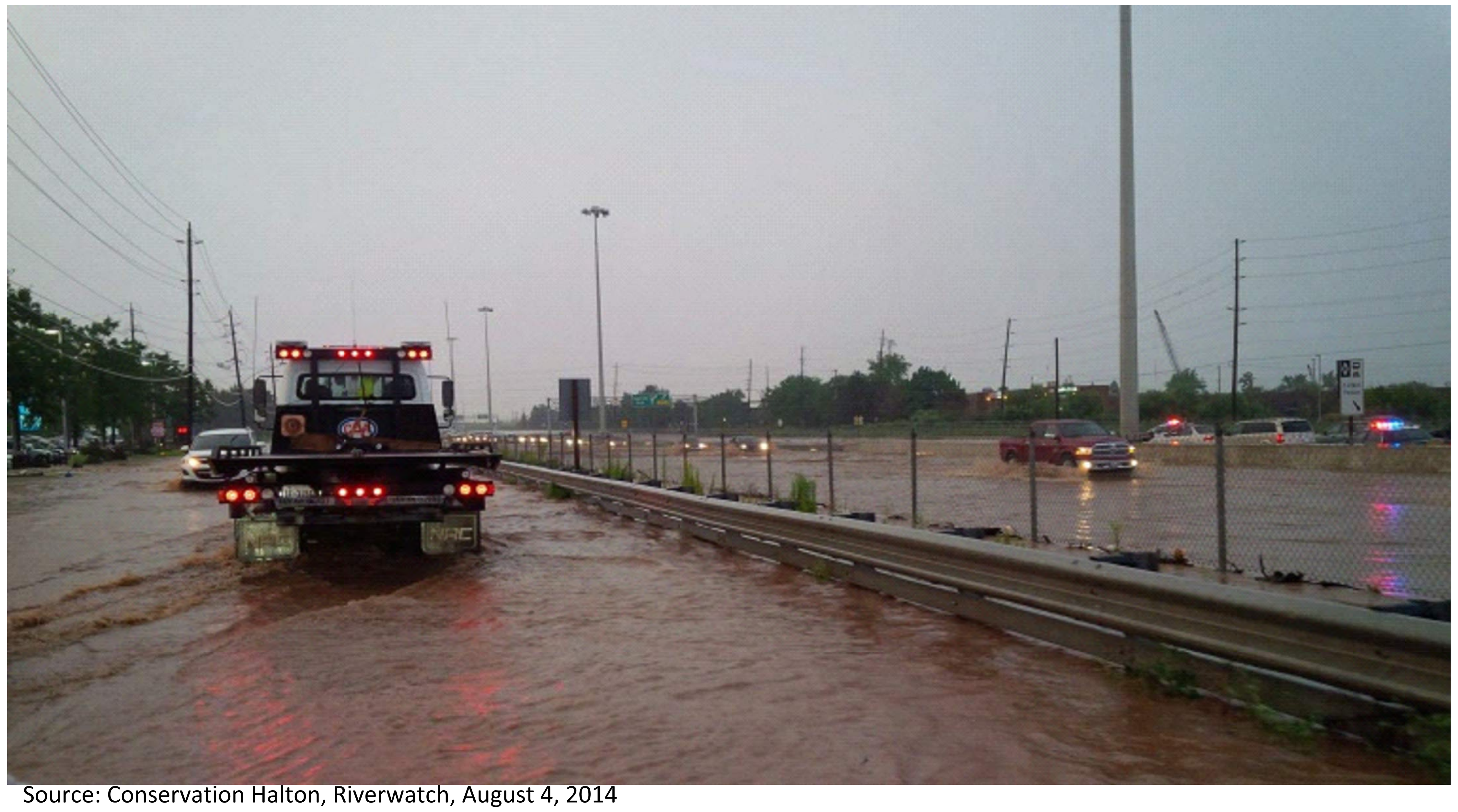
FLOODING TYPES

Flooding is a natural occurrence. Flooding occurs when water exceeds its banks and flows into normally dry low lying areas adjacent to a watercourse or a body of water.
Flooding is caused by severe weather events, snow melt, ice jams, debris jams or dam failure.

Types of flooding include:

1. Shoreline flooding due to high lake levels, storm surge, waves, tides etc.,
2. Urban Flooding/Basement Flooding due to flow exceeding capacity of overland flow paths and/or surcharging of storm sewers, and
3. Riverine Flooding where a watercourse overflows its banks.

This study will assess Riverine Flooding for the West Branch of Sixteen Mile Creek within Urban Milton



Source: Conservation Halton, Riverwatch, August 4, 2014

Source: City of Burlington, August 4, 2014

Conservation Halton

Greck

WHAT IS A FLOODPLAIN MAP?

A floodplain is an area of low-lying ground next to a watercourse, which may be subject to flooding.

A floodplain map identifies the areas predicted to flood during specified severe storm events.

Understanding the flood hazard is the first step in building flood resiliency!

Why Map the Floodplain?

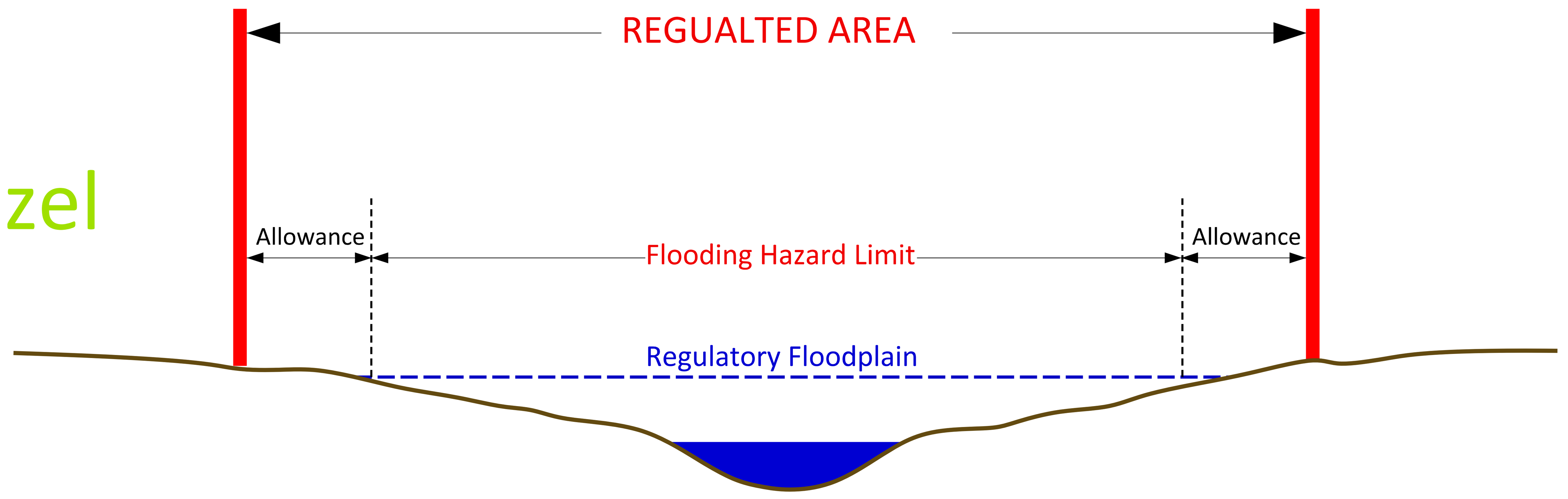
For Conservation Authorities and Governments, understanding the flood hazard supports:

- Community and land use planning
- Emergency planning and response
- Flood forecasting and warning
- Flood mitigation works
- Infrastructure design

For Businesses and Landowners, knowing the risk allows informed decisions on:

- Property use and improvements
- Personal emergency planning
- Insurance needs

Within Southern Ontario, the Regulatory Floodplain is defined by the greater floodplain from Hurricane Hazel or the 100-year event (1% probability of occurrence within a given year).



HURRICANE HAZEL

In 1954, Southern Ontario experienced significant flooding following the Hurricane Hazel storm which dropped approximately 285mm (11") of rain over 36 hours.

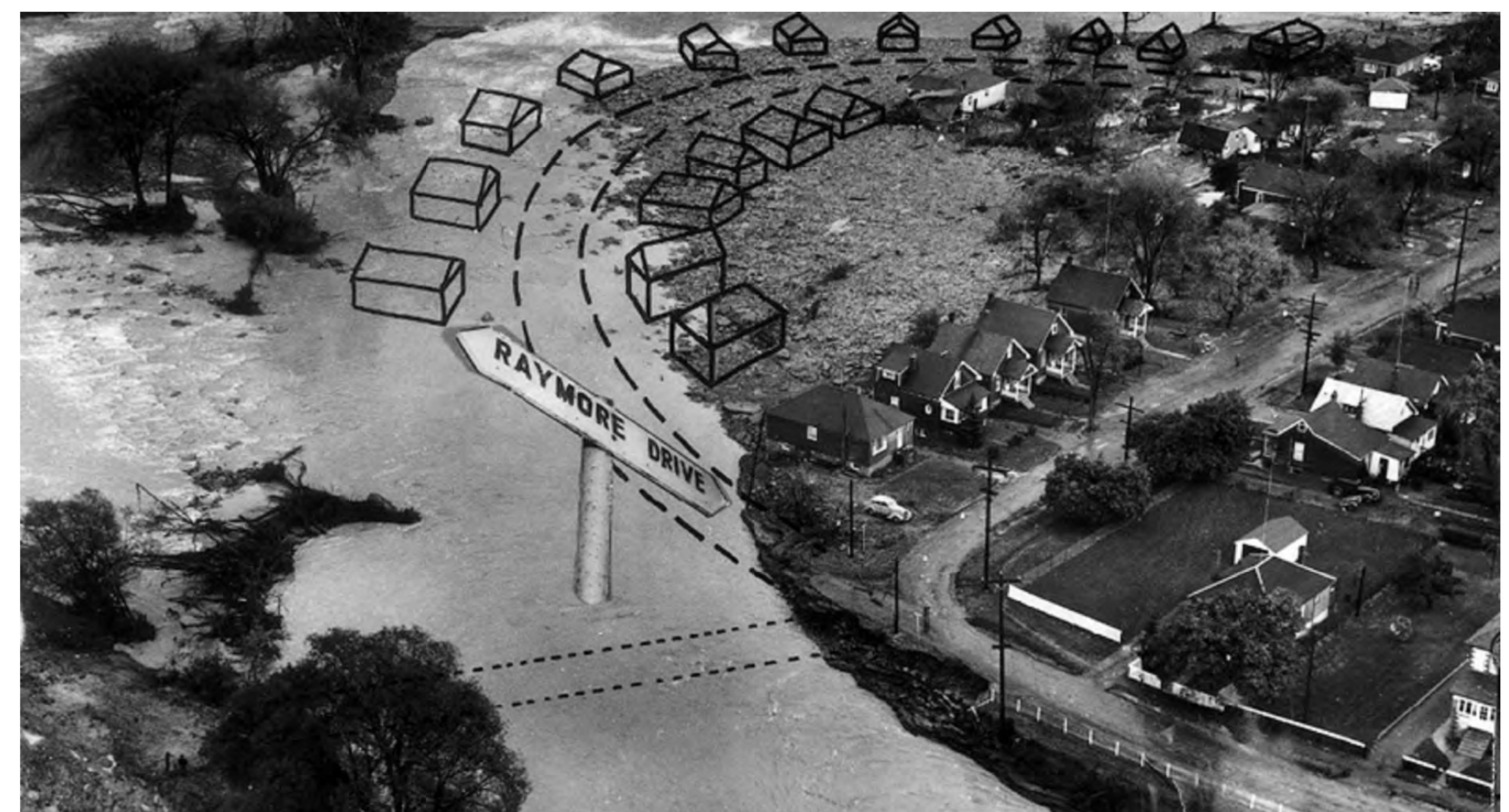
The main factors that contributed to flooding included: the extended period of rainfall preceding the storm followed by heavy rainfall, insufficient flood protection infrastructure and development within flood prone areas.

Hurricane Hazel caused significant flooding in Ontario resulting in:

- 81 deaths
- 4,000 families left homeless
- 32 houses washed away
- An estimated $1.3 billion (2018 dollars) in damages

Source: thecanadianencyclopedia.ca/en/article/hurricane-hazel

Source: thecanadianencyclopedia.ca/en/article/hurricane-hazel



Location of homes on Raymore Dr. washed away by the Hurricane Hazel floodwater (hurraicanehazel.ca)

Following Hurricane Hazel, the Conservation Authorities Act was amended, empowering Conservation Authorities to regulate development of floodplain lands.

ROLES AND RESPONSIBILITIES

Conservation Authorities and Municipalities work in partnership to prevent and manage flooding. Each agency and landowner has a unique role in flood prevention and management.

LOWER TIER MUNICIPALITY

MILTON

- Road Drainage
- Storm Sewers
- Parks & Trails
- Greenbelts
- Land Use and Zoning Approvals
- Tree Canopy
- Stormwater Management
- Emergency Services

UPPER TIER REGIONAL MUNICIPALITY

Halton REGION

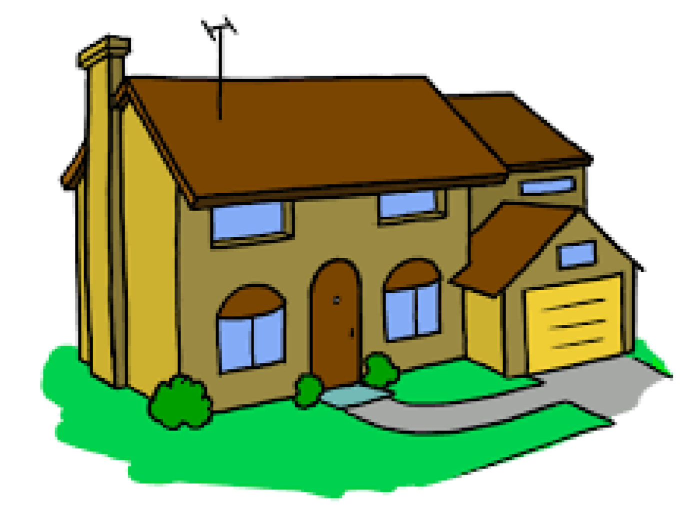
- Emergency Management
- Regional Roads
- Sanitary Sewers
- Land Use Approvals
- Natural Heritage

CONSERVATION AUTHORITY

Conservation Halton

- Natural Hazard (Flood, Erosion, Dynamic Beach), Hazardous Site (Karst), and Wetland Regulation
- Flood Forecasting and Warning
- Flood Control Infrastructure (Dams & Concrete Channels)
- Commenting Agency on Development Applications (Stormwater Management)
- Manage Flood Hazard Models
- Watershed Monitoring
- Stewardship and Restoration

LANDOWNERS



- Know the Risks: Is the property flood susceptible? Is flooding expected?
- Make a Plan: What can you do to protect your family and your property?
- Get a Kit: Do you have supplies for 72 hours?

HISTORY OF FLOOD MANAGEMENT

A number of flood mitigation strategies have been included within the Sixteen Mile Creek watershed:

Channelization

Urban Milton Flood Control Channel

Source: Greck and Associates Limited, 2019

Source: Greck and Associates Limited, 2019

Flow Control

Kelso, Hilton Falls and Scotch Block Reservoirs

Source: conservationhalton.ca/dams-and-channels

Source: conservationhalton.ca/dams-and-channels

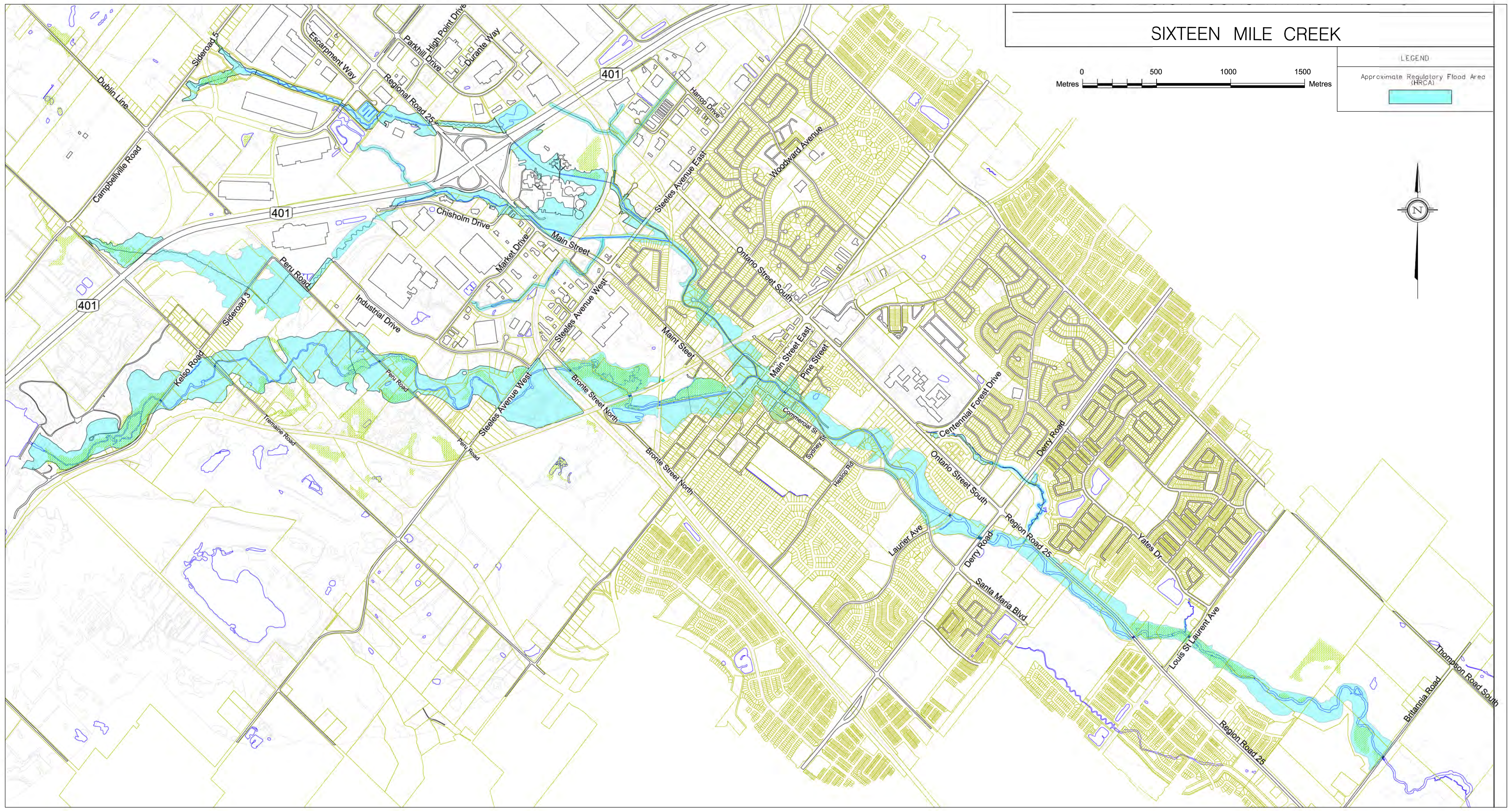
- Flood Forecasting Warning
- Protection of life and property through natural hazard regulation (O.Reg 162/06)
- Stormwater Management for new development

Conservation Halton

Greck

STUDY OBJECTIVES

This Study is being completed by Greck and Associates Limited on behalf of Conservation Halton in consultation with a Technical Advisory Committee which includes representatives from the Town of Milton, Town of Halton Hills, and Region of Halton.



Note: The extent of Conservation Halton's approximate Regulation Area may differ from what is shown, given the approximate regulation area also includes erosion hazards and wetlands
Above map indicates only the approximate flood hazard associated with the watercourses to be mapped as part of this study area shown.

Objective: update flood hazard models and flood hazard mapping for major tributaries of the West Branch of Sixteen Mile Creek within Urban MIlton.

Conservation Halton

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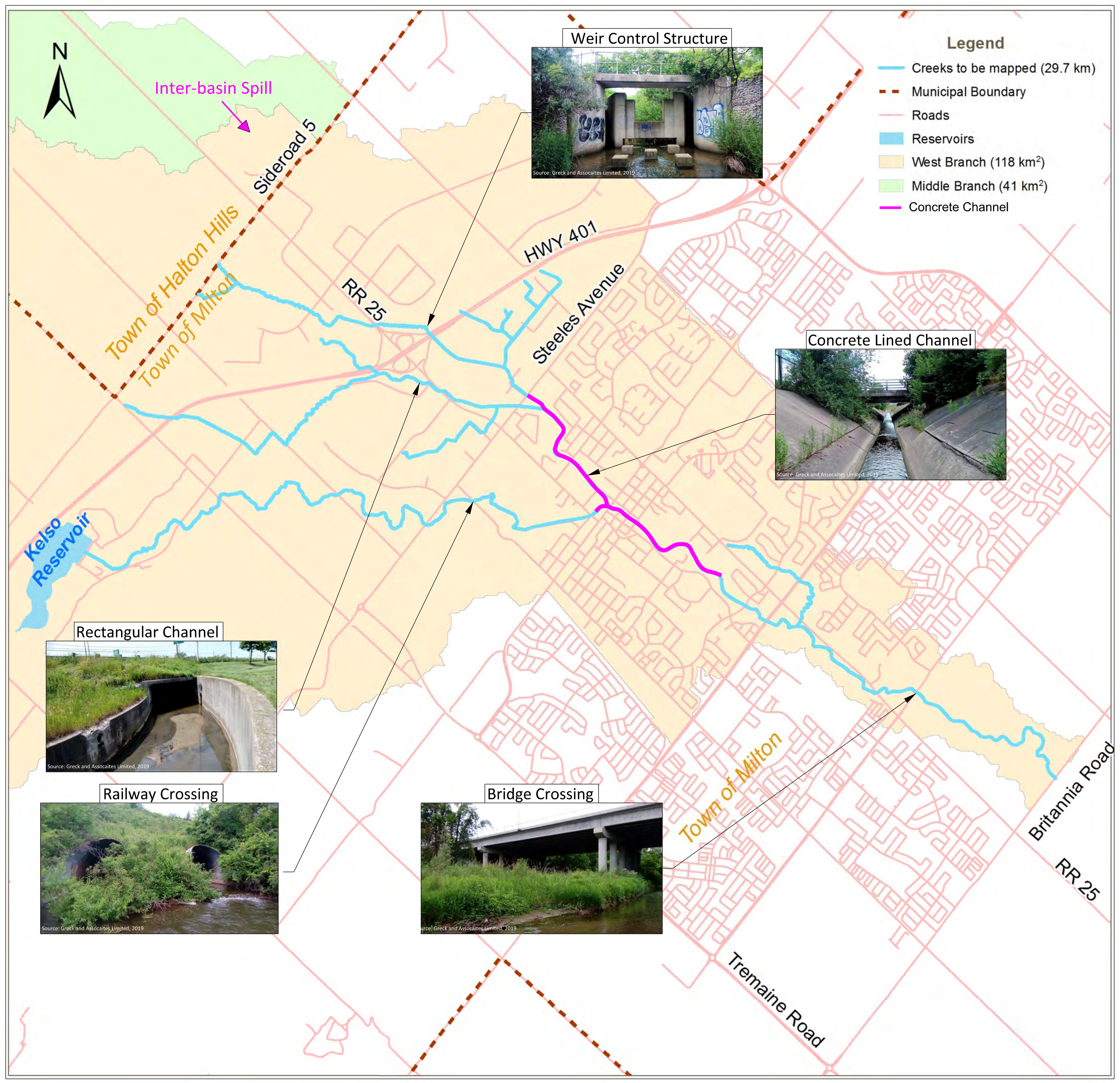
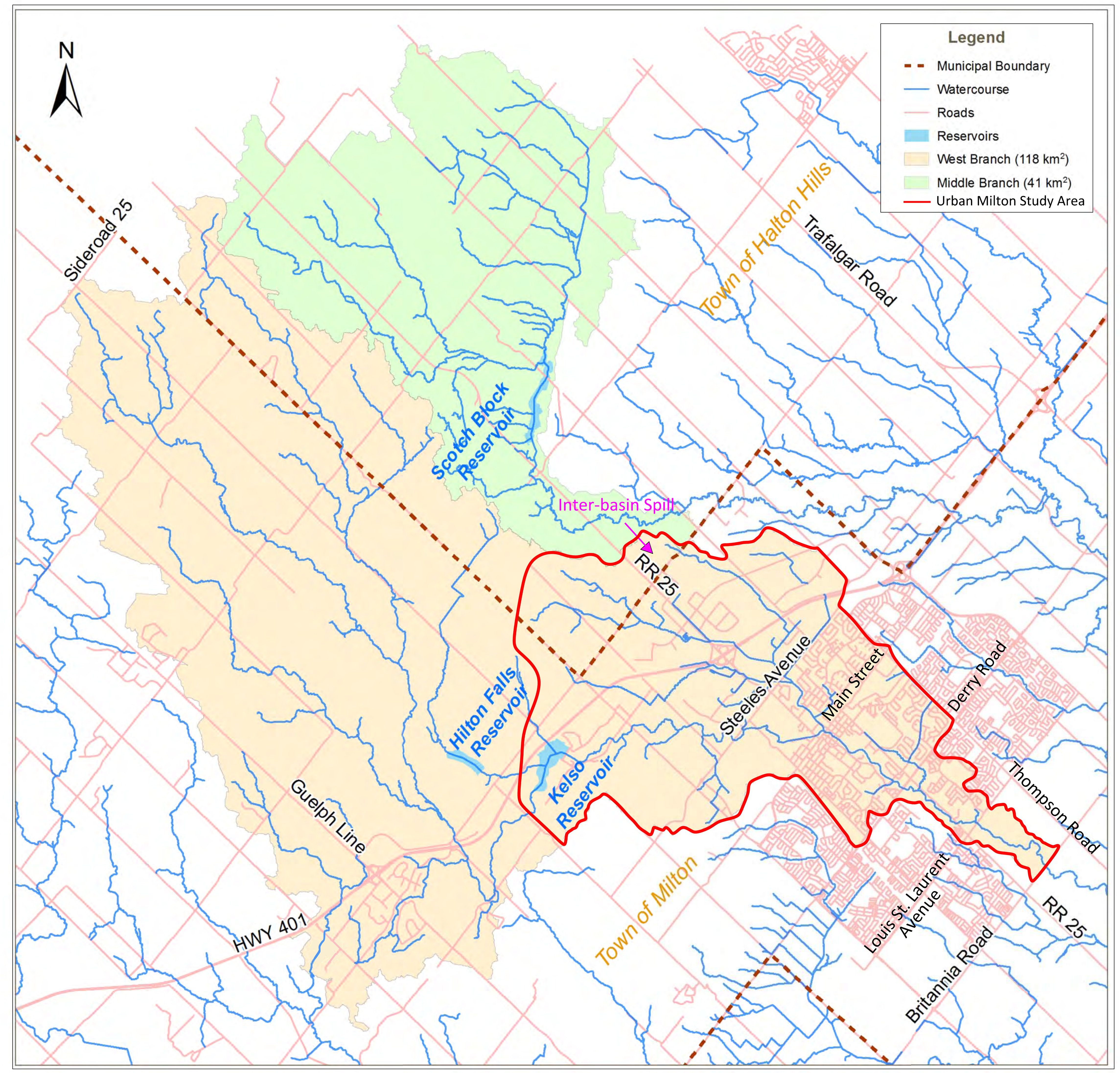
STUDY AREA DESCRIPTION

The floodplain area to be mapped is shown below, and in further detail on tables throughout the room.



Approximately 159 km^2 of upstream drainage area (including a potential inter-basin spill) contributes flow to the tributaries to be mapped. Understanding flows within the watershed is an important element in mapping the floodplain.



Conservation Halton

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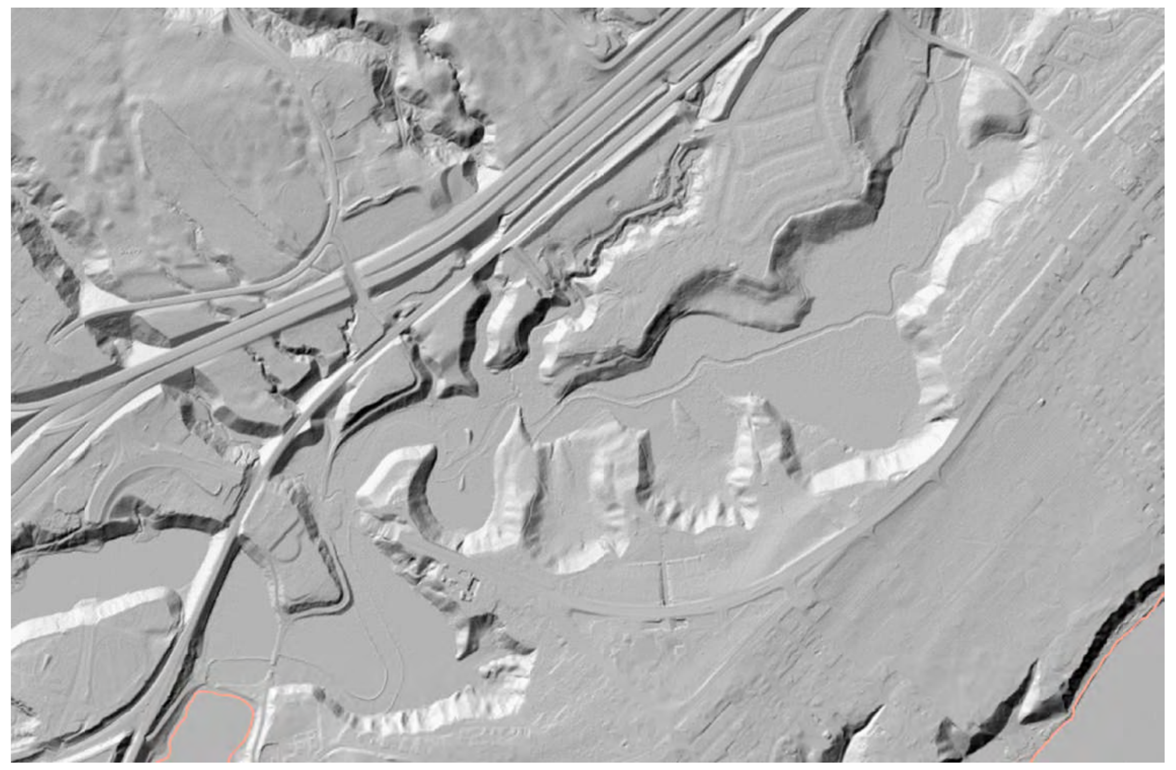
WHY UPDATE NOW

Several local scale studies have been completed to define the flood hazard limits within Milton. The last comprehensive flood hazard mapping study of the West Branch of Sixteen Mile Creek was the *Halton Region Conservation Authority Floodline Mapping Study of Sixteen Mile Creek* Completed in 1988 by Proctor and Redfern Group Consulting Engineers and Planners.

Floodplain mapping studies require periodic updates due to a number of reasons, such as:

- More accurate topographic information: The previous 16 Mile Creek Study supporting the FDRP study was based on surveyed cross sections and 2 m contours within the floodplain that were determined stereoscopically. This study will rely on LiDAR data (which generates 10 points/m^2), with a survey of all major crossing structures

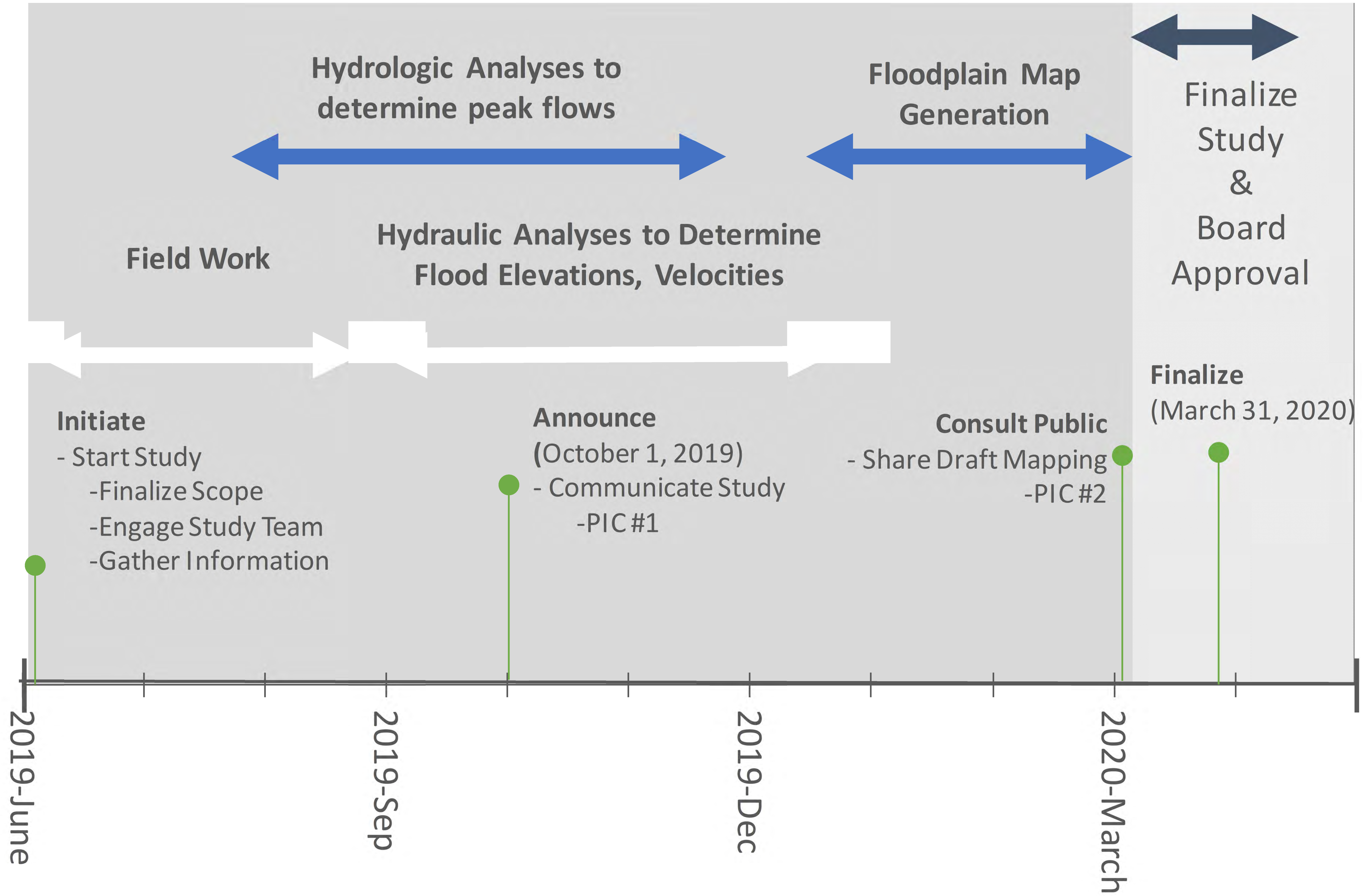


Source: Hillshade View of LiDAR Data, Airborne Imaging

- Land-use changes
- Climate change considerations
- Advances in modelling technologies and computer processing power

Source: commodor64computer.com

FLOODPLAIN MAPPING TIMELINE



CONTACT INFORMATION

For more information, please do not hesitate to contact the key study members below:

Amy Mayes, P.Eng.
Coordinator, Floodplain Mapping
Conservation Halton
2596 Britannia Rd. W.,
Burlington, ON L7P 0G3
Tel: (905) 336-1158 ext 2302
e-mail: amayes@hrca.on.ca

Brian Greck, P.Eng.
Senior Water Resources Engineer
Greck and Associates Limited
5770 Highway 7
Woodbridge, ON L4L 1T8
Tel: (289) 657-9797 ext 221
e-mail: bgreck@greck.ca

Please sign the attendance sheet, and submit comment sheets no later than October 15th, 2019.

Thank you for attending this open house. Additional information can be found at:

https://www.conservationhalton.ca/floodplainmapping

All information collected is pursuant to Municipal Freedom of Information and Protection of Privacy Legislation.

LEGEND

Approximate Regulatory Flood Area (HRCA)

Note:
The extent of Conservation Halton's approximate Regulation Area may differ from what is shown, given the approximate regulation area also includes erosion hazards and wetlands. The base map indicates only the approximate flood hazard associated with the watercourses to be mapped as part of this study area shown.

Conservation Halton
2596 BRITANNIA RD. BURLINGTON, ON L7P0G3

Greck

URBAN MILTON FLOOD AREA
HALTON REGION CONSERVATION AUTHORITY

SIXTEEN MILE CREEK

0 500 1000 1500
Metres Metres

N

Question Form

1. If the study team has any questions regarding the content of this comment card, may we contact you? Yes No
2. Do you currently live or own property within the proposed study area? Yes No
3. Do you have any specific concerns regarding the floodplain area to be mapped? Have you ever experienced riverine flooding? If so, please describe below:

____

____

____

____

____

____

Please fill in the section below with any comments or questions you may have regarding this study.

____

____

____

____

____

____

____

Name:	Email Address:

Thank you for your participation. Please hand in the Comment Sheet before you leave tonight, or send it in by October 15th, 2019 to:

Amy Mayes
Coordinator, Floodplain Mapping
Conservation Halton
905 336 1158 ext 2302
amayes@hrca.on.ca

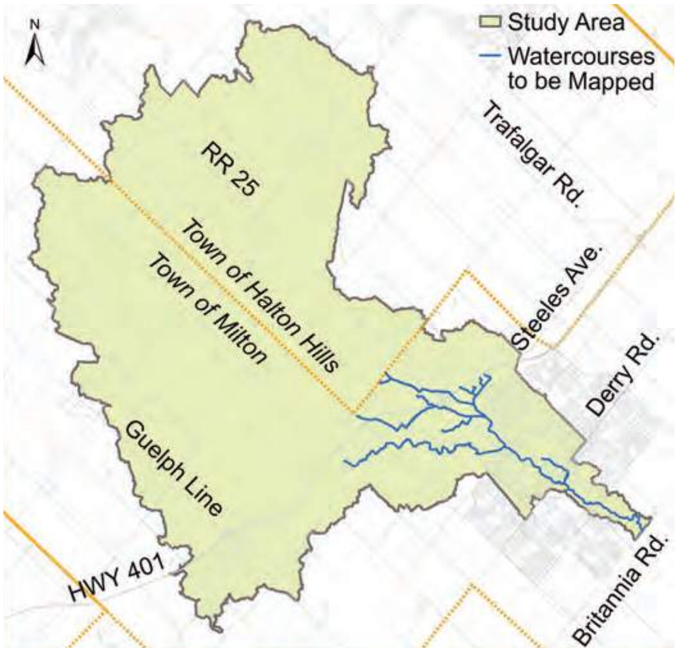
Conservation Halton

Greck

JOIN US for a Public Information Centre

Urban Milton Flood Hazard Mapping

Conservation Halton



Project & Purpose

Conservation Halton has retained Greck and Associates Ltd. to generate flood hazard mapping for tributaries of 16 Mile Creek (West Branch) in Urban Milton. Floodplain mapping is used to identify areas that may be susceptible to flooding during large storm events.

Floodplain mapping is an important tool used by Conservation Halton to fulfill its role as a watershed management agency. Conservation Halton is focused on protecting our communities, conserving our natural environment, and supporting our partners in the creation of sustainable communities. New models and updated mapping generated through this project may be used by Conservation Halton, and municipal partners, for many purposes including:

- flood forecasting and warning,
- emergency planning and response,
- prioritizing future flood mitigation works,
- community planning and land use decision making,
- infrastructure renewal, and
- restoration works.

Updated floodplain mapping also allows landowners and residents to prepare for and respond to potential flooding, and to make informed decisions on personal emergency plans, property improvements, and insurance needs.

Public Consultation

Over the course of this project Conservation Halton will seek community feedback through two Public Information Centres (PICs). The first PIC will summarize the project scope, methodology, schedule, and anticipated study outcomes. The second PIC will be held in March 2020, and will present draft study findings. Please drop by at any time over the course of the PIC to find out more, and have your questions answered.

Public Information Centre 1

Tuesday, October 1, 2019
6:30–8:30 p.m.
Conservation Halton Administrative Office
2596 Britannia Road West, Burlington, ON

Get Involved

Your thoughts and observations are important to us. Members of the public, watershed residents, businesses, landowners, Indigenous Peoples, stakeholder groups, governmental agencies and other interested parties are encouraged to join us at the PIC or view materials on-line (available after the PIC at conservationhalton.ca/floodplainmapping). To share your feedback, request additional information, or to be added to the project mailing list, please contact:

Amy Mayes, P.Eng.
Coordinator, Floodplain Mapping
Conservation Halton

905.336.1158 ext. 2302
amayes@hrca.on.ca

Information will be collected in accordance with the Freedom of Information and Protection of Privacy Act. With the exception of personal information, all comments will become part of the public record.

Summary of Public Consultation

Urban Milton Flood Hazard Mapping Study - PIC 2: March 24, 2020

Due to the Global Pandemic associated with the Sars-CoV-2 the planned Public Information Centre was re-structured as a digital information release.

Newspaper Ads:

- Ads ran March 12, 2019 in the Milton Champion and Halton Hills IFP – See sample ad attached

Social Media:

- Notices for PIC 2 were placed on CH Twitter and Facebook feeds

Stakeholder Mailing:

- A targeted e-mail message was sent out to identified stakeholders March 5, 2020 advising of the upcoming PIC. A second e-mail was sent March 19th confirming cancellation of the physical meeting, and March 25th confirming how to access the digital information. (mailing list and e-mails are attached.

Response to Community Questions:

  - Response to Community Questions will be provided as a Study Addendum following the close of the public comment period.

Website Content

- PIC 2 content was uploaded to Conservation Halton's website March 25, 2020 and will remain available until the study receives endorsement from Conservation Halton's Board of Directors. Timing for seeking board approval is yet to be determined, but further study work (through a separate contract) is planned in 2020.

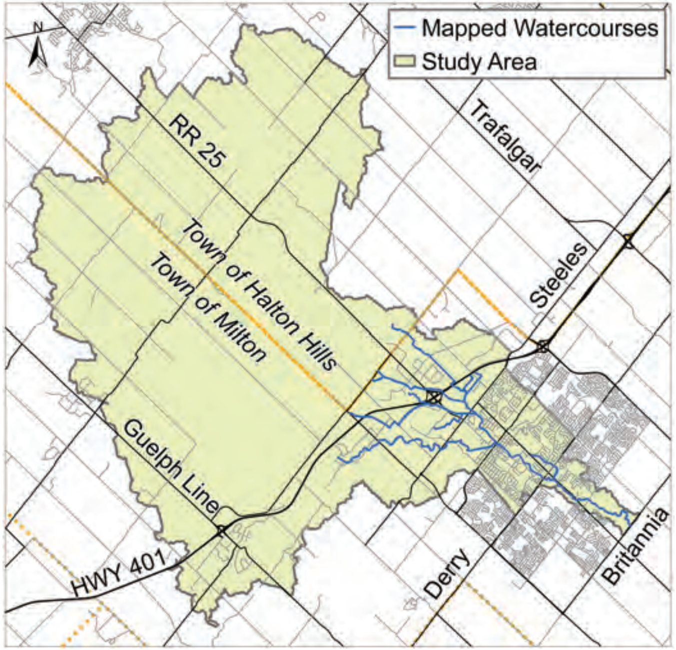
PIC 2 Content:

- PIC 1 Technical Display Boards (attached)

While the technical study information is provided in this appendix, the web page provides additional information including links to emergency preparedness and flood forecasting and warning.

Urban Milton Floodplain Mapping Project

Public Information Centre #2 on March 24, 2020



Conservation Halton has undertaken a study to update models and floodplain mapping for the West Branch of Sixteen Mile Creek through Urban Milton. Models and mapping generated by this project may be used by Conservation Halton, and municipal partners, for:

- flood forecasting and warning,
- emergency planning and response,
- prioritization of flood mitigation works,
- community planning and land use decision making, and
- infrastructure renewal.

Draft floodplain mapping will be shared at a drop-in style Open House. Conservation Halton staff, municipal staff and our project consultant will be available to answer questions on the study, and what this means for you and your property.

Urban Milton Floodplain Mapping Public Information Centre #2:

Tuesday March 24, 2020 | 6:30–8:30 pm
Milton Town Hall (Milton Room)
150 Mary St., Milton

Can't make the meeting? Draft mapping will be available for viewing at Conservation Halton's Administrative Office between March 25 and April 7. Additional study information available online at: **conservationhalton.ca/floodplainmapping**

Additional questions? To share your feedback or request additional information, please contact Amy Mayes, P.Eng., Coordinator, Floodplain Mapping, Conservation Halton 905.336.1158 x 2302 or amayes@hrca.on.ca

Stakeholder Consultation List for Urban Milton Flood Hazard Mapping Study

to Receive Notification of PICs, etc through e-mail

Organization	Title	Name	Street Address	Email
Conservation Halton	Chief Administrative Officer/Secretary-Treasurer	Hassaan Basit		
	Associate Director, Marketing & Communications	Katie Skillen		
	Associate Director, Science & Partnerships	Kim Barrett		
	Director, Corporate Compliance	Jill Ramseyer		
	Director, Foundation	Garner Beckett		
	Director, Planning & Watershed Management	Barb Veale		
	Interim Director, Parks & Operations	Mark Vytvytskyy		
	Manager, Office of the CAO	Adriana Birza		
	Senior Director, Corporate Services	Lawrence Wagner		
	Senior Manager, Human Resources	Plezzie Ramirez		
	Chair, Conservation Halton Board of Directors	Mr Gerry Smallegange		
	Vice Chair, Conservation Halton Board of Directors	Councillor Moya Johnson		
	Board of Directors	Councillor Allan Elgar		
	Board of Directors	Councillor Bryan Lewis		
	Board of Directors	Councillor Cathy Duddeck		
	Board of Directors	Councillor Dave Gittings		
	Board of Directors	Councillor Mike Cluett		
	Board of Directors	Councillor Rory Nisan		
	Board of Directors	Councillor Zeeshan Hamid		
	Board of Directors	Councillor Rick Di Lorenzo		
	Board of Directors	Dr. Zobia Jawed		
	Board of Directors	Mayor Gordon Krantz		
	Board of Directors	Mayor Marianne Meed Ward		
	Board of Directors	Mayor Rob Burton		
	Board of Directors	Mr. Hamza Ansari		
	Board of Directors	Mr. Jim Sweetlove		
	Board of Directors	Mr. Stephen Gilmour		
	Board of Directors	Mrs. Jean Williams		
	Board of Directors	Ms. Joanne Di Maio		
Municipalities				
Region of Halton	Commissioner of Public Works	Jim Harnum	1151 Bronte Road, Oakville L6M 3L1	jim.harnum@halton.ca
	Director, Waste Management and Road Operations	Rob Rivers	1151 Bronte Road, Oakville L6M 3L1	rob.rivers@halton.ca
	Director, Planning Services and Chief Planning Official	Curt Benson	1151 Bronte Road, Oakville L6M 3L1	curt.benson@halton.ca
	Regional Clerk	Graham Milne	1151 Bronte Road, Oakville L6M 3L1	Graham.Milne@halton.ca
	Source Water Protection	Daniel Banks		Daniel.Banks@halton.ca
	Water and Wastewater Planning	Adam Gilmore		Adam.Gilmore@halton.ca
	Chair, Halton Regional Council	Chair Garry Carr	1151 Bronte Road, Oakville L6M 3L1	gary.carr@halton.ca
	Chief of Emergency Management	Ralph Blauel	1151 Bronte Road, Oakville L6M 3L1	raloh.blauel@halton.ca
Town of Milton	Clerk			townclerk@milton.ca
	Commissioner, Planning & Development	Barb Koopmans		barb.koopmans@milton.ca
	Mayor	Mayor Gordon Krantz	E-mail as Part of Board of Directors	
	Regional Councillor Ward 1	Councillor Colin Best		colin.best@milton.ca
	Town Councillor Ward 1	Councillor Kristina Tesser Derksen		Kristina.TesserDerksen@milton.ca
	Regional Councillor Ward 2	Councillor Rick Malboef		rick.malboeuf@milton.ca
	Town Councillor Ward 2	Councillor John Challinor		john.challinorII@milton.ca
	Town Councillor Ward 3	Councillor Mike Cluett	E-mail as Part of Board of Directors	
	Town Councillor Ward 3	Councillor Rick Di Lorenzo	E-mail as Part of Board of Directors	
	Town Councillor Ward 4	Councillor Zeehan Hamid	E-mail as Part of Board of Directors	
	Town Councillor Ward 4	Councillor Sameera Ali		Sameera.Ali@milton.ca
Town of Halton Hills	Chief Administrative Officer	Brent Marshall		brentm@haltonhills.ca
	Commissioner of Transportation and Public Works	Chris Mills		chrism@haltonhills.ca
	Clerk	Suzanne Jones		Suzannej@haltonhills.ca
	Mayor	Rick Bonnette		rickb@haltonhills.ca
	Regional Councillor Wards 1 & 2	Clark Somerville		clarks@haltonhills.ca
	Ward 2 Councillor	Ted Brown		tedb@haltonhills.ca
	Ward 2 Councillor	Bryan Lewis	E-mail as Part of Board of Directors	
Technical Advisory Committee	Planner - Groundwater and Hydrology	Behnam Doulatyari	Halton Region	behnam.Doulatyari@halton.ca
	Senior Emerency Management Coordinator	Dr. Christopher Leite	Halton Region	Christopher.Leite@halton.ca
	Stormwater Manager	Rachel Ellerman	Town of Milton	Rachel.Ellerman@milton.ca
	Program Manager, Water Resources	Steve Grace	Town of Halton Hills	SteveG@haltonhills.ca
Grand River Conservation Authority	Director of Engineering	Dwighty Boyd		dboyd@grandriver.ca
Credit Valley Conservation Authority	Director, Watershed Management	Tim Mereu		tim.mereu@cvc.ca
Niagara Escarpment Commission	Senior Strategic Advisor	Kim Peters	232 Guelph St, Georgetown, ON L7G 4B1	kim.peters@ontario.ca
School Boards				
Halton District School Board	Senior Analyst, Planning	Michelle D'Aguiar	J.W. Singleton Education Centre, 2050 Guelph Line, Burlington, Ontario L7P 5A8	daguiarm@hdsb.ca
Halton Catholic District School Board			802 Drury Lane, Burlington, ON L7R 4L3	comments@hcdsb.org
Provincial Government				
MPP's	MPP- Milton	MPP Parm Gill		parm.gill@pc.ola.org
	MPP - Wellington - Halton Hills	MPP Ted Arnott		ted.arnott@pc.ola.org
Ministry of Transportation	Administrative Assistant, Central Division Provinical Highways Management Division	Judy Cooling	Bldg D 2nd Flr, 159 Sir Wiliem Hearst Ave, Toronto, ON M3M 0B7	judy.cooling@ontario.ca
	Manager, Environmental Policy Office Transportation Planning Branch	Dawn Irish	Garden City Tower 2nd Flr, 301 St Paul St , St Catherines, ON L2R 7R4	dawn.irish@ontario.ca
Ministry of Natural Resources and Forestry	Manager, (Acting) Program Services Section	Beth Brownson		beth.brownson@ontario.ca
	Natural Herigate & Landuse Planning Advisor, Natural Heritage Section (Natural Resources and Forestry)	Susan Cooper	2nd Flr S, 300 Water St , Peterborough, ON K9J 3C7	susan.cooper@ontario.ca
	District Manager (Acting), Aurora	BradAllan	50 Bloomington Rd., Aurora, ON L4G 0L8	brad.allan@ontario.ca
Ministry of Municipal Affairs and Housing	Executive Assistant (Acting), Local Government and Planning Policy Division	Bianca Cirella	College Park, 13th Floor, 777 Bay St., Toronto, ON M5G 2E5	Bianca.Cirella@ontario.ca
	Director, Provincial Planning Policy Branch	Laurie Miller	College Park, 13th Floor, 777 Bay St., Toronto, ON M5G 2E5	lauriemiller@ontario.ca
Infrastructure Ontario	Director (Acting), Realty Management Branch Realty Division	Trevor Bingler	College Park 2nd Flr, 777 Bay St., Toronto, ON M5G 2E5	trevor.bingler@ontario.ca
Federal				
Member of Parliament	MP - Milton	Adam van Koeverden		Adam.vanKoeverden@parl.gc.ca
Department of Fisheries and Oceans			304-3027 Harvester Road, Burlington, ON L7R 4K3	fisheriesprotection@dfo-mpo.gc.ca
Utilities				
Milton Hydro				customerservice@miltonhydro.com
Halton Hills Hydro				chrish@haltonhillshydro.com
Hydro One	Secondary Land Use Department			SecondaryLandUse@HydroOne.com
Enbridge?				ombudsman@enbridge.com
Union Gas	Lead Environmental Planner	Doug Schmidt		dschmidt@uniongas.com
~~Bell Canada~~				"accessible@bell.ca"
Railways / Transit				
CN				contact@cn.ca
Canadian Pacific Railway (CPR)	Area Manager Support	Josie Tomei	800-1290 Central Parkway West	Josie_Tomei@cpr.ca
Environmental Groups				
Economic Development				
Milton Chamber of Commerce				info@miltonchamber.ca
Halton Hills Chamber of Commerce				generalmanager@haltonhillschamber.on.ca
BILD				info@bildgta.ca
Downtown Milton Business Owners Association				Cheryl Ciccarelli <c.ciccarelli@downtownmilton.com>
Hamilton-Halton Home Builders' Association				info@hhhba.ca
Agriculture				
Halton Agricultural Advisory Committee	Agricultural Liaison Officer	Anna DeMarchi-Meyers		anna.demarchi-meyers@halton.ca

30 Members of the Public Requesting to be added to Mailing List

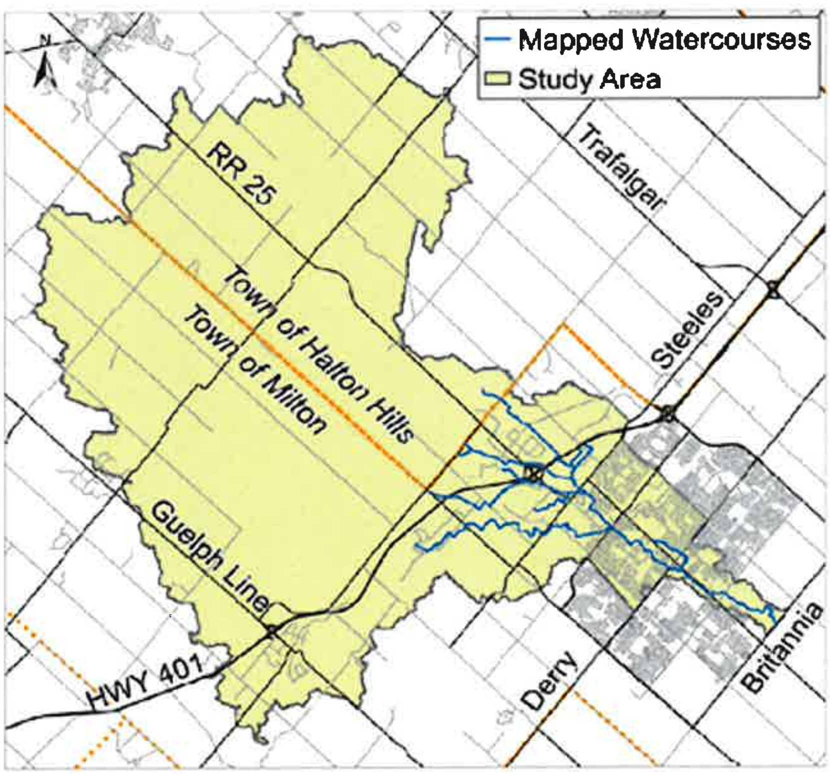
Amy Mayes

From: Amy Mayes
Sent: March 5, 2020 8:45 AM
To: Amy Mayes
Subject: Urban Milton Flood Study - Join us March 24th to learn more

In 2019, Conservation Halton retained Greck and Associates Ltd. to update models for the West Branch of Sixteen Mile Creek and update floodplain mapping within Urban Milton for this system (see Figure below that defines the study area and mapped watercourses). As our project nears completion, we are ready to share Draft Floodplain Mapping at a Public Information Centre. Please join us at a drop-in style open house to view the draft mapping, and learn more about this study and how to prepare for flooding. Conservation Halton staff, municipal staff, and the Project Consultant will be available to answer questions.

Urban Milton Floodplain Mapping
Public Information Centre #2:

Tuesday March 24th, 2020 | 6:30 - 8:30 p.m.
Milton Town Hall (Milton Room)
150 Mary Street, Milton



Conservation Halton is focused on protecting our communities, conserving our natural environment, and supporting our partners in the creation of sustainable communities. Floodplain mapping (which is used to identify areas that may be susceptible to flooding during very high flows) is an important tool that helps us fulfill our role as a watershed management agency. The models and mapping developed through this study may be used by Conservation Halton and our municipal partners for many purposes including:

- flood forecasting and warning,
- emergency planning and response,
- prioritization of flood mitigation works, and
- community planning and land use decision making.

Updated floodplain mapping also allows landowners to better prepare for and respond to potential flooding and to make informed decisions on personal emergency plans, property improvements, and insurance needs.

Following the PIC, the draft floodplain mapping will be available for viewing at Conservation Halton's Administration Office (2596 Britannia Road West, Burlington) between March 25th - April 7th. For additional study information please refer to: www.conservationhalton.ca/floodplainmapping.

To share your feedback, request additional information, or to be added to the project mailing list, please contact:

Amy Mayes, P.Eng.
Coordinator, Floodplain Mapping,
Conservation Halton
905.336.1158 ext. 2302
amayes@hrca.on.ca *

*Information will be collected in accordance with the Freedom of Information Act and Protection of Privacy Act. All information shared, with the exception of personal information, will become part of the public record.

Note: This message was sent to identified stakeholders that may have an interest in project outcomes. Please feel free to share notice of this event broadly within your community. If you do not wish to receive further notices related to this study, please respond to this e-mail requesting to be removed from the project mailing list.

Amy Mayes

From: Amy Mayes
Sent: March 19, 2020 4:53 PM
To: Amy Mayes
Subject: March 24th Urban Milton Flood Study PIC Cancelled - Information to be Shared Digitally

Dear Project Stakeholder - Due to concerns related to the spread of the CoVID-19 virus, Conservation Halton has cancelled the planned Public Information Centre for the Urban Milton Flood Hazard Mapping Project. We are working towards digitally sharing the **Draft** study findings, and I will share a link to the digital information, as well as detail on how to provide feedback on the Draft study findings in a subsequent e-mail that will be sent to you next week.

Thank you for your understanding in this matter,
-Amy

Amy Mayes, P.Eng.
Coordinator, Floodplain Mapping

Conservation Halton
2596 Britannia Road West, Burlington, ON L7P 0G3
905.336.1158 ext. 2302 | amayes@hrca.on.ca
conservationhalton.ca

Amy Mayes

From: Amy Mayes
Sent: March 25, 2020 1:54 PM
To: Amy Mayes
Subject: Urban Milton Floodplain Mapping Study - Summary of Draft Study Findings Now Available On-Line

Dear Project Stakeholder,

I'm writing to share that the study information planned to be released as part of the cancelled Public Information Centre for the Urban Milton Flood Hazard Mapping Study is now available here: https://conservationhalton.ca/milton-pic

Please take a moment to review this information.

kind regards,

Amy

Amy Mayes, P.Eng.
Coordinator, Floodplain Mapping

Conservation Halton
2596 Britannia Road West, Burlington, ON L7P 0G3
905.336.1158 ext. 2302 | amayes@hrca.on.ca
conservationhalton.ca

ephemeros

WELCOME

Urban Milton Flood Hazard Mapping Study

The first Public Information Centre (PIC) was held October 1, 2019, and focused on obtaining public input to inform the study.
The purpose of this second PIC is to:

1. Provide an overview flood hazard mapping practices and procedures
2. Present draft study results (Flood Risk Mapping)
3. Obtain public input on draft mapping
4. Answer questions on what it means for you and your property

Thank you for your interest. If you would like to provide comments on the draft study findings, please send them to Amy Mayes, Coordinator, Floodplain Mapping (amayes@hrca.on.ca)

Pease return all comments by: April 7 , 2020

All information collected is pursuant to Municipal Freedom of Information and Protection of Privacy Legislation.

For more information, please do not hesitate to contact the key study members below:

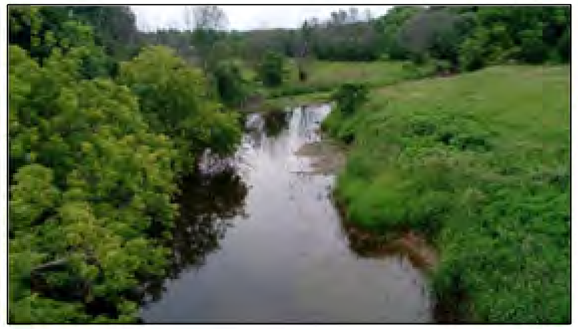
Amy Mayes, P.Eng.
Coordinator, Floodplain Mapping
Conservation Halton
2596 Britannia Rd. W.,
Burlington, ON L7P 0G3
Tel: (905) 336-1158 ext 2302
e-mail: amayes@hrca.on.ca

Brian Greck, P.Eng.
Senior Water Resources Engineer
Greck and Associates Limited
5770 Highway 7
Woodbridge, ON L4L 1T8
Tel: (289) 657-9797 ext 221
e-mail: bgreck@greck.ca


Source: Greck and Associates, Downstream of Wheelabrator Way, north of Steeles Ave , July 2019


Source: Greck and Associates, Upstream of Britannia Rd, July 2019


Source: Greck and Associates, Downstream of Main Street, west of Martin Street, July 2019


Source: Greck and Associates, Upstream of Laurier Ave, near Milton District High School, July 2019


Source: Greck and Associates, Upstream of Derry Road, west of Ontario Street , July 2019

Conservation Halton

Disclaimers
All information provided will be subjected to Freedom of Information and Protection of Privacy Act, and with the exception of personal information, it may be released upon request.
Public information will be included within the final study report.

Greck

FLOODING TYPES

Flooding is a natural occurrence. Flooding occurs when water exceeds its banks and flows into normally dry low lying areas adjacent to a watercourse or a body of water.
Flooding is caused by severe weather events, snow melt, ice jams, debris jams or dam failure.

Types of flooding include:

- Shoreline / coastal flooding due to high lake levels, storm surge, waves, tides etc.
- Urban Flooding/Basement Flooding due to flow exceeding capacity of overland flow paths and/or surcharging of storm sewers.
- Riverine Flooding where a watercourse overflows its banks.
- Seepage from the slow transition of groundwater from the earth through a building's foundation/walls

This study assesses Riverine Flooding for the West Branch of Sixteen Mile Creek within Urban Milton

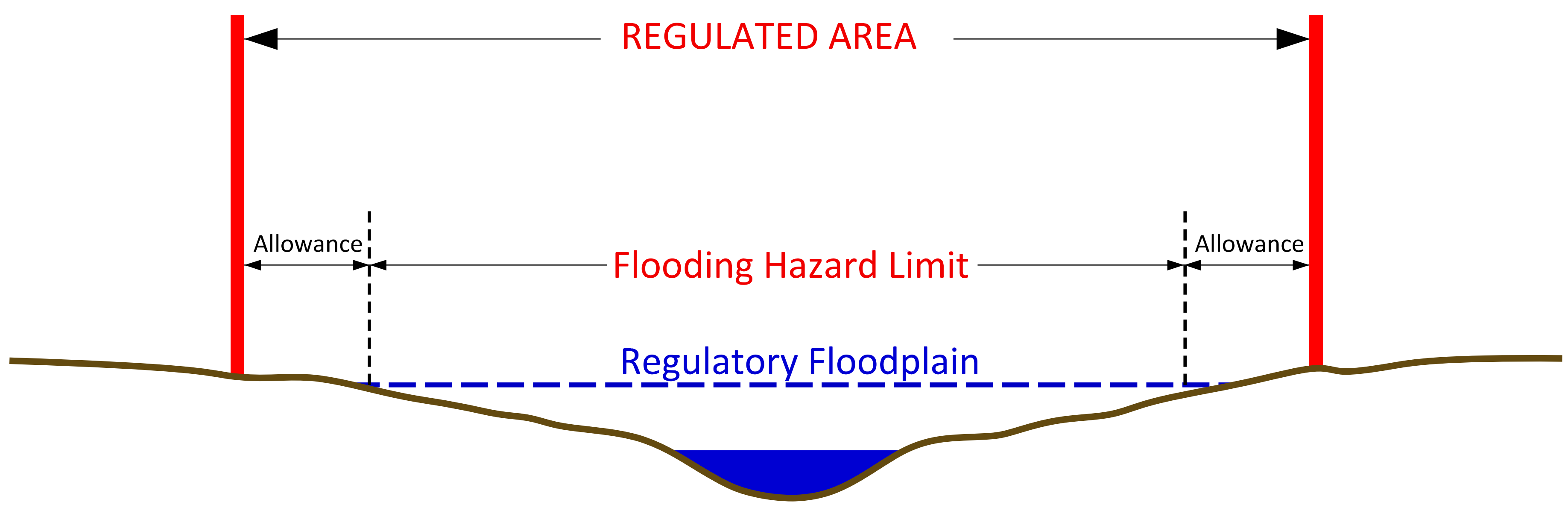
WHAT IS A FLOODPLAIN MAP?

A floodplain is an area of low-lying ground next to a watercourse, which may be subject to flooding.

A floodplain map identifies the areas predicted to flood during specified severe storm events.

Within Southern Ontario, the Regulatory Floodplain is defined by the greater floodplain from Hurricane Hazel, or the 100-year rainfall event (1% probability of occurrence within a given year).

Understanding the flood hazard is the first step in building flood resiliency!



Why Map the Floodplain?

For Conservation Authorities and Governments, understanding the flood hazard supports:

- Community and land use planning
- Emergency planning and response
- Flood forecasting and warning
- Flood mitigation works
- Infrastructure design

For Businesses and Landowners, knowing the risk allows informed decisions on:

- Property use and improvements
- Personal emergency planning
- Insurance needs

Conservation Halton

Greck

WHAT IS A REGULATORY STORM EVENT?

In 1954, Southern Ontario experienced significant flooding following the Hurricane Hazel storm, which dropped approximately 285mm (11") of rain over 36 hours.

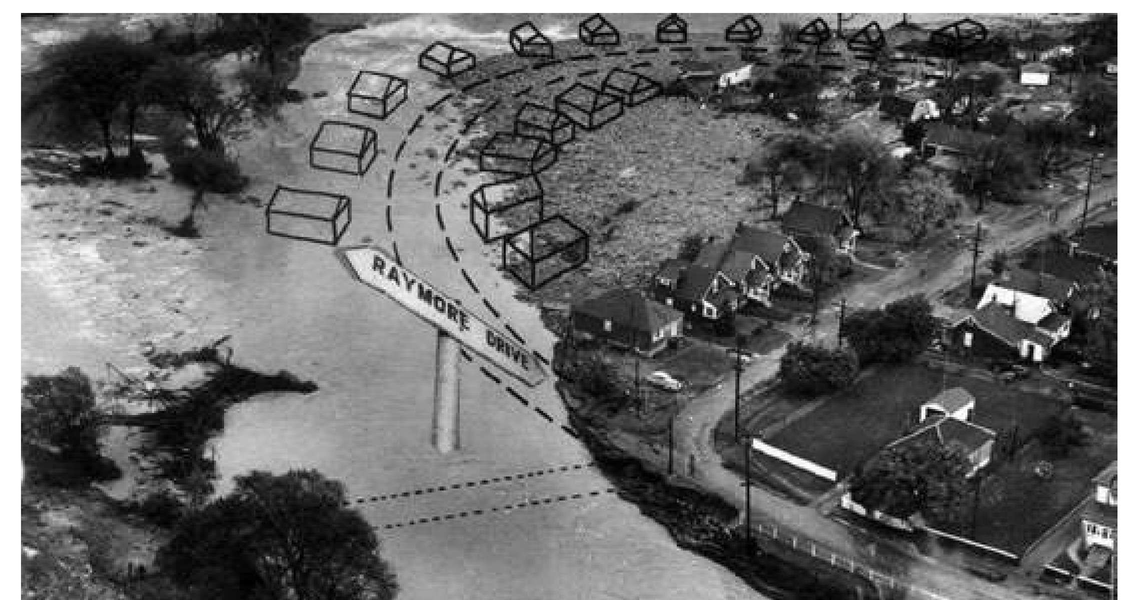
The main factors that contributed to flooding included: the extended period of rainfall preceding the storm followed by heavy rainfall, insufficient flood protection infrastructure and development within flood prone areas.

Hurricane Hazel caused significant flooding in Ontario resulting in:

- 81 deaths
- 4,000 families left homeless
- 32 houses washed away
- An estimated $1.3 billion (2018 dollars) in damages

Source: thecanadianencyclopedia.ca/en/article/hurricane-hazel

Source: thecanadianencyclopedia.ca/en/article/hurricane-hazel



Location of homes on Raymore Dr. washed away by the Hurricane Hazel floodwater (hurraicanehazel.ca)

Following Hurricane Hazel, the Conservation Authorities Act was amended, empowering Conservation Authorities to regulate development of floodplain lands.

ROLES AND RESPONSIBILITIES

Conservation Authorities and Municipalities work in partnership to prevent and manage flooding. Each agency and landowner has a unique role in flood prevention and watershed management.

This study was completed in partnership with watershed municipalities who participated on a Technical Advisory Committee (TAC).

LOWER TIER MUNICIPALITY

- Road Drainage
- Storm Sewers
- Parks & Trails
- Greenbelts
- Land Use and Zoning Approvals
- Tree Canopy
- Stormwater Management
- Emergency Services

UPPER TIER REGIONAL MUNICIPALITY

- Coordinate and provide emergency response
- Conduct land use planning and approval processes
- Own and maintain Regional Infrastructure (ponds, roads, sewers, etc.)
- Protect water quality and public health
- Plan and manage green spaces and natural heritage systems

CONSERVATION AUTHORITY

- Natural Hazard (Flood, Erosion, Dynamic Beach), Hazardous Site (Karst), and Wetland Regulation
- Flood Forecasting and Warning
- Flood Control Infrastructure (Dams & Concrete Channels)
- Commenting Agency on Development Applications (Stormwater Management)
- Manage Flood Hazard Models
- Watershed Monitoring
- Stewardship and Restoration

LANDOWNERS

- Know the Risks: Is the property flood susceptible? Is flooding expected?
- Make a Plan: What can you do to protect your family and your property?
- Get a Kit: Do you have supplies for 72 hours?

HISTORY OF FLOOD MANAGEMENT

A number of flood mitigation strategies have been included within the Sixteen Mile Creek watershed:

1. Channelization

Urban Milton Flood Control Channel

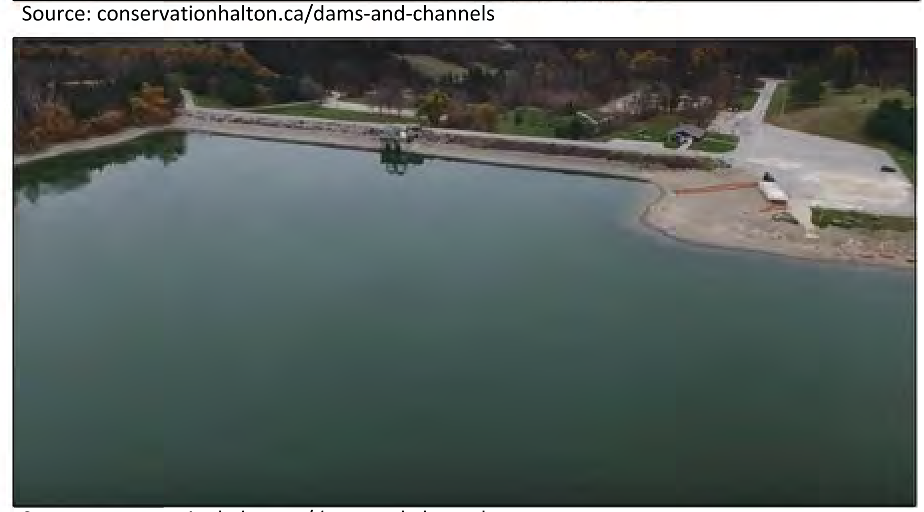
Source: Greck and Associates Limited, 2019

Source: Greck and Associates Limited, 2019

2. Water Management

Kelso, Hilton Falls and Scotch Block Reservoirs

Source: conservationhalton.ca/dams-and-channels



Source: conservationhalton.ca/dams-and-channels

3. Flood Forecasting Warning
4. Protection of life and property through natural hazard regulation (O.Reg 162/06)
5. Stormwater Management for new development

STUDY OBJECTIVES

This Study is being completed by Greck and Associates Limited on behalf of Conservation Halton in consultation with a Technical Advisory Committee (TAC), which includes representatives from the Town of Milton, Town of Halton Hills, and Region of Halton.

Primary Objective

Comprehensively update flood risk models for the major tributaries of the West Branch of Sixteen Mile Creek within Urban Milton to redefine the watershed flow (hydrology), and water level and velocity (hydraulics) to develop new flood hazard mapping.

The study follows the Provincial and Federal Guidelines for flood risk mapping.

Source: Conservation Halton, Riverwatch, August 4, 2014

Source: Conservation Halton –Feb. 12, 2009 Riverwatch

Source: City of Burlington, August 4, 2014

At the end of the study, the report and flood hazard maps will be available to the public (Spring 2020)

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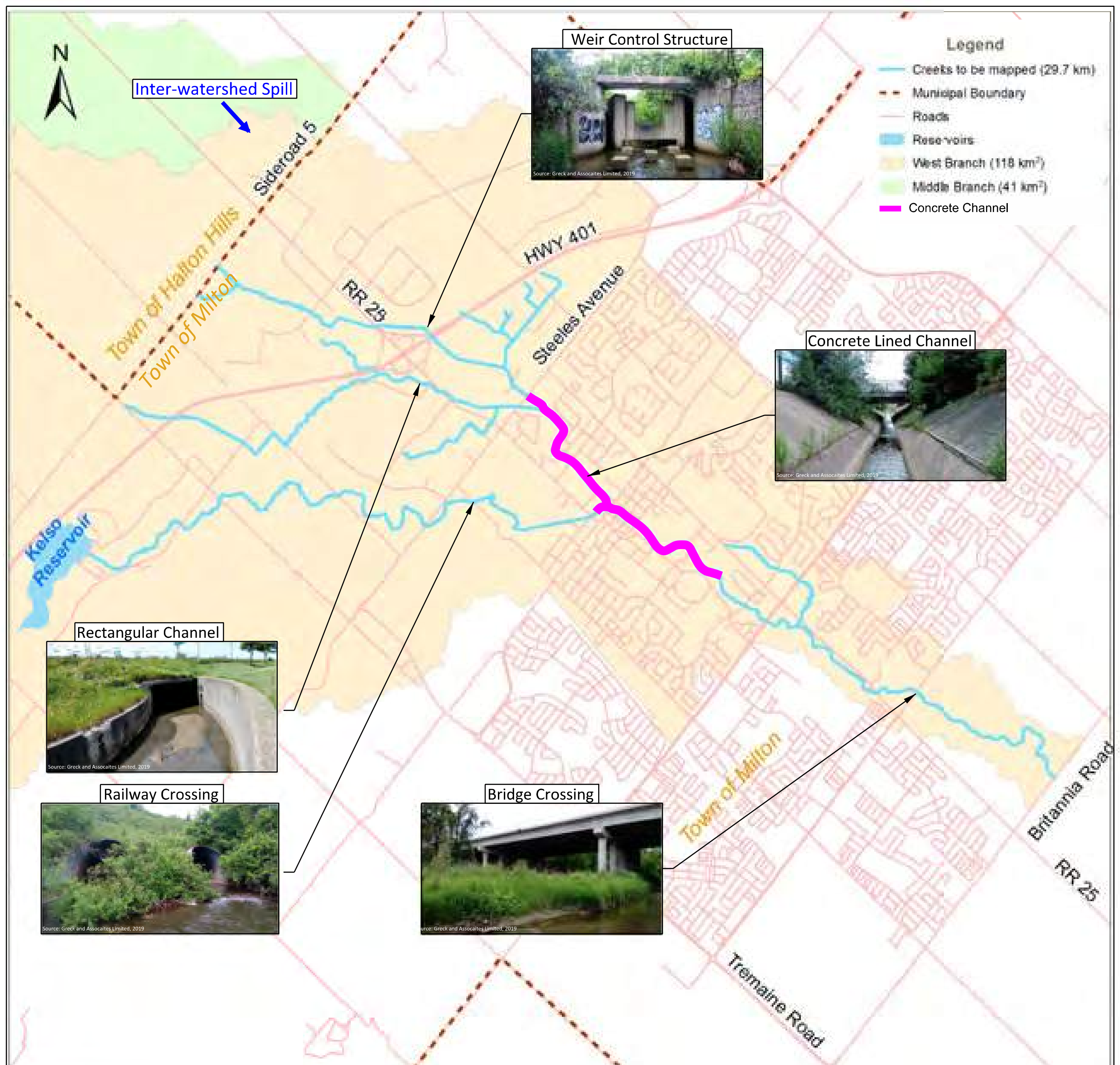
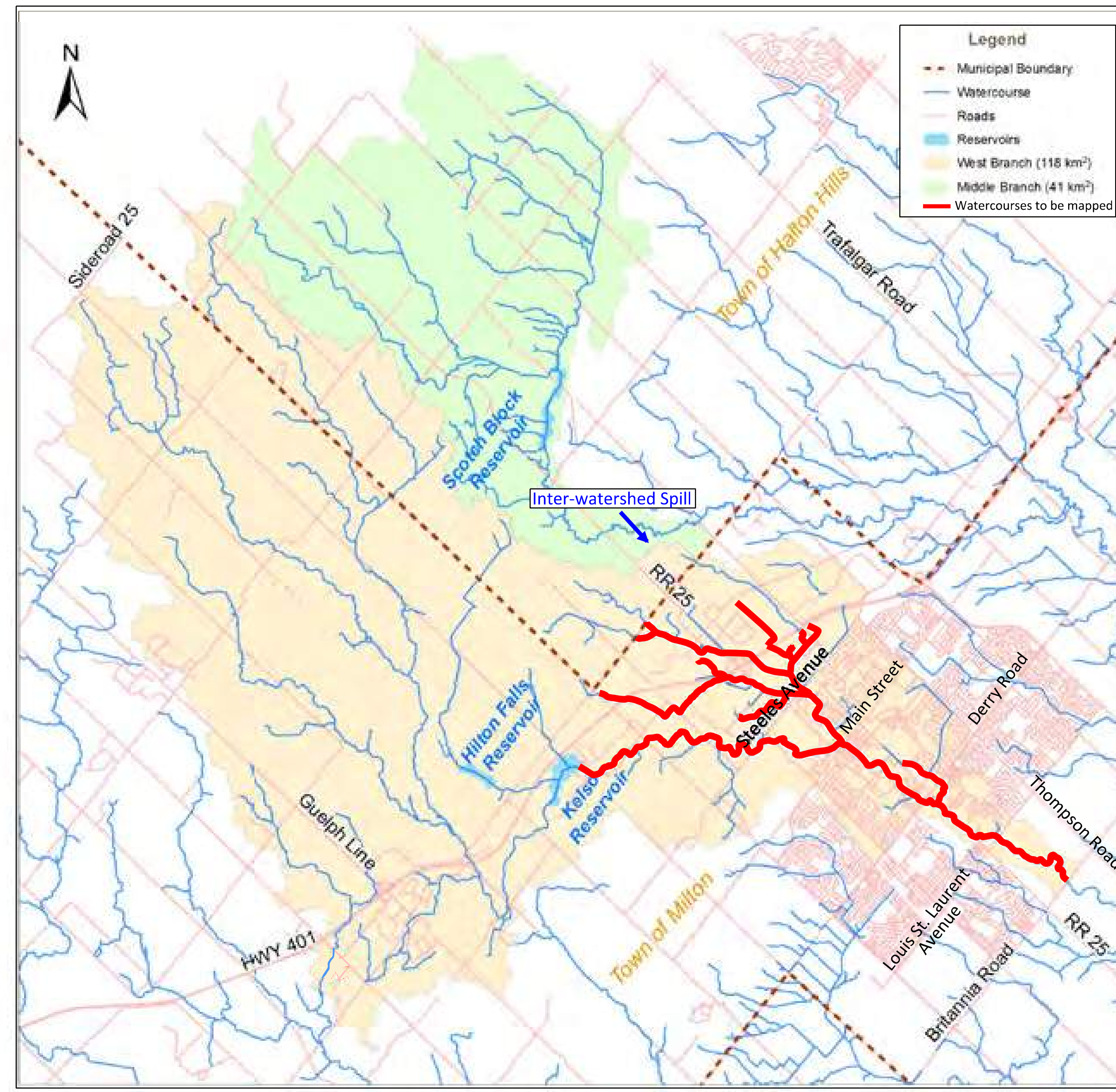
STUDY AREA DESCRIPTION

The floodplain area mapped is shown below.



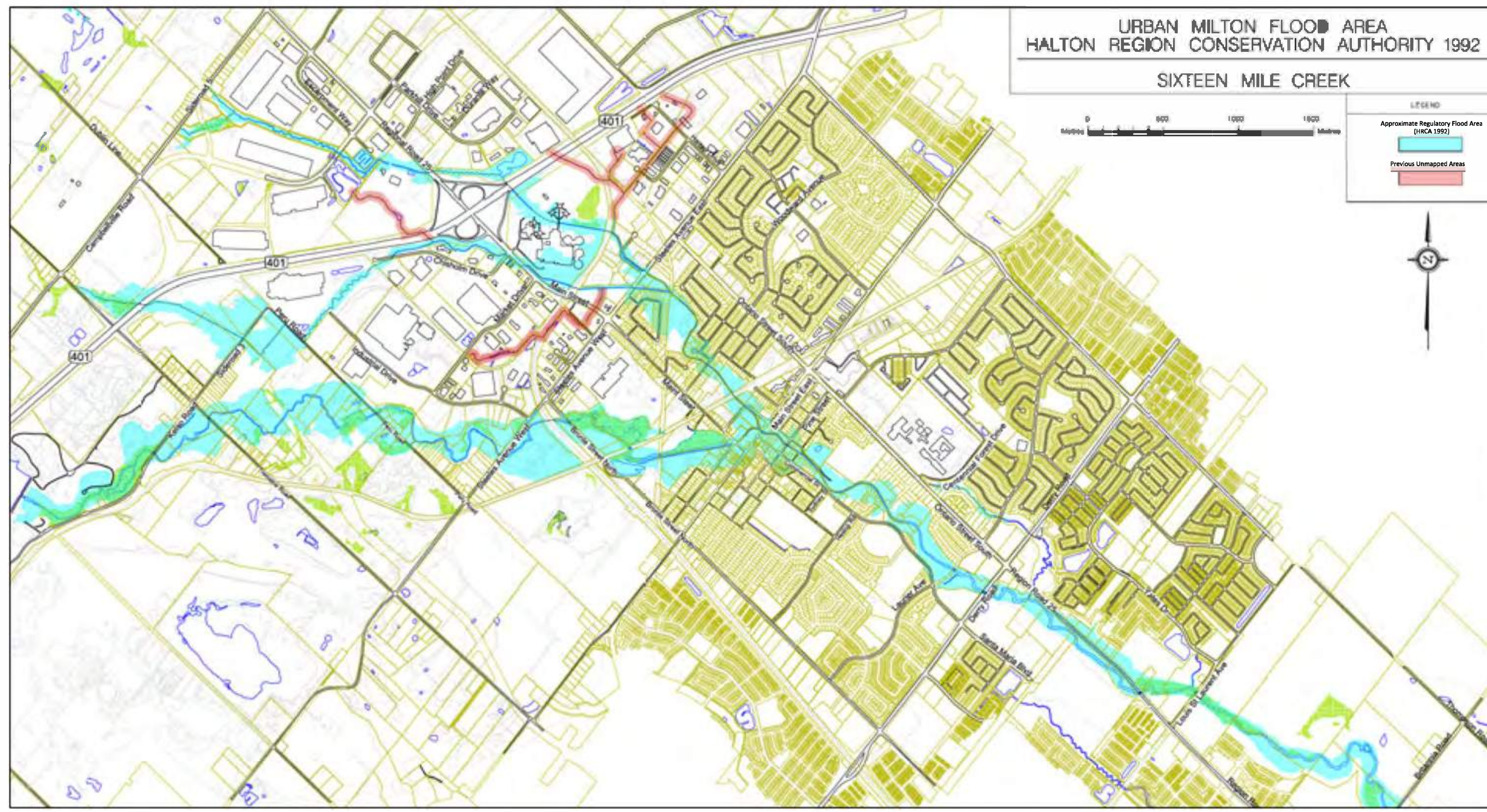
Approximately 159 km^2 of upstream drainage area (including a potential inter-basin spill) contributes flow to the mapped tributaries. Understanding flows within the watershed is an important element in mapping the floodplain.



PREVIOUS FLOOD HAZARD STUDIES

Several local-scale studies have been completed to define the flood hazard limits within Milton. The last comprehensive flood mapping study of the West Branch of Sixteen Mile Creek was the *Halton Region Conservation Authority Floodline Mapping Study of Sixteen Mile Creek* completed in 1988 by Proctor and Redfern Group Consulting Engineers and Planners.

- Floodplain models have been updated over time in support of local land use planning and CH permit applications but not on a comprehensive basis
- Significant technical advances since 1988 allow greater analytical complexity, giving a better understanding of flood risk
- Comprehensive modelling and mapping is necessary to support identification of the flood hazard



Note: The extent of Conservation Halton's approximate Regulation Area may differ from what is shown, given the approximate regulation area also includes erosion hazards and wetlands. Above map indicates only the historical approximate flood hazard assocaited with the watercourse to be mapped as part of the study area shown.

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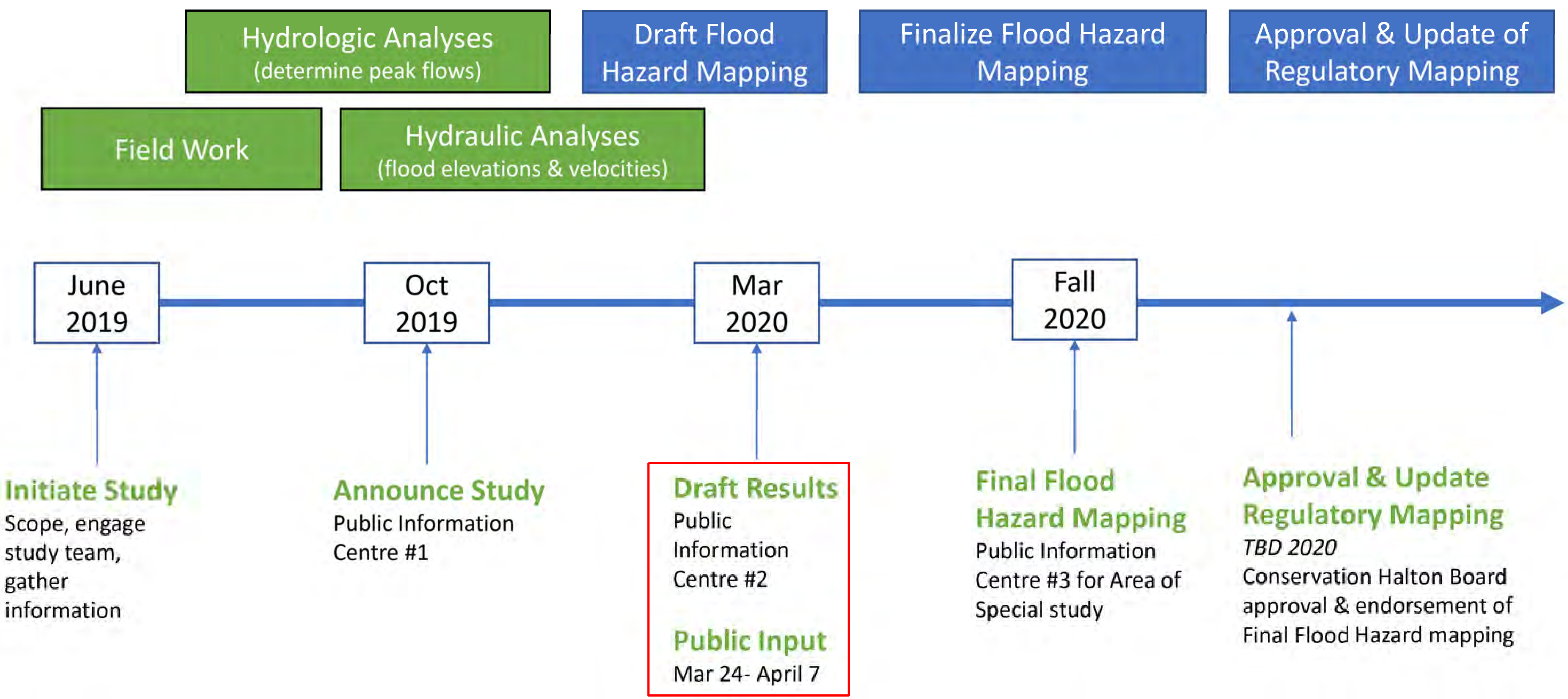
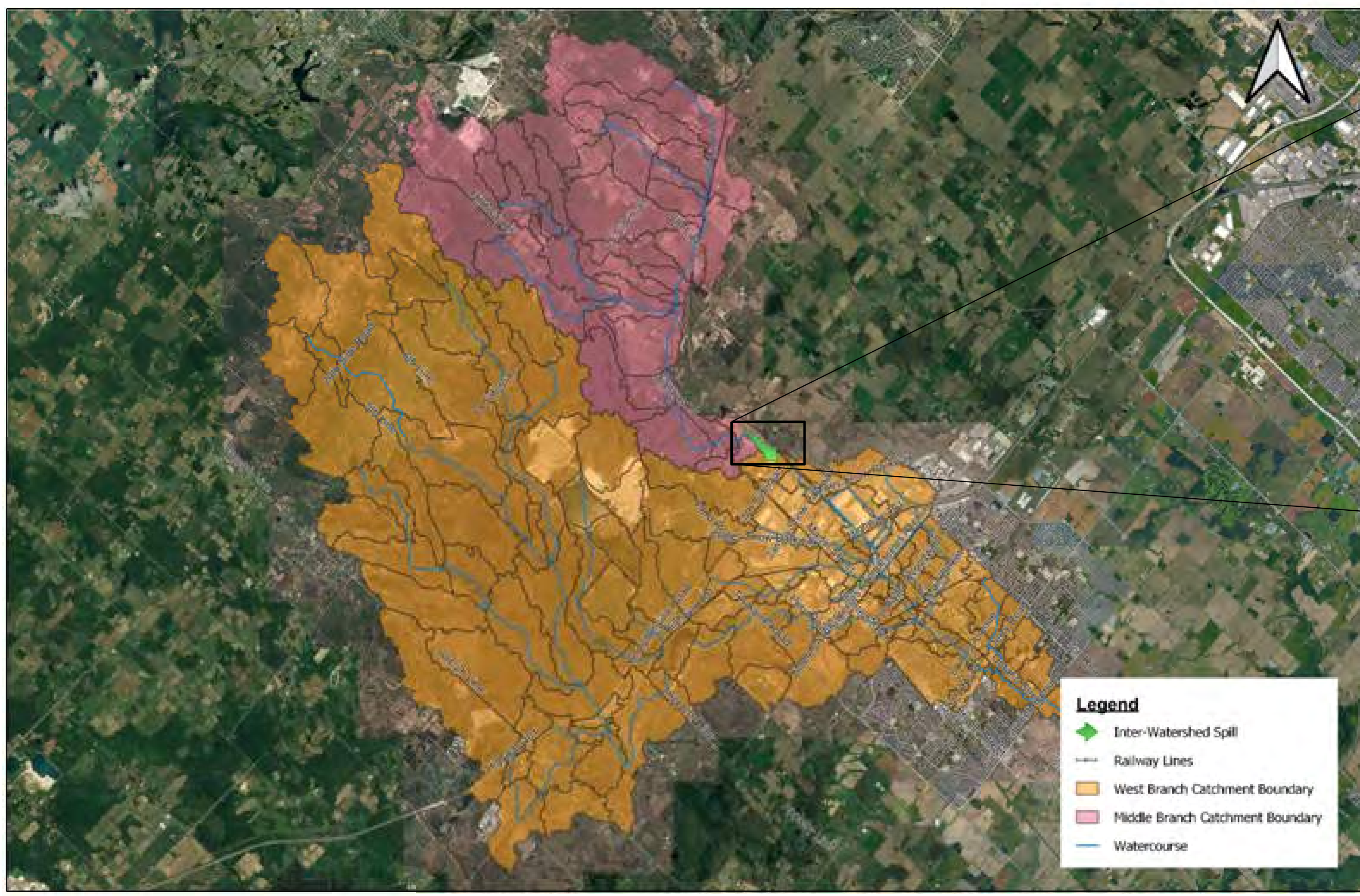
FLOOD HAZARD MAPPING TIMELINE

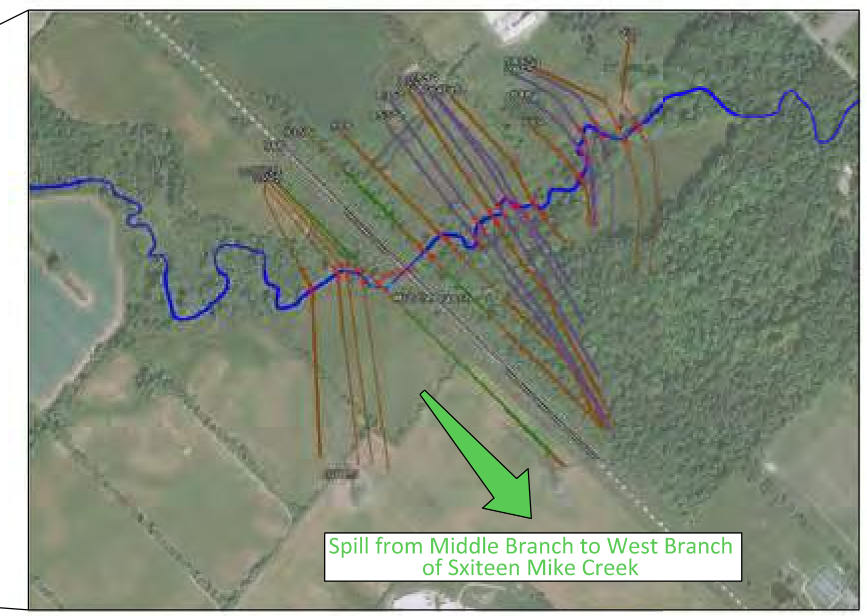


INTER-WATERSHED SPILL FLOWS

Incoming Spill Flows

- Spills occur when flood waters exceed the capacity of a valley system. Excess flood waters flow from one watershed, and travel overland, spilling into an adjacent system.
- Spills from adjacent watersheds impact Regional peak flows within the study area.
- Potential spills were noted between the Middle Branch of Sixteen Mile Creek and towards the West Branch of Sixteen MIle Creek near 5th Side road upstream of an existing railway crossing between 3rd Line and Regional Road 25.





Middle Branch of Sixteen Mile Creek

- 1D, non-steady state hydraulic model was created to quantify spill.
- During the Regional Storm Event, 16 m^3/s spills from the Middle Branch to the West Branch of Sixteen Mile Creek.

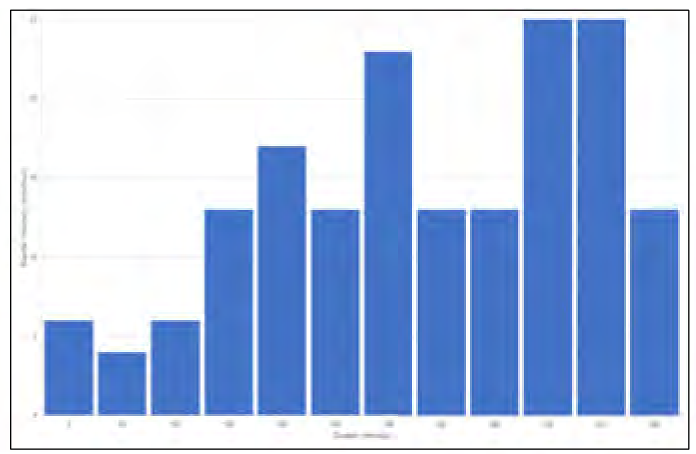
HYDROLOGY - HOW PEAK FLOWS ARE DETERMINED

- To estimate peak flows throughout the watershed, a computer-based hydrologic simulation model was developed incorporating the land use, soils, drainage patterns and rainfall data.
- The model was calibrated and validated using observed flow conditions throughout the watershed.
- Topographic survey (elevation information) was captured using LiDAR technology in the spring of 2018 and used to determine overall drainage patterns and sub-catchments.

DATA INPUTS

Soil Type

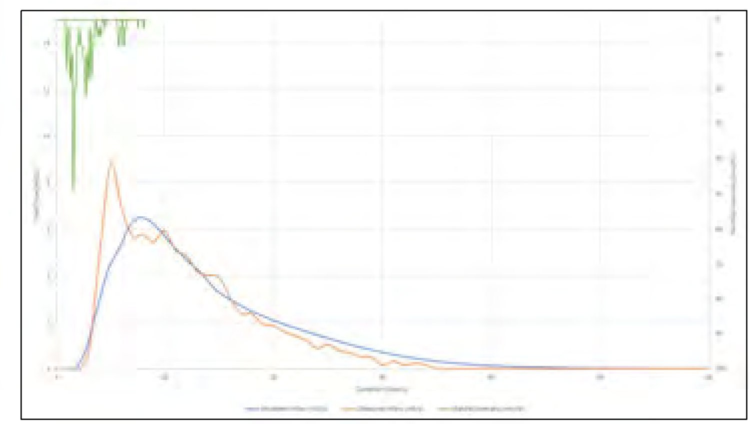
Rainfall

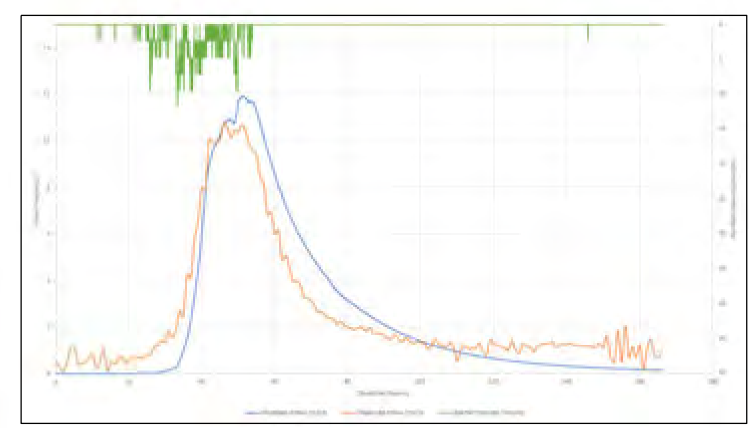


Catchments

Land Use

HYDROLOGY MODEL MODELLED VS. OBSERVED FLOWS





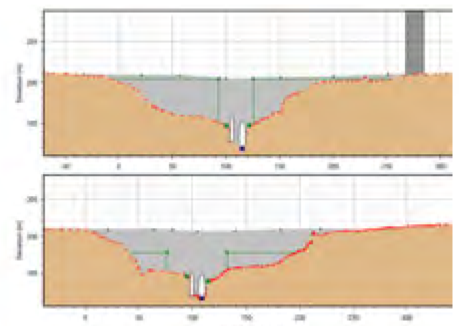
PEAK FLOW ESTIMATES

HYDRAULICS - HOW PEAK FLOOD LEVELS ARE DETERMINED

- A computer-based hydraulic simulation model was developed to predict flood elevations and the extent of flooding throughout the study area.
- The hydraulic model evaluates the impacts of bridges, the watercourse & valley shape, building obstructions and surface roughness (rough vegetation vs smooth concrete/asphalt) to produce the flood elevations and flow velocity associated with flows generated from the hydrologic model.

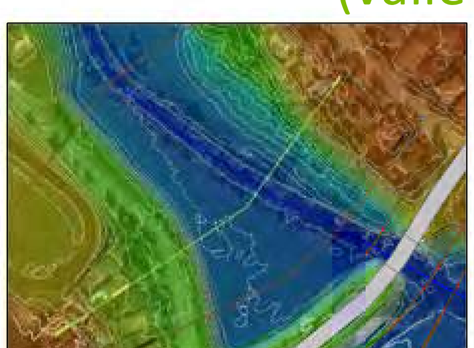
HYDRAULIC INPUTS

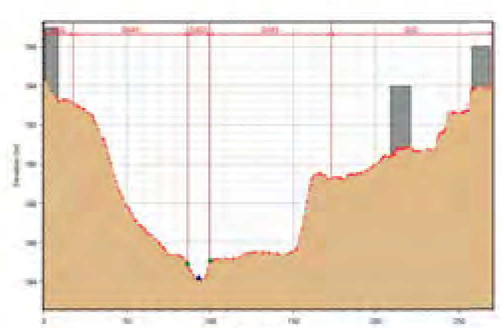
Survey to confirm bridge/culvert structures



Account for building obsturctions

Define cross sections from topography (valley shape)

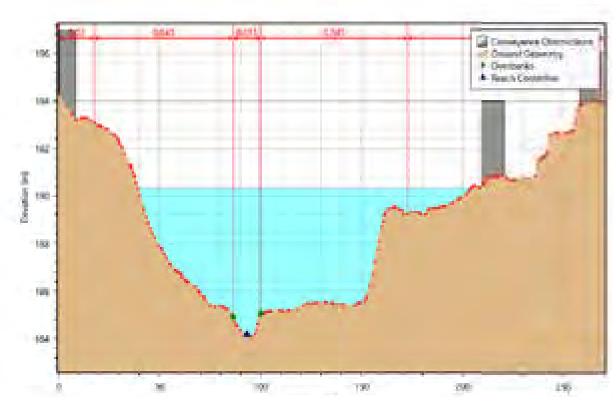




HYDRAULIC MODEL

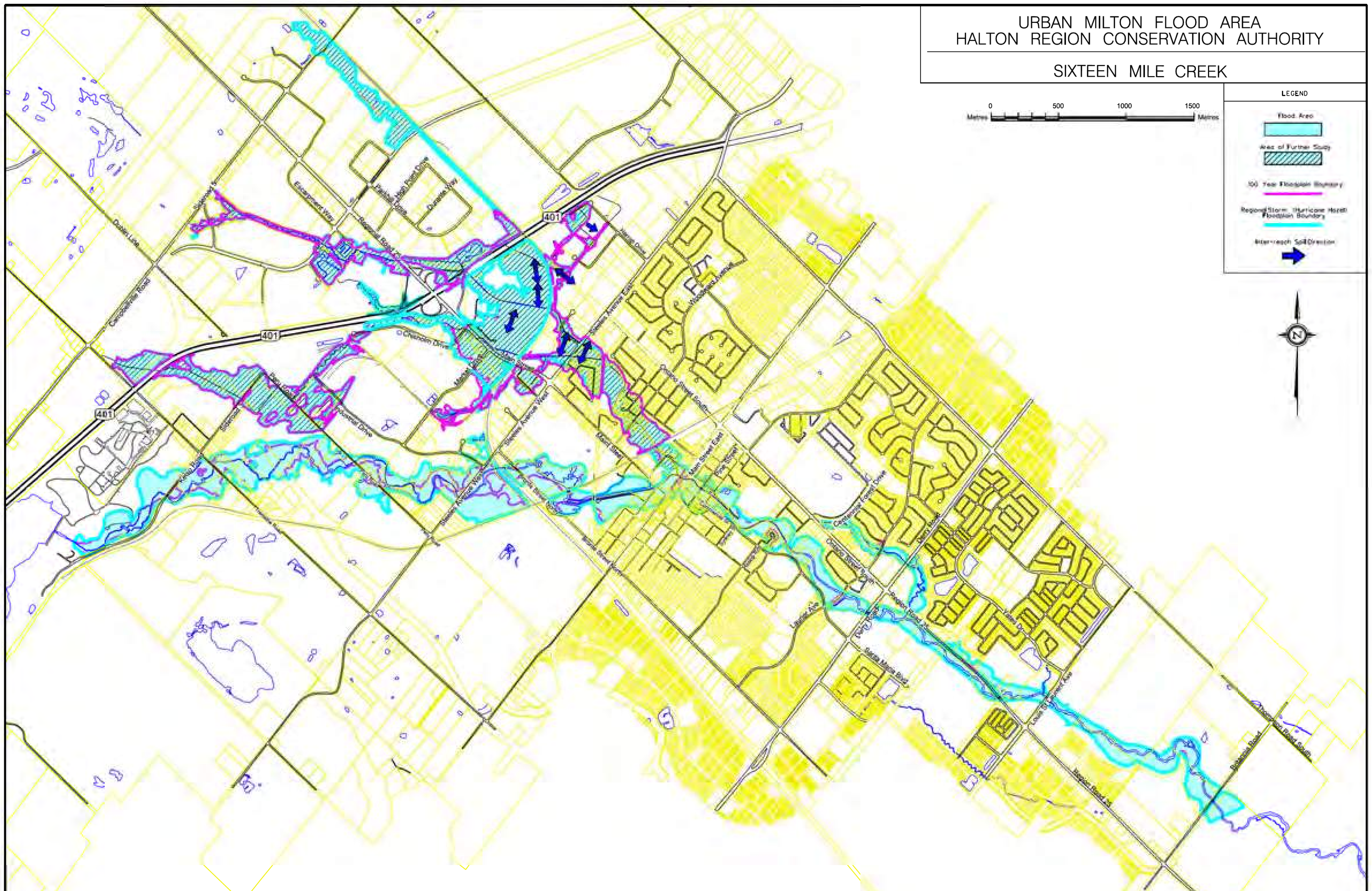
PEAK FLOW ESTIMATES FROM HYDROLOGY MODEL

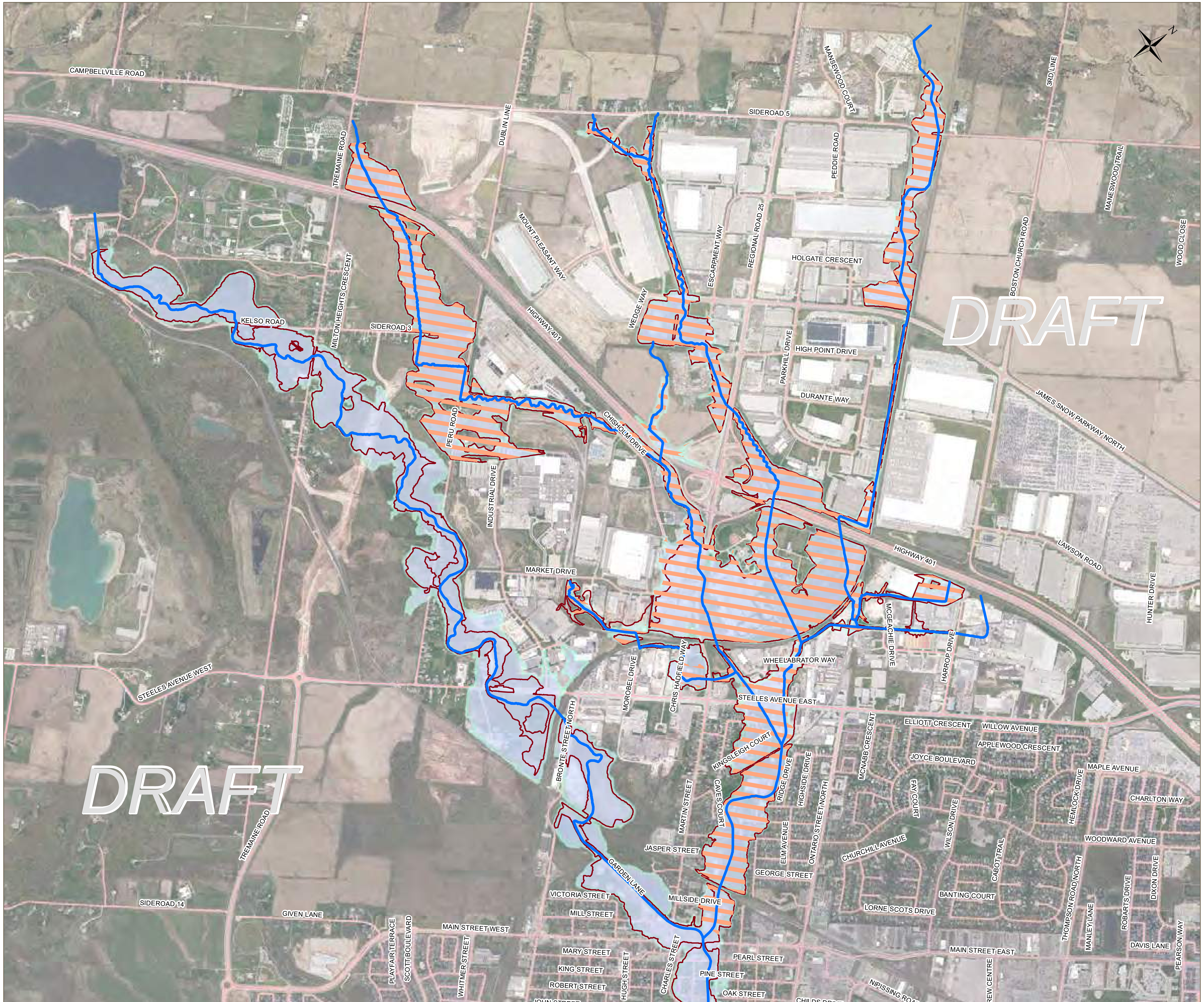
WATER LEVELS & FLOODING EXTENTS



SPILL BETWEEN REACHES

- Inter-reach spills occur throughout the watershed, where flood waters overtop the valley slope and spill to another area within the watershed.
- Flows through the reach are not reduced downstream of spills as per Provincial guidelines.





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Urban Milton Draft Flood Hazard Mapping Area 1

Legend

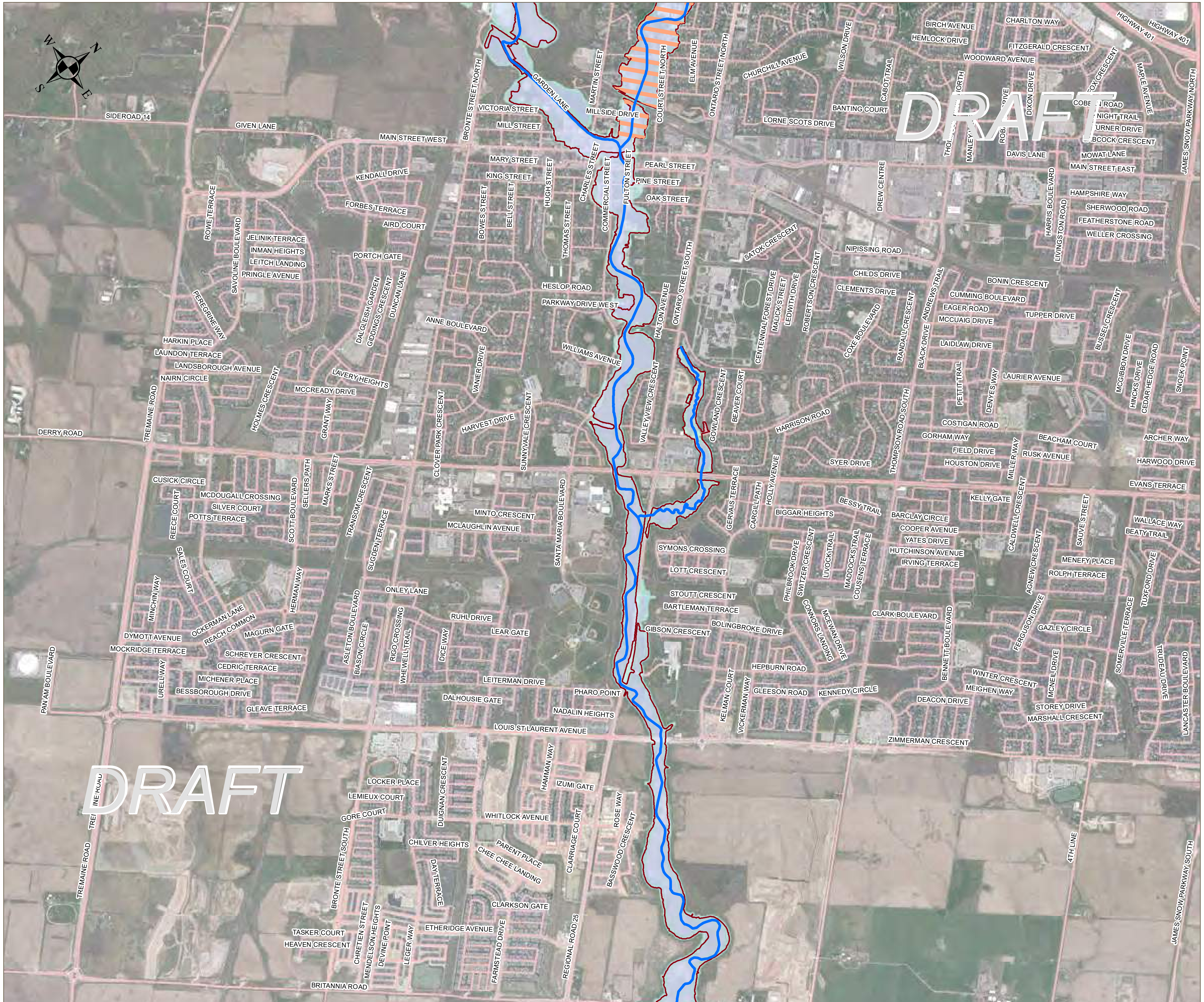
- Mapped Watercourses
- Area of Further Study
- Floodplain - 100 yr
- Floodplain - Regional
- Roads

The floodlines shown on this map were developed by Greck and Associates (March 2020), as part of the Urban Milton Flood Hazard Mapping Study. This mapping is draft and reflects flood hazards where updated mapping has been done. This mapping does not show Conservation Halton's regulation limit mapping. Additional hazards or regulated areas may be present within this area. Under Ontario Regulation 162/06, Conservation Halton regulates: 1) all development in or adjacent to river or stream valleys, wetlands, shorelines or hazardous lands; 2) alterations to a river, creek, stream or watercourse; and 3) interference with wetlands. More information related to Conservation Halton's regulation, policies and regulatory mapping can be found at: www.conservationhalton.ca.

Areas identified as 'Area of further study' will be subject to additional analysis. Future consultations will occur prior to finalizing the floodlines and prior to approval by Conservation Halton's Board of Directors.

Orthophoto imagery from Region of Halton (2019)

0 165 330 660 990 1,320 1,650 Metres



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Conservation Halton

Urban Milton Draft Flood Hazard Mapping Area 2

Legend

- Mapped Watercourses
- Area of Further Study
- Floodplain - 100 yr
- Floodplain - Regional
- Roads

The floodlines shown on this map were developed by Greck and Associates (March 2020), as part of the Urban Milton Flood Hazard Mapping Study. This mapping is draft and reflects flood hazards where updated mapping has been done. This mapping does not show Conservation Halton's regulation limit mapping. Additional hazards or regulated areas may be present within this area. Under Ontario Regulation 162/06, Conservation Halton regulates: 1) all development in or adjacent to river or stream valleys, wetlands, shorelines or hazardous lands; 2) alterations to a river, creek, stream or watercourse; and 3) interference with wetlands. More information related to Conservation Halton's regulation, policies and regulatory mapping can be found at: www.conservationhalton.ca.

Areas identified as 'Area of further study' will be subject to additional analysis. Future consultations will occur prior to finalizing the floodlines and prior to approval by Conservation Halton's Board of Directors.

Orthophoto imagery from Region of Halton (2019)

0 185 370 740 1,110 1,480 1,850 Metres

Summary of Public Consultation

Urban Milton Flood Hazard Mapping Study – PIC 3: February 22, 2023

Newspaper Ads:

- Notice of PIC 3 ran February 2, 2023 in the Milton Champion and Georgetown Independent/Acton Free Press

Social Media

- Notice of PIC 3 posted February 20, 2023 on CH Facebook

Stakeholder Mailing:

- Notice of PIC 3 was sent via email on February 3, 2023 to stakeholders following Conservation Ontario's, "*Procedures for Updating Section 28 Mapping: Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulations*" and to members of the public who registered for PICs 1-3 or requested to be added to the email list

- Notice of PIC 3 was sent via mail on January 30, 2023 to property owners potentially affected by the mapped flood hazard in a targeted area bounded by Steeles Avenue to north, Regional Road 25 to the east, CP Railway to the south and Martin Street to the west as a pilot outreach action

Website:

- Notice of PIC 3 and registration link posted February 2, 2023 on CH website (https://www.conservationhalton.ca/mapping-and-studies/)

- Draft updated mapping and report posted February 16, 2023 on CH website

- PIC 3 presentation slides and recording of session posted February 23, 2023 on CH website

PIC 3 Content

- Presentation slides
- Newspaper notice
- Email notice
- Email notice stakeholder and public list (abbreviated)
- Mail notice

CONSERVATION HALTON:
URBAN MILTON FLOOD HAZARD MAPPING STUDY

PUBLIC ENGAGEMENT SESSION #3
February 22, 2023

Conservation Halton

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WELCOME: AGENDA

1. Welcome & Introductions
2. About Conservation Halton and Flood Hazards
3. Urban Milton Flood Hazard Mapping Study Overview
4. Updated Draft Flood Hazard Mapping
5. Questions & Discussion
6. Next Steps

LAND ACKNOWLEDGEMENT

Halton is rich in history and modern traditions of many First Nations and Métis. From the Anishinaabe to the Attawandaron, the Wendat, the Haudenosaunee and the Métis – these lands surrounding the Great Lakes are steeped in Indigenous history. As we gather today on these treaty lands, we have the responsibility to honour and respect the four directions, land, waters, plants, animals, and ancestors that walked before us and all the wonderful elements of creation.

We acknowledge and thank the Mississaugas of the Credit First Nation for the opportunity to work in their traditional territory.

momentum

GREEN • RESILIENT • CONNECTED

OUR PURPOSE
Protect people from natural hazards, conserve nature and provide opportunities for outdoor recreation and education across our watershed.

OUR AMBITION
A green, resilient, connected tomorrow.

CONSERVATION HALTON: PRIORITIES

EDUCATION, EMPOWERMENT & ENGAGEMENT

NATURE & PARKS

SCIENCE, CONSERVATION & RESTORATION

DIGITAL TRANSFORMATION & INNOVATION

NATURAL HAZARDS & WATER

ORGANIZATIONAL SUSTAINABILITY

PEOPLE & TALENT

NATURAL HAZARDS & WATER

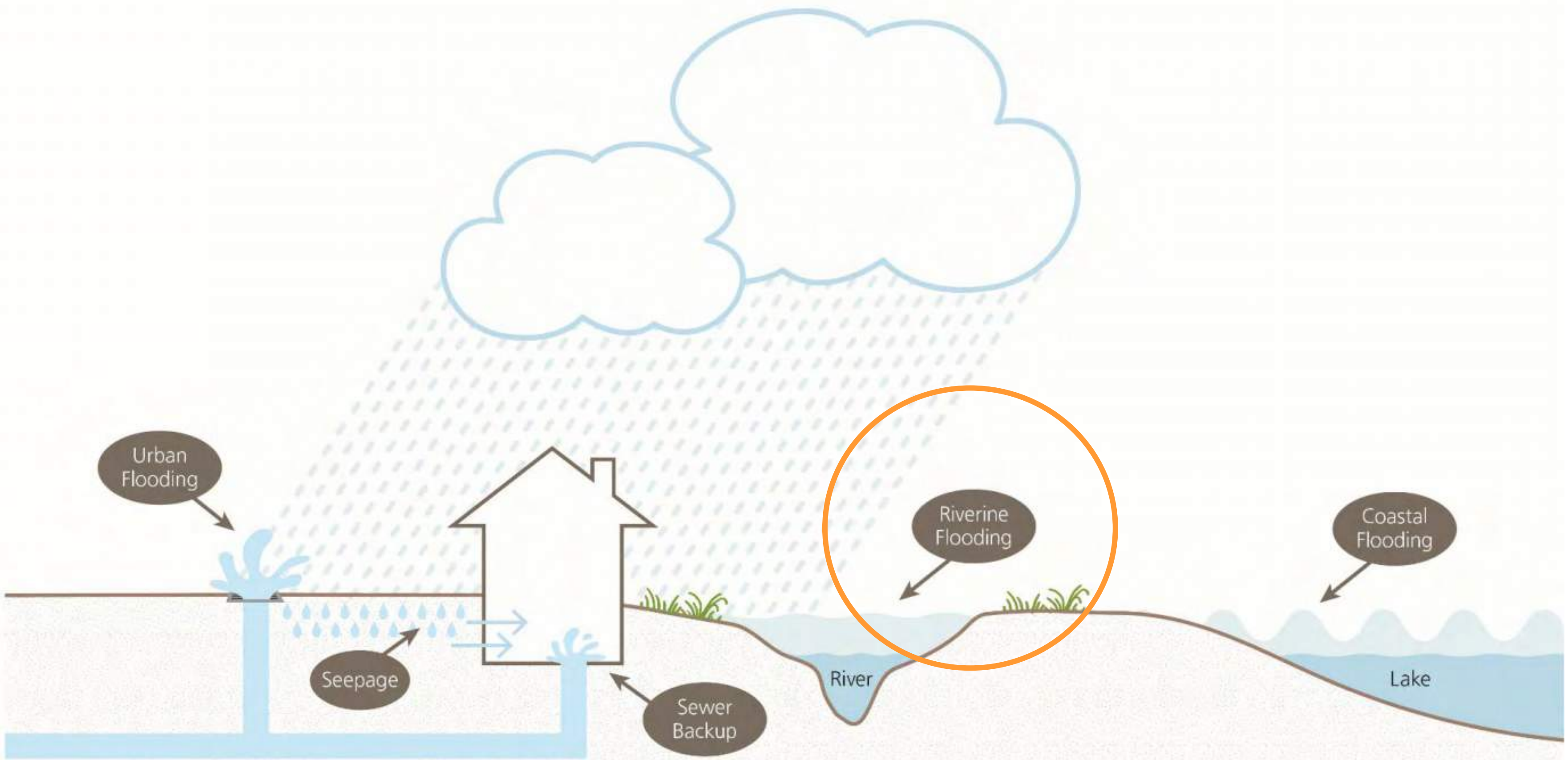
Protect people, property, drinking water sources and natural resources to support development that is in balance with the environment

Foster partnerships and identify opportunities to build mutual understanding, trust, respect, and support with watershed stakeholders

CONSERVATION HALTON: PRIORITIES

Conservation Halton's goal is to **protect people and property** from risks related to natural hazards (e.g. flooding & erosion hazards) and to make sure that existing hazards are **not worsened** and/or new hazards are **not created**

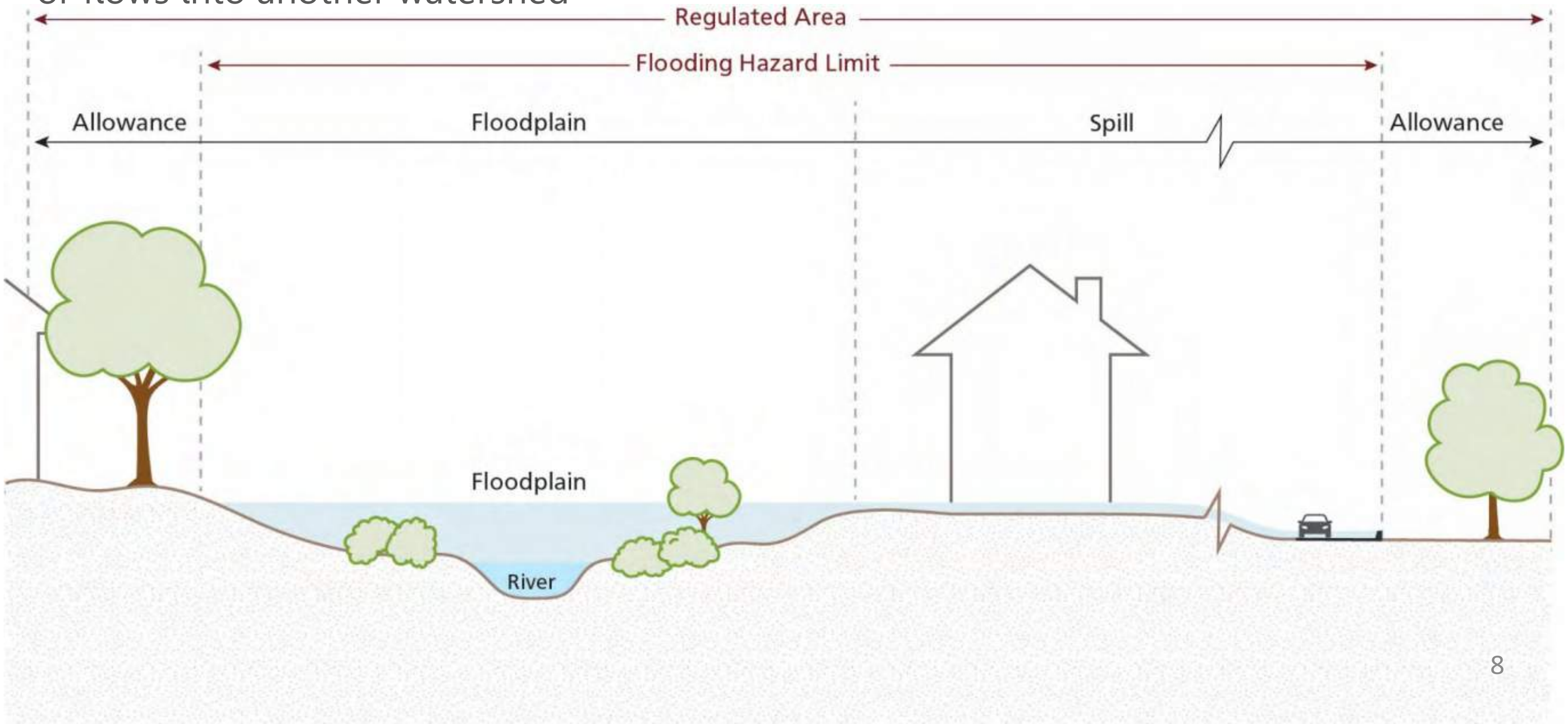
FLOOD HAZARDS: TYPES OF FLOODING



FLOOD HAZARDS: RIVERINE FLOOD HAZARDS

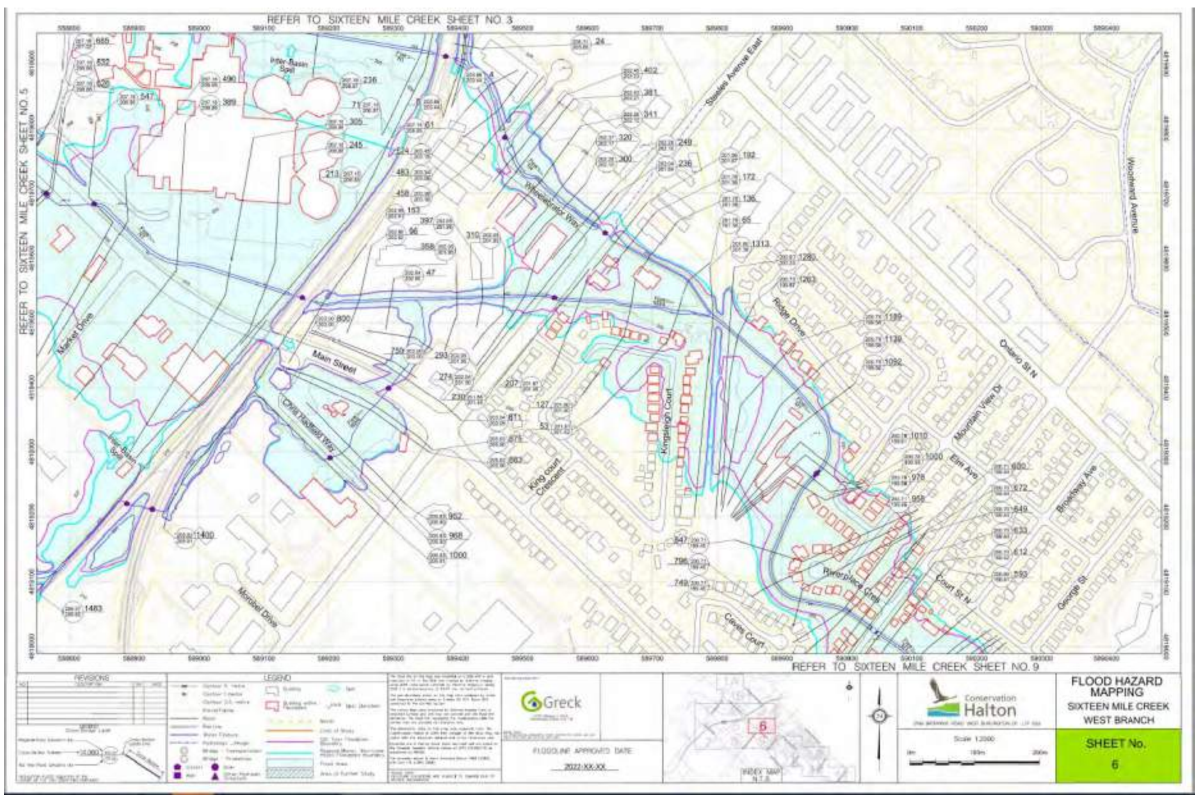
FLOODPLAIN: Area of land that is flooded by a nearby watercourse, such as a creek *(riverine)* or lake *(shoreline),* during large storm events

SPILL: When water leaves the watercourse *and* the valley and floodplain, flows into surrounding lands, and then returns to the watercourse at a distance downstream, or flows into another watershed



FLOOD HAZARDS: WHAT IS FLOOD HAZARD MAPPING?

FLOOD HAZARD MAPPING uses models to predict where riverine flooding will occur and the extent of riverine flood hazards in a given area. Flood hazard mapping ***does not create*** a flooding hazard—it shows where the hazard already exists.



FLOOD MITIGATION: ROLES & RESPONSIBILITIES

1

MILTON HALTON HILLS

MUNICIPALITY

- Emergency Preparedness & Services
- Road Drainage
- Stormwater Management
- Parks & Trails
- Subwatershed Planning
- Land Use Planning & Zoning

2

Halton Region

REGIONAL MUNICIPALITY

- Emergency Management
- Flooding Prevention & Recovery
- Basement Flooding Subsidy
- Regional Infrastructure
- Water Quality

3

Conservation Halton

CONSERVATION AUTHORITY

- Flood Hazard Mapping & Modelling
- Flood Forecasting & Warning
- Flood Control Infrastructure
- Natural Hazard & Wetland Regulations

4

RESIDENTS

- Know the Risks: Is your property flood susceptible? Is flooding expected?
- Make a plan to protect yourself and your property
- Prepare a kit with supplies for 72 hours

CONSERVATION HALTON'S REGULATION

- Section 28 (1) of the *Conservation Authorities Act* allows conservation authorities to make regulations related to development in hazardous lands

- CH's regulation is Ontario Regulation 162/06 and its purpose is to **protect people and property** from risks related to natural hazards

CONSERVATION HALTON'S REGULATION

- Under **Ontario Regulation 162/06**, Conservation Halton regulates:
  - Watercourses
  - Valleylands
  - Wetlands
  - Lake Ontario and Hamilton Harbour Shoreline
  - Hazardous Lands
  - Lands adjacent to these features
- Permission is required from Conservation Halton to develop in regulated areas

FLOOD HAZARDS: STORM EVENTS

REGULATORY FLOOD HAZARD

- Standard approved by Province to define the limit of the regulated flood hazard
- In CH's jurisdiction, the regulatory flood hazard is based on the greater of the Regional Storm (Hurricane Hazel) or the 100 year storm event

REGIONAL STORM

- The Hurricane Hazel or Regional storm event (1954) caused more than 80 deaths and left thousands homeless in Toronto (285mm of rain in 48 hours)
- CH simulates the precipitation produced by Hurricane Hazel over the watersheds in its jurisdiction to calculate the regulatory flood hazard

100 YEAR STORM

- 1 in 100 year storm is a storm event that statistically has a 1% chance of occurring in any given year, at any given place.

URBAN MILTON FLOOD HAZARD MAPPING STUDY PURPOSE

UPDATE FLOOD HAZARD MAPPING

- Undertake comprehensive update of riverine flood hazard mapping mostly affecting western parts of existing urban areas in the Town of Milton
- Better understand flood hazards using new tools and technologies
- Update floodlines & CH's regulatory mapping

PUBLIC AND STAKEHOLDER ENGAGEMENT

- Engage with public & stakeholders to ensure they are informed about flood hazards / risks and have opportunities to share input
- Work with a Technical Advisory Committee (TAC) with reps from Halton Region, Town of Milton and Town of Halton Hills

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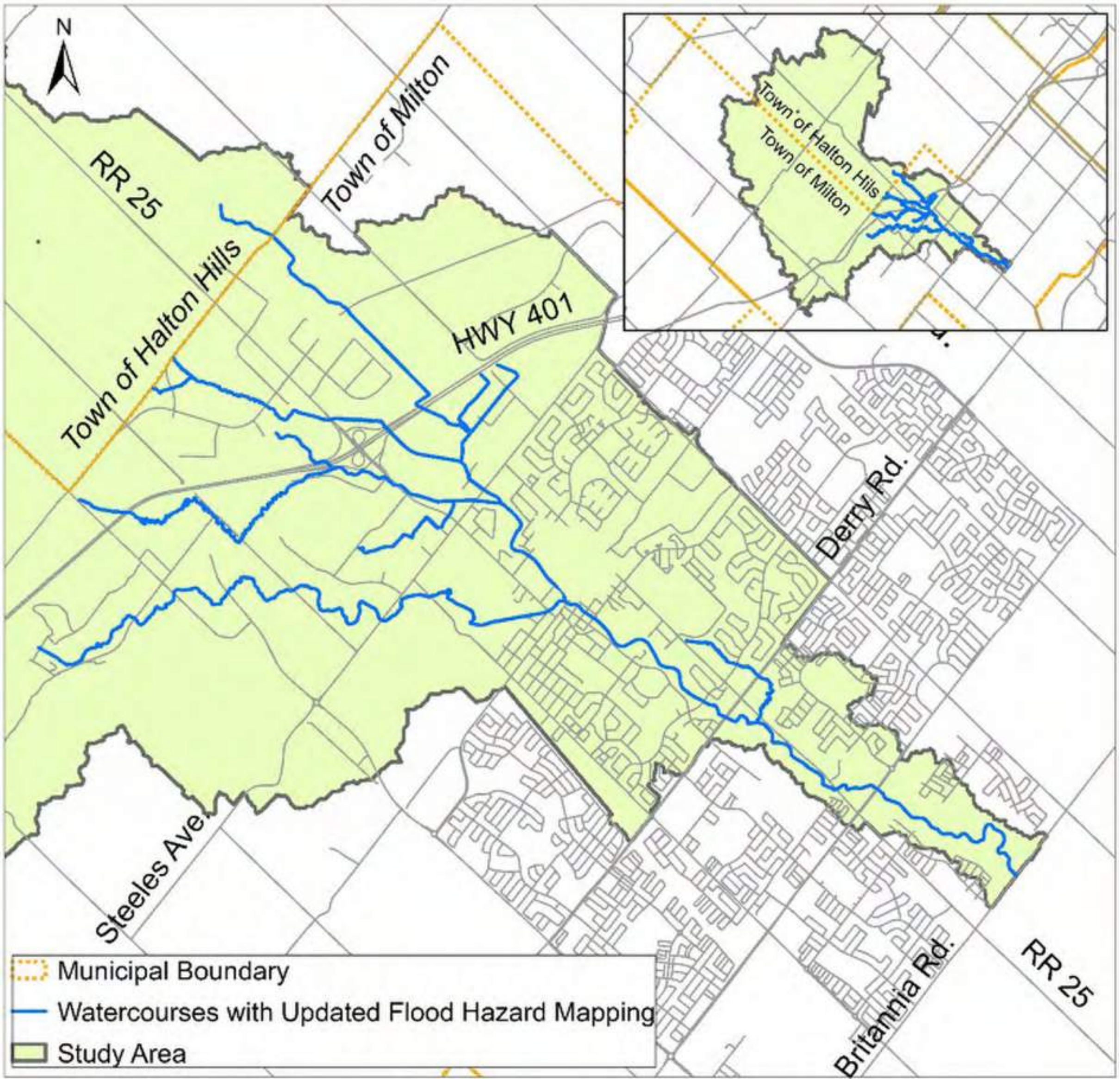
URBAN MILTON FLOOD HAZARD MAPPING STUDY AREA



URBAN MILTON FLOOD HAZARD MAPPING: HOW ARE FLOOD HAZARDS ARE DETERMINED?

Hydrology

- Determine how much water drains to the watercourse

Hydraulics

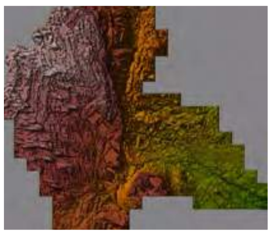
- Determine how much the watercourse "fills up"

Flood Hazard Mapping

- Delineate flood hazard limits to evaluate flood risks

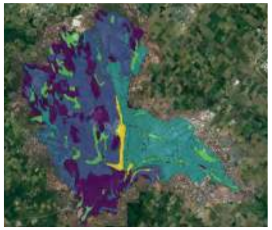
URBAN MILTON FLOOD HAZARD MAPPING: HYDROLOGY

- To estimate flood flows, a hydrologic model was developed incorporating the land-use, soils, drainage patterns and rainfall data
- Topographic (elevation) information was used to determine overall drainage patterns

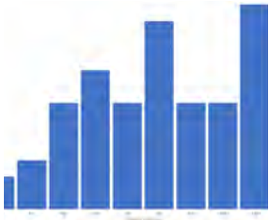


Topography

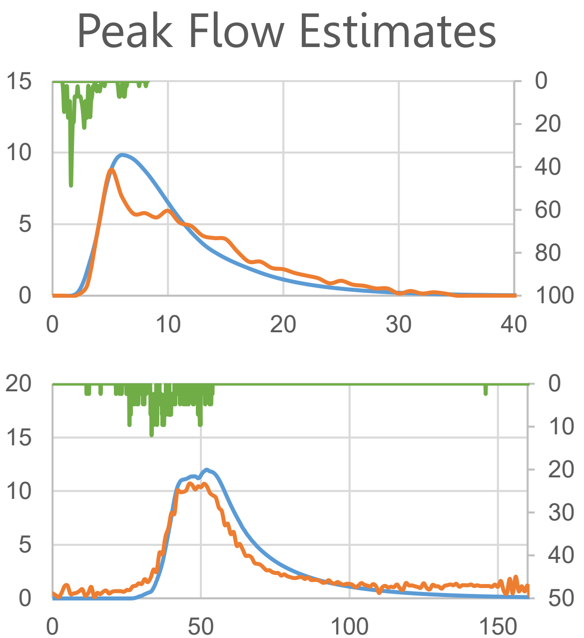
Land-Use



Soils



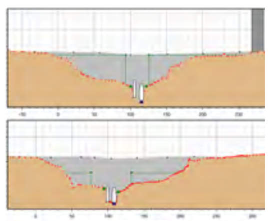
Rainfall



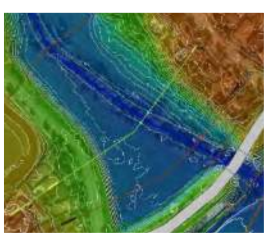
URBAN MILTON FLOOD HAZARD MAPPING: HYDRAULICS

- Surveys and a hydraulic model were developed to predict flood elevations and the extent of flooding throughout the study area
- The hydraulic model evaluates the impacts of bridges, river and valley shape among other things to determine flood elevations using flood flows from the hydrologic model

Survey Bridges



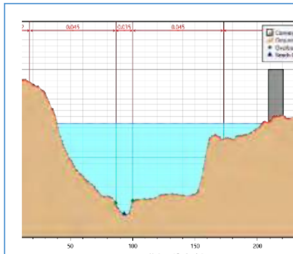
Model Bridges



Define river/valley geometry

Peak Flow Estimates from Hydrology

Hydraulic Models

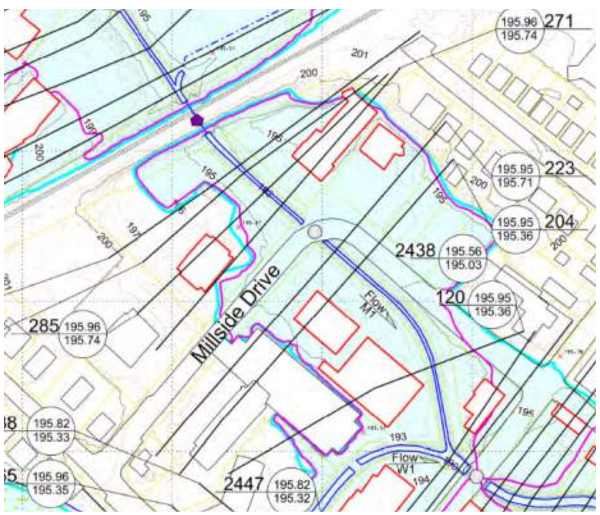


Flood Results

Flood Hazard Mapping

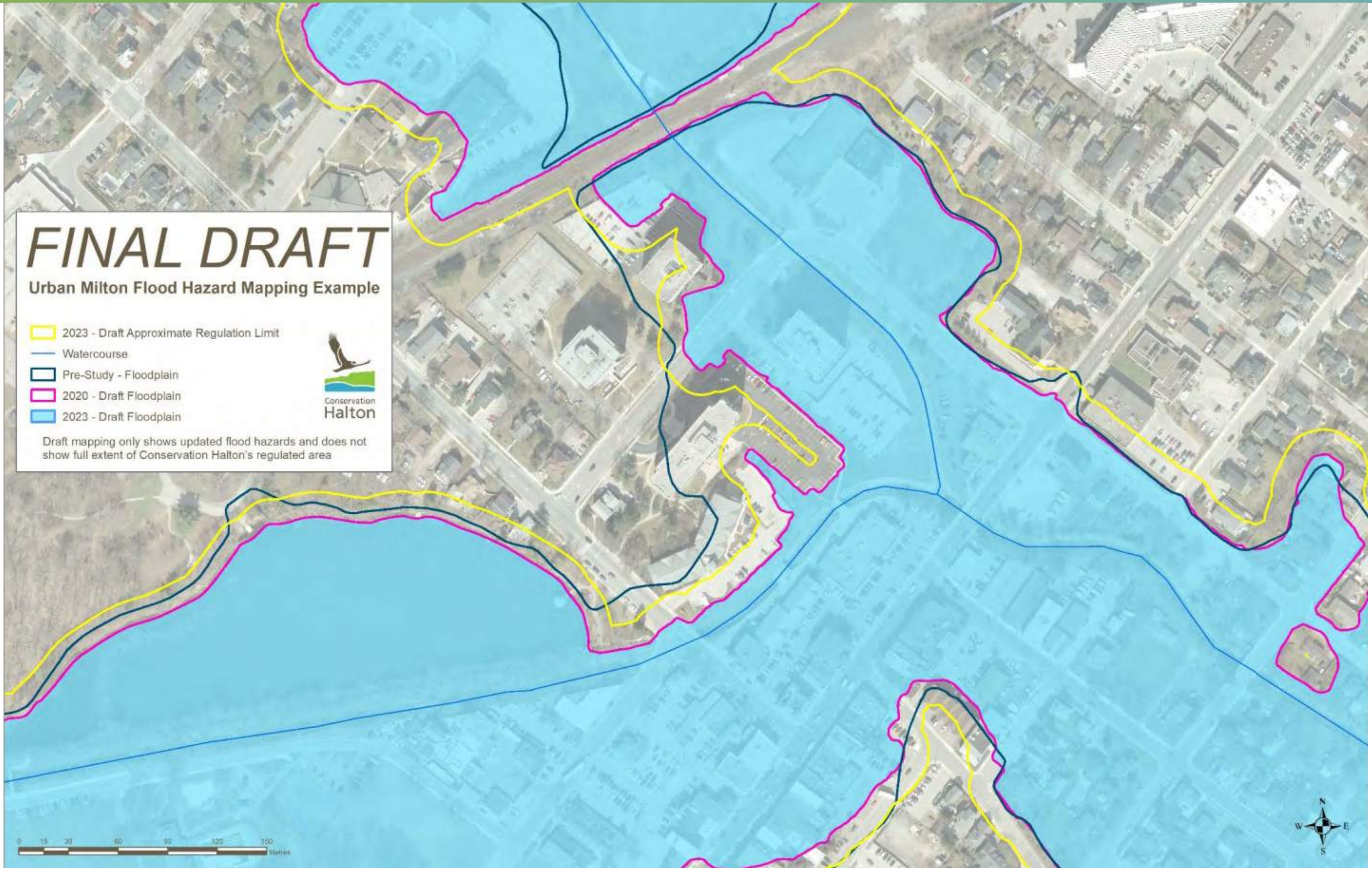
URBAN MILTON FLOOD HAZARD MAPPING: MAP SHEETS

- Results from the hydrologic and hydraulic flood hazard modelling are presented in overall flood hazard mapping
- Flood Hazard Mapsheets display both the “Regional Storm” and “100-year” storm floodlines
- The greater of the two defines the “Regulatory” flood hazard limit

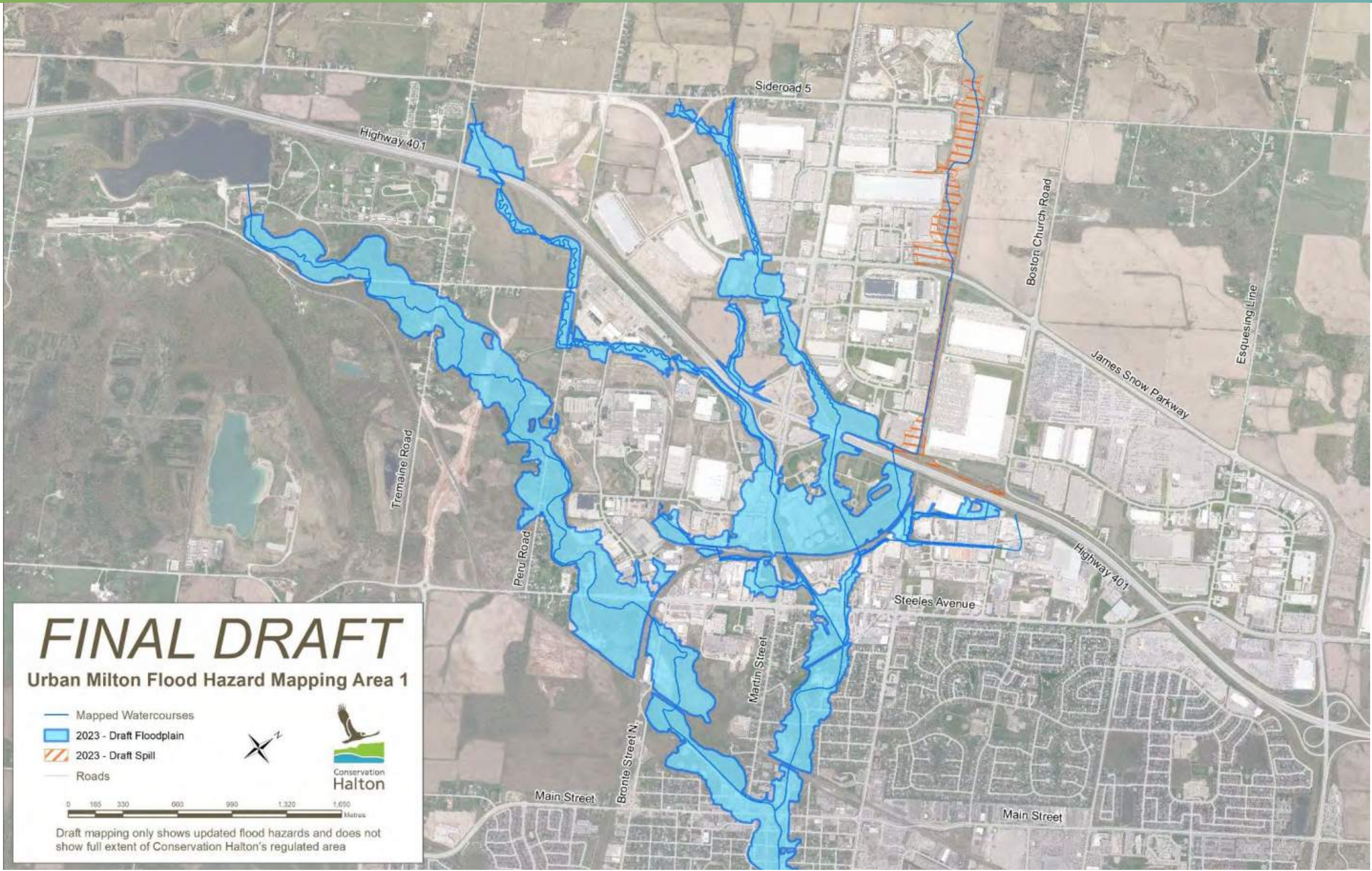


Flood Hazard Mapping Example

URBAN MILTON FLOOD HAZARD DRAFT MAPPING



URBAN MILTON FLOOD HAZARD DRAFT MAPPING



URBAN MILTON FLOOD HAZARD DRAFT MAPPING

QUESTIONS & DISCUSSION

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NEXT STEPS

COMPLETED:

Step 1: Field Work and Data Collection

Step 2: Hydrologic Model Generation

Step 3: Hydraulic Modelling

Step 4: Draft Mapping & Reporting

NEXT STEPS:

Step 5: Receive feedback and questions, finalize draft mapping & reporting

PRESENT TO CH BOARD OF DIRECTORS FOR APPROVAL

Spring 2023

- Final draft flood hazard mapping and reporting will be presented
- Opportunity for CH Board of Directors to review final draft flood hazard mapping, feedback received and receive recommendation for approval

HOW TO REACH US

Questions about your property? Comments and feedback?

- E-mail: floodplainmapping@hrca.on.ca
- Website: www.conservationhalton.ca/mapping-and-studies/
- 30-day public review and feedback on draft mapping until March 18

Matt Howatt

Manager, Policy & Special Initiatives

Conservation Halton

Tel: 905-336-1158 ext. 2311

Email: floodplainmapping@hrca.on.ca

Scott Sexton, P. Eng.

Water Resources Engineer – Project Manager

Greck & Associates Limited

Tel: 289-657-9797 ext. 229

Email: ssexton@greck.ca

Information will be collected in accordance with the Municipal Freedom of Information and Protection of Privacy Act. With the exception of personal information, all comments will become part of the public record.

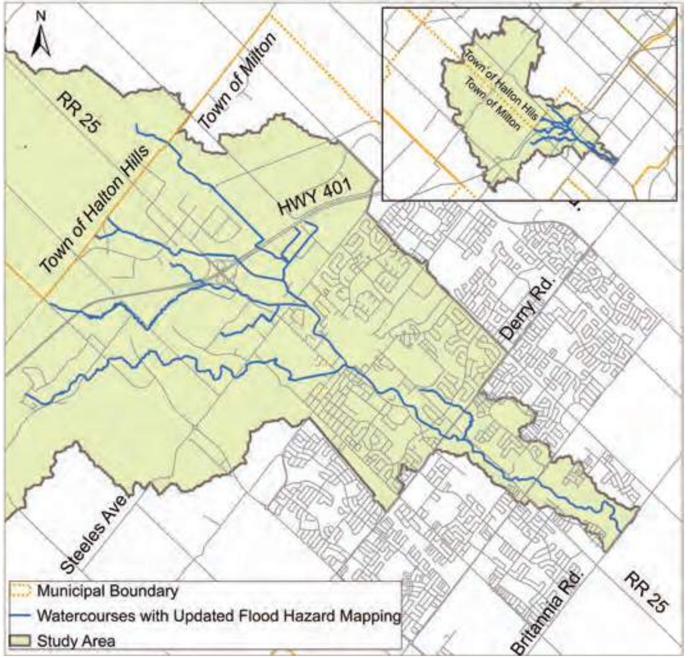
THANK YOU

Conservation Halton

Greck

JOIN US to engage in the Urban Milton Flood Hazard Mapping Study, February 22, 2023

Conservation Halton



Do you live near the **West Branch of Sixteen Mile Creek** in Milton or Halton Hills? Conservation Halton (CH) is updating flood hazard mapping for the West Branch of Sixteen Mile Creek in your community.

Flood hazard mapping is used by CH and its municipal partners to identify areas that may be susceptible to riverine or shoreline flooding, and to inform flood forecasting, emergency response, community and infrastructure planning and other flood mitigation efforts. Flood hazard means areas near a river or stream that are flooded during large storm events that are not ordinarily covered by water.

Join us for a virtual public engagement session on **February 22, 2023 at 7:00pm** to learn more about the draft updated flood hazard mapping, ask questions, and share feedback. Unable to join us live? Information will be available online and your feedback is encouraged until March 18, 2023. To learn more and register for the virtual public engagement session, please visit: **conservationhalton.ca/mapping-and-studies/** or contact:

Matt Howatt
Manager, Policy & Special Initiatives
Office 905.336.1158 ext. 2311 | floodplainmapping@hrca.on.ca

All feedback received will be reviewed and changes will be made to the draft mapping, as necessary. Final draft flood hazard mapping is anticipated to be brought to CH's Board of Directors for approval in Spring 2023.

Conservation Halton
Planning & Watershed Management
905.336.1158 | Fax: 905.336.6684
2596 Britannia Road West
Burlington, Ontario L7P 0G3
conservationhalton.ca

January 2023

BY MAIL

To: Property Owner

Re: Conservation Halton's Urban Milton Flood Hazard Mapping Study – Public Engagement Session

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Flood hazard mapping is an important tool that supports Conservation Halton's (CH) regulatory and planning and flood forecasting and warning programs, as well as municipal emergency management, flood mitigation, and infrastructure design. "Flood hazard" means an area near a river or stream not ordinarily covered by water that is flooded during extreme storm events.

To better understand the nature and extent of flood hazards across its jurisdiction, CH renewed its Flood Hazard Mapping Program in 2018. Flood hazard mapping for many of the creeks in our communities was last undertaken in the 1980s and 1990s. Since then, technology has advanced which allows us to better understand and predict the path and nature of flood hazards.

This letter is to provide you with an overview of CH's Urban Milton Flood Hazard Mapping Study and information about an upcoming virtual public engagement session on February 22, 2023 to learn more about the study and updated draft flood hazard mapping.

<u>Urban Milton Flood Hazard Mapping Study</u>

In 2019, CH hired a consultant, Greck & Associates, to undertake a study and update flood hazard modelling and mapping for the West Branch of Sixteen Mile Creek, which mostly affects the tributaries that traverse the western parts of the existing urban areas in the Town of Milton. Updated mapping provides CH, municipalities, the public, and stakeholders with a current understanding of the magnitude and extent of riverine flood hazards in this area. The study also provides background information and technical detail on how and why the riverine flood hazard modelling and mapping was updated.

In March 2020, after considerable analysis of the updated draft flood hazard modelling and mapping, the mapping was considered the best available information for:

1. Understanding the extent of flood hazards;
2. Assessing potential risk to life and property;
3. Identifying areas requiring further analysis; and
4. Making decisions when development is contemplated in hazardous areas regulated by CH

The updated draft flood hazard mapping was included in CH's Approximate Regulation Limit (ARL) mapping, which is a screening tool that is made publicly available through CH's website and shared with municipalities to provide property owners, residents, and other stakeholders with information about potential natural hazards in their communities.

Public engagement was undertaken to ensure that the public, local, provincial and federal agencies, and stakeholders were aware of the study and had opportunities to participate. Public Engagement Session #1 was held at CH's Administrative Office in October 2019 and Public Engagement Session #2 was posted online in March 2020. Background information is available on the Urban Milton Flood Hazard Mapping Study page at www.conservationhalton.ca/mapping-and-studies/.

Based on feedback received during Public Engagement Session #2 and from CH's stakeholders, the study scope and timelines were revised. Since that time, CH has worked to refine modelling and update draft flood hazard mapping with its consultant and the study's Technical Advisory Committee comprised of staff from the Town of Milton, Town of Halton Hills, and Region of Halton. The study and updated draft flood hazard mapping are now available for public and stakeholder review and feedback.

Property Specific Information

Based on the updated draft flood hazard mapping, your property has been identified as a site that may be located within or near a flood hazard and may be at risk of riverine flooding under extreme storm events. It also means your property may be regulated by CH and permission from CH may be required prior to any construction or development. Please contact me with any property specific questions via the contact information provided below.

Public Engagement Session #3

To learn more about the study and updated draft flood hazard mapping, you are invited to join us for a virtual public engagement session on **February 22, 2023 at 7:00pm.** This is an opportunity for those looking for further information to learn more and ask questions. If you are unable to join us live, information will be available online from **February 17** until **March 18, 2023**. To register for the virtual public engagement session, please visit https://www.conservationhalton.ca/mapping-and-studies/.

After the public engagement session and 30-day public review period, CH will review all feedback received and make any necessary revisions to the draft flood hazard mapping. It is anticipated that the final draft mapping and study will be presented to CH's Board of Directors for their approval and inclusion in CH's ARL mapping in Spring 2023.

Should you wish to have a conversation about your property or have any questions about the study or upcoming Public Engagement Session #3, please contact us via email at floodplainmapping@hrca.on.ca or call me at (905) 336-1158 extension 2311.

Thank you,

Matt Howatt
Manager, Policy & Special Initiatives

Conservation Halton
2596 Britannia Road West, Burlington, ON L7P 0G3
Office 905.336.1158 ext. 2311 | Fax 905.336.6684 | mhowatt@hrca.on.ca
conservationhalton.ca

From: Floodplain Mapping
To: Floodplain Mapping
Bcc:
Conservation Halton''s Urban Milton Flood Hazard Mapping Study - Public Engagement Session Notice
February 3, 2023 2:10:00 PM
image001.png

Subject:
Date:
Attachments:

Good afternoon,

Conservation Halton (CH) is updating flood hazard mapping for the West Branch of Sixteen Mile Creek which mostly affects the tributaries that traverse the western parts of the existing urban areas in the Town of Milton (please see map below).

Flood hazard mapping is an important tool that supports CH's regulatory and planning and flood forecasting and warning programs, as well as municipal emergency management, flood mitigation, and infrastructure design. "Flood hazard" means an area near a river or stream not ordinarily covered by water that is flooded during extreme storm events.

To learn more about CH's **Urban Milton Flood Hazard Mapping Study** and updated draft flood hazard mapping, we are inviting the public to join us for a virtual public engagement session on **February 22, 2023 at 7:00pm.** This is an opportunity for those looking for further information to learn more and ask questions.

To register for the virtual public engagement session, please visit https://www.conservationhalton.ca/mapping-and-studies/ or reply to floodplainmapping@hrca.on.ca. If you are unable to join us live, study information will be available online beginning **February 17, 2023** until **March 18, 2023**. A recording of the session will also be posted online after February 22.

After the public engagement session and 30-day public review period, CH will review all feedback received and make any necessary revisions to the draft flood hazard mapping. It is anticipated that the final draft mapping and study will be presented to CH's Board of Directors for their approval and inclusion in CH's online Approximate Regulation Limit mapping in Spring 2023.

Should you have any questions about the study or upcoming Public Engagement Session #3, please contact me via email at floodplainmapping@hrca.on.ca or at (905) 336-1158 extension 2311.

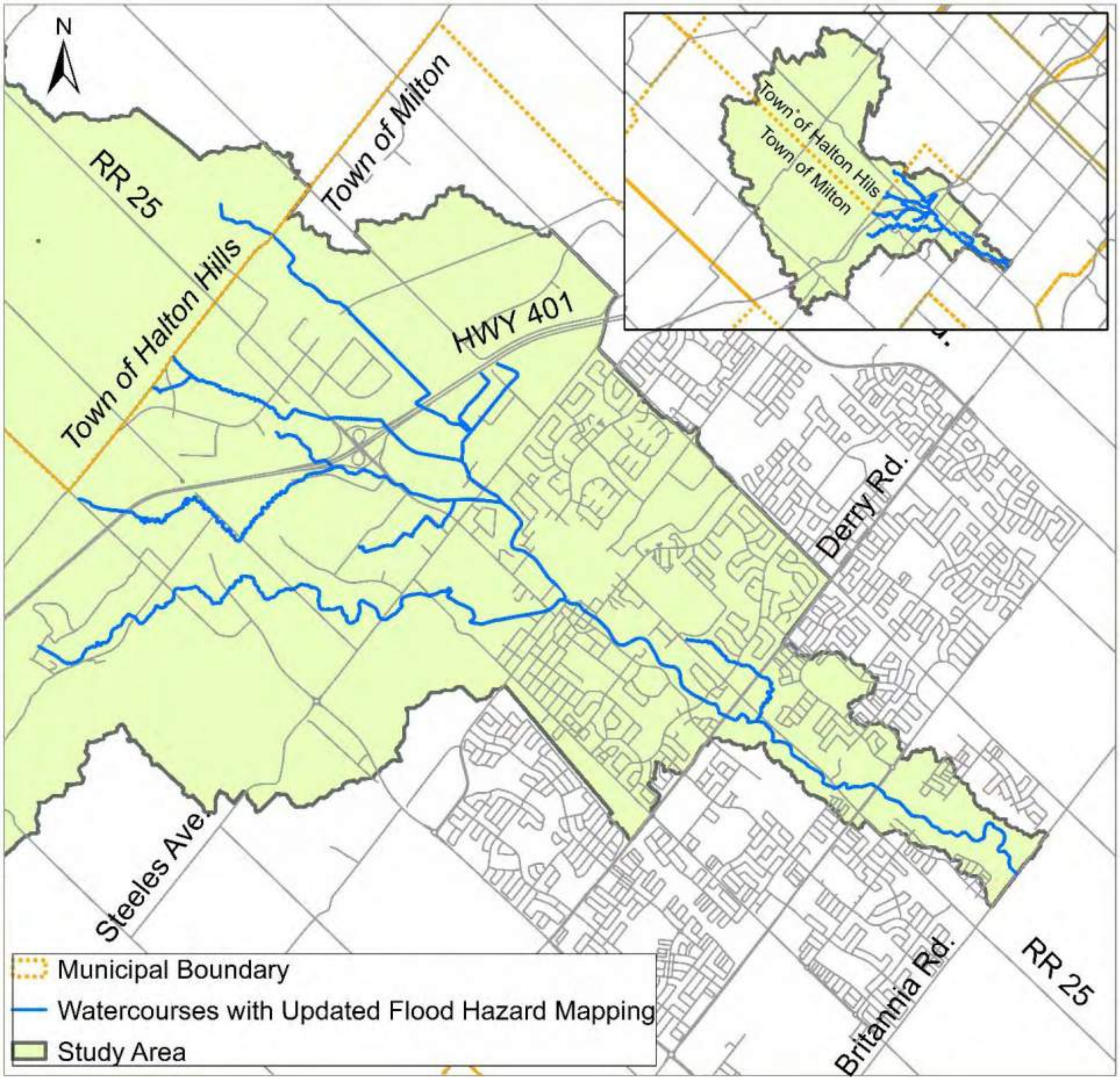
-

We look forward to hearing from you.

Sincerely,
Matt

Matt Howatt
Manager, Policy & Special Initiatives
Planning & Regulations

Conservation Halton
2596 Britannia Road West, Burlington, ON L7P 0G3
905.336.1158 ext. 2311 | Fax 905.336.6684 | mhowatt@hrca.on.ca
conservationhalton.ca



N
RR 25
Town of Milton
Town of Halton Hills
HWY 401
Derry Rd.
Steeles Ave.
Britannia Rd.
RR 25
Town of Halton Hills
Town of Milton
Municipal Boundary
Watercourses with Updated Flood Hazard Mapping
Study Area

Stakeholders
Urban Milton Public Engagement Session #3
CH Staff
CH Board of Directors
MPs/MPPs
Milton
Wellington-Halton Hills
Municipal Clerks
Halton Region
Town of Milton
Town of Halton Hills
Local and Regional Councillors
Town of Milton
Town of Halton Hills
Halton Region
BILD/Home Builders' Associations
Argo Development Corp.
ADI Development Group
BILD
West End Home Builders' Association
Hamilton-Halton Home Builders' Association
Business and Agricultural Groups
Milton Chamber of Commerce
Downtown Milton Business Improvement Area
Halton Agricultural Advisory Committee
Halton Region Federation of Agriculture
Halton Soil and Crop Improvement Association
Realtor Groups
Oakville, Milton and District Real Estate Board
Study Consultant
Greck & Associates
Indigenous Peoples
Mississaugas of the Credit First Nation
Metis Nation of Ontario
Six Nations of the Grand River
Haudenosaunee Development Institute

Rail Companies
Canadian National Railway
Canadian Pacific Railway
Halton Area Public Works Directors
Halton Area Planning Directors
Floodplain Mapping Advisory Committee
Urban Milton FHM Study Technical Advisory Committee
PIC Registrants and/or requested to be added (64 individuals)
Conservation Ontario Stakeholder List
Fisheries and Oceans Canada
Ministry of Northern Development, Mines, Natural Resources and Forestry
Ministry of Environment, Conservation and Parks
Ministry of Municipal Affairs & Housing
Ministry of Transportation
Ministry of Indigenous Affairs
Crown-Indigenous Relations and Northern Affairs Canada
Hydro One
Milton Hydro
Halton Hills Hydro
Burlington Hydro
Oakville Hydro
Enbridge
Ontario Power Generation Inc.
Rogers
Bell Canada
Halton District School Board
Halton Catholic District School Board
Niagara Escarpment Commission
Municipal Property Assessment Corporation
MPAC Zone 2: Golden Horseshoe

APPENDIX B: CULVERT INVENTORY SHEETS

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Spill us
Northing:	4822560.68 N
Easting:	587140.18 E

Inspected By:	Paul Greck, Brian Greck
Date:	2019-11-26
Weather:	5°C, Clear
Structure ID:	NA

Structure Type:	cast in place twin box culvert
# of Spans:	1
Span or Diameter (m):	2.6 both sides us - 5.5 ds
Rise (m):	3.23us 4.2ds
Length (m):	43.0

Material:	Concrete
Open Footing:	No
Skew Angle:	N/A
Sediment Depth (mm):	N/A
Barrier:	No

US Invert Elevation (m):	215.90
DS Invert Elevation (m):	216.02

US Obvert Elevation (m):	220.46
DS Obvert Elevation (m):	220.820

Inlet/Outlet Type:	Wingwalls, ds 30°, us Perp.
High Water Mark Depth (m):	Not Observed
Piers:	Yes
Pier Width:	0.356 and 19m long

Low Point in Deck Elevation (m):	228.7
Water Depth (mm):	0.82

Additional Notes:	Downstream section constructed from stone blocks
	downstream beaver dam causing sedimentation and backwater

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Conservation Halton   Greck

Location:	Britannia Road
Northing:	4816026.87 N
Easting:	594607.97 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-02
Weather:	24°C, Cloudy
Structure ID:	1

Structure Type:	Arch Bridge
# of Spans:	1
Span or Diameter (m):	19.4
Rise (m):	3.77
Length (m):	11.6

Material:	Concrete
Open Footing:	Yes
Skew Angle:	0
Sediment Depth (mm):	N/A
Barrier:	1.11m Railing

US Invert Elevation (m):	172.10
DS Invert Elevation (m):	172.10

US Obvert Elevation (m):	175.87
DS Obvert Elevation (m):	175.85

Inlet/Outlet Type:	N/A
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	176.9
Water Depth (mm):	290

Additional Notes:	

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Conservation Halton | Greck

Location:	Btwn Louis St. Laurent/Britannia
Northing:	4816561.72 N
Easting:	593742.62 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-02
Weather:	24°C, Cloudy
Structure ID:	2

Structure Type:	
# of Spans:	
Span or Diameter (m):	
Rise (m):	
Length (m):	

Material:	
Open Footing:	
Skew Angle:	
Sediment Depth (mm):	
Barrier:	

US Invert Elevation (m):	
DS Invert Elevation (m):	

US Obvert Elevation (m):	
DS Obvert Elevation (m):	

Inlet/Outlet Type:	
High Water Mark Depth (m):	
Piers:	
Pier Width:	

Low Point in Deck Elevation (m):	
Water Depth (mm):	

Additional Notes:	No crossing, east abutment still remaining.
	Giant Hogweed is present on site.

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Louis St. Laurent Ave.
Northing:	4816843.48 N
Easting:	593299.05 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-02
Weather:	24°C, Cloudy
Structure ID:	3

Structure Type:	Beam Bridge
# of Spans:	4
Span or Diameter (m):	36.0 Centre (2), 28.4 Side (2)
Rise (m):	11.3
Length (m):	32.4

Material:	Concrete
Open Footing:	Yes
Skew Angle:	0
Sediment Depth (mm):	N/A
Barrier:	1.37m Wall and Rail

US Invert Elevation (m):	179.70
DS Invert Elevation (m):	179.57

US Obvert Elevation (m):	191.00
DS Obvert Elevation (m):	191.06

Inlet/Outlet Type:	N/A
High Water Mark Depth (m):	Not Observed
Piers:	Yes
Pier Width:	1.52m Round Nose

Low Point in Deck Elevation (m):	192.4
Water Depth (mm):	200

Additional Notes:	Pedestrian barrier on deck is higher than outer barriers.
	3 rows of 6 round piers.
	Majority of flow through east of centre pier.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Conservation Halton   Greck

Location:	Regional Road 25
Northing:	4816839.5 N
Easting:	592931.1 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-02
Weather:	24°C, Cloudy
Structure ID:	4

Structure Type:	Beam Bridge
# of Spans:	1
Span or Diameter (m):	28.7
Rise (m):	5.35
Length (m):	23.2

Material:	Concrete
Open Footing:	Yes
Skew Angle:	0
Sediment Depth (mm):	N/A
Barrier:	1.06m Parapet Wall and Rail

US Invert Elevation (m):	179.89
DS Invert Elevation (m):	180.12

US Obvert Elevation (m):	185.24
DS Obvert Elevation (m):	185.39

Inlet/Outlet Type:	N/A
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	185.1
Water Depth (mm):	760

Additional Notes:	Paved walkway spanning under bridge beside south abutment.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Derry Road
Northing:	4817518.5 N
Easting:	591893.98 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-02
Weather:	24°C, Cloudy
Structure ID:	5

Structure Type:	Beam Bridge
# of Spans:	1
Span or Diameter (m):	30.3
Rise (m):	6.01
Length (m):	27.6

Material:	Concrete
Open Footing:	Yes
Skew Angle:	20
Sediment Depth (mm):	N/A
Barrier:	1.40m Parapet Wall and Rail

US Invert Elevation (m):	183.53
DS Invert Elevation (m):	183.55

US Obvert Elevation (m):	189.54
DS Obvert Elevation (m):	189.97

Inlet/Outlet Type:	N/A
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	191.0
Water Depth (mm):	720

Additional Notes:	Downstream girders are shorter than upstream girders.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Laurier Avenue
Northing:	4817660.6 N
Easting:	591684.42 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-03
Weather:	24°C, Sunny
Structure ID:	6

Structure Type:	Beam Bridge
# of Spans:	1
Span or Diameter (m):	24.3
Rise (m):	5.43
Length (m):	11.6

Material:	Concrete
Open Footing:	Yes
Skew Angle:	0
Sediment Depth (mm):	N/A
Barrier:	1.39 m Parapet Wall and Rail

US Invert Elevation (m):	183.71
DS Invert Elevation (m):	183.943

US Obvert Elevation (m):	189.14
DS Obvert Elevation (m):	189.373

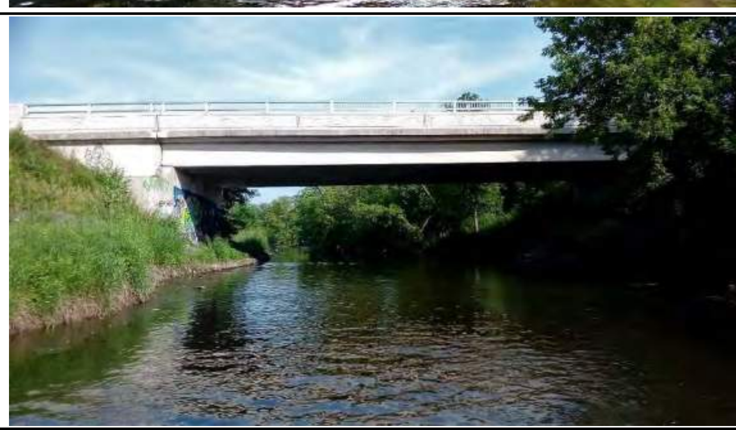
Inlet/Outlet Type:	N/A
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	189.6
Water Depth (mm):	410

Additional Notes:	Channel bottom on upstream side very weedy. Rip rap slopes span under bridge.

Upstream Photo:

Downstream Photo:



Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Trail at end of Parkway Dr. E
Northing:	4818077.25 N
Easting:	591234.48 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-03
Weather:	24°C, Sunny
Structure ID:	7

Structure Type:	Pedestrian Bridge
# of Spans:	1
Span or Diameter (m):	14.8
Rise (m):	3.77
Length (m):	3.2

Material:	Wood and Steel
Open Footing:	No
Skew Angle:	0
Sediment Depth (mm):	0
Barrier:	1.10m Railing

US Invert Elevation (m):	185.61
DS Invert Elevation (m):	185.60

US Obvert Elevation (m):	189.38
DS Obvert Elevation (m):	189.37

Inlet/Outlet Type:	N/A
High Water Mark Depth (m):	0.63
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	188.7
Water Depth (mm):	350

Additional Notes:	Chain link fence on top of slope on either side of channel. Trapezoidal, concrete lining continues upstream and downstream of crossing.

Upstream Photo:	
Downstream Photo:	

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Conservation Halton | Greck

Location:	Pine Street
Northing:	4818492.85 N
Easting:	590572.01 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-06-28
Weather:	30°C, Sunny
Structure ID:	8

Structure Type:	Beam Bridge
# of Spans:	1
Span or Diameter (m):	13.7
Rise (m):	4.2
Length (m):	13.5

Material:	Concrete
Open Footing:	No
Skew Angle:	0
Sediment Depth (mm):	0
Barrier:	1.52m Parapet Wall and Rail

US Invert Elevation (m):	189.38
DS Invert Elevation (m):	188.20

US Obvert Elevation (m):	191.63
DS Obvert Elevation (m):	192.40

Inlet/Outlet Type:	N/A
High Water Mark Depth (m):	1
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	191.7
Water Depth (mm):	600

Additional Notes:	Chain link fence on top of slope on either side of channel. Trapezoidal, concrete lining continues upstream and downstream of crossing.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Main Street
Northing:	4818585.11 N
Easting:	590403.51 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-06-28
Weather:	30°C, Sunny
Structure ID:	9

Structure Type:	Arch Culvert/Beam Bridge
# of Spans:	1
Span or Diameter (m):	6.5
Rise (m):	4.74
Length (m):	16.2

Material:	Stone and Concrete
Open Footing:	No
Skew Angle:	0
Sediment Depth (mm):	0
Barrier:	1.23m Parapet Wall and Rail

US Invert Elevation (m):	189.10
DS Invert Elevation (m):	188.90

US Obvert Elevation (m):	193.84
DS Obvert Elevation (m):	193.75

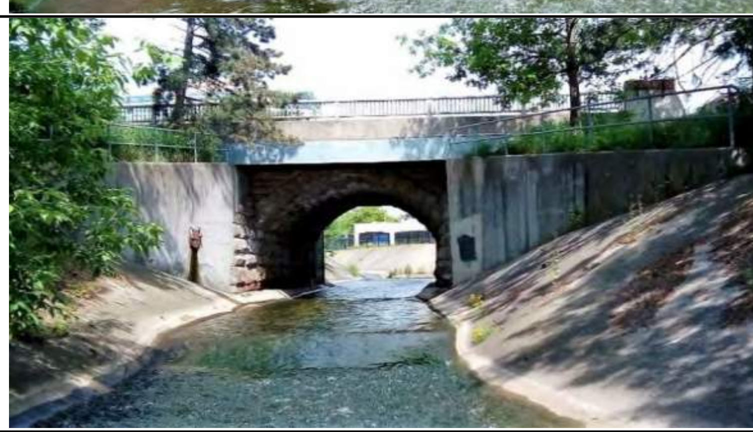
Inlet/Outlet Type:	20 Degree Wingwalls
High Water Mark Depth (m):	0.5
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	194.4
Water Depth (mm):	270

Additional Notes:	Archway is stone embedded in concrete superstructure.
	Trapezoidal, concrete lining continues upstream and downstream of crossing.
	Arch embedded 2.67m into structure from start of wingwall at inlet/outlet.
	Chain link fence on top of slope on either side of channel, and railing on wingwalls.

Upstream Photo:

Downstream Photo:



Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Between Main/Martin St.
Northing:	4818590.02 N
Easting:	590322.68 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-06-28
Weather:	30°C, Sunny
Structure ID:	10

Structure Type:	Pedestrian Bridge
# of Spans:	1
Span or Diameter (m):	7.0
Rise (m):	3.26
Length (m):	6.1

Material:	Concrete, Steel, Wood
Open Footing:	No
Skew Angle:	0
Sediment Depth (mm):	0
Barrier:	1.19m Parapet Wall and Rail

US Invert Elevation (m):	189.81
DS Invert Elevation (m):	189.67

US Obvert Elevation (m):	193.06
DS Obvert Elevation (m):	192.93

Inlet/Outlet Type:	30 Degree Wingwalls
High Water Mark Depth (m):	1.1
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	193.0
Water Depth (mm):	440

Additional Notes:	Chain link fence on top of slope on either side of channel.
	Trapezoidal, concrete lining continues upstream and downstream of channel.
	Primarily concrete substructure with steel girders and concrete/wood deck.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Conservation Halton | Greck

Location:	Btwn Main/Martin St.
Northing:	4818553.35 N
Easting:	590288.82 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-06-28
Weather:	30°C, Sunny
Structure ID:	11

Structure Type:	Box Culvert
# of Spans:	1
Span or Diameter (m):	6.7
Rise (m):	3.62
Length (m):	10.2

Material:	Concrete
Open Footing:	No
Skew Angle:	0
Sediment Depth (mm):	0
Barrier:	1.83m Chainlink Fence

US Invert Elevation (m):	190.14
DS Invert Elevation (m):	189.77

US Obvert Elevation (m):	193.76
DS Obvert Elevation (m):	193.71

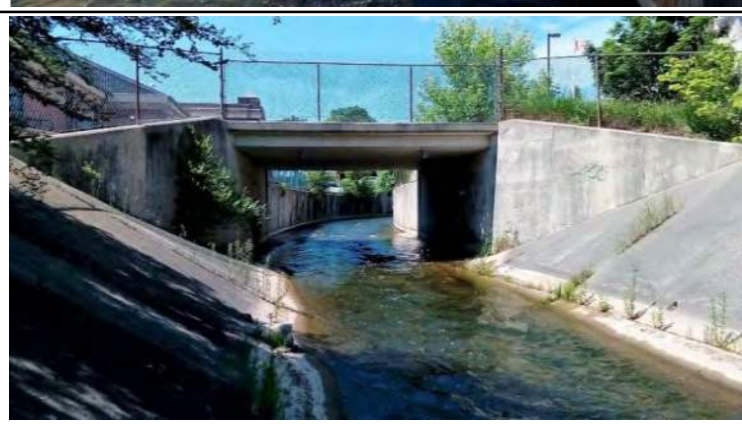
Inlet/Outlet Type:	Wingwalls, DS 20°, US Perp.
High Water Mark Depth (m):	0.67
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	193.5
Water Depth (mm):	500

Additional Notes:	Chain link fence on top of slope on either side of channel.
	Fairly flat concrete lining of channel throughout culvert.
	Concrete walls continue to border channel on upstream side.

Upstream Photo:

Downstream Photo:



Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	At Mill/Martin St.
Northing:	4818511.43 N
Easting:	590227.54 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-06-28
Weather:	30°C, Sunny
Structure ID:	12

Structure Type:	Box Culvert
# of Spans:	1
Span or Diameter (m):	6.7
Rise (m):	3.84
Length (m):	40.4

Material:	Concrete
Open Footing:	No
Skew Angle:	use google
Sediment Depth (mm):	Varies, max 350
Barrier:	1.19m Parapet Wall and Rail

US Invert Elevation (m):	190.19
DS Invert Elevation (m):	190.69

US Obvert Elevation (m):	194.03
DS Obvert Elevation (m):	194.09

Inlet/Outlet Type:	Perpend. Wingwalls, US N 10°
High Water Mark Depth (m):	1
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	194.5
Water Depth (mm):	840

Additional Notes:	Fairly flat concrete bottom of channel, trapezoidal at US side becoming natural further US.
	Sediment includes some large stones protruding from water surface within culvert.
	A bend to the north exists 6.25m into culvert from US inlet.
	Concrete walls continue to border channel on upstream side.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Conservation Halton   Greck

Location:	Trail off of Garden Ln
Northing:	4818423.34 N
Easting:	589820.63 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-10
Weather:	25°C, Sunny
Structure ID:	13

Structure Type:	Pedestrian Bridge
# of Spans:	1
Span or Diameter (m):	12.5
Rise (m):	2.82
Length (m):	2.7

Material:	Wood and Steel
Open Footing:	Yes
Skew Angle:	0
Sediment Depth (mm):	N/A
Barrier:	1.11m Railing

US Invert Elevation (m):	193.22
DS Invert Elevation (m):	193.17

US Obvert Elevation (m):	196.04
DS Obvert Elevation (m):	196.01

Inlet/Outlet Type:	N/A
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	194.4
Water Depth (mm):	350

Additional Notes:	There is an embankment with a trail separating the bridge from Mill Pond to the north.
	Downstream side has concrete retaining wall with a railing on Mill Pond side.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Trail at end of Garden Ln
Northing:	4818418.4 N
Easting:	589724.9 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-10
Weather:	20°C, Sunny
Structure ID:	14

Structure Type:	Beam Bridge
# of Spans:	2
Span or Diameter (m):	17.671 both spans
Rise (m):	5.253
Length (m):	2.6

Material:	Steel, Stone and Concrete
Open Footing:	Yes
Skew Angle:	0
Sediment Depth (mm):	N/A
Barrier:	1.08m Wooden Railing

US Invert Elevation (m):	193.78
DS Invert Elevation (m):	193.83

US Obvert Elevation (m):	199.03
DS Obvert Elevation (m):	199.09

Inlet/Outlet Type:	N/A
High Water Mark Depth (m):	Not Observed
Piers:	Yes
Pier Width:	2.2m Square Nose

Low Point in Deck Elevation (m):	200.6
Water Depth (mm):	320

Additional Notes:	Crossing spans over both channel and Mill Pond, separated by a pier and a trail embankment.
	Storm pipe outlet with metal grate and gabion on downstream side. Low flow, debris in grate.
	Could not measure depth of Mill Pond at centre, stated Rise is for the channel side only.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Conservation Halton · Greck

Location:	Rail Crossing
Northing:	4818470.3 N
Easting:	589526.87 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-10
Weather:	20°C, Sunny
Structure ID:	15

Structure Type:	Beam Bridge
# of Spans:	1
Span or Diameter (m):	18.2
Rise (m):	3.54
Length (m):	7.0

Material:	Concrete and Steel
Open Footing:	Yes
Skew Angle:	0
Sediment Depth (mm):	N/A
Barrier:	None

US Invert Elevation (m):	195.90
DS Invert Elevation (m):	196.10

US Obvert Elevation (m):	199.44
DS Obvert Elevation (m):	199.48

Inlet/Outlet Type:	25° WWs, sloped out at 15°
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	201.5
Water Depth (mm):	450

Additional Notes:	Wingwalls are sloped 15 degrees outwards from vertical.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Bronte Street North
Northing:	4818641 N
Easting:	589123.4 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-11
Weather:	26°C, Cloudy
Structure ID:	16

Structure Type:	Arch Bridge
# of Spans:	1
Span or Diameter (m):	12.2
Rise (m):	2.1
Length (m):	8.2

Material:	Concrete
Open Footing:	Yes
Skew Angle:	0
Sediment Depth (mm):	N/A
Barrier:	1.12m Railing

US Invert Elevation (m):	196.73
DS Invert Elevation (m):	196.51

US Obvert Elevation (m):	198.83
DS Obvert Elevation (m):	198.79

Inlet/Outlet Type:	N/A
High Water Mark Depth (m):	0.7
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	198.6
Water Depth (mm):	460

Additional Notes:	Sediment under bridge on north abutment side. Channel mainly flows through south side.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Conservation Halton   Greck

Location:	Rail Crossing
Northing:	4818655.86 N
Easting:	588987.23 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-11
Weather:	26°C, Cloudy
Structure ID:	17

Structure Type:	Circuar Pipe
# of Spans:	2*
Span or Diameter (m):	3.9
Rise (m):	4.68
Length (m):	63.9

Material:	Corrugated Steel
Open Footing:	No
Skew Angle:	25
Sediment Depth (mm):	100
Barrier:	None

US Invert Elevation (m):	196.56
DS Invert Elevation (m):	196.86

US Obvert Elevation (m):	201.24
DS Obvert Elevation (m):	201.10

Inlet/Outlet Type:	Mitered to slope
High Water Mark Depth (m):	1
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	211.8
Water Depth (mm):	470

Additional Notes:	*This form is for the south pipe only. See 17B for north pipe information.
	Access issues. Extremely vegetated and deep water.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Rail Crossing
Northing:	4818655.86 N
Easting:	588987.23 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-11
Weather:	26°C, Cloudy
Structure ID:	17

Structure Type:	Circuar Pipe
# of Spans:	2*
Span or Diameter (m):	4.1
Rise (m):	4.46
Length (m):	63.9

Material:	Corrugated Steel
Open Footing:	No
Skew Angle:	25
Sediment Depth (mm):	100
Barrier:	None

US Invert Elevation (m):	196.96
DS Invert Elevation (m):	196.81

US Obvert Elevation (m):	201.41
DS Obvert Elevation (m):	201.28

Inlet/Outlet Type:	Mitered to slope
High Water Mark Depth (m):	1
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	211.8
Water Depth (mm):	350

Additional Notes:	*This form is for the north pipe only. See 17 for south pipe information. Access issues. Extremely vegetated and deep water.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Conservation Halton · Greck

Location:	Steeles Avenue
Northing:	4818424.5 N
Easting:	588669.27 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-11
Weather:	25°C, Light Rain
Structure ID:	18

Structure Type:	Arch Bridge
# of Spans:	1
Span or Diameter (m):	14.5
Rise (m):	2.28
Length (m):	14.0

Material:	Concrete
Open Footing:	No
Skew Angle:	0
Sediment Depth (mm):	N/A
Barrier:	1.22m Parapet Wall and Rail

US Invert Elevation (m):	199.92
DS Invert Elevation (m):	199.83

US Obvert Elevation (m):	202.20
DS Obvert Elevation (m):	202.19

Inlet/Outlet Type:	N/A
High Water Mark Depth (m):	0.75
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	200.8
Water Depth (mm):	390

Additional Notes:	

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Peru Road
Northing:	4818700.91 N
Easting:	587834.45 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-11
Weather:	25°C, Sunny
Structure ID:	19

Structure Type:	Arch Bridge
# of Spans:	1
Span or Diameter (m):	12.2
Rise (m):	1.83
Length (m):	7.5

Material:	Concrete
Open Footing:	Yes
Skew Angle:	0
Sediment Depth (mm):	N/A
Barrier:	1.0m Parapet Wall and Rail

US Invert Elevation (m):	205.06
DS Invert Elevation (m):	204.79

US Obvert Elevation (m):	206.89
DS Obvert Elevation (m):	206.72

Inlet/Outlet Type:	N/A
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	207.2
Water Depth (mm):	390

Additional Notes:	

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Tremaine Road
Northing:	4818669.05 N
Easting:	586723.43 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-12
Weather:	20°C, Sunny
Structure ID:	20

Structure Type:	Arch Bridge
# of Spans:	1
Span or Diameter (m):	12.2
Rise (m):	2.29
Length (m):	11.5

Material:	Concrete
Open Footing:	Yes
Skew Angle:	0
Sediment Depth (mm):	N/A
Barrier:	1.07m Parapet Wall and Rail

US Invert Elevation (m):	210.60
DS Invert Elevation (m):	210.57

US Obvert Elevation (m):	212.89
DS Obvert Elevation (m):	212.77

Inlet/Outlet Type:	N/A
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	213.3
Water Depth (mm):	430

Additional Notes:	rip rap channel bottom.
	Gabion retaining wall along west side of downstream end.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Conservation Halton   Greck

Location:	Kelso Road
Northing:	4818439.41 N
Easting:	586357.6 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-12
Weather:	20°C, Sunny
Structure ID:	21

Structure Type:	Arch Bridge
# of Spans:	1
Span or Diameter (m):	9.8
Rise (m):	1.93
Length (m):	10.8

Material:	Concrete
Open Footing:	Yes
Skew Angle:	0
Sediment Depth (mm):	100
Barrier:	1.11m Railing

US Invert Elevation (m):	213.58
DS Invert Elevation (m):	213.36

US Obvert Elevation (m):	215.51
DS Obvert Elevation (m):	215.30

Inlet/Outlet Type:	N/A
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	214.6
Water Depth (mm):	180

Additional Notes:	

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Regional Road 25
Northing:	4817512.39 N
Easting:	592210.45 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-02
Weather:	24°C, Cloudy
Structure ID:	22

Structure Type:	Box Culvert
# of Spans:	1
Span or Diameter (m):	3.0
Rise (m):	2.3
Length (m):	46.9

Material:	Concrete
Open Footing:	Yes
Skew Angle:	20
Sediment Depth (mm):	N/A
Barrier:	0.89m Railing

US Invert Elevation (m):	183.43
DS Invert Elevation (m):	182.96

US Obvert Elevation (m):	185.73
DS Obvert Elevation (m):	185.09

Inlet/Outlet Type:	Projecting from slope
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	189.3
Water Depth (mm):	50

Additional Notes:	Armourstone retaining wall upstream side.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Derry Road
Northing:	4817903.06 N
Easting:	592194.26 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-03
Weather:	24°C, Sunny
Structure ID:	23

Structure Type:	Box Culvert
# of Spans:	1
Span or Diameter (m):	3.1
Rise (m):	2.44
Length (m):	52.0

Material:	Concrete
Open Footing:	No
Skew Angle:	0
Sediment Depth (mm):	0
Barrier:	0.95m Railing

US Invert Elevation (m):	188.00
DS Invert Elevation (m):	187.99

US Obvert Elevation (m):	190.44
DS Obvert Elevation (m):	190.42

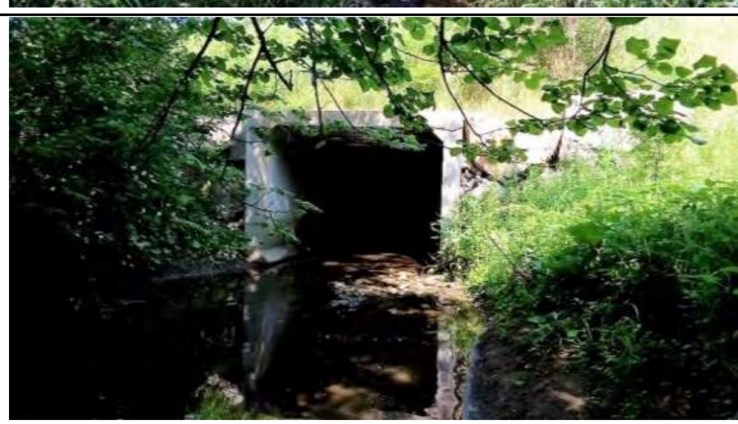
Inlet/Outlet Type:	Projecting from slope
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	193.6
Water Depth (mm):	20

Additional Notes:	Armourstone retaining wall both upstream and downstream sides. A bend exists 7.38m into the culvert from the downstream end.

Upstream Photo:

Downstream Photo:



Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Laurier Avenue
Northing:	4818005.38 N
Easting:	591992.11 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-03
Weather:	24°C, Sunny
Structure ID:	24

Structure Type:	Box Culvert
# of Spans:	1
Span or Diameter (m):	3.1
Rise (m):	2.45
Length (m):	38.9

Material:	Concrete
Open Footing:	No
Skew Angle:	0
Sediment Depth (mm):	Varies 100 DS - 400 US
Barrier:	0.98m Railing

US Invert Elevation (m):	189.79
DS Invert Elevation (m):	189.50

US Obvert Elevation (m):	192.24
DS Obvert Elevation (m):	191.44

Inlet/Outlet Type:	15° Wingwalls, DS S Perp.
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	194.0
Water Depth (mm):	150

Additional Notes:	Trapezoidal concrete lining throughout channel bottom.
	Storm pipe adjacent to downstream (diameter 2.12m) collects from road, outlets to creek.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Ontario Street South
Northing:	4818228.45 N
Easting:	591522.1 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-03
Weather:	24°C, Sunny
Structure ID:	25

Structure Type:	Box Culvert
# of Spans:	1
Span or Diameter (m):	3.7
Rise (m):	1.156
Length (m):	Could not retrieve

Material:	Concrete
Open Footing:	No
Skew Angle:	NA
Sediment Depth (mm):	200
Barrier:	0.89m Railing

US Invert Elevation (m):	-
DS Invert Elevation (m):	192.77

US Obvert Elevation (m):	-
DS Obvert Elevation (m):	193.93

Inlet/Outlet Type:	DS Headwall with Grate
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	195.3
Water Depth (mm):	130

Additional Notes:	Large stone around outlet bed, metal grate fixated to opening.
	No inlet found, continues underground.

Upstream Photo:	
Downstream Photo:	

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Millside Drive
Northing:	4818747.36 N
Easting:	590293 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-03
Weather:	24°C, Sunny
Structure ID:	26

Structure Type:	Beam Bridge
# of Spans:	1
Span or Diameter (m):	8.2
Rise (m):	2.512
Length (m):	22.6

Material:	Concrete
Open Footing:	No
Skew Angle:	30
Sediment Depth (mm):	0
Barrier:	1.13m Railing

US Invert Elevation (m):	191.09
DS Invert Elevation (m):	190.96

US Obvert Elevation (m):	193.61
DS Obvert Elevation (m):	193.64

Inlet/Outlet Type:	N/A
High Water Mark Depth (m):	0.31
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	194.2
Water Depth (mm):	100

Additional Notes:	Upstream cross section/railing is skewed to Millside Rd (west). DS side follows road bend.
	Trapezoidal, concrete lining continues upstream and downstream of channel.
	Chain link fence on top of slope on either side of channel.

Upstream Photo:	
Downstream Photo:	

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Conservation Halton   Greck

Location:	Rail Crossing
Northing:	4818822.8 N
Easting:	590211.88 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-03
Weather:	24°C, Sunny
Structure ID:	27

Structure Type:	Arch Culvert
# of Spans:	2*
Span or Diameter (m):	3.0
Rise (m):	3.26
Length (m):	25.1

Material:	Concrete
Open Footing:	No
Skew Angle:	0
Sediment Depth (mm):	200
Barrier:	Railing either side of tracks

US Invert Elevation (m):	192.78
DS Invert Elevation (m):	191.88

US Obvert Elevation (m):	196.04
DS Obvert Elevation (m):	195.14

Inlet/Outlet Type:	30° Wingwalls
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	200.48
Water Depth (mm):	Dry

Additional Notes:	*This form is for the Arch structure (east) only. See 27B for Elliptical pipe (west) information.
	Storm pipe inlet on US side dia 2.441m with metal grate, about 50mm of of flow.
	Chain link fence on top of slope on either side of channel.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Conservation Halton   Greck

Location:	Rail Crossing
Northing:	4818822.8 N
Easting:	590211.88 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-03
Weather:	24°C, Sunny
Structure ID:	27

Structure Type:	Elliptical Pipe
# of Spans:	2*
Span or Diameter (m):	5.5
Rise (m):	3.34
Length (m):	25.9

Material:	CSP with Concrete Bottom
Open Footing:	No
Skew Angle:	0
Sediment Depth (mm):	0
Barrier:	Railing either side of tracks

US Invert Elevation (m):	191.97
DS Invert Elevation (m):	191.51

US Obvert Elevation (m):	195.31
DS Obvert Elevation (m):	194.71

Inlet/Outlet Type:	30° Wingwalls
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	200.5
Water Depth (mm):	100

Additional Notes:	*This form is for the Elliptical structure (west) only. See 27 for Arch structure (east) information.
	Storm pipe inlet on US side dia 2.44m with metal grate, about 50mm of flow.

Upstream Photo:	
Downstream Photo:	

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Btwn Woodward Ave/Millside Dr.
Northing:	4818899.53 N
Easting:	590164.20 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-08
Weather:	25°C, Sunny
Structure ID:	between 27 - 28

Structure Type:	Pedestrian Bridge
# of Spans:	1
Span or Diameter (m):	9.8
Rise (m):	3.226
Length (m):	3.2

Material:	Wood and Steel
Open Footing:	No
Skew Angle:	0
Sediment Depth (mm):	N/A
Barrier:	1.53m Fence/Railing

US Invert Elevation (m):	192.18
DS Invert Elevation (m):	192.18

US Obvert Elevation (m):	195.40
DS Obvert Elevation (m):	195.40

Inlet/Outlet Type:	N/A
High Water Mark Depth (m):	Not Surveyed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	195.1
Water Depth (mm):	100

Additional Notes:	Chain link fence on top of slope on either side of channel.
	Trapezoidal, concrete lining continues upstream and downstream of channel.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Btwn Woodward Ave/Millside Dr.
Northing:	4818952.5 N
Easting:	590125.83 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-08
Weather:	25°C, Sunny
Structure ID:	28

Structure Type:	Pedestrian Bridge
# of Spans:	1
Span or Diameter (m):	11.4
Rise (m):	3.228
Length (m):	3.2

Material:	Wood and Steel
Open Footing:	No
Skew Angle:	0
Sediment Depth (mm):	N/A
Barrier:	1.51m Fence/Railing

US Invert Elevation (m):	192.36
DS Invert Elevation (m):	192.33

US Obvert Elevation (m):	195.58
DS Obvert Elevation (m):	195.56

Inlet/Outlet Type:	N/A
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	195.2
Water Depth (mm):	280

Additional Notes:	Chain link fence on top of slope on either side of channel. Trapezoidal, concrete lining continues upstream and downstream of channel.

Upstream Photo:	
Downstream Photo:	

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Woodward Avenue		Inspected By:	Paul Greck, Abby Wright
Northing:	4819029.16 N		Date:	2019-07-08
Easting:	590044.37 E		Weather:	25°C, Sunny
			Structure ID:	29

Structure Type:	Box Culvert		Material:	Concrete
# of Spans:	1		Open Footing:	No
Span or Diameter (m):	4.3		Skew Angle:	0
Rise (m):	3.6		Sediment Depth (mm):	0
Length (m):	12.5		Barrier:	1.122m Railing

US Invert Elevation (m):	192.64		US Obvert Elevation (m):	196.24
DS Invert Elevation (m):	192.81		DS Obvert Elevation (m):	196.19

Inlet/Outlet Type:	20° Wingwalls, DS E 30°		Low Point in Deck Elevation (m):	196.2
High Water Mark Depth (m):	0.51		Water Depth (mm):	420
Piers:	No			
Pier Width:	N/A			

Additional Notes:	Chain link fence on top of slope on either side of channel.
	Trapezoidal concrete lining is flat within structure, sloped upstream and downstream of crossing.
	Rectangular abutments on upstream portion of structure.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	W.I. Dick Middle School
Northing:	4819270 N
Easting:	589954.33 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-08
Weather:	25°C, Sunny
Structure ID:	30

Structure Type:	Box Culvert
# of Spans:	1
Span or Diameter (m):	4.9
Rise (m):	3.153
Length (m):	12.4

Material:	Concrete
Open Footing:	No
Skew Angle:	0
Sediment Depth (mm):	N/A
Barrier:	1.10m Parapet Wall and Rail

US Invert Elevation (m):	194.56
DS Invert Elevation (m):	194.44

US Obvert Elevation (m):	197.72
DS Obvert Elevation (m):	197.36

Inlet/Outlet Type:	15 Degree Wingwalls
High Water Mark Depth (m):	0.78
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	197.7
Water Depth (mm):	110

Additional Notes:	Two different culverts in a row. Difference of obverts is 0.96m with DS culvert lower.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet *Sixteen Mile Creek*

Location:	Steeles Avenue
Northing:	4819645.92 N
Easting:	589631.73 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-08
Weather:	25°C, Sunny
Structure ID:	31

Structure Type:	Box Culvert
# of Spans:	1
Span or Diameter (m):	4.9
Rise (m):	2.70
Length (m):	28.9

Material:	Concrete
Open Footing:	Yes
Skew Angle:	0
Sediment Depth (mm):	0
Barrier:	2.52m Parapet Wall & Fence

US Invert Elevation (m):	198.41
DS Invert Elevation (m):	197.85

US Obvert Elevation (m):	201.11
DS Obvert Elevation (m):	200.56

Inlet/Outlet Type:	Perp. Walls US, none DS
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	201.5
Water Depth (mm):	90

Additional Notes:	Storm pipe outlet (dia 1.83m) beside culvert outlet with metal grate, 80 mm flow.
	Trapezoidal, concrete lining DS of channel. Natural bottom througout and US of culvert.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Wheelabrator Way
Northing:	4819788.59 N
Easting:	589476.75 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-15
Weather:	20°C, Sunny
Structure ID:	32

Structure Type:	Box Culvert
# of Spans:	1
Span or Diameter (m):	9.1
Rise (m):	1.35
Length (m):	34.5

Material:	Concrete
Open Footing:	Yes
Skew Angle:	30
Sediment Depth (mm):	N/A
Barrier:	0.78m Guardrail

US Invert Elevation (m):	199.70
DS Invert Elevation (m):	199.28

US Obvert Elevation (m):	201.05
DS Obvert Elevation (m):	201.00

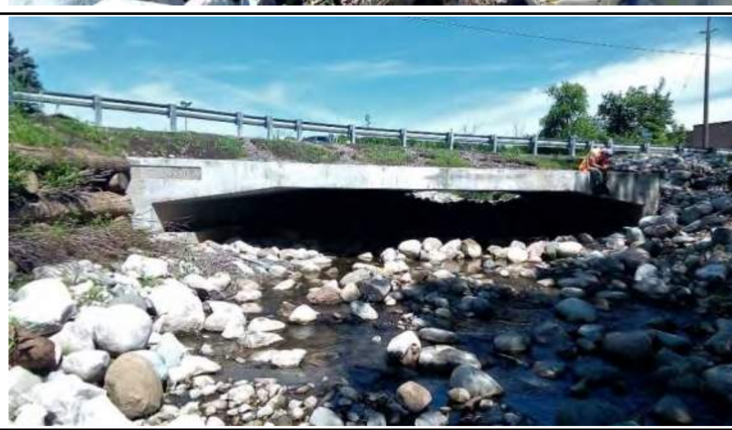
Inlet/Outlet Type:	Projecting from slope
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	202.4
Water Depth (mm):	100

Additional Notes:	Armourstone retaining walls US, cribwall and stone channel sides DS.

Upstream Photo:

Downstream Photo:



Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Rail Crossing
Northing:	4819913.82 N
Easting:	589380.03 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-15
Weather:	20°C, Sunny
Structure ID:	33

Structure Type:	Circular Pipe
# of Spans:	1
Span or Diameter (m):	2.5
Rise (m):	2.76
Length (m):	34.7

Material:	Corrugated Steel
Open Footing:	No
Skew Angle:	0
Sediment Depth (mm):	Varies from 0 US to 570 DS
Barrier:	None

US Invert Elevation (m):	201.51
DS Invert Elevation (m):	201.15

US Obvert Elevation (m):	204.27
DS Obvert Elevation (m):	204.30

Inlet/Outlet Type:	Mitered to Slope
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	209.6
Water Depth (mm):	80

Additional Notes:	Gabion lined channel bottom downstream, concrete lined upstream. About halfway through pipe from DS there is a step due to sediment (change in rise).

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Conservation Halton   Greck

Location:	Maplehurst
Northing:	4819954.66 N
Easting:	589134.52 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-15
Weather:	20°C, Sunny
Structure ID:	34

Structure Type:	
# of Spans:	
Span or Diameter (m):	
Rise (m):	
Length (m):	

Material:	
Open Footing:	
Skew Angle:	
Sediment Depth (mm):	
Barrier:	

US Invert Elevation (m):	
DS Invert Elevation (m):	

US Obvert Elevation (m):	
DS Obvert Elevation (m):	

Inlet/Outlet Type:	
High Water Mark Depth (m):	
Piers:	
Pier Width:	

Low Point in Deck Elevation (m):	
Water Depth (mm):	

Additional Notes:	Could not access

Upstream Photo:	
Downstream Photo:	

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Maplehurst
Northing:	4819970.87 N
Easting:	589050 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-15
Weather:	20°C, Sunny
Structure ID:	35

Structure Type:	
# of Spans:	
Span or Diameter (m):	
Rise (m):	
Length (m):	

Material:	
Open Footing:	
Skew Angle:	
Sediment Depth (mm):	
Barrier:	

US Invert Elevation (m):	
DS Invert Elevation (m):	

US Obvert Elevation (m):	
DS Obvert Elevation (m):	

Inlet/Outlet Type:	
High Water Mark Depth (m):	
Piers:	
Pier Width:	

Low Point in Deck Elevation (m):	
Water Depth (mm):	

Additional Notes:	Could not access

Upstream Photo:	
Downstream Photo:	

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Hwy. 401
Northing:	4820208.41 N
Easting:	588726.81 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-18
Weather:	22°C, Cloudy
Structure ID:	36

Structure Type:	Box Culvert
# of Spans:	1
Span or Diameter (m):	3.7
Rise (m):	1.83
Length (m):	80.3

Material:	Concrete
Open Footing:	No
Skew Angle:	20
Sediment Depth (mm):	0
Barrier:	None

US Invert Elevation (m):	204.68
DS Invert Elevation (m):	204.44

US Obvert Elevation (m):	206.51
DS Obvert Elevation (m):	206.22

Inlet/Outlet Type:	Projecting from slope
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	208.1
Water Depth (mm):	30

Additional Notes:	Concrete block bottom from downstream of weir wingwalls to upstream inlet of culvert.
	Storm outlets on both sides midway within culvert.
	Gabion slope on one side of DS end.

Upstream Photo:	
Downstream Photo:	

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	High Point Pond
Northing:	4820247 N
Easting:	588688.15 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-18
Weather:	22°C, Cloudy
Structure ID:	37

Structure Type:	Weir
# of Spans:	1
Span or Diameter (m):	3.7
Rise (m):	3.25
Length (m):	1.5

Material:	Concrete
Open Footing:	No
Skew Angle:	0
Sediment Depth (mm):	0
Barrier:	45" fence and curb

US Invert Elevation (m):	205.15
DS Invert Elevation (m):	205.05

US Obvert Elevation (m):	208.40
DS Obvert Elevation (m):	208.30

Inlet/Outlet Type:	20˚ Wingwalls
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	-
Water Depth (mm):	50

Additional Notes:	Gabion continues on 20 degree angle US, DS gabion is perpendicular to crossing.
	Concrete blocks line US bottom of channel, while DS side has concrete apron.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	High Point Pond
Northing:	4820288.35 N
Easting:	588606.3 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-18
Weather:	22°C, Cloudy
Structure ID:	38

Structure Type:	Box Culvert
# of Spans:	1
Span or Diameter (m):	1.8
Rise (m):	0.98
Length (m):	14.7

Material:	Concrete
Open Footing:	Yes
Skew Angle:	0
Sediment Depth (mm):	N/A
Barrier:	None

US Invert Elevation (m):	205.43
DS Invert Elevation (m):	205.38

US Obvert Elevation (m):	206.41
DS Obvert Elevation (m):	206.38

Inlet/Outlet Type:	Projecting from slope
High Water Mark Depth (m):	0.35
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	206.5
Water Depth (mm):	240

Additional Notes:	Rip rap channel bottom, larger stones surround inlet.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Regional Road 25
Northing:	4820303.91 N
Easting:	588192.47 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-15
Weather:	20°C, Sunny
Structure ID:	39

Structure Type:	Box Culvert
# of Spans:	1
Span or Diameter (m):	3.0
Rise (m):	2.25
Length (m):	50.8

Material:	Concrete
Open Footing:	No
Skew Angle:	30
Sediment Depth (mm):	0.1
Barrier:	0.75m Guardrail

US Invert Elevation (m):	207.66
DS Invert Elevation (m):	207.33

US Obvert Elevation (m):	209.92
DS Obvert Elevation (m):	209.48

Inlet/Outlet Type:	Projecting from slope
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	211.3
Water Depth (mm):	300

Additional Notes:

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Truck Town Service
Northing:	4820352.92 N
Easting:	587931.92 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-15
Weather:	20°C, Sunny
Structure ID:	40

Structure Type:	Box Culvert
# of Spans:	1
Span or Diameter (m):	3.0
Rise (m):	1.922
Length (m):	18.3

Material:	Concrete
Open Footing:	Yes
Skew Angle:	0
Sediment Depth (mm):	N/A
Barrier:	0.25m Concrete Curb

US Invert Elevation (m):	208.99
DS Invert Elevation (m):	208.70

US Obvert Elevation (m):	210.92
DS Obvert Elevation (m):	211.03

Inlet/Outlet Type:	Headwall
High Water Mark Depth (m):	0.7
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	212.2
Water Depth (mm):	0

Additional Notes:	Very low flow, upstream end dry.
	Large rip rap in channel bed throughout.
	Dense vegetation both upstream and downstream.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	James Snow Parkway
Northing:	4820437.01 N
Easting:	587583.14 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-12
Weather:	20°C, Sunny
Structure ID:	41

Structure Type:	Beam Bridge
# of Spans:	1
Span or Diameter (m):	13.0
Rise (m):	1.34
Length (m):	30.5

Material:	Concrete
Open Footing:	Yes
Skew Angle:	0
Sediment Depth (mm):	N/A
Barrier:	1.38m Railing

US Invert Elevation (m):	210.31
DS Invert Elevation (m):	210.25

US Obvert Elevation (m):	211.65
DS Obvert Elevation (m):	211.47

Inlet/Outlet Type:	N/A
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	212.3
Water Depth (mm):	130

Additional Notes:	Dense vegetation both US and DS. Full size US photo could not be obtained.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	James Snow Parkway
Northing:	4820395.68 N
Easting:	587560.90 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-06-27
Weather:	20°C, Sunny
Structure ID:	41B

Structure Type:	Arch Culverts
# of Spans:	2
Span or Diameter (m):	3.8
Rise (m):	0.94
Length (m):	35.6

Material:	Concrete
Open Footing:	Yes
Skew Angle:	0
Sediment Depth (mm):	N/A
Barrier:	1.38m Parapet Wall and Rail

US Invert Elevation (m):	211.35 both
DS Invert Elevation (m):	East is 211.25 West is 211.12

US Obvert Elevation (m):	212.57
DS Obvert Elevation (m):	212.61

Inlet/Outlet Type:	Headwall
High Water Mark Depth (m):	0.5
Piers:	Yes
Pier Width:	1.27m

Low Point in Deck Elevation (m):	212.5
Water Depth (mm):	200 both

Additional Notes:	Storm Pond Bridge
	Rip rap on sides of headwall and bottom of channel on DS and US ends.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Private, near 5th Sideroad
Northing:	4820832.81 N
Easting:	586746.44 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-12
Weather:	20°C, Sunny
Structure ID:	42

Structure Type:	Pedestrian Bridge
# of Spans:	1
Span or Diameter (m):	13.0
Rise (m):	1.99
Length (m):	1.4

Material:	Wood and Steel
Open Footing:	Yes
Skew Angle:	0
Sediment Depth (mm):	N/A
Barrier:	1.02m Railing

US Invert Elevation (m):	217.44
DS Invert Elevation (m):	217.16

US Obvert Elevation (m):	219.17
DS Obvert Elevation (m):	219.15

Inlet/Outlet Type:	N/A
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	219.4
Water Depth (mm):	90

Additional Notes:	Approximately 3:1 slopes on either sides of the abutments to the channel bed.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	5th Sideroad
Northing:	4820877.07 N
Easting:	586706.99 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-12
Weather:	20°C, Sunny
Structure ID:	43

Structure Type:	Circular Pipe
# of Spans:	1
Span or Diameter (m):	1.5
Rise (m):	1.48
Length (m):	26.9

Material:	Corrugated Steel
Open Footing:	No
Skew Angle:	0
Sediment Depth (mm):	Varies, 0 US to 430 DS
Barrier:	None

US Invert Elevation (m):	217.69
DS Invert Elevation (m):	217.56

US Obvert Elevation (m):	219.17
DS Obvert Elevation (m):	218.61

Inlet/Outlet Type:	Projecting from slope
High Water Mark Depth (m):	0.5
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	222.1
Water Depth (mm):	60

Additional Notes:	Pipe sagging midway through length.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Future 5th Sideroad		**Inspected By:**	Paul Greck, Abby Wright
Northing:	4820589.01 N		**Date:**	2019-07-12
Easting:	586704.25 E		**Weather:**	20°C, Cloudy
			Structure ID:	44

Structure Type:	Arch Culvert		**Material:**	Corrugated Steel
# of Spans:	1		**Open Footing:**	Yes
Span or Diameter (m):	9.2		**Skew Angle:**	0
Rise (m):	2.14		**Sediment Depth (mm):**	N/A
Length (m):	17.6		**Barrier:**	None yet

US Invert Elevation (m):	217.74		**US Obvert Elevation (m):**	219.88
DS Invert Elevation (m):	217.74		**DS Obvert Elevation (m):**	219.91

Inlet/Outlet Type:	Headwalls		**Low Point in Deck Elevation (m):**	219.5
High Water Mark Depth (m):	Not Observed		**Water Depth (mm):**	100
Piers:	No			
Pier Width:	N/A			

Additional Notes:	Crossing still under construction
	Top of deck is unfinished, no permanent top of deck grade available

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	5th Sideroad
Northing:	4820596.01 N
Easting:	586514.65 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-12
Weather:	20°C, Cloudy
Structure ID:	45

Structure Type:	Circular Pipe
# of Spans:	1
Span or Diameter (m):	1.5
Rise (m):	1.561
Length (m):	24.9

Material:	Corrugated Steel
Open Footing:	No
Skew Angle:	0
Sediment Depth (mm):	0
Barrier:	None

US Invert Elevation (m):	218.67
DS Invert Elevation (m):	218.57

US Obvert Elevation (m):	220.21
DS Obvert Elevation (m):	219.97

Inlet/Outlet Type:	Projecting from slope
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	221.9
Water Depth (mm):	300

Additional Notes:	Large Log within pipe and wire fence erect across channel at downstream end.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Industrial, btwn 401/Steeles
Northing:	4820111.24 N
Easting:	589432.61 E

Inspected By:	Paul Greck, Brian Greck
Date:	2019-11-26
Weather:	5°C, Clear
Structure ID:	46

Structure Type:	concrete box
# of Spans:	1
Span or Diameter (m):	3.0
Rise (m):	1.35
Length (m):	117.3

Material:	concrete
Open Footing:	No
Skew Angle:	0
Sediment Depth (mm):	0.2
Barrier:	No

US Invert Elevation (m):	203.82
DS Invert Elevation (m):	203.35

US Obvert Elevation (m):	205.17
DS Obvert Elevation (m):	204.70

Inlet/Outlet Type:	No wing wall
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	206.4
Water Depth (mm):	0.05

Additional Notes:	gabion baskets on ds slope and stream banks.
	Dense vegetation present at upsream end.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Industrial, btwn 401/Steeles
Northing:	4820196.34 N
Easting:	589472.26 E

Inspected By:	Paul Greck, Brian Greck
Date:	2019-11-26
Weather:	5°C, Clear
Structure ID:	47

Structure Type:	Three Pipes
# of Spans:	3
Span or Diameter (m):	0.6 US 0.92 DS
Rise (m):	0.6 US 0.92 DS
Length (m):	19.6

Material:	CSP US & concrete DS
Open Footing:	No
Skew Angle:	90 degrees
Sediment Depth (mm):	0.05
Barrier:	Large Shipping containers

US Invert Elevation (m):	*204.13
DS Invert Elevation (m):	205.32

US Obvert Elevation (m):	*204.73
DS Obvert Elevation (m):	206.24

Inlet/Outlet Type:	projected from slope
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	206.7
Water Depth (mm):	0.25

Additional Notes:	Relatively new culverts
	*GPS accuracy poor at both ends, LIDAR was used to determine the downstream invert/obvert elev.
	Poor access due to large shipping contained on both sides of culverts

Upstream Photo:	
Downstream Photo:	

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Mcgeachie Drive
Northing:	4820301.88 N
Easting:	589601.41 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-15
Weather:	20°C, Sunny
Structure ID:	48

Structure Type:	Box Culvert
# of Spans:	1
Span or Diameter (m):	4.9
Rise (m):	1.82
Length (m):	12.8

Material:	Concrete
Open Footing:	Yes
Skew Angle:	0
Sediment Depth (mm):	N/A
Barrier:	0.87m Railing

US Invert Elevation (m):	205.78
DS Invert Elevation (m):	205.61

US Obvert Elevation (m):	207.60
DS Obvert Elevation (m):	207.49

Inlet/Outlet Type:	Headwalls
High Water Mark Depth (m):	0.5
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	208.0
Water Depth (mm):	150

Additional Notes:	Railing is leaning on an angle on upstream side.
	Dense vegetation both upstream and downstream sides.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Conservation Halton   Greck

Location:	Industrial, btwn 401/Steeles
Northing:	4820529.49 N
Easting:	589785.55 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-15
Weather:	20°C, Sunny
Structure ID:	49

Structure Type:	Pedestrian Bridge
# of Spans:	1
Span or Diameter (m):	6.1
Rise (m):	0.762
Length (m):	1.5

Material:	Wood
Open Footing:	No
Skew Angle:	0
Sediment Depth (mm):	N/A
Barrier:	1.044m Hand Rail

US Invert Elevation (m):	206.89
DS Invert Elevation (m):	206.78

US Obvert Elevation (m):	207.66
DS Obvert Elevation (m):	207.97

Inlet/Outlet Type:	N/A
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	208.3
Water Depth (mm):	75

Additional Notes:	Bridge in poor condition and lopsided leaning toward US side.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Harrop Drive
Northing:	4820597.86 N
Easting:	589839.51 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-15
Weather:	20°C, Sunny
Structure ID:	50

Structure Type:	Box Culvert
# of Spans:	1
Span or Diameter (m):	2.4
Rise (m):	1.28
Length (m):	13.4

Material:	Concrete
Open Footing:	No
Skew Angle:	0
Sediment Depth (mm):	640
Barrier:	0.95m Railing

US Invert Elevation (m):	206.73
DS Invert Elevation (m):	206.69

US Obvert Elevation (m):	208.01
DS Obvert Elevation (m):	207.96

Inlet/Outlet Type:	Headwalls
High Water Mark Depth (m):	1.2
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	209.1
Water Depth (mm):	100

Additional Notes:	Single source is upstream storm outlet (dia 0.67m).
	High water mark appears to be above the obvert on the downstream side.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Industrial, btwn 401/Steeles
Northing:	4820653.52 N
Easting:	589798.35 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-15
Weather:	20°C, Sunny
Structure ID:	51

Structure Type:	
# of Spans:	
Span or Diameter (m):	
Rise (m):	
Length (m):	

Material:	
Open Footing:	
Skew Angle:	
Sediment Depth (mm):	
Barrier:	

US Invert Elevation (m):	
DS Invert Elevation (m):	

US Obvert Elevation (m):	
DS Obvert Elevation (m):	

Inlet/Outlet Type:	
High Water Mark Depth (m):	
Piers:	
Pier Width:	

Low Point in Deck Elevation (m):	
Water Depth (mm):	

Additional Notes:	Could not find, may be underground.

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Industrial, btwn 401/Steeles	**Inspected By:**	Paul Greck, Abby Wright
Northing:	4820728.17 N	**Date:**	2019-07-15
Easting:	589723.65 E	**Weather:**	20°C, Sunny
		Structure ID:	52

Structure Type:		**Material:**	
# of Spans:		**Open Footing:**	
Span or Diameter (m):		**Skew Angle:**	
Rise (m):		**Sediment Depth (mm):**	
Length (m):		**Barrier:**	

US Invert Elevation (m):		**US Obvert Elevation (m):**	
DS Invert Elevation (m):		**DS Obvert Elevation (m):**	

Inlet/Outlet Type:		**Low Point in Deck Elevation (m):**	
High Water Mark Depth (m):		**Water Depth (mm):**	
Piers:			
Pier Width:			

Additional Notes:	Could not find, may be underground.

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Hwy. 401
Northing:	4820844.84 N
Easting:	589709.97 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-23
Weather:	22°C, Sunny
Structure ID:	53

Structure Type:	Box Culvert
# of Spans:	1
Span or Diameter (m):	1.8
Rise (m):	1.21
Length (m):	56.6

Material:	Concrete
Open Footing:	No
Skew Angle:	20
Sediment Depth (mm):	550
Barrier:	0.81m Jersey Barrier median

US Invert Elevation (m):	208.97
DS Invert Elevation (m):	209.10

US Obvert Elevation (m):	210.18
DS Obvert Elevation (m):	209.75

Inlet/Outlet Type:	Projecting from slope
High Water Mark Depth (m):	N/A
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	211.2
Water Depth (mm):	40

Additional Notes:	Culvert almost at capacity, water level 14in below obvert.
	Very weedy DS side, with debris.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Hwy. 401		**Inspected By:**	Paul Greck, Abby Wright
Northing:	4820749.55 N		**Date:**	2019-07-23
Easting:	589569.26 E		**Weather:**	22°C, Sunny
			Structure ID:	54

Structure Type:	Box Culvert		**Material:**	Concrete
# of Spans:	1		**Open Footing:**	Yes
Span or Diameter (m):	1.8		**Skew Angle:**	check
Rise (m):	0.67		**Sediment Depth (mm):**	N/A
Length (m):	59.3		**Barrier:**	0.81 Jersey Barrier median

US Invert Elevation (m):	208.90		**US Obvert Elevation (m):**	209.57
DS Invert Elevation (m):	208.88		**DS Obvert Elevation (m):**	209.38

Inlet/Outlet Type:	Projecting from slope		**Low Point in Deck Elevation (m):**	210.9
High Water Mark Depth (m):	Not measured		**Water Depth (mm):**	220
Piers:	No			
Pier Width:	N/A			

Additional Notes:	Downstream culvert almost at capacity , water level 6in from obvert

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Harrop Drive
Northing:	4820710.38 N
Easting:	589605.74 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-15
Weather:	20°C, Sunny
Structure ID:	55

Structure Type:	Circular Pipe
# of Spans:	1
Span or Diameter (m):	0.6
Rise (m):	0.7
Length (m):	12.5

Material:	PVC
Open Footing:	No
Skew Angle:	0
Sediment Depth (mm):	100
Barrier:	None

US Invert Elevation (m):	208.67
DS Invert Elevation (m):	208.593

US Obvert Elevation (m):	209.37
DS Obvert Elevation (m):	209.293

Inlet/Outlet Type:	Projecting from slope
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	209.6
Water Depth (mm):	150

Additional Notes:	Dense vegetation at both upstream and downstream ends.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Industrial, btwn 401/Steeles
Northing:	4820665.15 N
Easting:	589646.35 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-15
Weather:	20°C, Sunny
Structure ID:	56

Structure Type:	
# of Spans:	
Span or Diameter (m):	
Rise (m):	
Length (m):	

Material:	
Open Footing:	
Skew Angle:	
Sediment Depth (mm):	
Barrier:	

US Invert Elevation (m):	
DS Invert Elevation (m):	

US Obvert Elevation (m):	
DS Obvert Elevation (m):	

Inlet/Outlet Type:	
High Water Mark Depth (m):	
Piers:	
Pier Width:	

Low Point in Deck Elevation (m):	
Water Depth (mm):	

Additional Notes:	Could not access

Upstream Photo:	
Downstream Photo:	

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Industrial, btwn 401/Steeles		**Inspected By:**	Paul Greck, Abby Wright
Northing:	4820485.43 N		**Date:**	2019-07-15
Easting:	589546.43 E		**Weather:**	20°C, Sunny
			Structure ID:	57

Structure Type:			**Material:**	
# of Spans:			**Open Footing:**	
Span or Diameter (m):			**Skew Angle:**	
Rise (m):			**Sediment Depth (mm):**	
Length (m):			**Barrier:**	

US Invert Elevation (m):			**US Obvert Elevation (m):**	
DS Invert Elevation (m):			**DS Obvert Elevation (m):**	

Inlet/Outlet Type:			**Low Point in Deck Elevation (m):**	
High Water Mark Depth (m):			**Water Depth (mm):**	
Piers:				
Pier Width:				

Additional Notes:	Could not access

Upstream Photo:	
Downstream Photo:	

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Rail Crossing
Northing:	4820247 N
Easting:	589450.68 E

Inspected By:	Paul Greck, Brian Greck
Date:	2019-11-26
Weather:	5°C, Clear
Structure ID:	58

Structure Type:	CSP
# of Spans:	1
Span or Diameter (m):	1.5
Rise (m):	1.5
Length (m):	35.9

Material:	Corrugated Steel
Open Footing:	No
Skew Angle:	N/A
Sediment Depth (mm):	N/A
Barrier:	No

US Invert Elevation (m):	205.82
DS Invert Elevation (m):	205.53

US Obvert Elevation (m):	207.32
DS Obvert Elevation (m):	207.03

Inlet/Outlet Type:	Projecting from slope
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	207.36
Water Depth (mm):	40

Additional Notes:	

Upstream Photo:	
Downstream Photo:	

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Hwy. 401
Northing:	4820414.82 N
Easting:	589048 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-23
Weather:	22°C, Sunny
Structure ID:	59

Structure Type:	Box Culvert
# of Spans:	1
Span or Diameter (m):	1.9
Rise (m):	1.233
Length (m):	89.7

Material:	Concrete
Open Footing:	No
Skew Angle:	40
Sediment Depth (mm):	Varies 0 US to 230 DS
Barrier:	0.81m Jersey Barrier median

US Invert Elevation (m):	207.78
DS Invert Elevation (m):	207.30

US Obvert Elevation (m):	209.02
DS Obvert Elevation (m):	208.53

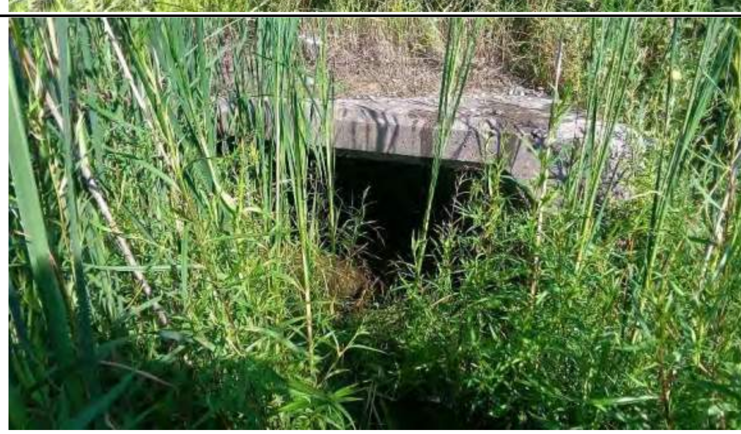
Inlet/Outlet Type:	Projecting from slope
High Water Mark Depth (m):	0.4
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	216.3
Water Depth (mm):	5

Additional Notes:	

Upstream Photo:

Downstream Photo:



Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Conservation Halton   Greck

Location:	Maplehurst
Northing:	4820315.18 N
Easting:	589248.94 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-15
Weather:	20°C, Sunny
Structure ID:	60

Structure Type:	
# of Spans:	
Span or Diameter (m):	
Rise (m):	
Length (m):	

Material:	
Open Footing:	
Skew Angle:	
Sediment Depth (mm):	
Barrier:	

US Invert Elevation (m):	
DS Invert Elevation (m):	

US Obvert Elevation (m):	
DS Obvert Elevation (m):	

Inlet/Outlet Type:	
High Water Mark Depth (m):	
Piers:	
Pier Width:	

Low Point in Deck Elevation (m):	
Water Depth (mm):	

Additional Notes:	Could not access

Upstream Photo:	
Downstream Photo:	

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Conservation Halton   Greck

Location:	Rail Crossing
Northing:	4820246.65 N
Easting:	589357.42 E

Inspected By:	Paul Greck, Brian Greck
Date:	2019-11-26
Weather:	5°C, Clear
Structure ID:	61

Structure Type:	Twin csp
# of Spans:	2
Span or Diameter (m):	1.2
Rise (m):	1.1
Length (m):	25.0

Material:	steel
Open Footing:	No
Skew Angle:	No
Sediment Depth (mm):	0.25
Barrier:	No

US Invert Elevation (m):	S: 206.33 - N:206.33
DS Invert Elevation (m):	S: 205.81 - N: 205.98

US Obvert Elevation (m):	S: 207.53 - N:207.53
DS Obvert Elevation (m):	S: 207.30 - N: 207.48

Inlet/Outlet Type:	projected
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	208.7
Water Depth (mm):	0.2

Additional Notes:	Could not access upstream end, on private property of correction complex.
	small channel <0.5m, well vegetated

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Tremaine Road
Northing:	4819539.35 N
Easting:	585823.6 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-12
Weather:	20°C, Sunny
Structure ID:	62

Structure Type:	Elliptical Pipe
# of Spans:	1
Span or Diameter (m):	1.9
Rise (m):	1.168
Length (m):	15.1

Material:	Corrugated Steel
Open Footing:	No
Skew Angle:	35
Sediment Depth (mm):	0
Barrier:	None

US Invert Elevation (m):	220.04
DS Invert Elevation (m):	220.19

US Obvert Elevation (m):	221.21
DS Obvert Elevation (m):	221.23

Inlet/Outlet Type:	Stone Headwall US, Proj. DS
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	222.0
Water Depth (mm):	280

Additional Notes:	Dense vegetation at upstream end.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Conservation Halton | Greck

Location:	Hwy. 401		**Inspected By:**	Paul Greck, Abby Wright
Northing:	4819432.51 N		**Date:**	2019-07-18
Easting:	586285.12 E		**Weather:**	22°C, Cloudy
			Structure ID:	63

Structure Type:	Box Culvert		**Material:**	Concrete
# of Spans:	1		**Open Footing:**	No
Span or Diameter (m):	3.0		**Skew Angle:**	50
Rise (m):	1.59		**Sediment Depth (mm):**	0
Length (m):	71.0		**Barrier:**	23in Guardrail

US Invert Elevation (m):	216.66		**US Obvert Elevation (m):**	218.25
DS Invert Elevation (m):	216.32		**DS Obvert Elevation (m):**	217.73

Inlet/Outlet Type:	Projecting from slope		**Low Point in Deck Elevation (m):**	219.7
High Water Mark Depth (m):	0.55		**Water Depth (mm):**	40
Piers:	No			
Pier Width:	N/A			

Additional Notes:	

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	3rd Sideroad
Northing:	4819201.01 N
Easting:	586947.75 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-12
Weather:	20°C, Sunny
Structure ID:	64

Structure Type:	Box Culvert
# of Spans:	1
Span or Diameter (m):	3.1
Rise (m):	1.08
Length (m):	10.9

Material:	Concrete
Open Footing:	Yes
Skew Angle:	0
Sediment Depth (mm):	N/A
Barrier:	None

US Invert Elevation (m):	212.33
DS Invert Elevation (m):	212.61

US Obvert Elevation (m):	213.41
DS Obvert Elevation (m):	213.49

Inlet/Outlet Type:	Projecting from slope
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	212.5
Water Depth (mm):	200

Additional Notes:	Dense vegetation at DS end.
	Could not find culvert bottom, assumed open.
	Deep sedimentation on both ends.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Peru Road
Northing:	4819176.49 N
Easting:	587352.87 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-11
Weather:	25°C, Sunny
Structure ID:	65

Structure Type:	Box Culvert
# of Spans:	1
Span or Diameter (m):	3.0
Rise (m):	1.62
Length (m):	7.2

Material:	Concrete
Open Footing:	Yes
Skew Angle:	0
Sediment Depth (mm):	N/A
Barrier:	0.27m Curb

US Invert Elevation (m):	209.94
DS Invert Elevation (m):	210.25

US Obvert Elevation (m):	211.56
DS Obvert Elevation (m):	211.78

Inlet/Outlet Type:	Headwalls
High Water Mark Depth (m):	0.4
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	210.6
Water Depth (mm):	100

Additional Notes:	

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Conservation Halton   Greck

Location:	Magna Karmax
Northing:	4819396.73 N
Easting:	587512.64 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-18
Weather:	22°C, Cloudy
Structure ID:	66

Structure Type:	
# of Spans:	
Span or Diameter (m):	
Rise (m):	
Length (m):	

Material:	
Open Footing:	
Skew Angle:	
Sediment Depth (mm):	
Barrier:	

US Invert Elevation (m):	
DS Invert Elevation (m):	

US Obvert Elevation (m):	
DS Obvert Elevation (m):	

Inlet/Outlet Type:	
High Water Mark Depth (m):	
Piers:	
Pier Width:	

Low Point in Deck Elevation (m):	
Water Depth (mm):	

Additional Notes:	Could not access

Upstream Photo:	
Downstream Photo:	

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Conservation Halton

Greck

Location:	Rail Crossing
Northing:	4819653.21 N
Easting:	587785.64 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-18
Weather:	22°C, Cloudy
Structure ID:	67

Structure Type:	Box Culverts
# of Spans:	2
Span or Diameter (m):	2.5
Rise (m):	2.46
Length (m):	16.3

Material:	Concrete
Open Footing:	Yes
Skew Angle:	40
Sediment Depth (mm):	N/A
Barrier:	1.27m Chain link Fence

US Invert Elevation (m):	206.65
DS Invert Elevation (m):	207.039

US Obvert Elevation (m):	209.10
DS Obvert Elevation (m):	209.02

Inlet/Outlet Type:	45 Degree Wingwalls
High Water Mark Depth (m):	0.9
Piers:	Yes
Pier Width:	0.356

Low Point in Deck Elevation (m):	210.5
Water Depth (mm):	150

Additional Notes:	Downstream outlet is weedy, and lined with rip rap.
	Chain link fence borders top of headwall and wingwalls.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Conservation Halton   Greck

Location:	Rail Crossing
Northing:	4819653.21 N
Easting:	587785.64 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-18
Weather:	22°C, Cloudy
Structure ID:	67

Structure Type:	Circular Pipe
# of Spans:	1
Span or Diameter (m):	0.6
Rise (m):	
Length (m):	

Material:	Corrugated Steel
Open Footing:	No
Skew Angle:	?
Sediment Depth (mm):	
Barrier:	Chainlink fence on skew

US Invert Elevation (m):	
DS Invert Elevation (m):	

US Obvert Elevation (m):	
DS Obvert Elevation (m):	

Inlet/Outlet Type:	Headwall, opening 0.592m
High Water Mark Depth (m):	400 ds
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	
Water Depth (mm):	

Additional Notes:	May bend
	Metal grate on outlet
	Could not access us inlet

Upstream Photo:	
Downstream Photo:	

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Chisholm Drive		**Inspected By:**	Paul Greck, Abby Wright
Northing:	4819741.36 N		**Date:**	2019-07-18
Easting:	587943.64 E		**Weather:**	22°C, Sunny
			Structure ID:	68

Structure Type:	Box Culvert		**Material:**	Concrete
# of Spans:	1		**Open Footing:**	Yes
Span or Diameter (m):	6.1		**Skew Angle:**	40
Rise (m):	1.76		**Sediment Depth (mm):**	N/A
Length (m):	31.1		**Barrier:**	None

US Invert Elevation (m):	206.25		**US Obvert Elevation (m):**	208.16
DS Invert Elevation (m):	206.28		**DS Obvert Elevation (m):**	207.92

Inlet/Outlet Type:	Projecting from slope		**Low Point in Deck Elevation (m):**	208.7
High Water Mark Depth (m):	0.35		**Water Depth (mm):**	230
Piers:	No			
Pier Width:	N/A			

Additional Notes:	30 degree gabion wingwalls, 1.2m high, upstream and downstream (only 1 DS).

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet *Sixteen Mile Creek*

Conservation Halton Greck

Location:	Chisholm Drive
Northing:	4819753.53 N
Easting:	588708.97 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-10
Weather:	25°C, Sunny
Structure ID:	69

Structure Type:	Box Culvert
# of Spans:	1
Span or Diameter (m):	4.3
Rise (m):	2.432
Length (m):	24.2

Material:	Concrete
Open Footing:	No
Skew Angle:	0
Sediment Depth (mm):	50
Barrier:	0.65m Guardrail

US Invert Elevation (m):	203.49
DS Invert Elevation (m):	203.62

US Obvert Elevation (m):	205.92
DS Obvert Elevation (m):	206.06

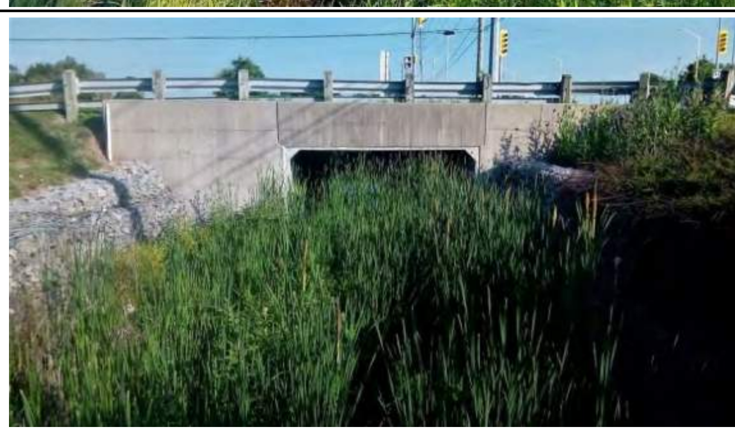
Inlet/Outlet Type:	Wingwalls US, Headwall DS
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	206.6
Water Depth (mm):	90

Additional Notes:	Gabion retaining walls perpendicular on both sides.
	Weedy in channel both upstream and downstream.
	Storm outlet (dia. 0.910m) upstream end.
	Wingwalls US 40° W & 10° E, Headwall DS.

Upstream Photo:

Downstream Photo:



Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Esso on Martin St.
Northing:	4819723.54 N
Easting:	588742.42 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-08
Weather:	25°C, Sunny
Structure ID:	70

Structure Type:	Elliptical Pipe
# of Spans:	1
Span or Diameter (m):	4.0
Rise (m):	2.61
Length (m):	45.7

Material:	Corrugated Steel
Open Footing:	No
Skew Angle:	0
Sediment Depth (mm):	0
Barrier:	None

US Invert Elevation (m):	203.36
DS Invert Elevation (m):	203.51

US Obvert Elevation (m):	205.97
DS Obvert Elevation (m):	206.12

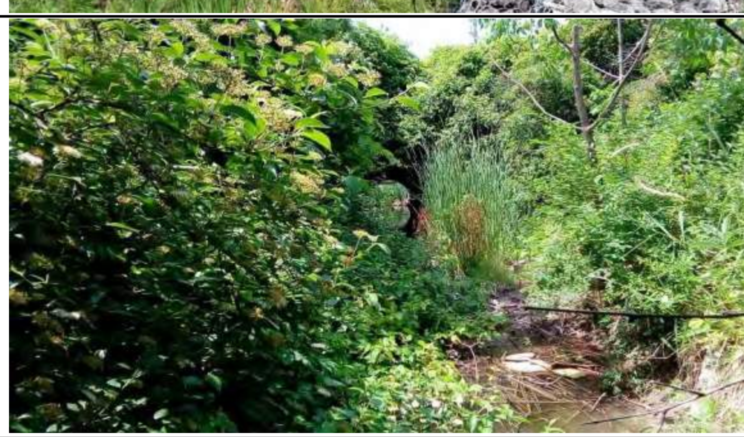
Inlet/Outlet Type:	Gabion Retaining Walls
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	206.8
Water Depth (mm):	95

Additional Notes:	Storm outlet pipe (150mm dia.) midway through culvert.
	Densely vegetated at both upstream and downstream ends.

Upstream Photo:

Downstream Photo:



Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Regional Road 25
Northing:	4819686.65 N
Easting:	588809.27 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-08
Weather:	25°C, Sunny
Structure ID:	71

Structure Type:	Elliptical Pipe
# of Spans:	1
Span or Diameter (m):	3.9
Rise (m):	2.69
Length (m):	12.3

Material:	Corrugated Steel
Open Footing:	No
Skew Angle:	60
Sediment Depth (mm):	0
Barrier:	0.81m Jersey Barrier

US Invert Elevation (m):	203.32
DS Invert Elevation (m):	Refer to sheet 71DS

US Obvert Elevation (m):	205.98
DS Obvert Elevation (m):	Refer to sheet 71DS

Inlet/Outlet Type:	Gabion and Steel Headwall
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	206.2
Water Depth (mm):	160

Additional Notes:	CSP has upheaval with punctures throughout length, approximately 0.5m at highest point. CSP changes to concrete box culvert after 12.3m *Refer to sheet 71 DS for outlet.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Regional Road 25
Northing:	4819686.65 N
Easting:	588809.27 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-08
Weather:	25°C, Sunny
Structure ID:	71

Structure Type:	Box Culvert
# of Spans:	1
Span or Diameter (m):	DS to US 3.89, 4.27, 4.29
Rise (m):	2.339
Length (m):	60.2

Material:	Concrete
Open Footing:	No
Skew Angle:	60
Sediment Depth (mm):	Varies, 0 US to 180 DS
Barrier:	0.66m Guardrail

US Invert Elevation (m):	Refer to sheet 71
DS Invert Elevation (m):	202.283

US Obvert Elevation (m):	Refer to sheet 71
DS Obvert Elevation (m):	204.622

Inlet/Outlet Type:	Curved Retaining Walls
High Water Mark Depth (m):	0.9
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	206.2
Water Depth (mm):	100

Additional Notes:	3 sections total, 2 most upstream sections hug the bend and have different dimensions.
	*Refer to sheet 71 for inlet.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Rail Crossing
Northing:	4819538.97 N
Easting:	589157.16 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-08
Weather:	25°C, Sunny
Structure ID:	72

Structure Type:	Circular Pipe
# of Spans:	1
Span or Diameter (m):	2.7
Rise (m):	2.7
Length (m):	42.6

Material:	Corrugated Steel
Open Footing:	No
Skew Angle:	20
Sediment Depth (mm):	0
Barrier:	None

US Invert Elevation (m):	200.92
DS Invert Elevation (m):	200.89

US Obvert Elevation (m):	203.62
DS Obvert Elevation (m):	203.59

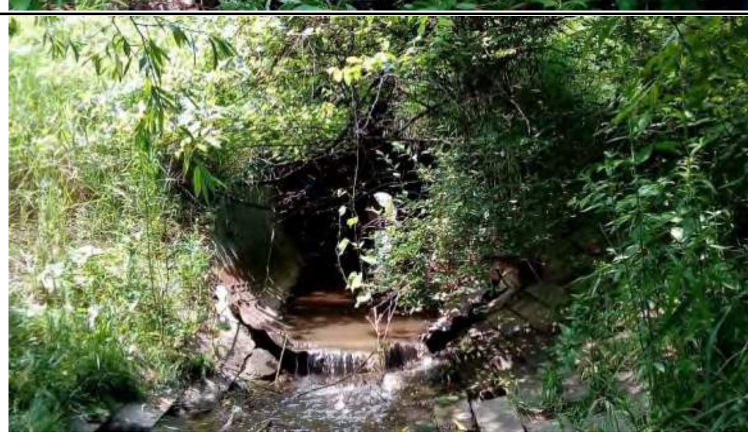
Inlet/Outlet Type:	Mitered to slope
High Water Mark Depth (m):	0.4 approx
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	210.0
Water Depth (mm):	200

Additional Notes:	Trapezoidal concrete lining upstream of channel.
	Concrete blocks lining downstream channel.
	Corrosion causing multiple holes within pipe bottom 5m into pipe from upstream end.
	Upstream end of CSP is caved in, covering about one quarter of opening.
	Densely vegetated upstream and downstream.

Upstream Photo:

Downstream Photo:



Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Steeles Avenue East
Northing:	4819541.47 N
Easting:	589545.99 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-08
Weather:	25°C, Sunny
Structure ID:	73

Structure Type:	Box Culvert
# of Spans:	1
Span or Diameter (m):	4.1
Rise (m):	3.2
Length (m):	23.1

Material:	Concrete
Open Footing:	Yes
Skew Angle:	35
Sediment Depth (mm):	N/A
Barrier:	1.16m Parapet Wall and Rail

US Invert Elevation (m):	198.40
DS Invert Elevation (m):	198.29

US Obvert Elevation (m):	201.04
DS Obvert Elevation (m):	201.10

Inlet/Outlet Type:	Headwalls
High Water Mark Depth (m):	0.6
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	201.5
Water Depth (mm):	630

Additional Notes:	US channel has concrete block lining, transitioning to sediment/open bottom within culvert bed.
	Gabion retaining wall at upstream end on one side, flush with end of headwall.
	Storm outlet partway through culvert.
	Storm outlet pipe (dia 0.835m) with metal grate and concrete structure on DS side.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Hwy. 401
Northing:	4819887.47 N
Easting:	588167.14 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-18
Weather:	22°C, Cloudy
Structure ID:	74

Structure Type:	Box Culvert
# of Spans:	1
Span or Diameter (m):	1.5
Rise (m):	1.2
Length (m):	77.7

Material:	Concrete
Open Footing:	Unsure
Skew Angle:	20
Sediment Depth (mm):	N/A
Barrier:	None

US Invert Elevation (m):	205.37
DS Invert Elevation (m):	205.32

US Obvert Elevation (m):	206.57
DS Obvert Elevation (m):	206.17

Inlet/Outlet Type:	Projecting from slope
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	207.1
Water Depth (mm):	600

Additional Notes:	Very dense vegetation at upstream end.
	Culvert at near capacity during normal flows.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Regional Road 25
Northing:	4819395.81 N
Easting:	589292.92 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-10
Weather:	25°C, Sunny
Structure ID:	75

Structure Type:	Box Culvert
# of Spans:	1
Span or Diameter (m):	1.9
Rise (m):	1.18
Length (m):	56.8

Material:	Concrete
Open Footing:	No
Skew Angle:	0
Sediment Depth (mm):	Varies, 0 US to 140 DS
Barrier:	None

US Invert Elevation (m):	201.73
DS Invert Elevation (m):	201.58

US Obvert Elevation (m):	203.01
DS Obvert Elevation (m):	202.81

Inlet/Outlet Type:	Projecting from slope
High Water Mark Depth (m):	0.4
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	205.3
Water Depth (mm):	60

Additional Notes:	Dense vegetation in channel both upstream and downstream.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Chris Hadfield Way
Northing:	4819292.37 N
Easting:	589207.48 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-10
Weather:	25°C, Sunny
Structure ID:	76

Structure Type:	Circular Pipe
# of Spans:	1
Span or Diameter (m):	1.0
Rise (m):	1.039
Length (m):	26.1

Material:	Corrugated Steel
Open Footing:	No
Skew Angle:	35
Sediment Depth (mm):	200
Barrier:	None

US Invert Elevation (m):	202.82
DS Invert Elevation (m):	202.60

US Obvert Elevation (m):	203.85
DS Obvert Elevation (m):	203.65

Inlet/Outlet Type:	Projecting from slope
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	204.1
Water Depth (mm):	380

Additional Notes:	There is a bend somewhere within the pipe. Could not access.
	DS end is perpendicular to road. US end has about 30 degree skew due to bend.
	Rip rap placed around both inlet and outlet on slope.

Upstream Photo:	
Downstream Photo:	

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Rail Crossing
Northing:	4819210.5 N
Easting:	588931.1 E

Inspected By:	Paul Greck, Brian Greck
Date:	2019-11-26
Weather:	5°C, Clear
Structure ID:	77

Structure Type:	Circular Pipe
# of Spans:	1
Span or Diameter (m):	1.5
Rise (m):	1.2
Length (m):	~41

Material:	Corrugated Steel
Open Footing:	No
Skew Angle:	0
Sediment Depth (mm):	0.4
Barrier:	No

US Invert Elevation (m):	203.98
DS Invert Elevation (m):	Not Found

US Obvert Elevation (m):	205.21
DS Obvert Elevation (m):	Not Found

Inlet/Outlet Type:	Projected
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	206.9
Water Depth (mm):	0.1m

Additional Notes:	Down stream CSP outlet buried in rubble and brush. Dense vegetation at upsteam end.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Rail Crossing
Northing:	4819220.5 N
Easting:	588888.3 E

Inspected By:	Paul Greck, Brian Greck
Date:	2019-11-26
Weather:	5°C, Clear
Structure ID:	78

Structure Type:	Circular Pipe
# of Spans:	1
Span or Diameter (m):	1.8
Rise (m):	1.5
Length (m):	27.6

Material:	Corrugated Steel
Open Footing:	No
Skew Angle:	25
Sediment Depth (mm):	0.2
Barrier:	No

US Invert Elevation (m):	204.26
DS Invert Elevation (m):	204.28

US Obvert Elevation (m):	205.74
DS Obvert Elevation (m):	205.50

Inlet/Outlet Type:	Projected
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	212.2
Water Depth (mm):	5

Additional Notes:	

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Market Drive
Northing:	4819116.54 N
Easting:	588442.46 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-10
Weather:	25°C, Sunny
Structure ID:	79

Structure Type:	Circular Pipe
# of Spans:	1
Span or Diameter (m):	0.7
Rise (m):	0.71
Length (m):	29.0

Material:	Corrugated Steel
Open Footing:	No
Skew Angle:	0
Sediment Depth (mm):	Varies, 10 at US to 460 at DS
Barrier:	None

US Invert Elevation (m):	205.79
DS Invert Elevation (m):	205.58

US Obvert Elevation (m):	206.67
DS Obvert Elevation (m):	206.30

Inlet/Outlet Type:	Mitered to slope
High Water Mark Depth (m):	Not Observed
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	206.8
Water Depth (mm):	280

Additional Notes:	Extremely dense vegetation at inlet and outlets. Unable to get photo at downstream outlet, mostly submerged.

Upstream Photo:

Downstream Photo:

Stream Crossing Field Inventory Sheet

Sixteen Mile Creek

Location:	Peru Road
Northing:	4818840.98 N
Easting:	587681.57 E

Inspected By:	Paul Greck, Abby Wright
Date:	2019-07-31
Weather:	23°C, Sunny
Structure ID:	Extra

Structure Type:	Box Culvert
# of Spans:	1
Span or Diameter (m):	2.4
Rise (m):	1.596
Length (m):	8.4

Material:	Concrete
Open Footing:	No
Skew Angle:	0
Sediment Depth (mm):	70
Barrier:	None

US Invert Elevation (m):	203.53
DS Invert Elevation (m):	203.529

US Obvert Elevation (m):	204.987
DS Obvert Elevation (m):	204.971

Inlet/Outlet Type:	Headwall
High Water Mark Depth (m):	0.75
Piers:	No
Pier Width:	N/A

Low Point in Deck Elevation (m):	205.2
Water Depth (mm):	180

Additional Notes:	Upstream, a tributary seems to have a triangular weir made of plywood. Not measured.

Upstream Photo:

Downstream Photo:

APPENDIX C: LIDAR TOPOGRAPHIC SURVEY INFO AND VERTICAL ACCURACY ASSESSMENT

Vertical Accuracy Assessment

Point #	Top	Lidar	Delta	Note
57	224.11	224.14	-0.03	Open Field in Hydro corridor
58	224.29	224.37	-0.08	
59	224.48	224.5	-0.02	
60	224.37	224.35	0.02	
61	224.21	224.23	-0.02	
2507	232.6	232.6	0.00	
2509	229.65	229.7	-0.05	
2515	225.75	225.69	0.06	
2522	226.46	226.49	-0.03	
2526	225.66	225.72	-0.06	
2562	193.17	193.11	0.06	Brian Best Park
2551	192.87	192.85	0.02	
2552	192.84	192.82	0.02	
2553	192.56	192.59	-0.03	
2554	191.52	191.51	0.01	
2555	192.11	192.09	0.02	
2559	193	192.86	0.14	
2558	192.94	192.87	0.07	
2557	192.39	192.33	0.06	
2556	192.55	192.47	0.08	
2000	221.77	221.82	-0.05	Floodplain / wetland near Campbellsville Road and Dublin Line
2001	221.15	220.96	0.19	
1999	221.11	221.3	-0.19	
1985	219.67	220.1	-0.43	
1989	219.67	220.01	-0.34	
1986	220.2	219.89	0.31	
1988	220.35	219.95	0.4	
1987	220.06	219.89	0.17	
390	189.16	189.13	0.03	Floodplain near Kingsway Place
389	191.63	191.68	-0.05	
388	191.89	191.95	-0.06	
386	192.02	191.9	0.12	
385	188.53	188.6	-0.07	
384	188.93	188.97	-0.04	
367	190.56	190.57	-0.01	
366	190.81	190.75	0.06	
365	190.52	190.46	0.06	
360	189.15	189.09	0.06	
100	208.76	208.74	0.02	MH on Chishold Drive
98	209.38	209.39	-0.01	MH on Chishold Drive
95	213.254	213.22	0.034	Mh on Jame Snow Parkway & Chudleigh way
63	208.67	208.64	0.03	MH on Harrop Drive
62	208.93	208.89	0.04	MH on Harrop Drive
624	198	197.97	0.03	Asphalt Parking Lot at WI Dick Middle School
623	197.91	197.93	-0.02	Asphalt Parking Lot at WI Dick Middle School
622	197.91	197.86	0.05	Asphalt Parking Lot at WI Dick Middle School
1771	212.61	212.63	-0.02	Gravel Driveway at highpoint Drive & 25
1770	212.34	212.32	0.02	Gravel Driveway at highpoint Drive & 25

	Standard Dev	n	Mean	Alpha	Confidence
Hydro corridor / Agricultural	0.04040077	10	-0.02	0.05	0.03
Park	0.047199341	10	0.04	0.05	0.03
Floodplain	0.202568475	18	0.01	0.05	0.09
Impervious	0.025228731	10	0.02	0.05	0.02

Conservation Halton 2018 Lidar

Survey Control and Accuracy Report

Prepared for:

Conservation Halton
2596 Britannia Road
Burlington, Ontario, L7P 0G3

Prepared by:

Airborne Imaging
2700 – 61 Avenue SE
Calgary, AB T2C 4V2

August 2018

Survey Control

Existing control used

During the Lidar survey, two Cannet stations were used to position the aircraft.
See below for the NRCan Station Reports.

Station Report - CGLP

Station 1 of 1

Site Identification					
Name	Province	NTS map sheet	Unique Number	Provincial Identifier	Network
cannet-GLP2	Ontario	040P09	CGLP		CANNET

Station Coordinates			
Coordinates	Geoid	Reference Frame	Epoch
geo	CGG2013a	NAD83(CSRS)	2010

Latitude	Longitude	h (metres)
N43° 32' 28.509451" ± 0.0000m	W80° 18' 21.646094" ± 0.0000m	315.118 ± 0.0000m
Vφ (mm/y)	Vλ (mm/y)	Vh (mm/y)
-1.38 ± 0.00	1.37 ± 0.00	-0.90 ± 0.00
N (metres)	H (metres)	Published date and project ID
-35.411 ± 0.009	350.529	2015-09-24 M15-703

Vertical Data

Use the value of H from the coordinates above.

Station Marker				
Marker Type	Inspected in	Established by	Status	Comments
Unknown		Cansel (cannet)		None

Station Report - CBUL

Station 1 of 1

Site Identification					
Name	Province	NTS map sheet	Unique Number	Provincial Identifier	Network
cannet-BURL	Ontario	030M05	CBUL		CANNET

Station Coordinates			
Coordinates	Geoid	Reference Frame	Epoch
geo	CGG2013a	NAD83(CSRS)	2010

Latitude	Longitude	h (metres)
N43° 21' 40.235947" ± 0.0000m	W79° 47' 28.507483" ± 0.0000m	87.886 ± 0.0000m
Vφ (mm/y)	Vλ (mm/y)	Vh (mm/y)
-1.30 ± 0.00	1.52 ± 0.00	-1.13 ± 0.00
N (metres)	H (metres)	Published date and project ID
-35.856 ± 0.009	123.742	2015-09-24 M15-703

Vertical Data

Use the value of H from the coordinates above.

Station Marker				
Marker Type	Inspected in	Established by	Status	Comments
Unknown		Cansel (cannet)		None

Accuracy Report

Vertical Accuracy Assessment

Kinematic

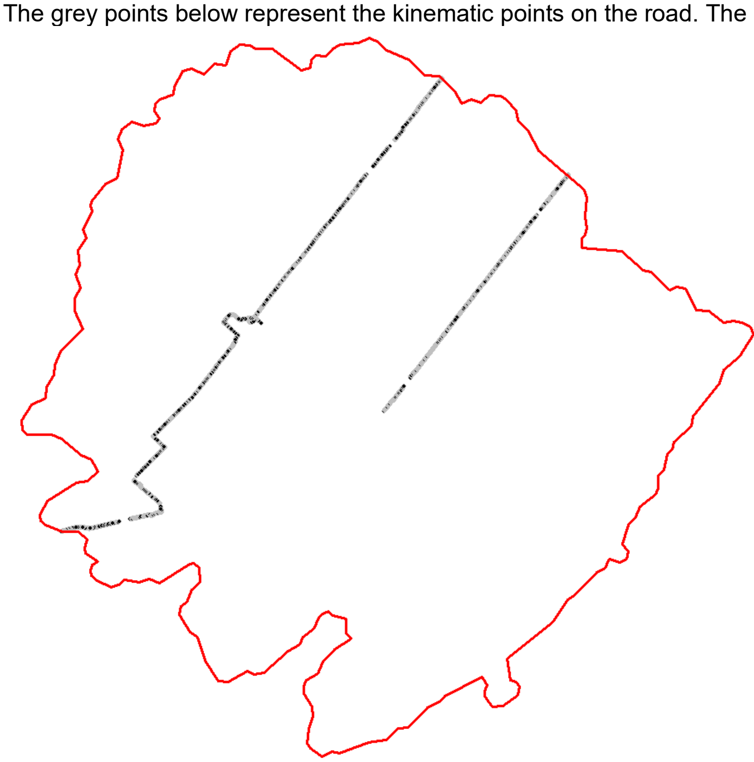
Vertical differences between kinematic surveyed points on roads versus Lidar elevations of the ground surface

Nad83 CSRS UTM zone 17, CGVD2013, meters

Statistics:

Number of kinematic points	13471	
Average dz	-0.001	m
Minimum dz	-0.121	m
Maximum dz	0.154	m
Average magnitude	0.028	m
Std deviation	0.034	m
Root mean square	0.034	m
Vertical Accuracy (2σ or 95%)	**0.066**	**m**

The grey points below represent the kinematic points on the road. The red boundary is the project area.



LiDAR Project Summary

Airborne Imaging

2700 - 61 Avenue SE
Calgary, Alberta, Canada
T2C 4V2

Telephone: (403) 215 2960
Fax: (403) 258 3189
www.airborneimaginginc.com

Project Information

Project Name:	Halton 2018
Project Number:	14790
Client:	Conservation Halton 2018

Project Type:	Wide Area
Project Location:	Milton, Ontario, Canada
Project Size:	1,062.9 sq km

Acquisition Projects

Project Name	Project Number	Vintage
Halton 2018	1675	May 2018

Acquisition Parameters

Date (MM/DD/YY)	Mission	Flying Height (m)	Flying Speed (knots)	Pulse Rate Rep (kHz)	Scan Freq (Hz)	Scan Angle (degree)	Side Lap %	Point Density (pts/m²)	LiDAR System
03/19/18	0718078a	1100	160	440	52.1	50	50	10.4	Leica ALS70
04/24/18	0718114a	1100	160	440	52.1	50	50	10.4	Leica ALS70
04/29/18	0718119a	1100	160	440	52.1	50	50	10.4	Leica ALS70
05/09/18	0718129a	1100	160	440	52.1	50	50	10.4	Leica ALS70
Multiple Return Capabilities:			YES		Number of returns recorded:				Maximum 4

Geodetic Control

Horizontal Datum:	Nad83 CSRS	Vertical Datum:	CGVD2013
Geoid Model:	CGG2013	UTM Zone:	17

Note: We established a local geodetic network fixed to the following control:

Station ID	Lat	Long	Ellp Height
GLP2	43 32 28.50977	-80 18 21.64656	315.149m
653196	43 35 30.99772	-79 36 11.54776	92.610m

Calibration Methodology

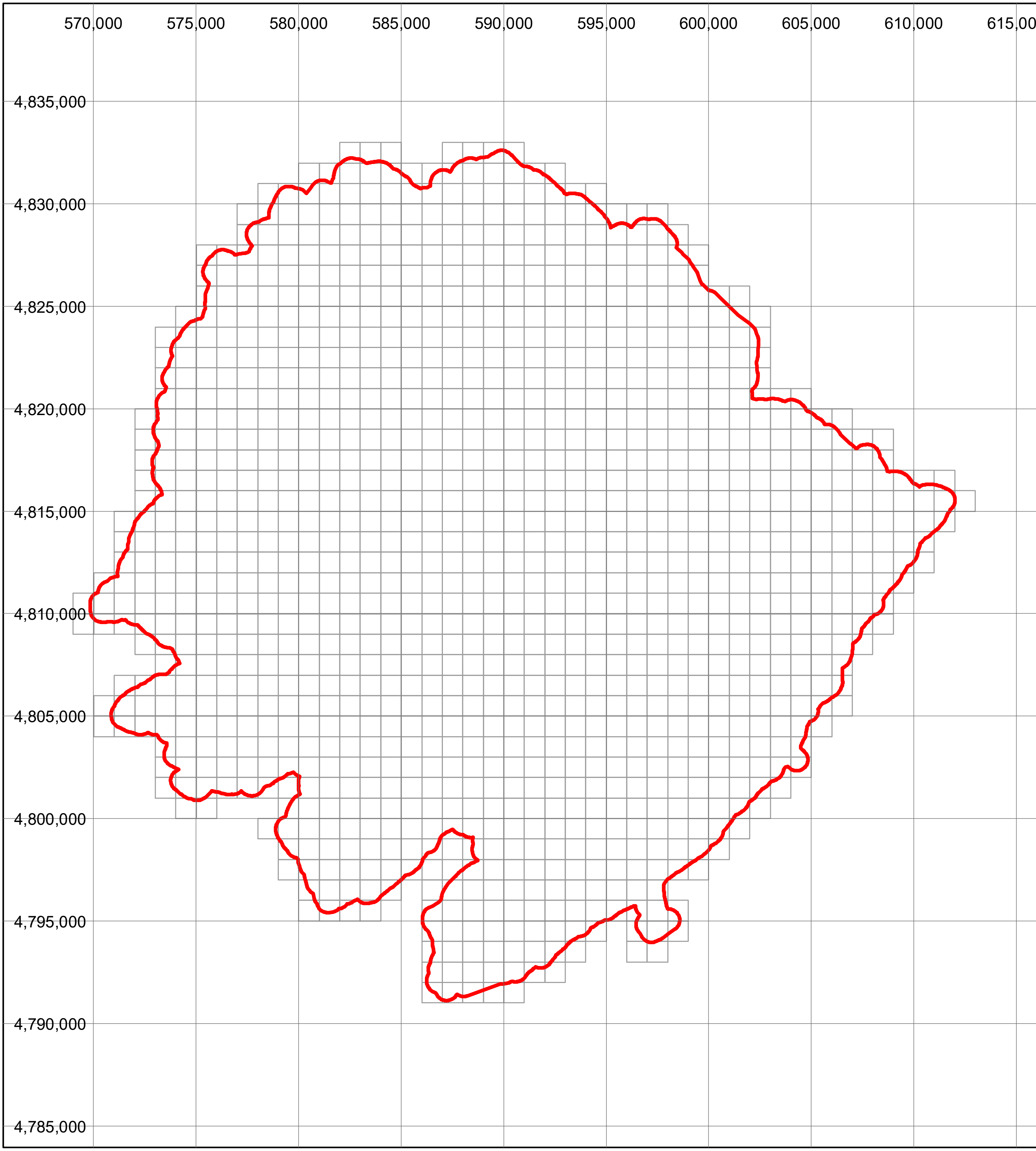
Airborne Imaging performs a complete calibration on every LiDAR acquisition flight, data is acquired over a calibration site flown with at least two passes in opposite directions before and after the flight. Any error in the attitude of the aircraft (roll, pitch and heading) can be observed and corrected for within system specifications. To statistically quantify the accuracy, we compare the LiDAR elevations with independently surveyed ground points. A GPS mounted truck collects data while driving on an open road. The kinematic positions on the road are post-processed from a nearby base station (common to the aerial survey)

Accuracy

Horizontal Accuracy, 95% or 2σ:	30 cm
Fundamental Vertical Accuracy (on flat hard surfaces), 95% or 2σ:	10 cm

Deliverables
1m Grids (ARCINFO Binary), Bare Earth and Full Feature
Hillshade Images (Geotiffs), Bare Earth and Full Feature
1m & 50cm Contours (SHP)
Point Cloud (LAS v1.2, ASPRS Classes)

Projected in UTM 17 NAD 83 CSRS   Summary Produced: August 2, 2018



14790 - Halton 2018 - Conservation Halton

The Red outline represents the extent of the data delivered.
The data is divided into 1km x 1km tiles following the
UTM Grid System, rounded to the nearest 500m with zeros cut-off.
Tiles are displayed by the bottom left corner of their
UTM coordinates as Easting_Northing.
Example 6460_53970 for 646,000m E, 5,397,000m N.

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A Clean Harbors Company

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    b. graphic files derived from the point data, showing the area in a shaded form, in a digital format

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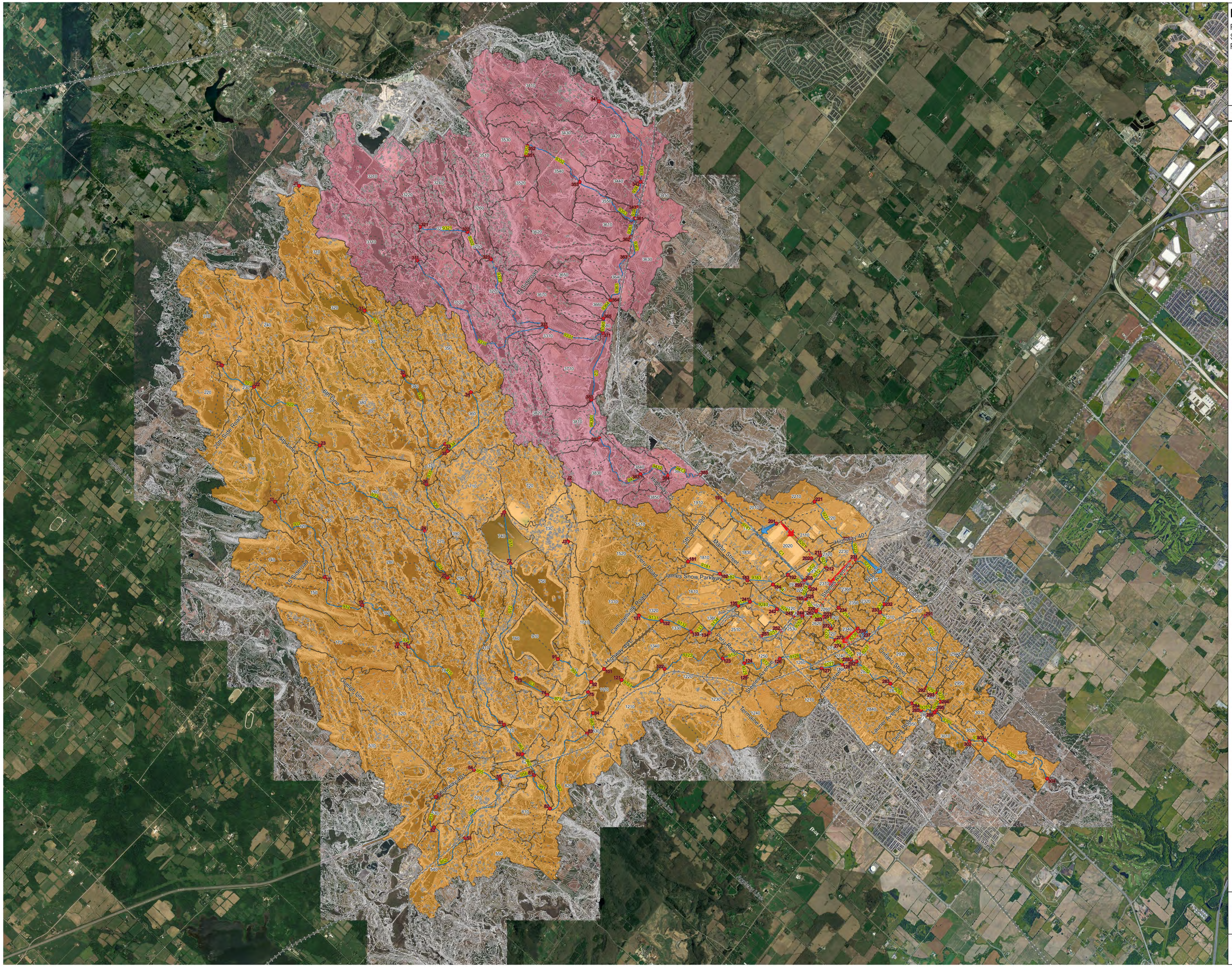
APPENDIX D: OVERALL CATCHMENT MAPPING



Hydrologic Model Layout

Flood Hazard Mapping - Urban Milton
Sixteen Mile Creek
Project No.19-609

0 1,000 2,000 m

NAD 1983 UTM Zone 17N

Legend

- Inter-Watershed Spill
- Railway Lines
- Node ID — Flow Nodes
- Catchment ID — West Branch Catchment Boundary
- Catchment ID — Middle Branch Catchment Boundary
- Routing ID — RoutePipe
- Routing ID — RouteChannel
- Elevation (m) — 1m Contours
- Major Flow Diversion
- Minor Flow Diversion
- Catchment Length

Greck

January 2020

Basemap Image via Airborne Imaging & Google Maps 2019.

Catchments delineated via PCSWMM by Greck and Associates Limited, January 2020

APPENDIX E: HYDORLOGIC MODELLING INPUTS

Verus SWMF
Peddie SWMF
Manheim Snoek SWMF
Lowes SWMF
James Snow Parkway
5th Sideroad
James Snow Parkway
Highway 401
Martin Street
Steeles Avenue
ow Parkway

Proposed Storm Sewer and Ponding Area Reconstruction
Peddie Road
Milton, Ontario

STORMWATER MANAGEMENT REPORT

Prepared for:

Kylin Developments Inc.

Prepared by:

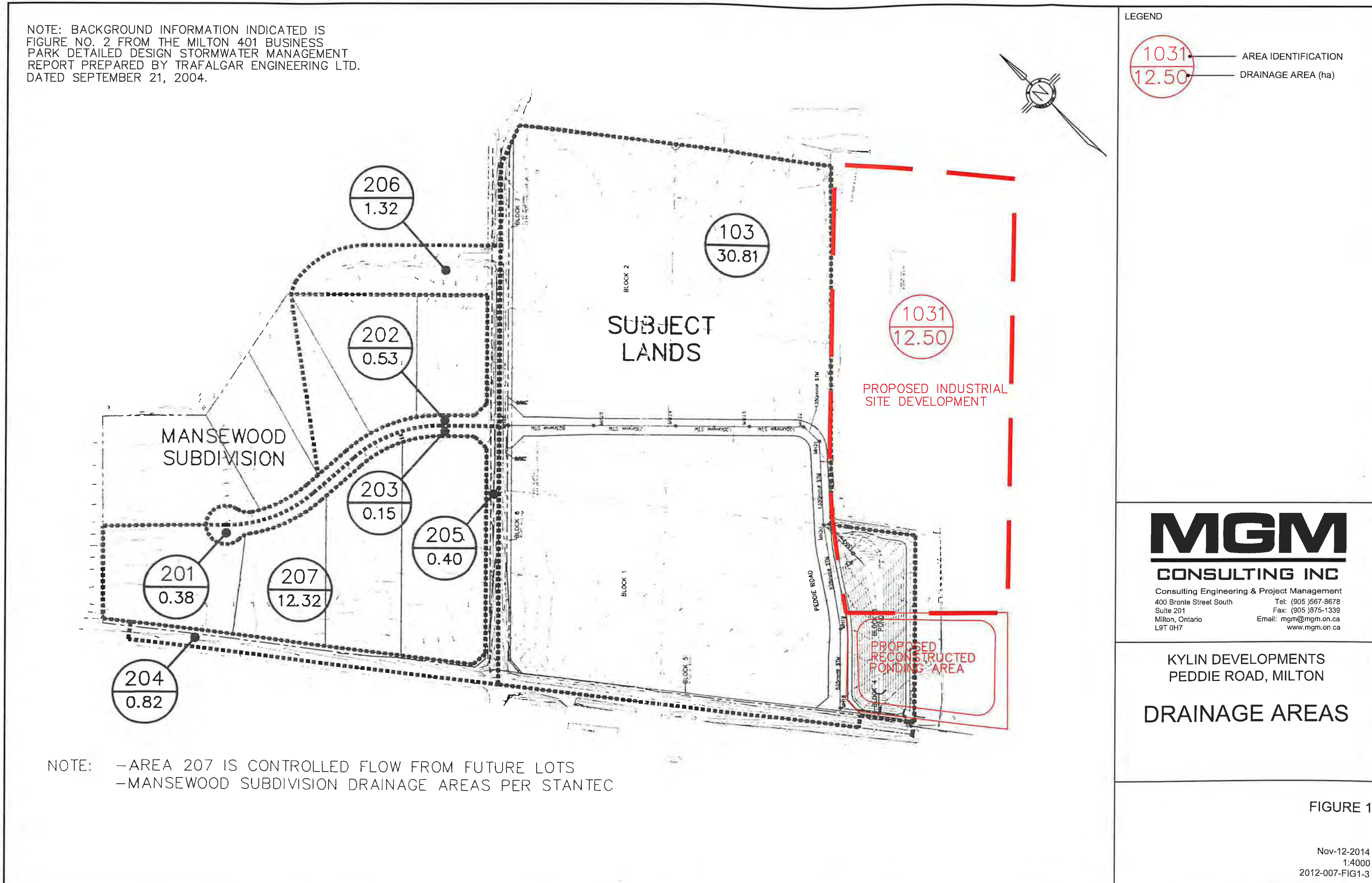
MGM Consulting Inc.
400 Bronte Street South
Suite 201
Milton, Ontario
L9T 0H7

File No. 2012-007

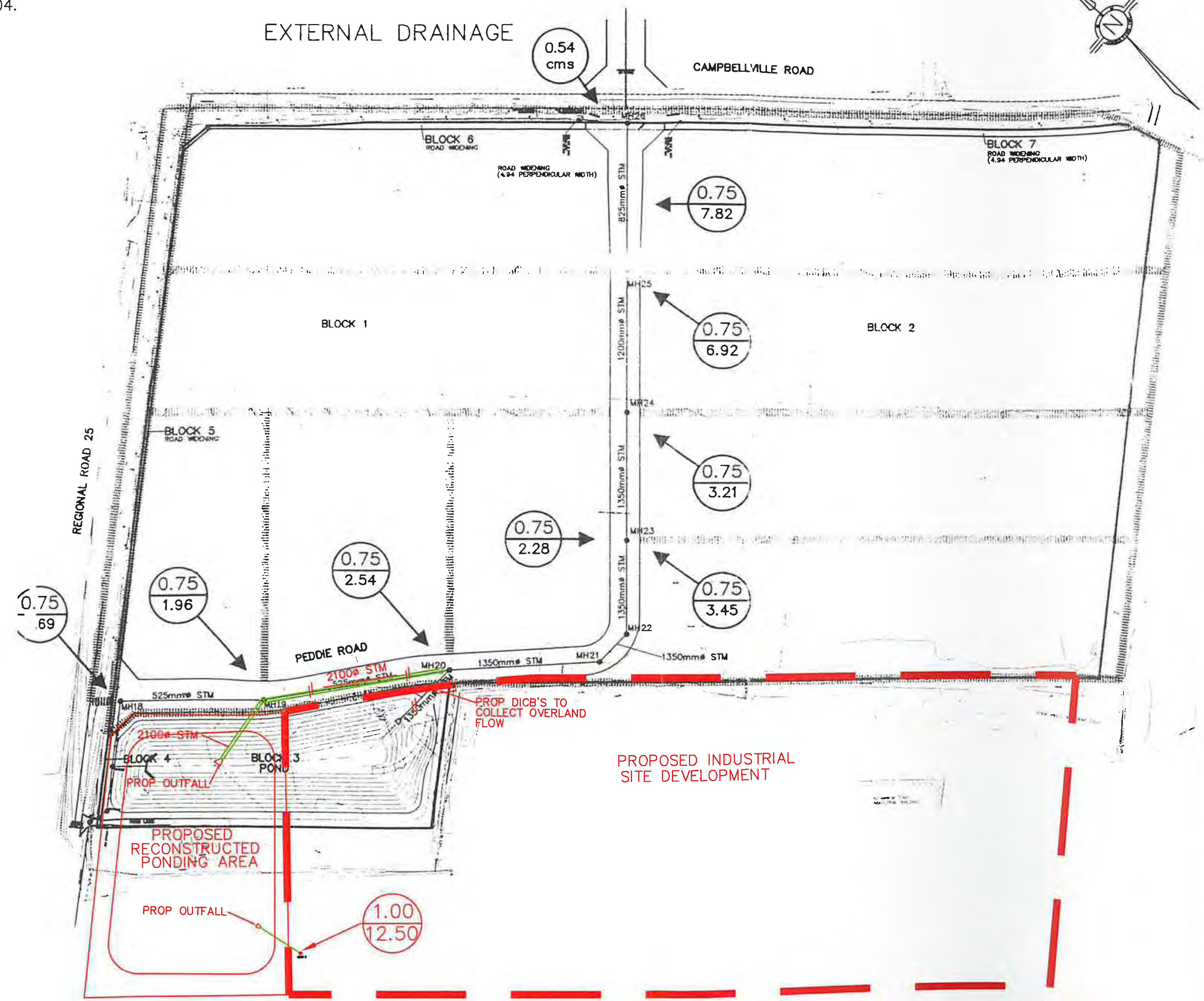
Rev April 27, 2015

Sp 26/14

2994
Peddie Rd


NOTE: BACKGROUND INFORMATION INDICATED IS FIGURE NO. 2 FROM THE MILTON 401 BUSINESS PARK DETAILED DESIGN STORMWATER MANAGEMENT REPORT PREPARED BY TRAFALGAR ENGINEERING LTD. DATED SEPTEMBER 21, 2004.
206 1.32
202 0.53
203 0.15
205 0.40
201 0.38
207 12.32
204 0.82
103 30.81
SUBJECT LANDS
MANSEWOOD SUBDIVISION
1031 12.50
PROPOSED INDUSTRIAL SITE DEVELOPMENT
PROPOSED RECONSTRUCTED PONDING AREA
PEDDIE ROAD
BLOCK 1
BLOCK 2
NOTE: -AREA 207 IS CONTROLLED FLOW FROM FUTURE LOTS
-MANSEWOOD SUBDIVISION DRAINAGE AREAS PER STANTEC
LEGEND
1031 AREA IDENTIFICATION
12.50 DRAINAGE AREA (ha)
MGM CONSULTING INC
Consulting Engineering & Project Management
400 Bronte Street South
Suite 201
Milton, Ontario
L9T 0H7
Tel: (905)567-8678
Fax: (905)875-1339
Email: mgm@mgm.on.ca
www.mgm.on.ca
KYLIN DEVELOPMENTS
PEDDIE ROAD, MILTON
DRAINAGE AREAS
FIGURE 1
Nov-12-2014
1:4000
2012-007-FIG1-3

NOTE: BACKGROUND INFORMATION INDICATED IS FIGURE NO. 3 FROM THE MILTON 401 BUSINESS PARK DETAILED DESIGN STORMWATER MANAGEMENT REPORT PREPARED BY TRAFALGAR ENGINEERING LTD. DATED SEPTEMBER 21, 2004.



LEGEND

0.75 — RUN-OFF CO-EFFICIENT

12.50 — DRAINAGE AREA (ha)

MGM

CONSULTING INC

Consulting Engineering & Project Management

400 Bronte Street South
Suite 201
Milton, Ontario
L9T 0H7

Tel: (905)567-8678
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KYLIN DEVELOPMENTS
PEDDIE ROAD, MILTON

SEWER DRAINAGE AREAS

FIGURE 2

Nov-12-2014
1:3000
2012-007-FIG1-3

Proposed Condition

Event	Total Pond Inflow (cms)	Pond WSEL (m)	Pond Storage (cu.m.)	Peak Outflow (cms)	HGL (m)
5 year 12 hr SCS	7.68	216.90	15,711	0.42	216.74
100 year 12 hr SCS	15.87	218.55	37,776	0.45	218.37

A summary of the existing and proposed pond storage requirements are as follows:

Elevation (m)	**Pond Depth (m)**	**Existing Pond Area (sq.m.)**	**Proposed Pond Area (sq.m.)**
214.50	0.00	5	5
215.00	0.50	2,253	4,199
215.50	1.00	3,423	6,126
216.00	1.50	4,650	7,977
216.50	2.00	5,918	9,713
217.00	2.50	7,017	10,997
217.50	3.00	8,624	12,876
218.00	3.50	10,081	14,304
218.50	4.00	11,605	15,606
219.00	4.50	13,322	16,927
219.50	5.00	15,017	17,967

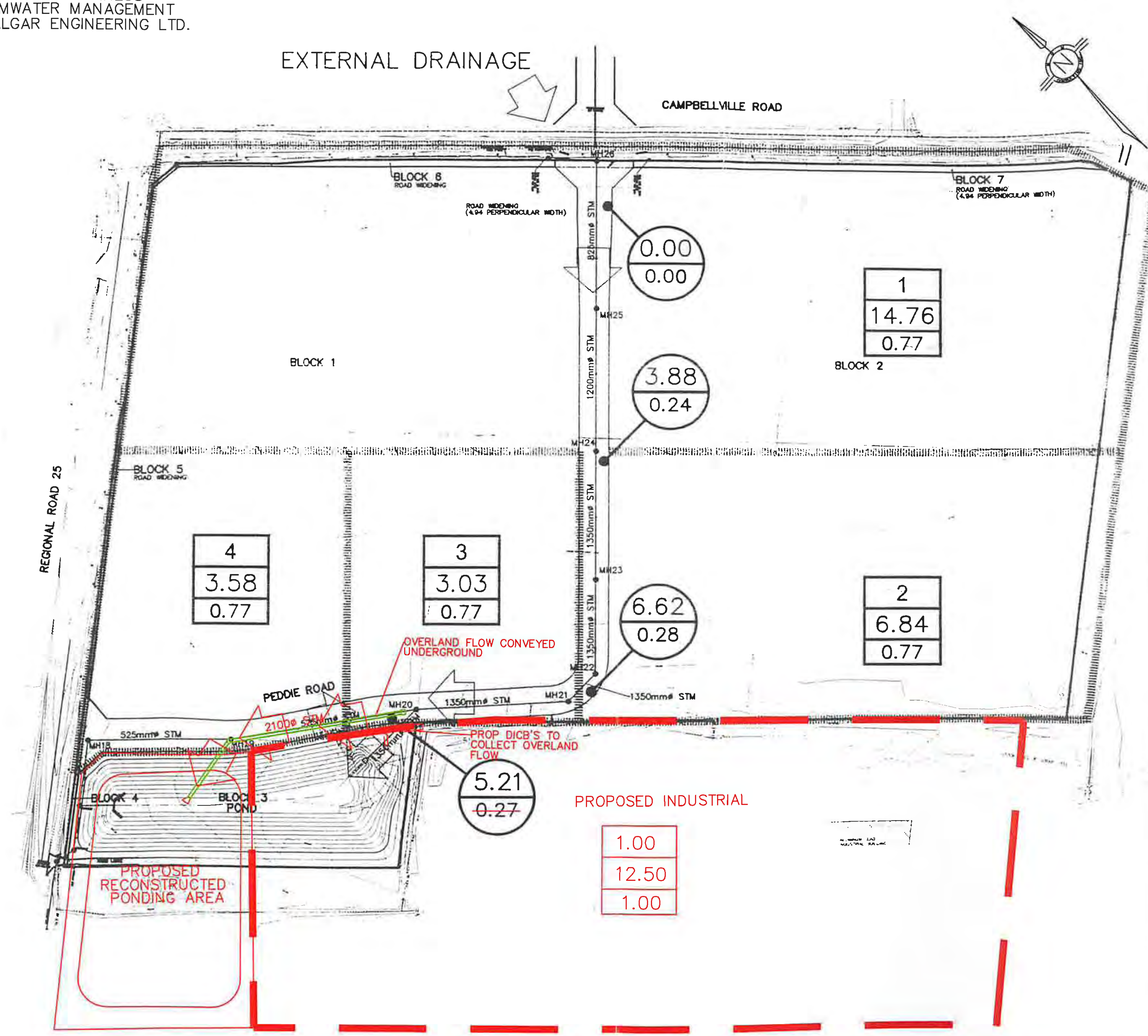
6.0 POND EXPANSION AND LAND REQUIREMENTS

The proposed pond re-orientation and private site development require lands previously in private ownership to be transferred to public ownership, and lands previously in public ownership, to be transferred to private ownership. At the time of the preparation of this report, the required land exchange between the Town and private developer, has proceeded as required. Lands exchanged between the Town and Kylin Developments Inc. is indicated in Figure No. 4.

7.0 CONSTRUCTION PHASING

Given that the proposed works will impact existing Town drainage infrastructure including existing storm sewers and the pond area, detailed construction phasing will be required in order to ensure that the stormwater management system remains functional at all times. Proposed construction phasing is indicated on Sheet 4 of 5. The proposed construction phasing provides for the construction of the required reconstruction of the SWM ponding area, and storm sewers

NOTE: BACKGROUND INFORMATION INDICATED IS FIGURE NO. 4 FROM THE MILTON 401 BUSINESS PARK DETAILED DESIGN STORMWATER MANAGEMENT REPORT PREPARED BY TRAFALGAR ENGINEERING LTD. DATED SEPTEMBER 21, 2004.



LEGEND

- 0.58 — OVERLAND FLOW (cms)
- 0.28 — DEPTH OF FLOW (m)
- 1.00 — OTTHYMO DRAINAGE AREA
- 12.50 — DRAINAGE AREA (ha)
- 0.75 — IMPERVIOUSNESS

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KYLIN DEVELOPMENTS
PEDDIE ROAD, MILTON

OVERLAND FLOW PATH

FIGURE 3

Nov-12-2014
1:3000
2012-007-FIG1-3

VALDOR ENGINEERING INC.
Project: Co-Steel Facility
File: 12128
Date: April 2015

Table 2: Existing and Proposed Pond Storage Requirements

Elevation (m)	Pond Depth (m)	[1]Existing Pond Area (m^2)	[2]Proposed Pond Area (m^2)
214.50	0.00	5	5
215.00	0.50	2,253	4,199
215.50	1.00	3,423	6,126
216.00	1.50	4,650	7,977
216.50	2.00	5,918	9,713
217.00	2.50	7,017	10,997
217.50	3.00	8,624	12,876
218.00	3.50	10,081	14,304
218.50	4.00	11,605	15,606
219.00	4.50	13,322	16,927
219.50	5.00	15,017	17,967

Notes:
1 -- Existing pond storage curve determined from modeling completed by Trafalgar Engineering (2004), with a correction to the area at depth 2.50 m as discussed in the footnotes of Table 1.
2 -- Proposed Pond 99 expansion is estimated to require a widening of approx. 10 m down to the bottom of the pond on the northeast and southeast sides of the existing pond.

Valdor Engineering Inc.
File: 12128
Date: April 17, 2015

VO2 Output: Regional Storm (Hurricane Hazel)

```
=================================================================================================
==========

     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: Valdor Engineering
      OOO     T      T    H   H    Y    M   M   OOO                  VO2-0156
```

Developed and Distributed by Greenland International Consulting Inc.


```
                    *****  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: S:\Projects\2012\12128\CO-STE~1\HYDROT~1\CO-STE~1\3-CO-S~1\Proposed Co-Steel
Site - Hazel Storm.out
  Summary filename: S:\Projects\2012\12128\CO-STE~1\HYDROT~1\CO-STE~1\3-CO-S~1\Proposed Co-Steel
Site - Hazel Storm.sum

DATE: 4/17/2015                                   TIME: 4:04:10 PM

USER:


COMMENTS: ____________________________________________________

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


 --------------------
 |   READ STORM      |     Filename: S:\Projects\2012\12128\Co-Steel S
 |                   |               ite - Milton\Hydrotechnical\
 |                   |               Co-Steel VO2 Model\3 - Co-Steel Site - Milton
 | Ptotal=212.00 mm  |     Comments: * Regional Storm - 12 Hour HAZEL - Based
 --------------------
                     TIME    RAIN |  TIME    RAIN |  TIME    RAIN |  TIME    RAIN
                      hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr |   hrs   mm/hr
                     1.00    6.00 |  4.00   13.00 |  7.00   23.00 | 10.00   53.00
                     2.00    4.00 |  5.00   17.00 |  8.00   13.00 | 11.00   38.00
                     3.00    6.00 |  6.00   13.00 |  9.00   13.00 | 12.00   13.00

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

 --------------------
 | CALIB              |
 | STANDHYD   (1031)  |    Area      (ha)=  12.50
 |ID= 1 DT= 5.0 min   |    Total Imp(%)=  99.00    Dir. Conn.(%)=  99.00
 --------------------
                                 IMPERVIOUS      PERVIOUS (i)
     Surface Area      (ha)=        12.38            .12
     Dep. Storage      (mm)=          .80           1.50
     Average Slope      (%)=          .70            .70
     Length             (m)=       288.70          40.00
     Mannings n           =          .013           .250

          NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.
```

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
.083	6.00	3.083	13.00	6.083	23.00	9.08	53.00
.167	6.00	3.167	13.00	6.167	23.00	9.17	53.00
.250	6.00	3.250	13.00	6.250	23.00	9.25	53.00
.333	6.00	3.333	13.00	6.333	23.00	9.33	53.00
.417	6.00	3.417	13.00	6.417	23.00	9.42	53.00
.500	6.00	3.500	13.00	6.500	23.00	9.50	53.00
.583	6.00	3.583	13.00	6.583	23.00	9.58	53.00
.667	6.00	3.667	13.00	6.667	23.00	9.67	53.00
.750	6.00	3.750	13.00	6.750	23.00	9.75	53.00
.833	6.00	3.833	13.00	6.833	23.00	9.83	53.00
.917	6.00	3.917	13.00	6.917	23.00	9.92	53.00
1.000	6.00	4.000	13.00	7.000	23.00	10.00	53.00
1.083	4.00	4.083	17.00	7.083	13.00	10.08	38.00
1.167	4.00	4.167	17.00	7.167	13.00	10.17	38.00
1.250	4.00	4.250	17.00	7.250	13.00	10.25	38.00
1.333	4.00	4.333	17.00	7.333	13.00	10.33	38.00
1.417	4.00	4.417	17.00	7.417	13.00	10.42	38.00
1.500	4.00	4.500	17.00	7.500	13.00	10.50	38.00
1.583	4.00	4.583	17.00	7.583	13.00	10.58	38.00
1.667	4.00	4.667	17.00	7.667	13.00	10.67	38.00
1.750	4.00	4.750	17.00	7.750	13.00	10.75	38.00
1.833	4.00	4.833	17.00	7.833	13.00	10.83	38.00
1.917	4.00	4.917	17.00	7.917	13.00	10.92	38.00
2.000	4.00	5.000	17.00	8.000	13.00	11.00	38.00
2.083	6.00	5.083	13.00	8.083	13.00	11.08	13.00
2.167	6.00	5.167	13.00	8.167	13.00	11.17	13.00
2.250	6.00	5.250	13.00	8.250	13.00	11.25	13.00
2.333	6.00	5.333	13.00	8.333	13.00	11.33	13.00
2.417	6.00	5.417	13.00	8.417	13.00	11.42	13.00
2.500	6.00	5.500	13.00	8.500	13.00	11.50	13.00
2.583	6.00	5.583	13.00	8.583	13.00	11.58	13.00
2.667	6.00	5.667	13.00	8.667	13.00	11.67	13.00
2.750	6.00	5.750	13.00	8.750	13.00	11.75	13.00
2.833	6.00	5.833	13.00	8.833	13.00	11.83	13.00
2.917	6.00	5.917	13.00	8.917	13.00	11.92	13.00
3.000	6.00	6.000	13.00	9.000	13.00	12.00	13.00

```
Max.Eff.Inten.(mm/hr)=      53.00          2708.37
           over (min)        5.00            10.00
Storage Coeff.  (min)=       6.92 (ii)        8.91 (ii)
Unit Hyd. Tpeak (min)=       5.00            10.00
Unit Hyd. peak  (cms)=        .17              .12
                                                           *TOTALS*
PEAK FLOW       (cms)=       1.82              .02           1.839 (iii)
TIME TO PEAK    (hrs)=      10.00            10.00          10.00
RUNOFF VOLUME    (mm)=     211.20           183.18         210.92
TOTAL RAINFALL   (mm)=     212.00           212.00         212.00
RUNOFF COEFFICIENT   =       1.00              .86            .99

   (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
         CN* =  89.0     Ia = Dep. Storage  (Above)
  (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
       THAN THE STORAGE COEFFICIENT.
 (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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

 --------------------
| CALIB               |
| STANDHYD   (0103)   |   Area      (ha)=   30.81
|ID= 1 DT= 5.0 min    |   Total Imp(%)=   77.00    Dir. Conn.(%)=   77.00
 --------------------
                            IMPERVIOUS      PERVIOUS (i)
 Surface Area     (ha)=       23.72            7.09
 Dep. Storage     (mm)=         .80            1.50
 Average Slope     (%)=        1.00            1.00
 Length            (m)=      453.21           40.00
 Mannings n           =        .013            .250

 Max.Eff.Inten.(mm/hr)=       53.00           51.46
            over (min)        10.00           20.00
 Storage Coeff.  (min)=        8.15 (ii)      19.49 (ii)
 Unit Hyd. Tpeak (min)=       10.00           20.00
 Unit Hyd. peak  (cms)=         .13             .06
                                                           *TOTALS*
 PEAK FLOW       (cms)=        3.49             .95          4.440 (iii)
 TIME TO PEAK    (hrs)=       10.00           10.08         10.00
 RUNOFF VOLUME    (mm)=      211.20          183.18        204.76
```

TOTAL RAINFALL (mm)=	212.00	212.00	212.00
RUNOFF COEFFICIENT =	1.00	.86	.97

(i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
CN* = 89.0 Ia = Dep. Storage (Above)
(ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL THAN THE STORAGE COEFFICIENT.
(iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

| CALIB
| STANDHYD (0206) |
|ID= 1 DT= 4.0 min |

Area (ha)= 1.32
Total Imp(%)= 25.00 Dir. Conn.(%)= 1.00

		IMPERVIOUS	PERVIOUS (i)
Surface Area	(ha)=	.33	.99
Dep. Storage	(mm)=	1.50	5.00
Average Slope	(%)=	2.00	4.00
Length	(m)=	4.50	4.00
Mannings n	=	.013	.035

NOTE: RAINFALL WAS TRANSFORMED TO 4.0 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
.067	6.00	3.067	13.00	6.067	23.00	9.07	53.00
.133	6.00	3.133	13.00	6.133	23.00	9.13	53.00
.200	6.00	3.200	13.00	6.200	23.00	9.20	53.00
.267	6.00	3.267	13.00	6.267	23.00	9.27	53.00
.333	6.00	3.333	13.00	6.333	23.00	9.33	53.00
.400	6.00	3.400	13.00	6.400	23.00	9.40	53.00
.467	6.00	3.467	13.00	6.467	23.00	9.47	53.00
.533	6.00	3.533	13.00	6.533	23.00	9.53	53.00
.600	6.00	3.600	13.00	6.600	23.00	9.60	53.00
.667	6.00	3.667	13.00	6.667	23.00	9.67	53.00
.733	6.00	3.733	13.00	6.733	23.00	9.73	53.00
.800	6.00	3.800	13.00	6.800	23.00	9.80	53.00
.867	6.00	3.867	13.00	6.867	23.00	9.87	53.00
.933	6.00	3.933	13.00	6.933	23.00	9.93	53.00
1.000	6.00	4.000	13.00	7.000	23.00	10.00	53.00
1.067	4.00	4.067	17.00	7.067	13.00	10.07	38.00
1.133	4.00	4.133	17.00	7.133	13.00	10.13	38.00
1.200	4.00	4.200	17.00	7.200	13.00	10.20	38.00
1.267	4.00	4.267	17.00	7.267	13.00	10.27	38.00
1.333	4.00	4.333	17.00	7.333	13.00	10.33	38.00
1.400	4.00	4.400	17.00	7.400	13.00	10.40	38.00
1.467	4.00	4.467	17.00	7.467	13.00	10.47	38.00
1.533	4.00	4.533	17.00	7.533	13.00	10.53	38.00
1.600	4.00	4.600	17.00	7.600	13.00	10.60	38.00
1.667	4.00	4.667	17.00	7.667	13.00	10.67	38.00
1.733	4.00	4.733	17.00	7.733	13.00	10.73	38.00
1.800	4.00	4.800	17.00	7.800	13.00	10.80	38.00
1.867	4.00	4.867	17.00	7.867	13.00	10.87	38.00
1.933	4.00	4.933	17.00	7.933	13.00	10.93	38.00
2.000	4.00	5.000	17.00	8.000	13.00	11.00	38.00
2.067	6.00	5.067	13.00	8.067	13.00	11.07	13.00
2.133	6.00	5.133	13.00	8.133	13.00	11.13	13.00
2.200	6.00	5.200	13.00	8.200	13.00	11.20	13.00
2.267	6.00	5.267	13.00	8.267	13.00	11.27	13.00
2.333	6.00	5.333	13.00	8.333	13.00	11.33	13.00
2.400	6.00	5.400	13.00	8.400	13.00	11.40	13.00
2.467	6.00	5.467	13.00	8.467	13.00	11.47	13.00
2.533	6.00	5.533	13.00	8.533	13.00	11.53	13.00
2.600	6.00	5.600	13.00	8.600	13.00	11.60	13.00
2.667	6.00	5.667	13.00	8.667	13.00	11.67	13.00
2.733	6.00	5.733	13.00	8.733	13.00	11.73	13.00
2.800	6.00	5.800	13.00	8.800	13.00	11.80	13.00
2.867	6.00	5.867	13.00	8.867	13.00	11.87	13.00
2.933	6.00	5.933	13.00	8.933	13.00	11.93	13.00
3.000	6.00	6.000	13.00	9.000	13.00	12.00	13.00

Max.Eff.Inten.(mm/hr)=	53.00	67.91
over (min)	5.00	4.00
Storage Coeff. (min)=	.42 (ii)	3.62 (ii)
Unit Hyd. Tpeak (min)=	4.00	4.00
Unit Hyd. peak (cms)=	.42	.28

TOTALS

```
PEAK FLOW          (cms)=       .00          .19           .189 (iii)
TIME TO PEAK       (hrs)=      9.13        10.00          10.00
RUNOFF VOLUME       (mm)=    210.50       180.98         181.28
TOTAL RAINFALL      (mm)=    212.00       212.00         212.00
RUNOFF COEFFICIENT     =        .99          .85            .86

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!
***** WARNING:FOR AREAS WITH IMPERVIOUS RATIOS BELOW 20%
              YOU SHOULD CONSIDER SPLITTING THE AREA.

     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
         CN*  =  86.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
         THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
---------------------
| ROUTE CHN (0015) |
| IN= 2---> OUT= 1 |     Routing time step (min)'=  2.00
---------------------
                <------ DATA FOR SECTION (    7.0) ------>
                Distance       Elevation       Manning
                   .00            .25           .0350      Main Channel
                  3.00            .00           .0350      Main Channel
                  6.00            .25           .0350      Main Channel

      <-------------------- TRAVEL TIME TABLE ---------------------->
      DEPTH     ELEV      VOLUME     FLOW RATE    VELOCITY    TRAV.TIME
       (m)       (m)     (cu.m.)       (cms)       (m/s)        (min)
       .01       .01    .384E+00        .0          .15         20.18
       .03       .03    .154E+01        .0          .24         12.71
       .04       .04    .346E+01        .0          .32          9.70
       .05       .05    .615E+01        .0          .38          8.01
       .07       .07    .961E+01        .0          .45          6.90
       .08       .08    .138E+02        .0          .50          6.11
       .09       .09    .188E+02        .1          .56          5.52
       .11       .11    .246E+02        .1          .61          5.05
       .12       .12    .311E+02        .1          .66          4.66
       .13       .13    .384E+02        .1          .71          4.35
       .14       .14    .465E+02        .2          .76          4.08
       .16       .16    .553E+02        .2          .80          3.85
       .17       .17    .650E+02        .3          .84          3.65
       .18       .18    .753E+02        .4          .89          3.47
       .20       .20    .865E+02        .4          .93          3.32
       .21       .21    .984E+02        .5          .97          3.18
       .22       .22    .111E+03        .6         1.01          3.05
       .24       .24    .125E+03        .7         1.05          2.94
       .25       .25    .139E+03        .8         1.09          2.83

                                    <---- hydrograph ---->    <-pipe / channel->
                           AREA     QPEAK    TPEAK    R.V.    MAX DEPTH  MAX VEL
                           (ha)     (cms)    (hrs)    (mm)       (m)      (m/s)
   INFLOW : ID= 2 (0206)   1.32      .19     10.00  181.28       .14       .75
   OUTFLOW: ID= 1 (0015)   1.32      .19     10.00  181.20       .14       .75

-------------------------------------------------------------------------------
----------------------
| CALIB              |
| STANDHYD  (0207)   |   Area    (ha)=  12.32
|ID= 1 DT= 4.0 min   |   Total Imp(%)=  60.00    Dir. Conn.(%)=  60.00
----------------------
                                 IMPERVIOUS     PERVIOUS (i)
    Surface Area        (ha)=        7.39          4.93
    Dep. Storage        (mm)=         .80          1.50
    Average Slope        (%)=        1.00          1.00
    Length               (m)=      286.59         40.00
    Mannings n              =        .013          .250

    Max.Eff.Inten.(mm/hr)=          53.00         50.63
             over (min)              8.00         20.00
    Storage Coeff.  (min)=           6.19 (ii)    17.60 (ii)
    Unit Hyd. Tpeak (min)=           8.00         20.00
    Unit Hyd. peak  (cms)=            .16           .06
                                                              *TOTALS*
    PEAK FLOW       (cms)=           1.09           .66         1.744 (iii)
    TIME TO PEAK    (hrs)=          10.00         10.07         10.00
    RUNOFF VOLUME    (mm)=         211.20        175.94        197.10
    TOTAL RAINFALL   (mm)=         212.00        212.00        212.00
    RUNOFF COEFFICIENT    =          1.00           .83           .93
```

```
     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
          CN* =  86.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
          THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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

----------------------
| RESERVOIR (0104)   |
| IN= 2---> OUT= 1   |
| DT=  4.0 min       |    OUTFLOW     STORAGE   |  OUTFLOW     STORAGE
----------------------     (cms)      (ha.m.)   |   (cms)      (ha.m.)
                           .0000       .0000    |  1.0850       .4400
                           .4170       .2200    |   .0000       .0000

                                 AREA       QPEAK       TPEAK        R.V.
                                 (ha)       (cms)       (hrs)        (mm)
    INFLOW : ID= 2 (0207)       12.32        1.74       10.00      197.10
    OUTFLOW: ID= 1 (0104)       12.32        1.30       10.87      197.08

                 PEAK   FLOW   REDUCTION [Qout/Qin](%)= 74.46
                 TIME SHIFT OF PEAK FLOW         (min)= 52.00
                 MAXIMUM  STORAGE  USED        (ha.m.)=  .5105

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

----------------------
| CALIB              |
| STANDHYD  (0202)   |    Area     (ha)=     .53
|ID= 1 DT= 4.0 min   |    Total Imp(%)=   35.00    Dir. Conn.(%)=    1.00
----------------------
                            IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=       .19          .35
    Dep. Storage     (mm)=      1.50         5.00
    Average Slope     (%)=      2.00         4.00
    Length            (m)=      4.50         4.00
    Mannings n           =      .013         .035

    Max.Eff.Inten.(mm/hr)=     53.00        78.88
              over (min)        5.00         4.00
    Storage Coeff.  (min)=       .42 (ii)     3.45 (ii)
    Unit Hyd. Tpeak (min)=      4.00         4.00
    Unit Hyd. peak  (cms)=       .42          .29
                                                          *TOTALS*
    PEAK FLOW       (cms)=       .00          .08           .077 (iii)
    TIME TO PEAK    (hrs)=      9.13        10.00          10.00
    RUNOFF VOLUME    (mm)=    210.50       184.69         184.95
    TOTAL RAINFALL   (mm)=    212.00       212.00         212.00
    RUNOFF COEFFICIENT   =       .99          .87            .87

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!
***** WARNING:FOR AREAS WITH IMPERVIOUS RATIOS BELOW 20%
              YOU SHOULD CONSIDER SPLITTING THE AREA.

     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
          CN* =  86.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
          THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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

----------------------
| ROUTE CHN (2031)   |
| IN= 2---> OUT= 1   |     Routing time step (min)'=  2.00
----------------------
            <------ DATA FOR SECTION (   2.0) ------>
            Distance      Elevation       Manning
                .00          1.16          .0350        Main Channel
               2.90           .00          .0350        Main Channel
               3.64           .00          .0350        Main Channel
               6.25           .95          .0350        Main Channel
               8.75          1.08          .0350        Main Channel

  <-------------------- TRAVEL TIME TABLE --------------------->
  DEPTH      ELEV       VOLUME     FLOW RATE    VELOCITY    TRAV.TIME
   (m)        (m)      (cu.m.)       (cms)        (m/s)       (min)
   .06        .06     .884E+01        .0           .53         5.49
   .11        .11     .207E+02        .1           .79         3.72
   .17        .17     .354E+02        .2           .98         2.98
   .23        .23     .532E+02        .3          1.14         2.55
```

.28	.28	.739E+02	.5	1.29	2.26
.34	.34	.976E+02	.8	1.43	2.04
.40	.40	.124E+03	1.1	1.55	1.88
.45	.45	.154E+03	1.5	1.67	1.74
.51	.51	.186E+03	1.9	1.79	1.63
.57	.57	.222E+03	2.4	1.90	1.53
.63	.63	.260E+03	3.0	2.01	1.45
.68	.68	.302E+03	3.6	2.11	1.38
.74	.74	.346E+03	4.4	2.21	1.32
.80	.80	.394E+03	5.2	2.31	1.26
.85	.85	.444E+03	6.1	2.40	1.21
.91	.91	.498E+03	7.1	2.50	1.17
.97	.97	.554E+03	8.0	2.52	1.16
1.02	1.02	.621E+03	8.6	2.41	1.21
1.08	1.08	.700E+03	9.5	2.37	1.23

		<---- hydrograph ---->			<-pipe / channel->	
	AREA (ha)	QPEAK (cms)	TPEAK (hrs)	R.V. (mm)	MAX DEPTH (m)	MAX VEL (m/s)
INFLOW : ID= 2 (0202)	.53	.08	10.00	184.95	.10	.70
OUTFLOW: ID= 1 (2031)	.53	.08	10.00	184.90	.10	.70

| CALIB
| STANDHYD (0201) |
|ID= 1 DT= 4.0 min |

Area (ha)= .38
Total Imp(%)= 35.00 Dir. Conn.(%)= 1.00

	IMPERVIOUS	PERVIOUS (i)	
Surface Area (ha)=	.13	.25	
Dep. Storage (mm)=	1.50	5.00	
Average Slope (%)=	2.00	4.00	
Length (m)=	4.50	4.00	
Mannings n =	.013	.035	
Max.Eff.Inten.(mm/hr)=	53.00	78.88	
over (min)	5.00	4.00	
Storage Coeff. (min)=	.42 (ii)	3.45 (ii)	
Unit Hyd. Tpeak (min)=	4.00	4.00	
Unit Hyd. peak (cms)=	.42	.29	
			TOTALS
PEAK FLOW (cms)=	.00	.05	.055 (iii)
TIME TO PEAK (hrs)=	9.13	10.00	10.00
RUNOFF VOLUME (mm)=	210.50	184.69	184.95
TOTAL RAINFALL (mm)=	212.00	212.00	212.00
RUNOFF COEFFICIENT =	.99	.87	.87

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!
***** WARNING: FOR AREAS WITH IMPERVIOUS RATIOS BELOW 20%
YOU SHOULD CONSIDER SPLITTING THE AREA.

(i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
CN* = 86.0 Ia = Dep. Storage (Above)
(ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
THAN THE STORAGE COEFFICIENT.
(iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

| ROUTE CHN (0001) |
| IN= 2---> OUT= 1 |

Routing time step (min)'= 2.00

<------ DATA FOR SECTION (1.0) ------>

Distance	Elevation	Manning	
.00	101.16	.0350	Main Channel
2.90	100.00	.0350	Main Channel
3.64	100.00	.0350	Main Channel
6.25	100.95	.0350	Main Channel
8.75	101.08	.0350	Main Channel

<-------------------- TRAVEL TIME TABLE ---------------------->

DEPTH (m)	ELEV (m)	VOLUME (cu.m.)	FLOW RATE (cms)	VELOCITY (m/s)	TRAV.TIME (min)
.06	100.06	.657E+01	.0	.53	4.08
.11	100.11	.153E+02	.1	.79	2.76
.17	100.17	.263E+02	.2	.98	2.21
.23	100.23	.395E+02	.3	1.14	1.89
.28	100.28	.549E+02	.5	1.29	1.68
.34	100.34	.725E+02	.8	1.43	1.52
.40	100.40	.923E+02	1.1	1.55	1.39

SERNAS ASSOCIATES
A Member of The Sernas Group Inc.

STORMWATER MANAGEMENT REPORT

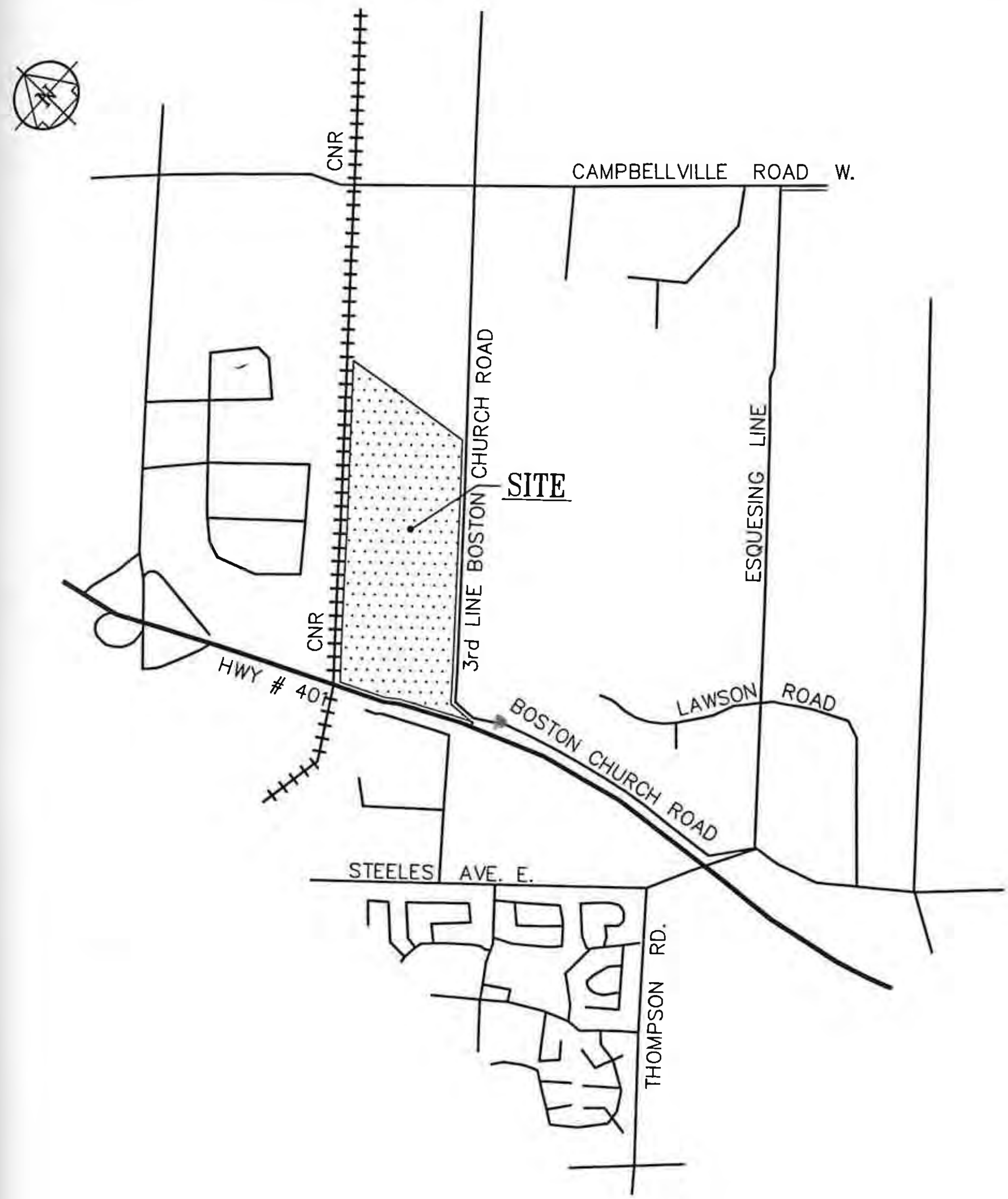
Land Development Engineering
Land Development Planning
Municipal Engineering Services
Transportation & Transit Planning
Utility Infrastructure Design
Water Resources Engineering

ARG MILTON INDUSTRIAL PARK
BOSTON CHURCH ROAD & 401
TOWN OF MILTON

PREPARED FOR:

ARG GROUP INC.

October, 2003
Revised: February, 2005
03211



KEY PLAN

N.T.S.

COMMENTS :

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ARG MILTON INDUSTRIAL

LOCATION PLAN

PROJECT No.

DRAWING No.

3.2 QUANTITY CONTROL

3.2.1 QUANTITY POND CALCULATIONS

The proposed stormwater management facility will also provide storage for detention of the lower frequency quantity events. The SWMHYMO hydrologic model was used to calculate the runoff hydrographs that will contribute to the facility. Table 3.2 shows the release rates and storage volumes for the 1:2-year to 1:100-year storms. Outlet control is achieved through the use of two control structures. Both the structures are outlet control manholes with water being supplied by reverse slope pipes. The first structure is located at the southwest end of the facility and controls flows to culvert 7, through a 450mm diameter orifice at an elevation of 210.6m. The second structure is located at the southeast end of the facility and controls flows to culvert 6, through a 290mm diameter orifice at an elevation of 209.5m and a 850mm wide by 600mm high rectangular orifice at an elevation of 210.6m. For schematics of the outlet structures see details on the Outlet Details drawings SWM-2, SWM-3 and SWM-4. The 750mm diameter outlet pipe from the west structure will outlet to culvert 7. Similarly the 1200mm diameter outlet pipe from the east structure will outlet to culvert 6 from UEL drawings.

TABLE 3.2: POST-DEVELOPMENT RELEASE RATES AND STORAGE VOLUMES

EVENT STORM	INFLOW (m^3/s)	FSEMS TARGET FLOWS FOR CULVERT 6 (cms)	DISCHARGE TO CULVERT 6 (cms)	FSEMS TARGET FLOWS FOR CULVERT 7 (cms)	DISCHARGE TO CULVERT 7 (cms)	TOTAL DISCHARGE (m^3/s)	STORAGE (m^3)	ELEVATION (m)
2 year	4.05	0.51	0.17	0.16	0.08	0.25	16,690	210.60
5 year	6.62	0.89	0.55	0.27	0.20	0.75	23,950	211.00
10 year	8.33	1.15	0.94	0.35	0.29	1.23	28,410	211.20
25 year	10.23	1.34	1.33	0.38	0.36	1.69	34,330	211.50
50 year	11.75	1.73	1.52	0.52	0.40	1.92	39,630	211.70
100 year	13.28	1.97	1.71	0.60	0.45	2.16	44,880	212.00
Regional Storm	13.86	10.73	10.5	3.69	3.40	13.9	52,220	212.30

The MTO has a 14m setback requirement from the present Highway 401 property limit. Our original report and SWM facility design contemplated grading within this 14m setback. At the request of the MTO, we now start our grading at the limit of the 14m setback.

5.0 CONCLUSIONS AND RECOMMENDATIONS

- The stormwater quality control criteria from the Ministry of Transportation, Halton Conservation and the Town of Milton can be achieved for the proposed Development Lands.

- The stormwater quantity control criteria outlined by the Functional Stormwater and Environmental Strategy Report and Conservation Authority can be achieved for the proposed Development Lands.

- An end-of-pipe wet pond type stormwater management facility will be constructed. The proposed stormwater management facility will:

  - Provide sufficient permanent pool volume for Level 1 quality control
  - Provide adequate extended detention time for the 25mm storm event and unit rates set out in the FSEMS
  - Provide flow control to meet the attenuated flow targets

- Controlled roof releases will be ensured with the use of reduced ground pipes sized to accommodate a roof release of 42 l/s/ha.

- Controlled site releases will be ensured with the use of site connections sized to accommodate a site release of 150 l/s/ha.

- Overflow from the development area will be directed to both culverts 6 and 7 under Highway 401.

- To ensure flow to Culvert 7 during frequent storm events, a release rate of 80 l/s will be directed to Culvert 7 up to the 2 year storm.

- As required by the Ministry of Transportation, a 14m buffer has been created between the stormwater management facility and the highway right-of-way and this buffer will be left in its present state.

- All flows north of the site will be piped to the stormwater management facility.

Respectfully submitted,

SERNAS ASSOCIATES

Douglas Emerson, B.Sc.
Water Resources Analyst

REGISTERED PROFESSIONAL ENGINEER
K. CHOW
PROVINCE OF ONTARIO

Ken Chow, P. Eng.
Principal, Manager, Water Resources

FIGURE 2.1 - EXISTING STORM DRAINAGE AREAS

CONTROL STRUCTURE CALCULATIONS

03211.400 Sernas Associates
DATE: June 9, 2003
FILE: 03211Pond-01.XLS
PRINTED: February 11, 2005

FLOW OVER WEIR: C_w= 1.8308

$Q_w=C_w*(H_w)^{1.5}*((L-0.2*H_w)+(0.8*TAN(THETA)*H_w))$

INVERT OF WEIR 1	212.00 m	THETA	1.2490 radians
WEIR 1 HEIGHT	0.3 m		71.565 degrees
WEIR 1 WIDTH of base	30 m		3 :1 Slope
INVERT OF WEIR 2	212.00 m	THETA	1.2490 radians
WEIR 1 HEIGHT	2 m		71.565 degrees
WEIR 1 WIDTH of base	10 m		3 :1 Slope

FLOW THROUGH ORIFICE

$Q_o=C_d*A_o*(2*g*H_o)^{0.5}$ C_d= 0.62

INVERT OF ORIFICE 1	209.50 m	WIDTH	m
		DIAMETER/HEIGHT	0.290 m
INVERT OF ORIFICE 2	210.60 m	WIDTH	0.850 m
		DIAMETER/HEIGHT	0.600 m
INVERT OF ORIFICE 3	210.60 m	WIDTH	m
		DIAMETER/HEIGHT	0.400 m

ELEVATION (m)	WEIR 1 FLOW (cms)	WIDTH (L) (m)	H (m)	WEIR 2 FLOW (cms)	WIDTH (L) (m)	H (m)	ORIFICE 1 FLOW (cms)	HEIGHT (m)	X-SECT AREA (m²)	Ho (m)	ORIFICE 2 FLOW (cms)	HEIGHT (m)	X-SECT AREA (m²)	Ho (m)	ORIFICE 3 FLOW (cms)	HEIGHT (m)	X-SECT AREA (m²)	Ho (m)	HICKENBOTTOM RISER ORIFICE HEAD (m)	HICKENBOTTOM RISER FLOW Cd = 0.0000 (cms)	TOTAL FLOW (cms)	CUMULATIVE POND VOLUME (m³)
209.50	0.000			0.000			0.0000	0.00		0.00	0.0000			0.00	0.0000			0.00	0.00	0.00000	0.000	-
209.60	0.000			0.000			0.0102	0.10	0.0167	0.05	0.0000			0.00	0.0000			0.00	0.00	0.00000	0.010	1,418
209.70	0.000			0.000			0.0395	0.20	0.0455	0.10	0.0000			0.00	0.0000			0.00	0.00	0.00000	0.039	2,871
209.80	0.000			0.000			0.0701	0.29	0.0648	0.16	0.0000			0.00	0.0000			0.00	0.00	0.00000	0.070	4,360
209.90	0.000			0.000			0.0899	0.29	0.0648	0.26	0.0000			0.00	0.0000			0.00	0.00	0.00000	0.090	5,884
210.00	0.000			0.000			0.1061	0.29	0.0648	0.36	0.0000			0.00	0.0000			0.00	0.00	0.00000	0.106	7,444
210.10	0.000			0.000			0.1201	0.29	0.0648	0.45	0.0000			0.00	0.0000			0.00	0.00	0.00000	0.120	9,040
210.20	0.000			0.000			0.1326	0.29	0.0648	0.55	0.0000			0.00	0.0000			0.00	0.00	0.00000	0.133	10,670
210.30	0.000			0.000			0.1441	0.29	0.0648	0.66	0.0000			0.00	0.0000			0.00	0.00	0.00000	0.144	12,337
210.40	0.000			0.000			0.1547	0.29	0.0648	0.76	0.0000			0.00	0.0000			0.00	0.00	0.00000	0.155	14,039
210.50	0.000			0.000			0.1646	0.29	0.0648	0.86	0.0000			0.00	0.0000			0.00	0.00	0.00000	0.165	15,776
210.60	0.000			0.000			0.1739	0.29	0.0648	0.95	0.0000	0.00		0.00	0.0000	0.00		0.00	0.00	0.00000	0.174	17,547
210.70	0.000			0.000			0.1828	0.29	0.0648	1.05	0.0522	0.10	0.0850	0.05	0.0110	0.10	0.0179	0.05	0.00	0.00000	0.246	19,351
210.75	0.000			0.000			0.1871	0.29	0.0648	1.11	0.0959	0.15	0.1275	0.08	0.0295	0.15	0.0392	0.08	0.00	0.00000	0.312	20,265
210.80	0.000			0.000			0.1913	0.29	0.0648	1.16	0.1476	0.20	0.1700	0.10	0.0546	0.20	0.0628	0.10	0.00	0.00000	0.394	21,187
210.90	0.000			0.000			0.1994	0.29	0.0648	1.26	0.2712	0.30	0.2550	0.15	0.1075	0.30	0.1011	0.15	0.00	0.00000	0.578	23,055
211.00	0.000			0.000			0.2072	0.29	0.0648	1.36	0.4176	0.40	0.3400	0.20	0.1514	0.40	0.1233	0.20	0.00	0.00000	0.776	24,955
211.10	0.000			0.000			0.2147	0.29	0.0648	1.45	0.5836	0.50	0.4250	0.25	0.1855	0.40	0.1233	0.30	0.00	0.00000	0.984	26,888
211.20	0.000			0.000			0.2220	0.29	0.0648	1.55	0.7671	0.60	0.5100	0.30	0.2142	0.40	0.1233	0.40	0.00	0.00000	1.203	28,853
211.30	0.000			0.000			0.2290	0.29	0.0648	1.66	0.8858	0.60	0.5100	0.40	0.2395	0.40	0.1233	0.50	0.00	0.00000	1.354	30,850
211.40	0.000			0.000			0.2358	0.29	0.0648	1.76	0.9904	0.60	0.5100	0.50	0.2623	0.40	0.1233	0.60	0.00	0.00000	1.488	32,880
211.50	0.000			0.000			0.2424	0.29	0.0648	1.86	1.0849	0.60	0.5100	0.60	0.2833	0.40	0.1233	0.70	0.00	0.00000	1.611	34,942
211.60	0.000			0.000			0.2489	0.29	0.0648	1.95	1.1718	0.60	0.5100	0.70	0.3029	0.40	0.1233	0.80	0.00	0.00000	1.724	37,037
211.70	0.000			0.000			0.2552	0.29	0.0648	2.05	1.2527	0.60	0.5100	0.80	0.3213	0.40	0.1233	0.90	0.00	0.00000	1.829	39,165
211.80	0.000			0.000			0.2613	0.29	0.0648	2.16	1.3287	0.60	0.5100	0.90	0.3386	0.40	0.1233	1.00	0.00	0.00000	1.929	41,326
211.90	0.000			0.000			0.2673	0.29	0.0648	2.26	1.4006	0.60	0.5100	1.00	0.3552	0.40	0.1233	1.10	0.00	0.00000	2.023	43,520
212.00	0.000	30.00	0.00	0.000	10.00	0.00	0.2732	0.29	0.0648	2.36	1.4690	0.60	0.5100	1.10	0.3710	0.40	0.1233	1.20	0.00	0.00000	2.113	45,747
212.10	1.751	30.00	0.10	0.593	10.00	0.10	0.2789	0.29	0.0648	2.45	1.5343	0.60	0.5100	1.20	0.3861	0.40	0.1233	1.30	0.00	0.00000	4.543	48,008
212.20	4.991	30.00	0.20	1.716	10.00	0.20	0.2845	0.29	0.0648	2.55	1.5969	0.60	0.5100	1.30	0.4007	0.40	0.1233	1.40	0.00	0.00000	8.990	50,302
212.30	9.242	30.00	0.30	3.225	10.00	0.30	0.2900	0.29	0.0648	2.66	1.6572	0.60	0.5100	1.40	0.4148	0.40	0.1233	1.50	0.00	0.00000	14.829	52,629
212.40	14.340	30.00	0.40	5.076	10.00	0.40	0.2954	0.29	0.0648	2.76	1.7154	0.60	0.5100	1.50	0.4284	0.40	0.1233	1.60	0.00	0.00000	21.855	54,989
212.50	20.196	30.00	0.50	7.250	10.00	0.50	0.3008	0.29	0.0648	2.86	1.7716	0.60	0.5100	1.60	0.4415	0.40	0.1233	1.70	0.00	0.00000	29.959	57,383

TABLE 6.2 - STAGE / STORAGE CALCULATIONS

PROJECT: ARG Milton
PROJECT: 03211.400
DATE June 9, 2003
REVISED: February 11, 2005

POND VOLUME CALCULATIONS

ELEVATION (m)	AREA (m²)	VOLUME (m³)	ACCUMULATED VOLUME (m³)
209.50	14,000		
209.60	14,356	1,418	1,418
209.70	14,711	1,453	2,871
209.80	15,066	1,489	4,360
209.90	15,421	1,524	5,884
210.00	15,776	1,560	7,444
210.10	16,131	1,595	9,040
210.20	16,486	1,631	10,670
210.30	16,841	1,666	12,337
210.40	17,196	1,702	14,039
210.50	17,551	1,737	15,776
210.60	17,874	1,771	17,547

REVERSE FLOW PIPE ORIFICE DESIGN CALCULATIONS

PONDING ELEVATION (m)	290mm ORIFICE		QUALITY DISCHARGE (cms)
	ORIFICE HEAD (m) INVERT 209.50	ORIFICE FLOW (cms) Cd = 0.6200 0.06605	
209.50	0.00	0.0000	0.0000
209.60	0.10	0.0102	0.0102
209.70	0.20	0.0395	0.0395
209.80	0.30	0.0701	0.0701
209.90	0.40	0.0899	0.0899
210.00	0.50	0.1061	0.1061
210.10	0.60	0.1201	0.1201
210.20	0.70	0.1326	0.1326
210.30	0.80	0.1441	0.1441
210.40	0.90	0.1547	0.1547
210.50	1.00	0.1646	0.1646
210.60	1.10	0.1739	0.1739

CUMULATIVE STORAGE TIME

WITH ORIFICE INSTALLED

AVERAGE DISCHARGE (cms)	VOLUME (m³)	INCREMENTAL DEWATERING TIME (hours)	CUMULATIVE DEWATERING TIME (hours)
0.0051	1,418	76.99	124.38
0.0249	1,453	16.24	47.38
0.0548	1,489	7.55	31.14
0.0800	1,524	5.29	23.59
0.0980	1,560	4.42	18.30
0.1131	1,595	3.92	13.87
0.1263	1,631	3.59	9.96
0.1383	1,666	3.35	6.37
0.1494	1,702	3.17	6.07
0.1596	1,737	3.02	3.02
0.1693	1,771	2.91	2.91

PROJECT:	*ARG Milton*	**STORMWATER MANAGEMENT CALCULATIONS**
PROJECT:	*03211.400*	**ARG MILTON**
DATE	June 9, 2003	**POND DESIGN**
REVISED:	03211.400	**INDUSTRIAL DEVELOPMENT**
	February 11, 2005	**TOWN OF MILTON**

					% impervious		
	Development Catchment Area:	72.16	Ha		85%		
	External Catchment Area:	74.00	Ha		0%		
	Treatment Area:	146.16	Ha				
	Directly Connected Area:	146.16	Ha				
	Level 1 Storage requirement for a wetpond with 85% impervious:	250	m^3/Ha				
	Less(Extened Detention):	40	m^3/Ha	→	40.0	m^3/Ha	Extended Detention
	Permenant Pool:	210	m^3/Ha				
Required	Permenant Pool:	15,154	m^3		5,846	m^3	Extended detention calculated @ 40m^3/Ha
	Extened Detention:	16,808	m^3		16,808	m^3	Extended detention calculated from a 11.5mm runoff
	Required Volume:	31,962	m^3				
Provided	Permanant Pool:	16,348	m^3	@	209.50		
	Extened Detention:	17,547	m^3	@	210.60		
	Provided Volume:	33,895	m^3		1.10		

POND VOLUME CALCULATIONS

ULTIMATE

PROJECT:	ARG Milton
PROJECT NO.:	03211.400
DATE:	9-Jun-03
FILE:	03211Pond-01.XLS
REVISED	11-Feb-05

Elev. (m)	Area (m2)	Inc. Vol. (m3)	Volume (m3)			
	Sediment Forebay		3389 m^3			
	Plunge Pool		0 m^3			
			3,389			
207.50	4,185		3,389			
207.60	4,410	430	3,818			
207.70	4,634	452	4,271			
207.80	4,859	475	4,745			
207.90	5,084	497	5,243			
208.00	5,309	520	5,762			
208.10	5,533	542	6,304			
208.20	5,758	565	6,869			
208.30	5,983	587	7,456			
208.40	6,207	609	8,065			
208.50	6,432	632	8,697			
208.60	6,676	655	9,353			
208.70	6,920	680	10,032			
208.80	7,163	704	10,737			
208.90	7,407	729	11,465			
209.00	7,651	753	12,218			
209.10	7,895	777	12,995			
209.20	8,139	802	13,797			
209.30	8,382	826	14,623			
209.40	8,626	850	15,473			
209.50	8,870	875	16,348			
209.50	14,000	-	16,348		**Permenant Pool**	16,348
209.60	14,356	1,418	17,766	1,418		
209.70	14,711	1,453	19,219	2,871		
209.80	15,066	1,489	20,708	4,360		
209.90	15,421	1,524	22,233	5,884		
210.00	15,776	1,560	23,792	7,444		
210.10	16,131	1,595	25,388	9,040		
210.20	16,486	1,631	27,019	10,670		
210.30	16,841	1,666	28,685	12,337		
210.40	17,196	1,702	30,387	14,039		
210.50	17,551	1,737	32,124	15,776		
210.60	17,874	1,771	33,895	17,547	**Extended Detention**	17,547
210.70	18,197	1,804	35,699	19,351		
210.75	18,359	914	36,613	20,265		
210.80	18,520	922	37,535	21,187		
210.90	18,843	1,868	39,403	23,055		
211.00	19,166	1,900	41,303	24,955		
211.10	19,489	1,933	43,236	26,888		
211.20	19,812	1,965	45,201	28,853		
211.30	20,135	1,997	47,199	30,850		
211.40	20,458	2,030	49,228	32,880		
211.50	20,781	2,062	51,290	34,942		
211.60	21,113	2,095	53,385	37,037		
211.70	21,445	2,128	55,513	39,165		
211.80	21,777	2,161	57,674	41,326		
211.90	22,109	2,194	59,868	43,520		
212.00	22,441	2,227	62,096	45,747		
212.10	22,773	2,261	64,356	48,008		
212.20	23,105	2,294	66,650	50,302		
212.30	23,437	2,327	68,977	52,629		
212.40	23,769	2,360	71,338	54,989		
212.50	24,101	2,393	73,731	57,383		

```
    Metric units /\
*****************************************************************************
**  Project Name: [ARG Milton Industrial] ProjectNumber[03211.400]   100yr
**  Date          : 07-24-2003
**  Revised       : November 12, 2003
**  Revised       : February 10, 2005, By: FH (rev James Snow Pkwy drainage area)
**  Modeller      : [DME], KC
**  Company       : The Sernas Group
**  License #     :  2640114
*****************************************************************************
START                   TZERO=[0.0],  METOUT=[2],  NSTORM=[1],  NRUN=[1]
                        []<-storm filename, one per line for NSTORM time
*-----------------|-----------------------------------------------------------|
READ STORM              STORM_FILENAME=["HH100y3h.stm"]
*-----------------|-----------------------------------------------------------|
*****************************************************************************
**  Internal North Block 100
**  Roof                 101
**  Paved/Landscape      102
*****************************************************************************
CALIB STANDHYD          ID=[1], NHYD=["0101"], DT=[3](min), AREA=[12.12](ha),
                        XIMP=[0.90], TIMP=[0.95], DWF=[0](cms), LOSS=[2],
                        SCS curve number CN=[76],
                        Pervious   surfaces: IAper=[2.5](mm), SLPP=[2](%),
                                             LGP=[30](m), MNP=[0.25], SCP=[0](min),
                        Impervious surfaces: IAimp=[2.5](mm), SLPI=[2](%),
                                             LGI=[284](m), MNI=[0.013], SCI=[0](min)
                        RAINFALL=[-1](mm/hr) ,  END=-1
*-----------------|-----------------------------------------------------------|
*****************************************************************************
**  Control roof release to 42 l/s/ha for Area 101
*****************************************************************************
ROUTE RESERVOIR         IDout=[7],   NHYD=[8101],  IDin=[1],
                        RDT=[3](min),
                             TABLE of ( OUTFLOW-STORAGE ) values
                                      (cms)  -  (ha-m)
                                      0.00         0.00
                                      0.05         0.05
                                      0.45         0.68
                                      0.50         0.70
                                       -1               (max twenty pts)
*-----------------|-----------------------------------------------------------|
CALIB STANDHYD          ID=[2], NHYD=["0102"], DT=[3](min), AREA=[12.11](ha),
                        XIMP=[0.75], TIMP=[0.80], DWF=[0](cms), LOSS=[2],
                        SCS curve number CN=[75.5],
                        Pervious   surfaces: IAper=[2.5](mm), SLPP=[2](%),
                                             LGP=[30](m), MNP=[0.25], SCP=[0](min),
                        Impervious surfaces: IAimp=[2.5](mm), SLPI=[2](%),
                                             LGI=[254](m), MNI=[0.013], SCI=[0](min)
                        RAINFALL=[-1](mm/hr) ,  END=-1
*-----------------|-----------------------------------------------------------|
ADD HYD                 IDsum=[8], NHYD=[0100], IDs to add=[7 2]
*-----------------|-----------------------------------------------------------|
*****************************************************************************
**  Control release to 150 l/s/ha for Area 100
*****************************************************************************
ROUTE RESERVOIR         IDout=[9],   NHYD=[8001],  IDin=[8],
                        RDT=[3](min),
                             TABLE of ( OUTFLOW-STORAGE ) values
                                      (cms)  -  (ha-m)
                                      0.00         0.00
                                      0.50         0.05
                                      3.59         0.17
                                      3.64         0.20
                                       -1               (max twenty pts)
*-----------------|-----------------------------------------------------------|
*****************************************************************************
**
**  External North Area 200
**
*****************************************************************************
CALIB NASHYD            ID=[1], NHYD=["0200"], DT=[12]min, AREA=[71.8](ha),
                        DWF=[0](cms),  CN/C=[76], IA=[2.5](mm),
                        N=[3], TP=[1.0]hrs,
                        RAINFALL=[-1](mm/hr),  END=-1
*-----------------|-----------------------------------------------------------|
ADD HYD                 IDsum=[4], NHYD=[9001], IDs to add=[9 1]
*-----------------|-----------------------------------------------------------|
*****************************************************************************
**
**  James Snow Parkway 200
**  Revised(feb05) drainage area from 2.16 to 2.20ha.
**
*****************************************************************************
CALIB STANDHYD          ID=[1], NHYD=["02001"], DT=[5](min), AREA=[2.20](ha),
                        XIMP=[0.75], TIMP=[0.75], DWF=[0](cms), LOSS=[2],
                        SCS curve number CN=[76],
                        Pervious   surfaces: IAper=[2.5](mm), SLPP=[2](%),
                                             LGP=[30](m), MNP=[0.25], SCP=[0](min),
                        Impervious surfaces: IAimp=[2.5](mm), SLPI=[2](%),
                                             LGI=[122](m), MNI=[0.013], SCI=[0](min)
                        RAINFALL=[-1](mm/hr) ,  END=-1
*-----------------|-----------------------------------------------------------|
ADD HYD                 IDsum=[5], NHYD=[9001], IDs to add=[4 1]
*-----------------|-----------------------------------------------------------|
*****************************************************************************
**
**  Boston Church Road 300
**
*****************************************************************************
CALIB STANDHYD          ID=[1], NHYD=["0300"], DT=[5](min), AREA=[3.02](ha),
                        XIMP=[0.7], TIMP=[0.75], DWF=[0](cms), LOSS=[2],
                        SCS curve number CN=[76],
                        Pervious   surfaces: IAper=[2.5](mm), SLPP=[2](%),
                                             LGP=[30](m), MNP=[0.25], SCP=[0](min),
                        Impervious surfaces: IAimp=[2.5](mm), SLPI=[2](%),
                                             LGI=[122](m), MNI=[0.013], SCI=[0](min)
                        RAINFALL=[-1](mm/hr) ,  END=-1
*-----------------|-----------------------------------------------------------|
ADD HYD                 IDsum=[6], NHYD=[9002], IDs to add=[1 5]
*-----------------|-----------------------------------------------------------|
*****************************************************************************
**
**  External North East Block 400
**
*****************************************************************************
CALIB STANDHYD          ID=[1], NHYD=["0400"], DT=[5](min), AREA=[4.66](ha),
                        XIMP=[0.65], TIMP=[0.75], DWF=[0](cms), LOSS=[2],
                        SCS curve number CN=[75.5],
                        Pervious   surfaces: IAper=[2.5](mm), SLPP=[2](%),
                                             LGP=[40](m), MNP=[0.25], SCP=[0](min),
                        Impervious surfaces: IAimp=[2.5](mm), SLPI=[2](%),
                                             LGI=[152](m), MNI=[0.013], SCI=[0](min)
                        RAINFALL=[-1](mm/hr) ,  END=-1
*-----------------|-----------------------------------------------------------|
ADD HYD                 IDsum=[7], NHYD=[9003], IDs to add=[1 6]
*-----------------|-----------------------------------------------------------|
*****************************************************************************
**  SNOEK
**  Area reduced from 10.8 hectares to 2.88 hectares as per MTM
**  Paved/Landscape          502
*****************************************************************************
CALIB STANDHYD          ID=[2], NHYD=["0502"], DT=[5](min), AREA=[2.88](ha),
                        XIMP=[0.75], TIMP=[0.80], DWF=[0](cms), LOSS=[2],
                        SCS curve number CN=[76],
                        Pervious   surfaces: IAper=[2.5](mm), SLPP=[2](%),
                                             LGP=[30](m), MNP=[0.25], SCP=[0](min),
                        Impervious surfaces: IAimp=[2.5](mm), SLPI=[2](%),
                                             LGI=[120](m), MNI=[0.013], SCI=[0](min)
                        RAINFALL=[-1](mm/hr) ,  END=-1
*-----------------|-----------------------------------------------------------|
ADD HYD                 IDsum=[8], NHYD=[9004], IDs to add=[7 2]
*-----------------|-----------------------------------------------------------|
*****************************************************************************
**  Internal South East Block 600
**  Roof                      601
**  Paved/Landscape           602
*****************************************************************************
CALIB STANDHYD          ID=[1], NHYD=["0601"], DT=[5](min), AREA=[6.72](ha),
                        XIMP=[0.90], TIMP=[0.95], DWF=[0](cms), LOSS=[2],
                        SCS curve number CN=[76],
                        Pervious   surfaces: IAper=[2.5](mm), SLPP=[2](%),
                                             LGP=[30](m), MNP=[0.25], SCP=[0](min),
                        Impervious surfaces: IAimp=[2.5](mm), SLPI=[2](%),
                                             LGI=[211](m), MNI=[0.013], SCI=[0](min)
                        RAINFALL=[-1](mm/hr) ,  END=-1
*-----------------|-----------------------------------------------------------|
*****************************************************************************
**  Control roof release to 42 l/s/ha for Area 601
*****************************************************************************
ROUTE RESERVOIR         IDout=[3],   NHYD=[8601],  IDin=[1],
                        RDT=[5](min),
                             TABLE of ( OUTFLOW-STORAGE ) values
                                      (cms)  -  (ha-m)
                                      0.00         0.00
                                      0.05         0.05
                                      0.25         0.34
                                      0.28         0.38
                                       -1               (max twenty pts)
*-----------------|-----------------------------------------------------------|
CALIB STANDHYD          ID=[2], NHYD=["0602"], DT=[5](min), AREA=[6.72](ha),
                        XIMP=[0.75], TIMP=[0.80], DWF=[0](cms), LOSS=[2],
                        SCS curve number CN=[76],
                        Pervious   surfaces: IAper=[2.5](mm), SLPP=[2](%),
                                             LGP=[30](m), MNP=[0.25], SCP=[0](min),
                        Impervious surfaces: IAimp=[2.5](mm), SLPI=[2](%),
                                             LGI=[189](m), MNI=[0.013], SCI=[0](min)
                        RAINFALL=[-1](mm/hr) ,  END=-1
*-----------------|-----------------------------------------------------------|
ADD HYD                 IDsum=[4], NHYD=[0600], IDs to add=[3 2]
*-----------------|-----------------------------------------------------------|
*****************************************************************************
**  Control release to 150 l/s/ha for Area 600
*****************************************************************************
ROUTE RESERVOIR         IDout=[5],   NHYD=[8002],  IDin=[4],
                        RDT=[5](min),
                             TABLE of ( OUTFLOW-STORAGE ) values
                                      (cms)  -  (ha-m)
                                      0.00         0.00
                                      0.50         0.05
                                      1.97         0.10
                                      2.02         0.12
                                       -1               (max twenty pts)
*-----------------|-----------------------------------------------------------|
ADD HYD                 IDsum=[9], NHYD=[9005], IDs to add=[8 5]
*-----------------|-----------------------------------------------------------|
*****************************************************************************
**  Internal South East Block 700
**  Roof                      701
**  Paved/Landscape           702
*****************************************************************************
CALIB STANDHYD          ID=[3], NHYD=["0701"], DT=[3](min), AREA=[6.63](ha),
                        XIMP=[0.90], TIMP=[0.95], DWF=[0](cms), LOSS=[2],
                        SCS curve number CN=[76],
                        Pervious   surfaces: IAper=[2.5](mm), SLPP=[2](%),
                                             LGP=[30](m), MNP=[0.25], SCP=[0](min),
                        Impervious surfaces: IAimp=[2.5](mm), SLPI=[2](%),
                                             LGI=[210](m), MNI=[0.013], SCI=[0](min)
                        RAINFALL=[-1](mm/hr) ,  END=-1
*-----------------|-----------------------------------------------------------|
*****************************************************************************
**  Control roof release to 42 l/s/ha for Area 701
*****************************************************************************
ROUTE RESERVOIR         IDout=[4],   NHYD=[8701],  IDin=[3],
                        RDT=[3](min),
                             TABLE of ( OUTFLOW-STORAGE ) values
                                      (cms)  -  (ha-m)
                                      0.00         0.00
                                      0.05         0.05
                                      0.24         0.37
                                      0.27         0.39
                                       -1               (max twenty pts)
*-----------------|-----------------------------------------------------------|
*****************************************************************************
**  Divert Flow to Culvert 7
**  'clean' roof runoff
*****************************************************************************
COMPUTE DUALHYD         IDin=[4], CINLET=[0.08](cms), NINLET=[1],
                        MAJID=[2], MajNHYD=[7002],
                        MINID=[10], MinNHYD=[7001],
                        TMJSTO=[0](cu-m)
*-----------------|-----------------------------------------------------------|
CALIB STANDHYD          ID=[1], NHYD=[0702], DT=[3](min), AREA=[6.62](ha),
                        XIMP=[0.75], TIMP=[0.80], DWF=[0](cms), LOSS=[2],
                        SCS curve number CN=[76],
                        Pervious   surfaces: IAper=[2.5](mm), SLPP=[2](%),
                                             LGP=[30](m), MNP=[0.25], SCP=[0](min),
                        Impervious surfaces: IAimp=[2.5](mm), SLPI=[2](%),
                                             LGI=[187](m), MNI=[0.013], SCI=[0](min)
                        RAINFALL=[-1](mm/hr) ,  END=-1
*-----------------|-----------------------------------------------------------|
ADD HYD                 IDsum=[5], NHYD=[0700], IDs to add=[1 2]
*-----------------|-----------------------------------------------------------|
*****************************************************************************
**  Control release to 150 l/s/ha for Area 700
*****************************************************************************
ROUTE RESERVOIR         IDout=[6],   NHYD=[8003],  IDin=[5],
                        RDT=[3](min),
                             TABLE of ( OUTFLOW-STORAGE ) values
                                      (cms)  -  (ha-m)
                                      0.00         0.00
                                      0.50         0.04
                                      1.93         0.09
                                      1.98         0.11
```

```
                                        -1              (max twenty pts)
*:-----------------|-----------------------------------------------------------[
ADD HYD            IDsum=[1], NHYD=[9006], IDs to add=[6 9]
*:-----------------|-----------------------------------------------------------[
*******************************************************************************
**
**  Internal SWM Facility Block 800
**
*******************************************************************************
CALIB NASHYD       ID=[2], NHYD=["0800"], DT=[12]min, AREA=[2.75](ha),
                   DWF=[0](cms),  CN/C=[76], IA=[2.5](mm),
                   N=[3], TP=[1.0]hrs,
                   RAINFALL=[-1](mm/hr),  END=-1
*:-----------------|-----------------------------------------------------------|
ADD HYD            IDsum=[4], NHYD=[9011], IDs to add=[2 1]
*:-----------------|-----------------------------------------------------------|
ROUTE RESERVOIR    IDout=[5],   NHYD=[6000],  IDin=[4],
                   RDT=[3](min),
                        TABLE of ( OUTFLOW-STORAGE ) values
                                (cms)   -   (ha-m)
                               [0.000      0.000
                                0.039      0.287
                                0.090      0.588
                                0.120      0.904
                                0.144      1.234
                                0.165      1.578
                                0.174      1.755
                                0.246      1.935
                                0.394      2.118
                                0.776      2.496
                                1.203      2.885
                                1.488      3.288
                                1.724      3.704
                                1.929      4.133
                                2.113      4.575
                                4.543      4.801
                                8.990      5.030
                                14.93      5.263
                                21.86      5.499
                                29.96      5.738
                                -1 ]  (max twenty pts)
*:-----------------|-----------------------------------------------------------|
*******************************************************************************
**
**  Total controled release Diversion plus SWM Facility
**
*******************************************************************************
ADD HYD            IDsum=[9], NHYD=[9100], IDs to add=[5 10]
*:-----------------|-----------------------------------------------------------|
*******************************************************************************
**  Output Facility IN/OUT Hydrographs
*******************************************************************************
SAVE HYD           ID=[4],    # OF PCYCLES=[1],  ICASEsh=[1]
                   HYD_COMMENT=["03211 Pond In"]
*:-----------------|-----------------------------------------------------------|
SAVE HYD           ID=[3],    # OF PCYCLES=[1],  ICASEsh=[1]
                   HYD_COMMENT=["03211 Pond Out"]
*:-----------------|-----------------------------------------------------------[
FINISH
```

```
2      Metric units /\
*************************************************************************
**   Project Name: [ARG Milton Industrial] ProjectNumber[03211.400]   100yr
**   Date         : 07-24-2003
**   Revised      : November 12, 2003
**   Revised      : February 10, 2005, By: FH (rev James Snow Pkwy drainage area)
**   Modeller     : [DME], KC
**   Company      : The Sernas Group
**   License #    : 2640114
*************************************************************************
START              TZERO=[0.0],   METOUT=[2],   NSTORM=[1],   NRUN=[1]
*#                 []<-storm filename, one per line for NSTORM time
*%-----------------|--------------------------------------------------------|
READ STORM         STORM_FILENAME=["Hhrs-12m.stm"]
*%-----------------|--------------------------------------------------------|
*************************************************************************
**   Internal North Block 100
**   Roof                    101
**   Paved/Landscape         102
*************************************************************************
CALIB STANDHYD     ID=[1], NHYD=["0101"], DT=[3](min), AREA=[12.12](ha),
                   XIMP=[0.90], TIMP=[0.95], DWF=[0](cms), LOSS=[2],
                   SCS curve number CN=[89],
                   Pervious   surfaces: IAper=[2.5](mm), SLPP=[2](%),
                                        LGP=[30](m), MNP=[0.25], SCP=[0](min),
                   Impervious surfaces: IAimp=[2.5](mm), SLPI=[2](%),
                                        LGI=[284](m), MNI=[0.013], SCI=[0](min)
                   RAINFALL=[-1](mm/hr) ,  END=-1
*%-----------------|--------------------------------------------------------|
*************************************************************************
**   Control roof release to 42 l/s/ha for Area 101
*************************************************************************
ROUTE RESERVOIR    IDout=[7],   NHYD=[8101],   IDin=[1],
                   RDT=[3](min),
                          TABLE of ( OUTFLOW-STORAGE ) values
                                    (cms)  -   (ha-m)
                                    0.00          0.00
                                    0.05          0.05
                                    0.45          0.68
                                    0.50          0.70
                                     -1                  (max twenty pts)
*%-----------------|--------------------------------------------------------|
CALIB STANDHYD     ID=[2], NHYD=["0102"], DT=[3](min), AREA=[12.11](ha),
                   XIMP=[0.75], TIMP=[0.80], DWF=[0](cms), LOSS=[2],
                   SCS curve number CN=[89],
                   Pervious   surfaces: IAper=[2.5](mm), SLPP=[2](%),
                                        LGP=[30](m), MNP=[0.25], SCP=[0](min),
                   Impervious surfaces: IAimp=[2.5](mm), SLPI=[2](%),
                                        LGI=[254](m), MNI=[0.013], SCI=[0](min)
                   RAINFALL=[-1](mm/hr) ,  END=-1
*%-----------------|--------------------------------------------------------|
ADD HYD            IDsum=[8], NHYD=[0100], IDs to add=[7 2]
*%-----------------|--------------------------------------------------------|
*************************************************************************
**   Control release to 150 l/s/ha for Area 100
*************************************************************************
ROUTE RESERVOIR    IDout=[9],   NHYD=[8001],   IDin=[8],
                   RDT=[3](min),
                          TABLE of ( OUTFLOW-STORAGE ) values
                                    (cms)  -   (ha-m)
                                    0.00          0.00
                                    0.50          0.05
                                    3.59          0.17
                                    3.64          0.20
                                     -1                  (max twenty pts)
*%-----------------|--------------------------------------------------------|
*************************************************************************
**
**   External North Area 200
**
*************************************************************************
CALIB NASHYD       ID=[1], NHYD=["0200"], DT=[12]min, AREA=[71.8](ha),
                   DWF=[0](cms),   CN/C=[89], IA=[2.5](mm),
                   N=[3], TP=[1.0]hrs,
                   RAINFALL=[-1](mm/hr),   END=-1
*%-----------------|--------------------------------------------------------|
ADD HYD            IDsum=[4], NHYD=[9001], IDs to add=[9 1]
*%-----------------|--------------------------------------------------------|
*************************************************************************
**
**   James Snow Parkway 200
**   Revised(feb05) drainage area from 2.16 to 2.20ha.
**
*************************************************************************
CALIB STANDHYD     ID=[1], NHYD=["02001"], DT=[5](min), AREA=[2.20](ha),
                   XIMP=[0.75], TIMP=[0.75], DWF=[0](cms), LOSS=[2],
                   SCS curve number CN=[89],
                   Pervious   surfaces: IAper=[2.5](mm), SLPP=[2](%),
                                        LGP=[30](m), MNP=[0.25], SCP=[0](min),
                   Impervious surfaces: IAimp=[2.5](mm), SLPI=[2](%),
                                        LGI=[122](m), MNI=[0.013], SCI=[0](min)
                   RAINFALL=[-1](mm/hr) ,  END=-1
*%-----------------|--------------------------------------------------------|
ADD HYD            IDsum=[5], NHYD=[9001], IDs to add=[4 1]
*%-----------------|--------------------------------------------------------|
*************************************************************************
**
**   Boston Church Road 300
**
*************************************************************************
CALIB STANDHYD     ID=[1], NHYD=["0300"], DT=[5](min), AREA=[3.02](ha),
                   XIMP=[0.7], TIMP=[0.75], DWF=[0](cms), LOSS=[2],
                   SCS curve number CN=[89],
                   Pervious   surfaces: IAper=[2.5](mm), SLPP=[2](%),
                                        LGP=[30](m), MNP=[0.25], SCP=[0](min),
                   Impervious surfaces: IAimp=[2.5](mm), SLPI=[2](%),
                                        LGI=[122](m), MNI=[0.013], SCI=[0](min)
                   RAINFALL=[-1](mm/hr) ,  END=-1
*%-----------------|--------------------------------------------------------|
ADD HYD            IDsum=[6], NHYD=[9002], IDs to add=[1 5]
*%-----------------|--------------------------------------------------------|
*************************************************************************
**
**   External North East Block 400
**
*************************************************************************
CALIB STANDHYD     ID=[1], NHYD=["0400"], DT=[5](min), AREA=[4.66](ha),
                   XIMP=[0.65], TIMP=[0.75], DWF=[0](cms), LOSS=[2],
                   SCS curve number CN=[89],
                   Pervious   surfaces: IAper=[2.5](mm), SLPP=[2](%),
                                        LGP=[40](m), MNP=[0.25], SCP=[0](min),
                   Impervious surfaces: IAimp=[2.5](mm), SLPI=[2](%),
                                        LGI=[152](m), MNI=[0.013], SCI=[0](min)
                   RAINFALL=[-1](mm/hr) ,  END=-1
*%-----------------|--------------------------------------------------------|
ADD HYD            IDsum=[7], NHYD=[9003], IDs to add=[1 6]
*%-----------------|--------------------------------------------------------|
*************************************************************************
**   SNOEK
**   Area reduced from 10.8 hectares to 2.88 hectares as per MTM
**   Paved/Landscape          502
*************************************************************************
CALIB STANDHYD     ID=[2], NHYD=["0502"], DT=[5](min), AREA=[2.88](ha),
                   XIMP=[0.75], TIMP=[0.80], DWF=[0](cms), LOSS=[2],
                   SCS curve number CN=[89],
                   Pervious   surfaces: IAper=[2.5](mm), SLPP=[2](%),
                                        LGP=[30](m), MNP=[0.25], SCP=[0](min),
                   Impervious surfaces: IAimp=[2.5](mm), SLPI=[2](%),
                                        LGI=[120](m), MNI=[0.013], SCI=[0](min)
                   RAINFALL=[-1](mm/hr) ,  END=-1
*%-----------------|--------------------------------------------------------|
ADD HYD            IDsum=[8], NHYD=[9004], IDs to add=[7 2]
*%-----------------|--------------------------------------------------------|
*************************************************************************
**   Internal South East Block 600
**   Roof                    601
**   Paved/Landscape         602
*************************************************************************
CALIB STANDHYD     ID=[1], NHYD=["0601"], DT=[5](min), AREA=[6.72](ha),
                   XIMP=[0.90], TIMP=[0.95], DWF=[0](cms), LOSS=[2],
                   SCS curve number CN=[89],
                   Pervious   surfaces: IAper=[2.5](mm), SLPP=[2](%),
                                        LGP=[30](m), MNP=[0.25], SCP=[0](min),
                   Impervious surfaces: IAimp=[2.5](mm), SLPI=[2](%),
                                        LGI=[211](m), MNI=[0.013], SCI=[0](min)
                   RAINFALL=[-1](mm/hr) ,  END=-1
*%-----------------|--------------------------------------------------------|
*************************************************************************
**   Control roof release to 42 l/s/ha for Area 601
*************************************************************************
ROUTE RESERVOIR    IDout=[3],   NHYD=[8601],   IDin=[1],
                   RDT=[5](min),
                          TABLE of ( OUTFLOW-STORAGE ) values
                                    (cms)  -   (ha-m)
                                    0.00          0.00
                                    0.05          0.05
                                    0.25          0.34
                                    0.28          0.38
                                     -1                  (max twenty pts)
*%-----------------|--------------------------------------------------------|
CALIB STANDHYD     ID=[2], NHYD=["0602"], DT=[5](min), AREA=[6.72](ha),
                   XIMP=[0.75], TIMP=[0.80], DWF=[0](cms), LOSS=[2],
                   SCS curve number CN=[89],
                   Pervious   surfaces: IAper=[2.5](mm), SLPP=[2](%),
                                        LGP=[30](m), MNP=[0.25], SCP=[0](min),
                   Impervious surfaces: IAimp=[2.5](mm), SLPI=[2](%),
                                        LGI=[189](m), MNI=[0.013], SCI=[0](min)
                   RAINFALL=[-1](mm/hr) ,  END=-1
*%-----------------|--------------------------------------------------------|
ADD HYD            IDsum=[4], NHYD=[0600], IDs to add=[3 2]
*%-----------------|--------------------------------------------------------|
*************************************************************************
**   Control release to 150 l/s/ha for Area 600
*************************************************************************
ROUTE RESERVOIR    IDout=[5],   NHYD=[8002],   IDin=[4],
                   RDT=[5](min),
                          TABLE of ( OUTFLOW-STORAGE ) values
                                    (cms)  -   (ha-m)
                                    0.00          0.00
                                    0.50          0.05
                                    1.97          0.10
                                    2.02          0.12
                                     -1                  (max twenty pts)
*%-----------------|--------------------------------------------------------|
ADD HYD            IDsum=[9], NHYD=[9005], IDs to add=[8 5]
*%-----------------|--------------------------------------------------------|
*************************************************************************
**   Internal South East Block 700
**   Roof                    701
**   Paved/Landscape         702
*************************************************************************
CALIB STANDHYD     ID=[3], NHYD=["0701"], DT=[3](min), AREA=[6.63](ha),
                   XIMP=[0.90], TIMP=[0.95], DWF=[0](cms), LOSS=[2],
                   SCS curve number CN=[89],
                   Pervious   surfaces: IAper=[2.5](mm), SLPP=[2](%),
                                        LGP=[30](m), MNP=[0.25], SCP=[0](min),
                   Impervious surfaces: IAimp=[2.5](mm), SLPI=[2](%),
                                        LGI=[210](m), MNI=[0.013], SCI=[0](min)
                   RAINFALL=[-1](mm/hr) ,  END=-1
*%-----------------|--------------------------------------------------------|
*************************************************************************
**   Control roof release to 42 l/s/ha for Area 701
*************************************************************************
ROUTE RESERVOIR    IDout=[4],   NHYD=[8701],   IDin=[3],
                   RDT=[3](min),
                          TABLE of ( OUTFLOW-STORAGE ) values
                                    (cms)  -   (ha-m)
                                    0.00          0.00
                                    0.05          0.05
                                    0.24          0.37
                                    0.27          0.39
                                     -1                  (max twenty pts)
*%-----------------|--------------------------------------------------------|
*************************************************************************
**   Divert Flow to Culvert 7
**   'clean' roof runoff
*************************************************************************
COMPUTE DUALHYD    IDin=[4], CINLET=[0.08](cms), NINLET=[1],
                   MAJID=[2], MajNHYD=[7002],
                   MINID=[10], MinNHYD=[7001],
                   TMJSTO=[0](cu-m)
*%-----------------|--------------------------------------------------------|
CALIB STANDHYD     ID=[1], NHYD=[0702], DT=[3](min), AREA=[6.62](ha),
                   XIMP=[0.75], TIMP=[0.80], DWF=[0](cms), LOSS=[2],
                   SCS curve number CN=[89],
                   Pervious   surfaces: IAper=[2.5](mm), SLPP=[2](%),
                                        LGP=[30](m), MNP=[0.25], SCP=[0](min),
                   Impervious surfaces: IAimp=[2.5](mm), SLPI=[2](%),
                                        LGI=[187](m), MNI=[0.013], SCI=[0](min)
                   RAINFALL=[-1](mm/hr) ,  END=-1
*%-----------------|--------------------------------------------------------|
ADD HYD            IDsum=[5], NHYD=[0700], IDs to add=[1 2]
*%-----------------|--------------------------------------------------------|
*************************************************************************
**   Control release to 150 l/s/ha for Area 700
*************************************************************************
ROUTE RESERVOIR    IDout=[6],   NHYD=[8003],   IDin=[5],
                   RDT=[3](min),
                          TABLE of ( OUTFLOW-STORAGE ) values
                                    (cms)  -   (ha-m)
                                    0.00          0.00
                                    0.50          0.04
                                    1.93          0.09
                                    1.98          0.11
```

```
                                      -1                  (max twenty pts)
*%-----------------|--------------------------------------------------------------|
ADD HYD            IDsum=[1], NHYD=[9006], IDs to add=[6 9]
*%-----------------|--------------------------------------------------------------|
**************************************************************************************
**
**  Internal SWM Facility Block 800
**
**************************************************************************************
CALIB NASHYD       ID=[2], NHYD=["0800"], DT=[12]min, AREA=[2.75](ha),
                   DWF=[0](cms),   CN/C=[89], IA=[2.5](mm),
                   N=[3], TP=[1.0]hrs,
                   RAINFALL=[-1](mm/hr),   END=-1
*%-----------------|--------------------------------------------------------------|
ADD HYD            IDsum=[4], NHYD=[9011], IDs to add=[2 1]
*%-----------------|--------------------------------------------------------------|
ROUTE RESERVOIR    IDout=[5],    NHYD=[6000],   IDin=[4],
                   RDT=[3](min),
                         TABLE of ( OUTFLOW-STORAGE ) values
                                   (cms)   -   (ha-m)
                                  [0.000       0.000
                                   0.039       0.287
                                   0.090       0.588
                                   0.120       0.904
                                   0.144       1.234
                                   0.165       1.578
                                   0.174       1.755
                                   0.246       1.935
                                   0.394       2.118
                                   0.776       2.496
                                   1.203       2.885
                                   1.488       3.288
                                   1.724       3.704
                                   1.929       4.133
                                   2.113       4.575
                                   4.543       4.801
                                   8.990       5.030
                                   14.93       5.263
                                   21.86       5.499
                                   29.96       5.738
                                   -1 ]   (max twenty pts)
*%-----------------|--------------------------------------------------------------|
**************************************************************************************
**
**  Total controled release Diversion plus SWM Facility
**
**************************************************************************************
ADD HYD            IDsum=[9], NHYD=[9100], IDs to add=[5 10]
*%-----------------|--------------------------------------------------------------|
**************************************************************************************
**  Output Facility IN/OUT Hydrographs
**************************************************************************************
SAVE HYD           ID=[4],     # OF PCYCLES=[1],   ICASEsh=[1]
                   HYD_COMMENT=["03211 Pond In"]
*%-----------------|--------------------------------------------------------------|
SAVE HYD           ID=[3],     # OF PCYCLES=[1],   ICASEsh=[1]
                   HYD_COMMENT=["03211 Pond Out"]
*%-----------------|--------------------------------------------------------------|
FINISH
```

```
 ===========================================================================

 SSSSS  W   W   M   M  H   H  Y   Y  M   M   OOO        999    999   =========
 S      W W W   MM MM  H   H   Y Y   MM MM  O   O      9   9  9   9
 SSSSS  W W W   M M M  HHHHH    Y    M M M  O   O  ##  9   9  9   9  Ver. 4.02
     S   W W    M   M  H   H    Y    M   M  O   O       9999   9999  July 1999
 SSSSS   W W    M   M  H   H    Y    M   M   OOO           9      9  =========
                                                       9   9  9   9  # 2640114
      StormWater Management HYdrologic Model            999    999   =========

 ********************** SWMHYMO-99 Ver/4.02 ******************************
 *******   A single event and continuous hydrologic simulation model   *******
 *******        based on the principles of HYMO and its successors     *******
 *******                 OTTHYMO-83 and OTTHYMO-89.                    *******
 ***************************************************************************
 ******* Distributed by:  J.F. Sabourin and Associates Inc.            *******
 *******                  Ottawa, Ontario: (613) 727-5199              *******
 *******                  Gatineau, Quebec: (819) 243-6858             *******
 *******                  E-Mail: swmhymo@jfsa.Com                     *******
 ***************************************************************************

 +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
 ++++++ Licensed user: The Sernas Group                                +++++++
 +++++++               Mississauga              SERIAL#:2640114        +++++++
 +++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

 ***************************************************************************
 *******          ++++++ PROGRAM ARRAY DIMENSIONS ++++++              *******
 *******          Maximum value for ID numbers   :      10            *******
 *******          Max. number of rainfall points:  15000              *******
 *******          Max. number of flow points     :  15000             *******
 ***************************************************************************

 *******************   D E T A I L E D   O U T P U T   ********************
 ***************************************************************************
 *       DATE: 2005-02-10       TIME: 11:29:13       RUN COUNTER: 001256    *
 ***************************************************************************
 * Input    filename: P:\SWM\03211--1\FEB200~1\regional.DAT                *
 * Output   filename: P:\SWM\03211--1\FEB200~1\regional.out                *
 * Summary  filename: P:\SWM\03211--1\FEB200~1\regional.sum                *
 * User comments:                                                          *
 * 1:______________________________________________________________________*
 * 2:______________________________________________________________________*
 * 3:______________________________________________________________________*
 ***************************************************************************

 ---------------------------------------------------------------------------
 001:0001------------------------------------------------------------------
 ***************************************************************************
 **  Project Name: [ARG Milton Industrial] ProjectNumber[03211.400]    100yr
 **  Date          : 07-24-2003
 **  Revised       : November 12, 2003
 **  Revised       : February 10, 2005, By: FH.(rev James Snow Pkwy drainage area)
 **  Modeller      : [DME], KC
 **  Company       : The Sernas Group
 **  License #     : 2640114
 ***************************************************************************
 ---------------------
 | START             |    Project  dir.: P:\SWM\03211--1\FEB200~1\
 ---------------------    Rainfall dir.: P:\SWM\03211--1\FEB200~1\
    TZERO =    .00 hrs on          0
    METOUT=    2 (output = METRIC)
    NRUN  =  001
    NSTORM=    1
          #  1=()<-storm filename, one per line for NSTORM time
 ---------------------------------------------------------------------------
 001:0002------------------------------------------------------------------
 ---------------------
 | READ STORM        |    Filename: P:\SWM\03211--1\FEB200~1\Hhrs-12m.stm
 | Ptotal= 211.27 mm|    Comments: REGIONAL STORM - HURRICANE HAZEL (12 HOU
 ---------------------
          TIME     RAIN |   TIME    RAIN |   TIME    RAIN |   TIME    RAIN
           hrs    mm/hr |    hrs   mm/hr |    hrs   mm/hr |    hrs   mm/hr
           .20    6.350 |   3.20  12.700 |   6.20  23.200 |   9.20  52.750
           .40    6.350 |   3.40  12.700 |   6.40  23.200 |   9.40  52.750
           .60    6.350 |   3.60  12.700 |   6.60  23.200 |   9.60  52.750
           .80    6.350 |   3.80  12.700 |   6.80  23.200 |   9.80  52.750
          1.00    6.350 |   4.00  12.700 |   7.00  23.200 |  10.00  52.750
          1.20    4.220 |   4.20  16.900 |   7.20  12.700 |  10.20  38.000
          1.40    4.220 |   4.40  16.900 |   7.40  12.700 |  10.40  38.000
          1.60    4.220 |   4.60  16.900 |   7.60  12.700 |  10.60  38.000
          1.80    4.220 |   4.80  16.900 |   7.80  12.700 |  10.80  38.000
          2.00    4.220 |   5.00  16.900 |   8.00  12.700 |  11.00  38.000
          2.20    6.350 |   5.20  12.700 |   8.20  12.700 |  11.20  12.700
          2.40    6.350 |   5.40  12.700 |   8.40  12.700 |  11.40  12.700
          2.60    6.350 |   5.60  12.700 |   8.60  12.700 |  11.60  12.700
          2.80    6.350 |   5.80  12.700 |   8.80  12.700 |  11.80  12.700
          3.00    6.350 |   6.00  12.700 |   9.00  12.700 |  12.00  12.700

 ---------------------------------------------------------------------------
 001:0003------------------------------------------------------------------
 ***************************************************************************
 **  Internal North Block 100
 **  Roof                 101
 **  Paved/Landscape      102
 ***************************************************************************
 ---------------------
 | CALIB STANDHYD    |   Area    (ha)=   12.12
 | 01:0101  DT= 3.00 |   Total Imp(%)=   95.00   Dir. Conn.(%)=   90.00
 ---------------------
                            IMPERVIOUS    PERVIOUS (i)
     Surface Area    (ha)=     11.51          .61
     Dep. Storage    (mm)=      2.50         2.50
     Average Slope    (%)=      2.00         2.00
     Length           (m)=    284.00        30.00
     Mannings n          =      .013         .250

     Max.eff.Inten.(mm/hr)=    52.75       104.60
                over (min)      6.00        12.00
     Storage Coeff.  (min)=     5.01 (ii)   10.85 (ii)
     Unit Hyd. Tpeak (min)=     6.00        12.00
     Unit Hyd. peak  (cms)=      .21          .10
                                                          *TOTALS*
     PEAK FLOW       (cms)=     1.60          .17          1.773 (iii)
     TIME TO PEAK    (hrs)=    10.00        10.00          10.000
     RUNOFF VOLUME    (mm)=   208.77       195.41         207.435
     TOTAL RAINFALL   (mm)=   211.27       211.27         211.270
     RUNOFF COEFFICIENT  =      .99          .92            .982

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
           CN* =  89.0     Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

 ---------------------------------------------------------------------------
 001:0004------------------------------------------------------------------
 ***************************************************************************
 **  Control roof release to 42 l/s/ha for Area 101
 ***************************************************************************
 ---------------------
 | ROUTE RESERVOIR   |    Requested routing time step =   3.0 min.
 |  IN>01:(0101   )  |
 | OUT<07:(008101)   |    =========  OUTFLOW STORAGE TABLE  =========
 ---------------------     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
                            (cms)     (ha.m.)   |   (cms)     (ha.m.)
                             .000   .0000E+00   |    .450   .6800E+00
                             .050   .5000E-01   |    .500   .7000E+00
       *** WARNING: STORAGE-Q values were extrapolated.
                    Increase curve or use overflow option.

       ROUTING RESULTS             AREA      QPEAK     TPEAK       R.V.
       ------------------          (ha)      (cms)     (hrs)       (mm)
       INFLOW >01: (0101   )      12.12      1.773    10.000    207.435
       OUTFLOW<07: (008101)       12.12      1.219    11.000    207.434

                PEAK  FLOW   REDUCTION [Qout/Qin](%)=   68.737
                TIME SHIFT OF PEAK FLOW         (min)=   60.00
                MAXIMUM  STORAGE  USED      (ha.m.)=.9881E+00

 ---------------------------------------------------------------------------
 001:0005------------------------------------------------------------------
 ---------------------
 | CALIB STANDHYD    |   Area    (ha)=   12.11
 | 02:0102  DT= 3.00 |   Total Imp(%)=   80.00   Dir. Conn.(%)=   75.00
 ---------------------
                            IMPERVIOUS    PERVIOUS (i)
     Surface Area    (ha)=      9.69         2.42
     Dep. Storage    (mm)=      2.50         2.50
     Average Slope    (%)=      2.00         2.00
     Length           (m)=    254.00        30.00
     Mannings n          =      .013         .250

     Max.eff.Inten.(mm/hr)=    52.75        64.63
                over (min)      6.00        12.00
     Storage Coeff.  (min)=     4.69 (ii)   11.76 (ii)
     Unit Hyd. Tpeak (min)=     6.00        12.00
     Unit Hyd. peak  (cms)=      .22          .10
                                                          *TOTALS*
     PEAK FLOW       (cms)=     1.33          .43          1.761 (iii)
     TIME TO PEAK    (hrs)=    10.00        10.00          10.000
     RUNOFF VOLUME    (mm)=   208.77       186.84         203.289
     TOTAL RAINFALL   (mm)=   211.27       211.27         211.270
     RUNOFF COEFFICIENT  =      .99          .88            .962

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
           CN* =  89.0     Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

 ---------------------------------------------------------------------------
 001:0006------------------------------------------------------------------
 ---------------------
 | ADD HYD (000100) | ID: NHYD       AREA    QPEAK   TPEAK    R.V.    DWF
 ---------------------               (ha)    (cms)   (hrs)    (mm)   (cms)
                  ID1 07:008101     12.12    1.219   11.00  207.43    .000
                 +ID2 02:0102       12.11    1.761   10.00  203.29    .000
                  =======================================================
                  SUM 08:000100     24.23    2.829   10.00  205.36    .000

       NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

 ---------------------------------------------------------------------------
 001:0007------------------------------------------------------------------
 ***************************************************************************
 **  Control release to 150 l/s/ha for Area 100
 ***************************************************************************
 ---------------------
 | ROUTE RESERVOIR   |    Requested routing time step =   3.0 min.
 |  IN>08:(000100)   |
 | OUT<09:(008001)   |    =========  OUTFLOW STORAGE TABLE  =========
 ---------------------     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
                            (cms)     (ha.m.)   |   (cms)     (ha.m.)
                             .000   .0000E+00   |   3.590   .1700E+00
                             .500   .5000E-01   |   3.640   .2000E+00

       ROUTING RESULTS             AREA      QPEAK     TPEAK       R.V.
       ------------------          (ha)      (cms)     (hrs)       (mm)
       INFLOW >08: (000100)       24.23      2.829    10.000    205.362
       OUTFLOW<09: (008001)       24.23      2.770    10.050    205.362

                PEAK  FLOW   REDUCTION [Qout/Qin](%)=   97.919
                TIME SHIFT OF PEAK FLOW         (min)=    3.00
                MAXIMUM  STORAGE  USED      (ha.m.)=.1383E+00

 ---------------------------------------------------------------------------
 001:0008------------------------------------------------------------------
 ***************************************************************************
 **
 **  External North Area 200
 **
 ***************************************************************************
 ---------------------
 | CALIB NASHYD      |   Area      (ha)=    71.80   Curve Number   (CN)=89.00
 | 01:0200  DT=12.00 |   Ia        (mm)=    2.500   # of Linear Res.(N)= 3.00
 ---------------------   U.H. Tp(hrs)=      1.000

     Unit Hyd Qpeak   (cms)=     2.742

     PEAK FLOW        (cms)=     7.497 (i)
     TIME TO PEAK     (hrs)=    11.000
     RUNOFF VOLUME     (mm)=   181.480
     TOTAL RAINFALL    (mm)=   211.270
     RUNOFF COEFFICIENT   =      .859

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

 ---------------------------------------------------------------------------
 001:0009------------------------------------------------------------------
 ---------------------
 | ADD HYD (009001) | ID: NHYD       AREA    QPEAK   TPEAK    R.V.    DWF
 ---------------------               (ha)    (cms)   (hrs)    (mm)   (cms)
                  ID1 09:008001     24.23    2.770   10.05  205.36    .000
                 +ID2 01:0200       71.80    7.497   11.00  181.48    .000
                  =======================================================
                  SUM 04:009001     96.03    9.985   11.00  187.51    .000

       NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

 ---------------------------------------------------------------------------
 001:0010------------------------------------------------------------------
```

```
 ***************************************************************************
 **
 **  James Snow Parkway 200
 **  Revised(feb05) drainage area from 2.16 to 2.20ha.
 **
 ***************************************************************************
 ----------------------
 | CALIB STANDHYD      |    Area      (ha)=     2.20
 | 01:02001  DT= 5.00 |    Total Imp(%)=    75.00    Dir. Conn.(%)=    75.00
 ----------------------
                              IMPERVIOUS     PERVIOUS (i)
     Surface Area      (ha)=        1.65           .55
     Dep. Storage      (mm)=        2.50          2.50
     Average Slope      (%)=        2.00          2.00
     Length             (m)=      122.00         30.00
     Mannings n            =        .013          .250

     Max.eff.Inten.(mm/hr)=        52.75         51.22
                over (min)          6.00         12.00
     Storage Coeff.   (min)=        3.02 (ii)    10.78 (ii)
     Unit Hyd. Tpeak  (min)=        6.00         12.00
     Unit Hyd. peak   (cms)=         .24           .10
                                                              *TOTALS*
     PEAK FLOW        (cms)=         .24           .08           .319 (iii)
     TIME TO PEAK     (hrs)=        9.80         10.00         10.000
     RUNOFF VOLUME     (mm)=      208.77        181.48        201.948
     TOTAL RAINFALL    (mm)=      211.27        211.27        211.270
     RUNOFF COEFFICIENT   =          .99           .86           .956
      *** WARNING: Storage Coefficient is smaller than DT!
                   Use a smaller DT or a larger area.

     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
          CN* =  89.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
          THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

 ----------------------------------------------------------------------------
 001:0011--------------------------------------------------------------------
 --------------------
 | ADD HYD (009001) | ID: NHYD      AREA      QPEAK    TPEAK    R.V.     DWF
 --------------------               (ha)      (cms)    (hrs)    (mm)    (cms)
              ID1 04:009001        96.03      9.985    11.00  187.51     .000
             +ID2 01:02001          2.20       .319    10.00  201.95     .000
              ====================================================
              SUM 05:009001        98.23     10.217    11.00  187.83     .000

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

 ----------------------------------------------------------------------------
 001:0012--------------------------------------------------------------------
 ***************************************************************************
 **
 **  Boston Church Road 300
 **
 ***************************************************************************
 ----------------------
 | CALIB STANDHYD      |    Area      (ha)=     3.02
 | 01:0300   DT= 5.00 |    Total Imp(%)=    75.00    Dir. Conn.(%)=    70.00
 ----------------------
                              IMPERVIOUS     PERVIOUS (i)
     Surface Area      (ha)=        2.27           .75
     Dep. Storage      (mm)=        2.50          2.50
     Average Slope      (%)=        2.00          2.00
     Length             (m)=      122.00         30.00
     Mannings n            =        .013          .250

     Max.eff.Inten.(mm/hr)=        52.75         61.95
                over (min)          6.00         12.00
     Storage Coeff.   (min)=        3.02 (ii)    10.21 (ii)
     Unit Hyd. Tpeak  (min)=        6.00         12.00
     Unit Hyd. peak   (cms)=         .24           .10
                                                              *TOTALS*
     PEAK FLOW        (cms)=         .31           .13           .439 (iii)
     TIME TO PEAK     (hrs)=        9.80         10.00         10.000
     RUNOFF VOLUME     (mm)=      208.77        185.93        201.919
     TOTAL RAINFALL    (mm)=      211.27        211.27        211.270
     RUNOFF COEFFICIENT   =          .99           .88           .956
      *** WARNING: Storage Coefficient is smaller than DT!
                   Use a smaller DT or a larger area.

     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
          CN* =  89.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
          THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

 ----------------------------------------------------------------------------
 001:0013--------------------------------------------------------------------
 --------------------
 | ADD HYD (009002) | ID: NHYD      AREA      QPEAK    TPEAK    R.V.     DWF
 --------------------               (ha)      (cms)    (hrs)    (mm)    (cms)
              ID1 01:0300           3.02       .439    10.00  201.92     .000
             +ID2 05:009001        98.23     10.217    11.00  187.83     .000
              ====================================================
              SUM 06:009002       101.25     10.534    11.00  188.25     .000

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

 ----------------------------------------------------------------------------
 001:0014--------------------------------------------------------------------
 ***************************************************************************
 **
 **  External North East Block 400
 **
 ***************************************************************************
 ----------------------
 | CALIB STANDHYD      |    Area      (ha)=     4.66
 | 01:0400   DT= 5.00 |    Total Imp(%)=    75.00    Dir. Conn.(%)=    65.00
 ----------------------
                              IMPERVIOUS     PERVIOUS (i)
     Surface Area      (ha)=        3.49          1.16
     Dep. Storage      (mm)=        2.50          2.50
     Average Slope      (%)=        2.00          2.00
     Length             (m)=      152.00         40.00
     Mannings n            =        .013          .250

     Max.eff.Inten.(mm/hr)=        52.75         72.65
                over (min)          6.00         12.00
     Storage Coeff.   (min)=        3.45 (ii)    11.47 (ii)
     Unit Hyd. Tpeak  (min)=        6.00         12.00
     Unit Hyd. peak   (cms)=         .23           .10
                                                              *TOTALS*
     PEAK FLOW        (cms)=         .44           .23           .677 (iii)
     TIME TO PEAK     (hrs)=       10.00         10.00         10.000
     RUNOFF VOLUME     (mm)=      208.77        189.23        201.931
     TOTAL RAINFALL    (mm)=      211.27        211.27        211.270
     RUNOFF COEFFICIENT   =          .99           .90           .956
      *** WARNING: Storage Coefficient is smaller than DT!
                   Use a smaller DT or a larger area.

     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
          CN* =  89.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
          THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

 ----------------------------------------------------------------------------
 001:0015--------------------------------------------------------------------
 --------------------
 | ADD HYD (009003) | ID: NHYD      AREA      QPEAK    TPEAK    R.V.     DWF
 --------------------               (ha)      (cms)    (hrs)    (mm)    (cms)
              ID1 01:0400           4.66       .677    10.00  201.93     .000
             +ID2 06:009002       101.25     10.534    11.00  188.25     .000
              ====================================================
              SUM 07:009003       105.91     11.024    11.00  188.85     .000

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

 ----------------------------------------------------------------------------
 001:0016--------------------------------------------------------------------
 ***************************************************************************
 **  SNOEK
 **  Area reduced from 10.8 hectares to 2.88 hectares as per MTM
 **  Paved/Landscape         502
 ***************************************************************************
 ----------------------
 | CALIB STANDHYD      |    Area      (ha)=     2.88
 | 02:0502   DT= 5.00 |    Total Imp(%)=    80.00    Dir. Conn.(%)=    75.00
 ----------------------
                              IMPERVIOUS     PERVIOUS (i)
     Surface Area      (ha)=        2.30           .58
     Dep. Storage      (mm)=        2.50          2.50
     Average Slope      (%)=        2.00          2.00
     Length             (m)=      120.00         30.00
     Mannings n            =        .013          .250

     Max.eff.Inten.(mm/hr)=        52.75         64.63
                over (min)          6.00         12.00
     Storage Coeff.   (min)=        2.99 (ii)    10.06 (ii)
     Unit Hyd. Tpeak  (min)=        6.00         12.00
     Unit Hyd. peak   (cms)=         .25           .10
                                                              *TOTALS*
     PEAK FLOW        (cms)=         .32           .10           .419 (iii)
     TIME TO PEAK     (hrs)=        9.80         10.00         10.000
     RUNOFF VOLUME     (mm)=      208.77        186.85        203.289
     TOTAL RAINFALL    (mm)=      211.27        211.27        211.270
     RUNOFF COEFFICIENT   =          .99           .88           .962
      *** WARNING: Storage Coefficient is smaller than DT!
                   Use a smaller DT or a larger area.

     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
          CN* =  89.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
          THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

 ----------------------------------------------------------------------------
 001:0017--------------------------------------------------------------------
 --------------------
 | ADD HYD (009004) | ID: NHYD      AREA      QPEAK    TPEAK    R.V.     DWF
 --------------------               (ha)      (cms)    (hrs)    (mm)    (cms)
              ID1 07:009003       105.91     11.024    11.00  188.85     .000
             +ID2 02:0502           2.88       .419    10.00  203.29     .000
              ====================================================
              SUM 08:009004       108.79     11.327    11.00  189.23     .000

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

 ----------------------------------------------------------------------------
 001:0018--------------------------------------------------------------------
 ***************************************************************************
 **  Internal South East Block 600
 **  Roof                    601
 **  Paved/Landscape         602
 ***************************************************************************
 ----------------------
 | CALIB STANDHYD      |    Area      (ha)=     6.72
 | 01:0601   DT= 5.00 |    Total Imp(%)=    95.00    Dir. Conn.(%)=    90.00
 ----------------------
                              IMPERVIOUS     PERVIOUS (i)
     Surface Area      (ha)=        6.38           .34
     Dep. Storage      (mm)=        2.50          2.50
     Average Slope      (%)=        2.00          2.00
     Length             (m)=      211.00         30.00
     Mannings n            =        .013          .250

     Max.eff.Inten.(mm/hr)=        52.75        104.60
                over (min)          6.00         12.00
     Storage Coeff.   (min)=        4.19 (ii)    10.03 (ii)
     Unit Hyd. Tpeak  (min)=        6.00         12.00
     Unit Hyd. peak   (cms)=         .22           .10
                                                              *TOTALS*
     PEAK FLOW        (cms)=         .89           .10           .983 (iii)
     TIME TO PEAK     (hrs)=       10.00         10.00         10.000
     RUNOFF VOLUME     (mm)=      208.77        195.42        207.435
     TOTAL RAINFALL    (mm)=      211.27        211.27        211.270
     RUNOFF COEFFICIENT   =          .99           .92           .982
      *** WARNING: Storage Coefficient is smaller than DT!
                   Use a smaller DT or a larger area.

     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
          CN* =  89.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
          THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

 ----------------------------------------------------------------------------
 001:0019--------------------------------------------------------------------
 ***************************************************************************
 **  Control roof release to 42 l/s/ha for Area 601
 ***************************************************************************
 ----------------------
 | ROUTE RESERVOIR     |      Requested routing time step =  5.0 min.
 | IN>01:(0601  )      |
 | OUT<03:(008601)     |     =========  OUTFLOW STORAGE TABLE  =========
 ----------------------       OUTFLOW    STORAGE   |   OUTFLOW    STORAGE
                               (cms)     (ha.m.)   |    (cms)     (ha.m.)
                                .000   .0000E+00   |     .250   .3400E+00
                                .050   .5000E-01   |     .280   .3800E+00
      *** WARNING: STORAGE-Q values were extrapolated.
                   Increase curve or use overflow option.

     ROUTING RESULTS          AREA      QPEAK      TPEAK        R.V.
```

```
      --------------------          (ha)      (cms)      (hrs)       (mm)
      INFLOW >01: (0601  )          6.72       .983     10.000    207.435
      OUTFLOW<03: (008601)          6.72       .473     11.100    207.434

                      PEAK    FLOW    REDUCTION [Qout/Qin](%)=    48.093
                      TIME SHIFT OF PEAK FLOW          (min)=     66.00
                      MAXIMUM   STORAGE   USED       (ha.m.)=.6390E+00

 --------------------------------------------------------------------------
 001:0020------------------------------------------------------------------
 ---------------------
 | CALIB STANDHYD      |    Area     (ha)=     6.72
 | 02:0602    DT= 5.00 |    Total Imp(%)=     80.00    Dir. Conn.(%)=    75.00
 ---------------------
                                  IMPERVIOUS      PERVIOUS (i)
      Surface Area        (ha)=       5.38            1.34
      Dep. Storage        (mm)=       2.50            2.50
      Average Slope       (%)=        2.00            2.00
      Length              (m)=      189.00           30.00
      Mannings n           =          .013            .250

      Max.eff.Inten.(mm/hr)=         52.75           64.63
                 over (min)           6.00           12.00
      Storage Coeff.   (min)=         3.93 (ii)      11.00 (ii)
      Unit Hyd. Tpeak  (min)=         6.00           12.00
      Unit Hyd. peak   (cms)=          .22             .10
                                                                *TOTALS*
      PEAK FLOW         (cms)=         .74             .24          .978 (iii)
      TIME TO PEAK      (hrs)=       10.00           10.00        10.000
      RUNOFF VOLUME     (mm)=       208.77          186.85       203.289
      TOTAL RAINFALL    (mm)=       211.27          211.27       211.270
      RUNOFF COEFFICIENT  =            .99             .88          .962
       *** WARNING: Storage Coefficient is smaller than DT!
                    Use a smaller DT or a larger area.

        (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
             CN* =  89.0     Ia = Dep. Storage  (Above)
       (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
             THAN THE STORAGE COEFFICIENT.
      (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

 --------------------------------------------------------------------------
 001:0021------------------------------------------------------------------
 -------------------
 | ADD HYD (000600) | ID: NHYD      AREA      QPEAK     TPEAK     R.V.     DWF
 -------------------                 (ha)      (cms)     (hrs)     (mm)    (cms)
                    ID1 03:008601    6.72       .473     11.10 207.43    .000
                   +ID2 02:0602      6.72       .978     10.00 203.29    .000
                    ==================================================
                    SUM 04:000600   13.44      1.368     10.00 205.36    .000

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

 --------------------------------------------------------------------------
 001:0022------------------------------------------------------------------
 **************************************************************************
 **  Control release to 150 l/s/ha for Area 600
 **************************************************************************
 ---------------------
 | ROUTE RESERVOIR    |     Requested routing time step =   5.0 min.
 |   IN>04:(000600)   |
 | OUT<05:(008002)    |     =========  OUTLFOW STORAGE TABLE  =========
 ---------------------      OUTFLOW    STORAGE   |   OUTFLOW     STORAGE
                             (cms)     (ha.m.)   |    (cms)      (ha.m.)
                              .000   .0000E+00   |    1.970   .1000E+00
                              .500   .5000E-01   |    2.020   .1200E+00

      ROUTING RESULTS               AREA      QPEAK      TPEAK        R.V.
      --------------------          (ha)      (cms)      (hrs)       (mm)
      INFLOW >04: (000600)         13.44      1.368     10.000    205.362
      OUTFLOW<05: (008002)         13.44      1.351     10.000    205.362

                      PEAK    FLOW    REDUCTION [Qout/Qin](%)=    98.758
                      TIME SHIFT OF PEAK FLOW          (min)=       .00
                      MAXIMUM   STORAGE   USED       (ha.m.)=.7926E-01

 --------------------------------------------------------------------------
 001:0023------------------------------------------------------------------
 -------------------
 | ADD HYD (009005) | ID: NHYD      AREA      QPEAK     TPEAK     R.V.     DWF
 -------------------                 (ha)      (cms)     (hrs)     (mm)    (cms)
                    ID1 08:009004  108.79     11.327     11.00 189.23    .000
                   +ID2 05:008002   13.44      1.351     10.00 205.36    .000
                    ==================================================
                    SUM 09:009005  122.23     12.500     11.00 191.01    .000

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

 --------------------------------------------------------------------------
 001:0024------------------------------------------------------------------
 **************************************************************************
 **   Internal South East Block 700
 **   Roof                        701
 **   Paved/Landscape             702
 **************************************************************************
 ---------------------
 | CALIB STANDHYD      |    Area     (ha)=     6.63
 | 03:0701    DT= 3.00 |    Total Imp(%)=     95.00    Dir. Conn.(%)=    90.00
 ---------------------
                                  IMPERVIOUS      PERVIOUS (i)
      Surface Area        (ha)=       6.30             .33
      Dep. Storage        (mm)=       2.50            2.50
      Average Slope       (%)=        2.00            2.00
      Length              (m)=      210.00           30.00
      Mannings n           =          .013            .250

      Max.eff.Inten.(mm/hr)=         52.75          104.61
                 over (min)           3.00            9.00
      Storage Coeff.   (min)=         4.18 (ii)      10.02 (ii)
      Unit Hyd. Tpeak  (min)=         3.00            9.00
      Unit Hyd. peak   (cms)=          .29             .12
                                                                *TOTALS*
      PEAK FLOW         (cms)=         .87             .10          .970 (iii)
      TIME TO PEAK      (hrs)=       10.00           10.00        10.000
      RUNOFF VOLUME     (mm)=       208.77          195.42       207.435
      TOTAL RAINFALL    (mm)=       211.27          211.27       211.270
      RUNOFF COEFFICIENT  =            .99             .92          .982

        (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
             CN* =  89.0     Ia = Dep. Storage  (Above)
       (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
             THAN THE STORAGE COEFFICIENT.
      (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

 --------------------------------------------------------------------------
 001:0025------------------------------------------------------------------
 **************************************************************************
```

```
 **  Control roof release to 42 l/s/ha for Area 701
 **************************************************************************
 ---------------------
 | ROUTE RESERVOIR    |     Requested routing time step =   3.0 min.
 |   IN>03:(0701   )  |
 | OUT<04:(008701)    |     =========  OUTLFOW STORAGE TABLE  =========
 ---------------------      OUTFLOW    STORAGE   |   OUTFLOW     STORAGE
                             (cms)     (ha.m.)   |    (cms)      (ha.m.)
                              .000   .0000E+00   |     .240   .3700E+00
                              .050   .5000E-01   |     .270   .3900E+00
       *** WARNING: STORAGE-Q values were extrapolated.
                    Increase curve or use overflow option.

      ROUTING RESULTS               AREA      QPEAK      TPEAK        R.V.
      --------------------          (ha)      (cms)      (hrs)       (mm)
      INFLOW >03: (0701  )          6.63       .970     10.000    207.435
      OUTFLOW<04: (008701)          6.63       .581     11.050    207.434

                      PEAK    FLOW    REDUCTION [Qout/Qin](%)=    59.912
                      TIME SHIFT OF PEAK FLOW          (min)=     63.00
                      MAXIMUM   STORAGE   USED       (ha.m.)=.5985E+00

 --------------------------------------------------------------------------
 001:0026------------------------------------------------------------------
 **************************************************************************
 **   Divert Flow to Culvert 7
 **   'clean' roof runoff
 **************************************************************************
 ----------------------
 | COMPUTE DUALHYD      |   Average inlet capacities    [CINLET] =    .080  (cms)
 | TotalHyd 04:008701   |   Number of inlets in system  [NINLET] =       1
 ----------------------     Total minor system capacity          =    .080  (cms)
                            Total major system storage [TMJSTO]  =      0.(cu.m.)

                    ID: NHYD        AREA       QPEAK      TPEAK      R.V.      DWF
                                    (ha)       (cms)      (hrs)      (mm)     (cms)
     TOTAL HYD.    04:008701        6.63        .581     11.050   207.434     .000
     ==========================================================================
     MAJOR SYST    02:007002        3.89        .501     11.050   207.434     .000
     MINOR SYST    10:007001        2.74        .080      3.800   207.436     .000

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

 --------------------------------------------------------------------------
 001:0027------------------------------------------------------------------
 ---------------------
 | CALIB STANDHYD      |    Area     (ha)=     6.62
 | 01:000702 DT= 3.00  |    Total Imp(%)=     80.00    Dir. Conn.(%)=    75.00
 ---------------------
                                  IMPERVIOUS      PERVIOUS (i)
      Surface Area        (ha)=       5.30            1.32
      Dep. Storage        (mm)=       2.50            2.50
      Average Slope       (%)=        2.00            2.00
      Length              (m)=      187.00           30.00
      Mannings n           =          .013            .250

      Max.eff.Inten.(mm/hr)=         52.75           64.63
                 over (min)           3.00           12.00
      Storage Coeff.   (min)=         3.90 (ii)      10.97 (ii)
      Unit Hyd. Tpeak  (min)=         3.00           12.00
      Unit Hyd. peak   (cms)=          .30             .10
                                                                *TOTALS*
      PEAK FLOW         (cms)=         .73             .24          .963 (iii)
      TIME TO PEAK      (hrs)=       10.00           10.00        10.000
      RUNOFF VOLUME     (mm)=       208.77          186.85       203.289
      TOTAL RAINFALL    (mm)=       211.27          211.27       211.270
      RUNOFF COEFFICIENT  =            .99             .88          .962

        (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
             CN* =  89.0     Ia = Dep. Storage  (Above)
       (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
             THAN THE STORAGE COEFFICIENT.
      (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

 --------------------------------------------------------------------------
 001:0028------------------------------------------------------------------
 -------------------
 | ADD HYD (000700) | ID: NHYD      AREA      QPEAK     TPEAK     R.V.     DWF
 -------------------                 (ha)      (cms)     (hrs)     (mm)    (cms)
                    ID1 01:000702    6.62       .963     10.00 203.29    .000
                   +ID2 02:007002    3.89       .501     11.05 207.43    .000
                    ==================================================
                    SUM 05:000700   10.51      1.366     10.00 204.82    .000

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

 --------------------------------------------------------------------------
 001:0029------------------------------------------------------------------
 **************************************************************************
 **  Control release to 150 l/s/ha for Area 700
 **************************************************************************
 ---------------------
 | ROUTE RESERVOIR    |     Requested routing time step =   3.0 min.
 |   IN>05:(000700)   |
 | OUT<06:(008003)    |     =========  OUTLFOW STORAGE TABLE  =========
 ---------------------      OUTFLOW    STORAGE   |   OUTFLOW     STORAGE
                             (cms)     (ha.m.)   |    (cms)      (ha.m.)
                              .000   .0000E+00   |    1.930   .9000E-01
                              .500   .4000E-01   |    1.980   .1100E+00

      ROUTING RESULTS               AREA      QPEAK      TPEAK        R.V.
      --------------------          (ha)      (cms)      (hrs)       (mm)
      INFLOW >05: (000700)         10.51      1.366     10.000    204.824
      OUTFLOW<06: (008003)         10.51      1.337     10.000    204.824

                      PEAK    FLOW    REDUCTION [Qout/Qin](%)=    97.896
                      TIME SHIFT OF PEAK FLOW          (min)=       .00
                      MAXIMUM   STORAGE   USED       (ha.m.)=.6954E-01

 --------------------------------------------------------------------------
 001:0030------------------------------------------------------------------
 -------------------
 | ADD HYD (009006) | ID: NHYD      AREA      QPEAK     TPEAK     R.V.     DWF
 -------------------                 (ha)      (cms)     (hrs)     (mm)    (cms)
                    ID1 06:008003   10.51      1.337     10.00 204.82    .000
                   +ID2 09:009005  122.23     12.500     11.00 191.01    .000
                    ==================================================
                    SUM 01:009006  132.74     13.692     11.00 192.10    .000

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

 --------------------------------------------------------------------------
 001:0031------------------------------------------------------------------
 **************************************************************************
 **
 **   Internal SWM Facility Block 800
 **
```

```
*****************************************************************************
---------------------
| CALIB NASHYD      |   Area      (ha)=    2.75   Curve Number   (CN)=89.00
| 02:0800  DT=12.00 |   Ia        (mm)=   2.500   # of Linear Res.(N)= 3.00
---------------------   U.H. Tp(hrs)=     1.000

    Unit Hyd Qpeak  (cms)=      .105

    PEAK FLOW        (cms)=      .287 (i)
    TIME TO PEAK     (hrs)=    11.000
    RUNOFF VOLUME     (mm)=   181.480
    TOTAL RAINFALL    (mm)=   211.270
    RUNOFF COEFFICIENT   =       .859

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

-----------------------------------------------------------------------------
001:0032---------------------------------------------------------------------
---------------------
| ADD HYD (009011) | ID: NHYD      AREA     QPEAK    TPEAK    R.V.     DWF
---------------------               (ha)     (cms)    (hrs)    (mm)    (cms)
            ID1 02:0800            2.75      .287    11.00  181.48     .000
           +ID2 01:009006        132.74    13.692    11.00  192.10     .000
            =================================================================
            SUM 04:009011        135.49    13.979    11.00  191.89     .000

  NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-----------------------------------------------------------------------------
001:0033---------------------------------------------------------------------
---------------------
| ROUTE RESERVOIR    |     Requested routing time step =   3.0 min.
| IN>04:(009011)     |
| OUT<05:(006000)    |     =========  OUTFLOW STORAGE TABLE  =========
---------------------       OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
                             (cms)     (ha.m.)   |   (cms)     (ha.m.)
                              .000   .0000E+00   |   1.203   .2885E+01
                              .039   .2870E+00   |   1.488   .3288E+01
                              .090   .5890E+00   |   1.724   .3704E+01
                              .120   .9040E+00   |   1.929   .4133E+01
                              .144   .1234E+01   |   2.113   .4575E+01
                              .165   .1578E+01   |   4.543   .4801E+01
                              .174   .1755E+01   |   8.990   .5030E+01
                              .246   .1935E+01   |  14.930   .5263E+01
                              .394   .2118E+01   |  21.860   .5499E+01
                              .776   .2496E+01   |  29.960   .5738E+01

  ROUTING RESULTS          AREA      QPEAK      TPEAK       R.V.
  --------------------     (ha)      (cms)      (hrs)       (mm)
  INFLOW >04: (009011)    135.49     13.979     11.000     191.885
  OUTFLOW<05: (006000)    135.49     13.864     11.000     191.883

      PEAK  FLOW   REDUCTION [Qout/Qin](%)=    99.179
      TIME SHIFT OF PEAK FLOW         (min)=      .00
      MAXIMUM  STORAGE   USED       (ha.m.)=.5222E+01

-----------------------------------------------------------------------------
001:0034---------------------------------------------------------------------
*****************************************************************************
**
**  Total controled release Diversion plus SWM Facility
**
*****************************************************************************
---------------------
| ADD HYD (009100) | ID: NHYD      AREA     QPEAK    TPEAK    R.V.     DWF
---------------------               (ha)     (cms)    (hrs)    (mm)    (cms)
            ID1 05:006000        135.49    13.864    11.00  191.88     .000
           +ID2 10:007001          2.74      .080     3.80  207.44     .000
            =================================================================
            SUM 09:009100        138.23    13.944    11.00  192.19     .000

  NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-----------------------------------------------------------------------------
001:0035---------------------------------------------------------------------
*****************************************************************************
**  Output Facility IN/OUT Hydrographs
*****************************************************************************
---------------------
| SAVE HYD           |    AREA       (ha)=  135.492
| ID=04 (009011)     |    QPEAK     (cms)=   13.979 (i)
| DT= 3.00 PCYC= 1   |    TPEAK     (hrs)=   11.000
---------------------     VOLUME     (mm)=  191.865
  Filename: P:\SWM\03211--1\FEB200-1\H-009011.001
  Comments: 03211 Pond In

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

TIME hrs	FLOW cms	TIME hrs	FLOW cms	TIME hrs	FLOW cms	TIME hrs	FLOW cms	TIME hrs	FLOW cms
.00	.000	9.50	9.975	19.00	.192	28.50	.009	38.00	.000
.05	.000	9.55	10.274	19.05	.190	28.55	.009	38.05	.000
.10	.000	9.60	10.561	19.10	.188	28.60	.009	38.10	.000
.15	.000	9.65	10.867	19.15	.185	28.65	.009	38.15	.000
.20	.000	9.70	11.165	19.20	.183	28.70	.008	38.20	.000
.25	.000	9.75	11.452	19.25	.181	28.75	.008	38.25	.000
.30	.000	9.80	11.735	19.30	.179	28.80	.008	38.30	.000
.35	.005	9.85	12.023	19.35	.177	28.85	.008	38.35	.000
.40	.010	9.90	12.307	19.40	.175	28.90	.008	38.40	.000
.45	.090	9.95	12.587	19.45	.173	28.95	.008	38.45	.000
.50	.181	10.00	12.863	19.50	.171	29.00	.008	38.50	.000
.55	.231	10.05	12.878	19.55	.169	29.05	.007	38.55	.000
.60	.282	10.10	12.824	19.60	.167	29.10	.007	38.60	.000
.65	.322	10.15	12.837	19.65	.165	29.15	.007	38.65	.000
.70	.360	10.20	12.852	19.70	.163	29.20	.007	38.70	.000
.75	.392	10.25	12.888	19.75	.161	29.25	.007	38.75	.000
.80	.421	10.30	12.941	19.80	.159	29.30	.007	38.80	.000
.85	.448	10.35	13.032	19.85	.157	29.35	.007	38.85	.000
.90	.472	10.40	13.135	19.90	.155	29.40	.007	38.90	.000
.95	.494	10.45	13.215	19.95	.153	29.45	.006	38.95	.000
1.00	.515	10.50	13.301	20.00	.152	29.50	.006	39.00	.000
1.05	.507	10.55	13.398	20.05	.150	29.55	.006	39.05	.000
1.10	.494	10.60	13.499	20.10	.148	29.60	.006	39.10	.000
1.15	.494	10.65	13.567	20.15	.146	29.65	.006	39.15	.000
1.20	.492	10.70	13.638	20.20	.145	29.70	.006	39.20	.000
1.25	.494	10.75	13.711	20.25	.143	29.75	.006	39.25	.000
1.30	.496	10.80	13.785	20.30	.141	29.80	.006	39.30	.000
1.35	.500	10.85	13.833	20.35	.140	29.85	.006	39.35	.000
1.40	.504	10.90	13.881	20.40	.138	29.90	.006	39.40	.000
1.45	.509	10.95	13.930	20.45	.136	29.95	.005	39.45	.000
1.50	.516	11.00	13.979	20.50	.135	30.00	.005	39.50	.000
1.55	.522	11.05	13.573	20.55	.133	30.05	.005	39.55	.000
1.60	.529	11.10	13.055	20.60	.131	30.10	.005	39.60	.000
1.65	.537	11.15	12.656	20.65	.130	30.15	.005	39.65	.000
1.70	.545	11.20	12.264	20.70	.128	30.20	.005	39.70	.000
1.75	.553	11.25	11.926	20.75	.127	30.25	.005	39.75	.000
1.80	.561	11.30	11.620	20.80	.125	30.30	.005	39.80	.000
1.85	.570	11.35	11.384	20.85	.123	30.35	.005	39.85	.000
1.90	.578	11.40	11.171	20.90	.122	30.40	.005	39.90	.000
1.95	.587	11.45	10.951	20.95	.120	30.45	.005	39.95	.000
2.00	.596	11.50	10.745	21.00	.118	30.50	.004	40.00	.000
2.05	.634	11.55	10.560	21.05	.117	30.55	.004	40.05	.000
2.10	.676	11.60	10.382	21.10	.115	30.60	.004	40.10	.000
2.15	.705	11.65	10.191	21.15	.114	30.65	.004	40.15	.000
2.20	.734	11.70	10.004	21.20	.112	30.70	.004	40.20	.000
2.25	.761	11.75	9.823	21.25	.111	30.75	.004	40.25	.000
2.30	.787	11.80	9.646	21.30	.109	30.80	.004	40.30	.000
2.35	.810	11.85	9.465	21.35	.108	30.85	.004	40.35	.000
2.40	.833	11.90	9.285	21.40	.106	30.90	.004	40.40	.000
2.45	.855	11.95	9.109	21.45	.105	30.95	.004	40.45	.000
2.50	.876	12.00	8.934	21.50	.103	31.00	.004	40.50	.000
2.55	.897	12.05	8.546	21.55	.102	31.05	.004	40.55	.000
2.60	.916	12.10	8.104	21.60	.100	31.10	.004	40.60	.000
2.65	.936	12.15	7.726	21.65	.099	31.15	.004	40.65	.000
2.70	.955	12.20	7.370	21.70	.098	31.20	.003	40.70	.000
2.75	.974	12.25	7.066	21.75	.096	31.25	.003	40.75	.000
2.80	.992	12.30	6.772	21.80	.095	31.30	.003	40.80	.000
2.85	1.010	12.35	6.504	21.85	.094	31.35	.003	40.85	.000
2.90	1.028	12.40	6.247	21.90	.092	31.40	.003	40.90	.000
2.95	1.045	12.45	5.999	21.95	.091	31.45	.003	40.95	.000
3.00	1.063	12.50	5.758	22.00	.090	31.50	.003	41.00	.000
3.05	1.168	12.55	5.526	22.05	.089	31.55	.003	41.05	.000
3.10	1.287	12.60	5.299	22.10	.087	31.60	.003	41.10	.000
3.15	1.366	12.65	5.084	22.15	.086	31.65	.003	41.15	.000
3.20	1.447	12.70	4.872	22.20	.085	31.70	.003	41.20	.000
3.25	1.522	12.75	4.673	22.25	.084	31.75	.003	41.25	.000
3.30	1.595	12.80	4.482	22.30	.083	31.80	.003	41.30	.000
3.35	1.659	12.85	4.308	22.35	.082	31.85	.003	41.35	.000
3.40	1.720	12.90	4.134	22.40	.080	31.90	.003	41.40	.000
3.45	1.782	12.95	3.962	22.45	.079	31.95	.003	41.45	.000
3.50	1.841	13.00	3.790	22.50	.078	32.00	.003	41.50	.000
3.55	1.896	13.05	3.637	22.55	.077	32.05	.003	41.55	.000
3.60	1.950	13.10	3.485	22.60	.076	32.10	.002	41.60	.000
3.65	2.004	13.15	3.334	22.65	.074	32.15	.002	41.65	.000
3.70	2.057	13.20	3.163	22.70	.073	32.20	.002	41.70	.000
3.75	2.107	13.25	3.052	22.75	.072	32.25	.002	41.75	.000
3.80	2.157	13.30	2.923	22.80	.071	32.30	.002	41.80	.000
3.85	2.207	13.35	2.794	22.85	.069	32.35	.002	41.85	.000
3.90	2.264	13.40	2.666	22.90	.068	32.40	.002	41.90	.000
3.95	2.318	13.45	2.558	22.95	.067	32.45	.002	41.95	.000
4.00	2.369	13.50	2.450	23.00	.066	32.50	.002	42.00	.000
4.05	2.480	13.55	2.343	23.05	.065	32.55	.002	42.05	.000
4.10	2.605	13.60	2.237	23.10	.064	32.60	.002	42.10	.000
4.15	2.706	13.65	2.148	23.15	.063	32.65	.002	42.15	.000
4.20	2.807	13.70	2.059	23.20	.063	32.70	.002	42.20	.000
4.25	2.899	13.75	1.970	23.25	.060	32.75	.002	42.25	.000
4.30	2.987	13.80	1.882	23.30	.059	32.80	.002	42.30	.000
4.35	3.067	13.85	1.809	23.35	.058	32.85	.002	42.35	.000
4.40	3.143	13.90	1.736	23.40	.057	32.90	.002	42.40	.000
4.45	3.216	13.95	1.664	23.45	.056	32.95	.002	42.45	.000
4.50	3.288	14.00	1.592	23.50	.055	33.00	.002	42.50	.000
4.55	3.356	14.05	1.533	23.55	.054	33.05	.002	42.55	.000
4.60	3.423	14.10	1.473	23.60	.053	33.10	.002	42.60	.000
4.65	3.489	14.15	1.415	23.65	.052	33.15	.002	42.65	.000
4.70	3.554	14.20	1.356	23.70	.051	33.20	.002	42.70	.000
4.75	3.617	14.25	1.308	23.75	.050	33.25	.002	42.75	.000
4.80	3.679	14.30	1.260	23.80	.050	33.30	.002	42.80	.000
4.85	3.740	14.35	1.213	23.85	.049	33.35	.002	42.85	.000
4.90	3.800	14.40	1.165	23.90	.048	33.40	.002	42.90	.000
4.95	3.859	14.45	1.127	23.95	.047	33.45	.002	42.95	.000
5.00	3.918	14.50	1.088	24.00	.046	33.50	.002	43.00	.000
5.05	3.911	14.55	1.050	24.05	.045	33.55	.001	43.05	.000
5.10	3.889	14.60	1.011	24.10	.044	33.60	.001	43.10	.000
5.15	3.888	14.65	.980	24.15	.044	33.65	.001	43.15	.000
5.20	3.887	14.70	.948	24.20	.043	33.70	.001	43.20	.000
5.25	3.887	14.75	.917	24.25	.042	33.75	.001	43.25	.000
5.30	3.893	14.80	.885	24.30	.041	33.80	.001	43.30	.000
5.35	3.906	14.85	.859	24.35	.041	33.85	.001	43.35	.000
5.40	3.922	14.90	.834	24.40	.040	33.90	.001	43.40	.000
5.45	3.933	14.95	.808	24.45	.039	33.95	.001	43.45	.000
5.50	3.947	15.00	.783	24.50	.039	34.00	.001	43.50	.000
5.55	3.964	15.05	.762	24.55	.038	34.05	.001	43.55	.000
5.60	3.982	15.10	.741	24.60	.037	34.10	.001	43.60	.000
5.65	3.994	15.15	.720	24.65	.037	34.15	.001	43.65	.000
5.70	4.007	15.20	.699	24.70	.036	34.20	.001	43.70	.000
5.75	4.021	15.25	.682	24.75	.035	34.25	.001	43.75	.000
5.80	4.036	15.30	.665	24.80	.035	34.30	.001	43.80	.000
5.85	4.046	15.35	.648	24.85	.034	34.35	.001	43.85	.000
5.90	4.056	15.40	.631	24.90	.033	34.40	.001	43.90	.000
5.95	4.067	15.45	.616	24.95	.033	34.45	.001	43.95	.000
6.00	4.078	15.50	.602	25.00	.032	34.50	.001	44.00	.000
6.05	4.244	15.55	.588	25.05	.032	34.55	.001	44.05	.000
6.10	4.448	15.60	.573	25.10	.031	34.60	.001	44.10	.000
6.15	4.598	15.65	.561	25.15	.030	34.65	.001	44.15	.000
6.20	4.747	15.70	.550	25.20	.030	34.70	.001	44.20	.000
6.25	4.881	15.75	.538	25.25	.029	34.75	.001	44.25	.000
6.30	5.004	15.80	.526	25.30	.029	34.80	.001	44.30	.000
6.35	5.120	15.85	.516	25.35	.028	34.85	.001	44.35	.000
6.40	5.227	15.90	.505	25.40	.028	34.90	.001	44.40	.000
6.45	5.328	15.95	.495	25.45	.027	34.95	.001	44.45	.000
6.50	5.423	16.00	.485	25.50	.027	35.00	.001	44.50	.000
6.55	5.502	16.05	.476	25.55	.026	35.05	.001	44.55	.000
6.60	5.577	16.10	.467	25.60	.026	35.10	.001	44.60	.000
6.65	5.654	16.15	.458	25.65	.025	35.15	.001	44.65	.000
6.70	5.729	16.20	.450	25.70	.025	35.20	.001	44.70	.000
6.75	5.800	16.25	.442	25.75	.025	35.25	.001	44.75	.000
6.80	5.876	16.30	.434	25.80	.024	35.30	.001	44.80	.000
6.85	5.950	16.35	.426	25.85	.024	35.35	.001	44.85	.000
6.90	6.022	16.40	.418	25.90	.023	35.40	.001	44.90	.000
6.95	6.091	16.45	.411	25.95	.023	35.45	.001	44.95	.000
7.00	6.160	16.50	.404	26.00	.022	35.50	.001	45.00	.000
7.05	6.048	16.55	.397	26.05	.022	35.55	.001	45.05	.000
7.10	5.896	16.60	.390	26.10	.022	35.60	.001	45.10	.000
7.15	5.804	16.65	.384	26.15	.021	35.65	.001	45.15	.000
7.20	5.712	16.70	.378	26.20	.021	35.70	.001	45.20	.000
7.25	5.643	16.75	.372	26.25	.021	35.75	.001	45.25	.000
7.30	5.585	16.80	.366	26.30	.020	35.80	.001	45.30	.000
7.35	5.558	16.85	.361	26.35	.020	35.85	.001	45.35	.000
7.40	5.539	16.90	.355	26.40	.019	35.90	.001	45.40	.000
7.45	5.510	16.95	.350	26.45	.019	35.95	.001	45.45	.000
7.50	5.487	17.00	.344	26.50	.019	36.00	.001	45.50	.000
7.55	5.471	17.05	.339	26.55	.018	36.05	.001	45.55	.000
7.60	5.458	17.10	.334	26.60	.018	36.10	.001	45.60	.000
7.65	5.434	17.15	.329	26.65	.018	36.15	.001	45.65	.000
7.70	5.412	17.20	.324	26.70	.017	36.20	.001	45.70	.000
7.75	5.393	17.25	.319	26.75	.017	36.25	.001	45.75	.000
7.80	5.375	17.30	.314	26.80	.017	36.30	.001	45.80	.000
7.85	5.350	17.35	.309	26.85	.017	36.35	.001	45.85	.000
7.90	5.326	17.40	.303	26.90	.016	36.40	.001	45.90	.000
7.95	5.302	17.45	.299	26.95	.016	36.45	.001	45.95	.000
8.00	5.280	17.50	.295	27.00	.016	36.50	.001	46.00	.000
8.05	5.254	17.55	.290	27.05	.015	36.55	.001	46.05	.000
8.10	5.228	17.60	.286	27.10	.015	36.60	.000	46.10	.000
8.15	5.203	17.65	.282	27.15	.015	36.65	.000	46.15	.000
8.20	5.178	17.70	.278	27.20	.015	36.70	.000	46.20	.000

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     8.25    5.152|   17.75    .274|   27.25    .014|   36.75    .000|   46.25    .000
     8.30    5.127|   17.80    .270|   27.30    .014|   36.80    .000|   46.30    .000
     8.35    5.102|   17.85    .266|   27.35    .014|   36.85    .000|   46.35    .000
     8.40    5.077|   17.90    .262|   27.40    .014|   36.90    .000|   46.40    .000
     8.45    5.054|   17.95    .258|   27.45    .013|   36.95    .000|   46.45    .000
     8.50    5.031|   18.00    .254|   27.50    .013|   37.00    .000|   46.50    .000
     8.55    5.008|   18.05    .250|   27.55    .013|   37.05    .000|   46.55    .000
     8.60    4.985|   18.10    .246|   27.60    .013|   37.10    .000|   46.60    .000
     8.65    4.965|   18.15    .243|   27.65    .012|   37.15    .000|   46.65    .000
     8.70    4.945|   18.20    .239|   27.70    .012|   37.20    .000|   46.70    .000
     8.75    4.925|   18.25    .235|   27.75    .012|   37.25    .000|   46.75    .000
     8.80    4.905|   18.30    .232|   27.80    .012|   37.30    .000|   46.80    .000
     8.85    4.888|   18.35    .228|   27.85    .012|   37.35    .000|   46.85    .000
     8.90    4.871|   18.40    .225|   27.90    .011|   37.40    .000|   46.90    .000
     8.95    4.854|   18.45    .221|   27.95    .011|   37.45    .000|   46.95    .000
     9.00    4.837|   18.50    .218|   28.00    .011|   37.50    .000|   47.00    .000
     9.05    5.454|   18.55    .215|   28.05    .011|   37.55    .000|   47.05    .000
     9.10    6.215|   18.60    .212|   28.10    .011|   37.60    .000|   47.10    .000
     9.15    6.882|   18.65    .210|   28.15    .010|   37.65    .000|   47.15    .000
     9.20    7.560|   18.70    .207|   28.20    .010|   37.70    .000|   47.20    .000
     9.25    8.101|   18.75    .204|   28.25    .010|   37.75    .000|   47.25    .000
     9.30    8.583|   18.80    .202|   28.30    .010|   37.80    .000|   47.30    .000
     9.35    8.954|   18.85    .199|   28.35    .010|   37.85    .000|   47.35    .000
     9.40    9.297|   18.90    .197|   28.40    .009|   37.90    .000|   47.40    .000
     9.45    9.646|   18.95    .195|   28.45    .009|   37.95    .000|
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 001:0036--------------------------------------------------------------------------
 ---------------------
 | SAVE HYD            |    AREA     (ha)=     6.630
 | ID=03 (0701   )     |    QPEAK   (cms)=      .970 (i)
 | DT= 3.00 PCYC=  1   |    TPEAK   (hrs)=    10.000
 ---------------------      VOLUME   (mm)=   207.435
    Filename: P:\SWM\03211--1\FEB200~1\H-0701.001
    Comments: 03211 Pond Out

       (i)  PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.
    TIME    FLOW |  TIME    FLOW |  TIME    FLOW |  TIME    FLOW |  TIME    FLOW
     hrs     cms |   hrs     cms |   hrs     cms |   hrs     cms |   hrs     cms
     .00    .000|   2.70    .113|   5.40    .234|   8.10    .233|  10.80    .700
     .05    .000|   2.75    .113|   5.45    .233|   8.15    .233|  10.85    .700
     .10    .000|   2.80    .113|   5.50    .233|   8.20    .233|  10.90    .700
     .15    .000|   2.85    .113|   5.55    .233|   8.25    .233|  10.95    .700
     .20    .000|   2.90    .114|   5.60    .233|   8.30    .233|  11.00    .700
     .25    .000|   2.95    .114|   5.65    .233|   8.35    .233|  11.05    .482
     .30    .000|   3.00    .114|   5.70    .233|   8.40    .233|  11.10    .371
     .35    .000|   3.05    .168|   5.75    .233|   8.45    .233|  11.15    .310
     .40    .007|   3.10    .196|   5.80    .233|   8.50    .233|  11.20    .278
     .45    .058|   3.15    .211|   5.85    .233|   8.55    .233|  11.25    .260
     .50    .083|   3.20    .218|   5.90    .233|   8.60    .233|  11.30    .251
     .55    .095|   3.25    .223|   5.95    .233|   8.65    .233|  11.35    .245
     .60    .101|   3.30    .225|   6.00    .233|   8.70    .233|  11.40    .241
     .65    .104|   3.35    .226|   6.05    .323|   8.75    .233|  11.45    .239
     .70    .106|   3.40    .227|   6.10    .369|   8.80    .233|  11.50    .237
     .75    .107|   3.45    .228|   6.15    .394|   8.85    .233|  11.55    .236
     .80    .108|   3.50    .228|   6.20    .407|   8.90    .233|  11.60    .236
     .85    .108|   3.55    .229|   6.25    .415|   8.95    .233|  11.65    .235
     .90    .109|   3.60    .229|   6.30    .419|   9.00    .233|  11.70    .235
     .95    .109|   3.65    .229|   6.35    .421|   9.05    .578|  11.75    .235
    1.00    .109|   3.70    .230|   6.40    .423|   9.10    .754|  11.80    .234
    1.05    .091|   3.75    .230|   6.45    .424|   9.15    .850|  11.85    .234
    1.10    .082|   3.80    .230|   6.50    .424|   9.20    .901|  11.90    .234
    1.15    .078|   3.85    .230|   6.55    .425|   9.25    .928|  11.95    .234
    1.20    .076|   3.90    .230|   6.60    .425|   9.30    .944|  12.00    .234
    1.25    .075|   3.95    .230|   6.65    .425|   9.35    .953|  12.05    .125
    1.30    .074|   4.00    .230|   6.70    .425|   9.40    .958|  12.10    .069
    1.35    .074|   4.05    .267|   6.75    .426|   9.45    .962|  12.15    .038
    1.40    .074|   4.10    .285|   6.80    .426|   9.50    .964|  12.20    .022
    1.45    .074|   4.15    .295|   6.85    .426|   9.55    .966|  12.25    .013
    1.50    .074|   4.20    .300|   6.90    .426|   9.60    .967|  12.30    .008
    1.55    .074|   4.25    .303|   6.95    .426|   9.65    .968|  12.35    .006
    1.60    .074|   4.30    .305|   7.00    .426|   9.70    .969|  12.40    .004
    1.65    .074|   4.35    .306|   7.05    .336|   9.75    .969|  12.45    .003
    1.70    .074|   4.40    .307|   7.10    .290|   9.80    .970|  12.50    .002
    1.75    .074|   4.45    .307|   7.15    .265|   9.85    .970|  12.55    .001
    1.80    .074|   4.50    .307|   7.20    .251|   9.90    .970|  12.60    .001
    1.85    .074|   4.55    .308|   7.25    .244|   9.95    .970|  12.65    .001
    1.90    .074|   4.60    .308|   7.30    .240|  10.00    .970|  12.70    .001
    1.95    .074|   4.65    .308|   7.35    .238|  10.05    .843|  12.75    .000
    2.00    .074|   4.70    .308|   7.40    .236|  10.10    .779|  12.80    .000
    2.05    .093|   4.75    .308|   7.45    .235|  10.15    .743|  12.85    .000
    2.10    .102|   4.80    .308|   7.50    .235|  10.20    .725|  12.90    .000
    2.15    .107|   4.85    .309|   7.55    .234|  10.25    .715|  12.95    .000
    2.20    .109|   4.90    .309|   7.60    .234|  10.30    .709|  13.00    .000
    2.25    .111|   4.95    .309|   7.65    .234|  10.35    .706|  13.05    .000
    2.30    .112|   5.00    .309|   7.70    .234|  10.40    .704|  13.10    .000
    2.35    .112|   5.05    .273|   7.75    .234|  10.45    .702|  13.15    .000
    2.40    .112|   5.10    .254|   7.80    .234|  10.50    .701|  13.20    .000
    2.45    .113|   5.15    .245|   7.85    .234|  10.55    .701|  13.25    .000
    2.50    .113|   5.20    .239|   7.90    .233|  10.60    .700|  13.30    .000
    2.55    .113|   5.25    .237|   7.95    .233|  10.65    .700|  13.35    .000
    2.60    .113|   5.30    .235|   8.00    .233|  10.70    .700|
    2.65    .113|   5.35    .234|   8.05    .233|  10.75    .700|
 ----------------------------------------------------------------------------------
 001:0037--------------------------------------------------------------------------
      FINISH
 ----------------------------------------------------------------------------------
 **********************************************************************************
      WARNINGS / ERRORS / NOTES
      -------------------------
  001:0004 ROUTE RESERVOIR
      *** WARNING: STORAGE-Q values were extrapolated.
                   Increase curve or use overflow option.

  001:0010 CALIB STANDHYD
      *** WARNING: Storage Coefficient is smaller than DT!
                   Use a smaller DT or a larger area.

  001:0012 CALIB STANDHYD
      *** WARNING: Storage Coefficient is smaller than DT!
                   Use a smaller DT or a larger area.

  001:0014 CALIB STANDHYD
      *** WARNING: Storage Coefficient is smaller than DT!
                   Use a smaller DT or a larger area.

  001:0016 CALIB STANDHYD
      *** WARNING: Storage Coefficient is smaller than DT!
                   Use a smaller DT or a larger area.

  001:0018 CALIB STANDHYD
      *** WARNING: Storage Coefficient is smaller than DT!
                   Use a smaller DT or a larger area.

  001:0019 ROUTE RESERVOIR
      *** WARNING: STORAGE-Q values were extrapolated.
                   Increase curve or use overflow option.

  001:0020 CALIB STANDHYD
      *** WARNING: Storage Coefficient is smaller than DT!
                   Use a smaller DT or a larger area.

  001:0025 ROUTE RESERVOIR
      *** WARNING: STORAGE-Q values were extrapolated.
                   Increase curve or use overflow option.
     Simulation ended on 2005-02-10      at 11:29:14
 ==================================================================================
```

```
===============================================================================
 SSSSS  W   W  M   M  H   H  Y   Y  M   M   OOO        999      999    =========
        W W W  MM MM  H   H   Y Y   MM MM  O   O      9   9    9   9
 S
 SSSSS  W W W  M M M  HHHHH    Y    M M M  O   O  ##  9   9    9   9  Ver. 4.02
     S   W W   M   M  H   H    Y    M   M  O   O       9999     9999  July 1999
 SSSSS   W W   M   M  H   H    Y    M   M   OOO           9        9  =========
                                                      9   9    9   9  # 2640114
      StormWater Management HYdrologic Model           999      999   =========

*******************************************************************************
************************* SWMHYMO-99 Ver/4.02 *********************************
******* A single event and continuous hydrologic simulation model ******
*******       based on the principles of HYMO and its successors     *******
*******                 OTTHYMO-83 and OTTHYMO-89.                    *******
*******************************************************************************
******* Distributed by:  J.F. Sabourin and Associates Inc.            *******
*******                  Ottawa, Ontario: (613) 727-5199              *******
*******                  Gatineau, Quebec: (819) 243-6858             *******
*******                  E-Mail: swmhymo@jfsa.Com                     *******
*******************************************************************************

+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+++++++ Licensed user: The Sernas Group                               +++++++
+++++++                 Mississauga          SERIAL#:2640114          +++++++
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++

*******************************************************************************
*******          ++++++ PROGRAM ARRAY DIMENSIONS ++++++               *******
*******          Maximum value for ID numbers  :    10                *******
*******          Max. number of rainfall points:  15000               *******
*******          Max. number of flow points    :  15000               *******
*******************************************************************************


*******************  D E T A I L E D   O U T P U T  *******************
*******************************************************************************
*    DATE: 2005-02-10       TIME: 11:27:49      RUN COUNTER: 001255        *
*******************************************************************************
* Input   filename: P:\SWM\03211~1\FEB200~1\100yr01.DAT                      *
* Output  filename: P:\SWM\03211~1\FEB200~1\100yr01.out                      *
* Summary filename: P:\SWM\03211~1\FEB200~1\100yr01.sum                      *
* User comments:                                                              *
* 1:_________________________________________________________________________*
* 2:_________________________________________________________________________*
* 3:_________________________________________________________________________*
*******************************************************************************

-------------------------------------------------------------------------------
001:0001-----------------------------------------------------------------------
*******************************************************************************
** Project Name: [ARG Milton Industrial] ProjectNumber[03211.400]   100yr
** Date        : 07-24-2003
** Revised     : November 12, 2003
** Revised     : February 10, 2005, By: FH.(rev James Snow Pkwy drainage area)
** Modeller    : [DME], KC
** Company     : The Sernas Group
** License #   : 2640114
*******************************************************************************
--------------------
| START             |   Project dir.: P:\SWM\03211~1\FEB200~1\
--------------------    Rainfall dir.: P:\SWM\03211~1\FEB200~1\
   TZERO =    .00 hrs on       0
   METOUT=     2 (output = METRIC)
   NRUN  =   001
   NSTORM=     1
           #  1=[]<-storm filename, one per line for NSTORM time
-------------------------------------------------------------------------------
001:0002-----------------------------------------------------------------------
--------------------
| READ STORM        |     Filename: P:\SWM\03211~1\FEB200~1\HH100y3h.stm
| Ptotal=  82.62 mm|     Comments: * 100 year 3 hr Chicago - Halton Hills S
--------------------
            TIME      RAIN |   TIME      RAIN |   TIME      RAIN |   TIME     RAIN
             hrs     mm/hr |    hrs     mm/hr |    hrs     mm/hr |    hrs    mm/hr
             .08     6.883 |    .83    15.365 |   1.58    53.674 |   2.33   11.260
             .17     7.303 |    .92    18.006 |   1.67    37.782 |   2.42   10.390
             .25     7.796 |   1.00    21.800 |   1.75    29.050 |   2.50    9.654
             .33     8.361 |   1.08    27.682 |   1.83    23.587 |   2.58    9.021
             .42     9.023 |   1.17    37.916 |   1.92    19.869 |   2.67    8.472
             .50     9.810 |   1.25    59.552 |   2.00    17.183 |   2.75    7.990
             .58    10.762 |   1.33   128.515 |   2.08    15.156 |   2.83    7.565
             .67    11.937 |   1.42   206.774 |   2.17    13.572 |   2.92    7.186
             .75    13.423 |   1.50    89.935 |   2.25    12.302 |   3.00    6.846
-------------------------------------------------------------------------------
001:0003-----------------------------------------------------------------------
*******************************************************************************
** Internal North Block 100
**   Roof                   101
**   Paved/Landscape        102
*******************************************************************************
--------------------
| CALIB STANDHYD    |    Area     (ha)=    12.12
| 01:0101   DT= 3.00 |    Total Imp(%)=    95.00   Dir. Conn.(%)=    90.00
--------------------
                              IMPERVIOUS      PERVIOUS (i)
     Surface Area       (ha)=     11.51            .61
     Dep. Storage       (mm)=      2.50           2.50
     Average Slope      (%)=       2.00           2.00
     Length             (m)=     284.00          30.00
     Mannings n            =       .013           .250

     Max.eff.Inten.(mm/hr)=     206.77         309.23
                over (min)        5.00           5.00
     Storage Coeff.   (min)=      2.90 (ii)      6.68 (ii)
     Unit Hyd. Tpeak (min)=       5.00           5.00
     Unit Hyd. peak   (cms)=       .28            .18
                                                            *TOTALS*
     PEAK FLOW        (cms)=      5.77            .36         6.131 (iii)
     TIME TO PEAK     (hrs)=      1.42           1.42         1.417
     RUNOFF VOLUME     (mm)=     80.12          54.50        77.555
     TOTAL RAINFALL    (mm)=     82.62          82.62        82.617
     RUNOFF COEFFICIENT   =        .97            .66          .939
     *** WARNING: Storage Coefficient is smaller than DT!
                  Use a smaller DT or a larger area.

     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN* =   76.0     Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
            THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.
-------------------------------------------------------------------------------
001:0004-----------------------------------------------------------------------
*******************************************************************************
**   Control roof release to 42 l/s/ha for Area 101
*******************************************************************************
--------------------
| ROUTE RESERVOIR   |     Requested routing time step =   3.0 min.
|   IN>01:(0101  )  |
| OUT<07:(008101)   |     =========  OUTFLOW STORAGE TABLE  =========
--------------------      OUTFLOW     STORAGE    |  OUTFLOW     STORAGE
                           (cms)      (ha.m.)    |   (cms)      (ha.m.)
                            .000    .0000E+00    |    .450    .6800E+00
                            .050    .5000E-01    |    .500    .7000E+00

     ROUTING RESULTS              AREA      QPEAK      TPEAK        R.V.
     --------------------         (ha)      (cms)      (hrs)        (mm)
     INFLOW >01: (0101  )        12.12      6.131      1.417      77.555
     OUTFLOW<07: (008101)        12.12       .489      2.125      77.555

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=    7.972
                   TIME SHIFT OF PEAK FLOW        (min)=    42.50
                   MAXIMUM  STORAGE   USED     (ha.m.)=.6956E+00

-------------------------------------------------------------------------------
001:0005-----------------------------------------------------------------------
--------------------
| CALIB STANDHYD    |    Area     (ha)=    12.11
| 02:0102   DT= 3.00 |    Total Imp(%)=    80.00   Dir. Conn.(%)=    75.00
--------------------
                              IMPERVIOUS      PERVIOUS (i)
     Surface Area       (ha)=      9.69           2.42
     Dep. Storage       (mm)=      2.50           2.50
     Average Slope      (%)=       2.00           2.00
     Length             (m)=     254.00          30.00
     Mannings n            =       .013           .250

     Max.eff.Inten.(mm/hr)=     206.77         116.88
                over (min)        5.00          10.00
     Storage Coeff.   (min)=      2.71 (ii)      8.29 (ii)
     Unit Hyd. Tpeak (min)=       5.00          10.00
     Unit Hyd. peak   (cms)=       .29            .13
                                                            *TOTALS*
     PEAK FLOW        (cms)=      4.86            .62         5.298 (iii)
     TIME TO PEAK     (hrs)=      1.42           1.50         1.417
     RUNOFF VOLUME     (mm)=     80.12          44.35        71.174
     TOTAL RAINFALL    (mm)=     82.62          82.62        82.617
     RUNOFF COEFFICIENT   =        .97            .54          .861
     *** WARNING: Storage Coefficient is smaller than DT!
                  Use a smaller DT or a larger area.

     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN* =   75.5     Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
            THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.
-------------------------------------------------------------------------------
001:0006-----------------------------------------------------------------------
--------------------
| ADD HYD (000100) | ID: NHYD        AREA      QPEAK   TPEAK    R.V.     DWF
--------------------                 (ha)      (cms)   (hrs)    (mm)    (cms)
                 ID1 07:008101      12.12       .489    2.13   77.56     .000
                +ID2 02:0102        12.11      5.298    1.42   71.17     .000
                ==========================================================
                 SUM 08:000100      24.23      5.561    1.42   74.37     .000

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
001:0007-----------------------------------------------------------------------
*******************************************************************************
**   Control release to 150 l/s/ha for Area 100
*******************************************************************************
--------------------
| ROUTE RESERVOIR   |     Requested routing time step =   3.0 min.
|   IN>08:(000100)  |
| OUT<09:(008001)   |     =========  OUTFLOW STORAGE TABLE  =========
--------------------      OUTFLOW     STORAGE    |  OUTFLOW     STORAGE
                           (cms)      (ha.m.)    |   (cms)      (ha.m.)
                            .000    .0000E+00    |   3.590    .1700E+00
                            .500    .5000E-01    |   3.640    .2000E+00

     ROUTING RESULTS              AREA      QPEAK      TPEAK        R.V.
     --------------------         (ha)      (cms)      (hrs)        (mm)
     INFLOW >08: (000100)        24.23      5.561      1.417      74.366
     OUTFLOW<09: (008001)        24.23      3.626      1.500      74.366

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=   65.203
                   TIME SHIFT OF PEAK FLOW        (min)=     5.00
                   MAXIMUM  STORAGE   USED     (ha.m.)=.1917E+00

-------------------------------------------------------------------------------
001:0008-----------------------------------------------------------------------
*******************************************************************************
**
**   External North Area 200
**
*******************************************************************************
--------------------
| CALIB NASHYD      |    Area     (ha)=    71.80   Curve Number   (CN)=76.00
| 01:0200  DT=12.00 |    Ia       (mm)=    2.500   # of Linear Res.(N)= 3.00
--------------------     U.H. Tp(hrs)=     1.000

     Unit Hyd Qpeak   (cms)=     2.742

     PEAK FLOW        (cms)=     3.554 (i)
     TIME TO PEAK     (hrs)=     2.500
     RUNOFF VOLUME     (mm)=    37.118
     TOTAL RAINFALL    (mm)=    82.617
     RUNOFF COEFFICIENT   =      .449

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

-------------------------------------------------------------------------------
001:0009-----------------------------------------------------------------------
--------------------
| ADD HYD (009001) | ID: NHYD        AREA      QPEAK   TPEAK    R.V.     DWF
--------------------                 (ha)      (cms)   (hrs)    (mm)    (cms)
                 ID1 09:008001      24.23      3.626    1.50   74.37     .000
                +ID2 01:0200        71.80      3.554    2.50   37.12     .000
                ==========================================================
                 SUM 04:009001      96.03      4.640    1.58   46.52     .000

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
001:0010-----------------------------------------------------------------------
*******************************************************************************
**
**   James Snow Parkway 200
**   Revised(feb05) drainage area from 2.16 to 2.20ha.
```

```
 **
 ****************************************************************************
 ---------------------
 | CALIB STANDHYD      |    Area     (ha)=      2.20
 | 01:02001   DT= 5.00 |    Total Imp(%)=    75.00    Dir. Conn.(%)=    75.00
 ---------------------
                          IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=     1.65          .55
     Dep. Storage     (mm)=     2.50         2.50
     Average Slope     (%)=     2.00         2.00
     Length            (m)=   122.00        30.00
     Mannings n           =     .013         .250

     Max.eff.Inten.(mm/hr)=   206.77        84.54
                over (min)      5.00        10.00
     Storage Coeff.  (min)=     1.75 (ii)    8.10 (ii)
     Unit Hyd. Tpeak (min)=     5.00        10.00
     Unit Hyd. peak  (cms)=      .32          .13
                                                        *TOTALS*
     PEAK FLOW        (cms)=      .93          .10        .997 (iii)
     TIME TO PEAK     (hrs)=     1.42         1.50       1.417
     RUNOFF VOLUME     (mm)=    80.12        40.04      70.096
     TOTAL RAINFALL    (mm)=    82.62        82.62      82.617
     RUNOFF COEFFICIENT    =      .97          .48        .848
     *** WARNING: Storage Coefficient is smaller than DT!
                  Use a smaller DT or a larger area.

     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
          CN* =  76.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
          THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

 ----------------------------------------------------------------------------
 001:0011--------------------------------------------------------------------
 ---------------------
 | ADD HYD (009001) | ID: NHYD      AREA     QPEAK    TPEAK    R.V.     DWF
 ---------------------               (ha)     (cms)    (hrs)    (mm)    (cms)
                 ID1 04:009001      96.03    4.640     1.58   46.52     .000
                +ID2 01:02001        2.20     .997     1.42   70.10     .000
                 ===================================================
                 SUM 05:009001      98.23    4.985     1.58   47.04     .000

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

 ----------------------------------------------------------------------------
 001:0012--------------------------------------------------------------------
 ****************************************************************************
 **
 **  Boston Church Road 300
 **
 ****************************************************************************
 ---------------------
 | CALIB STANDHYD      |    Area     (ha)=      3.02
 | 01:0300    DT= 5.00 |    Total Imp(%)=    75.00    Dir. Conn.(%)=    70.00
 ---------------------
                          IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=     2.27          .75
     Dep. Storage     (mm)=     2.50         2.50
     Average Slope     (%)=     2.00         2.00
     Length            (m)=   122.00        30.00
     Mannings n           =     .013         .250

     Max.eff.Inten.(mm/hr)=   206.77       149.22
                over (min)      5.00         5.00
     Storage Coeff.  (min)=     1.75 (ii)    6.81 (ii)
     Unit Hyd. Tpeak (min)=     5.00         5.00
     Unit Hyd. peak  (cms)=      .32          .18
                                                        *TOTALS*
     PEAK FLOW        (cms)=     1.19          .21       1.397 (iii)
     TIME TO PEAK     (hrs)=     1.42         1.42       1.417
     RUNOFF VOLUME     (mm)=    80.12        44.01      69.284
     TOTAL RAINFALL    (mm)=    82.62        82.62      82.617
     RUNOFF COEFFICIENT    =      .97          .53        .839
     *** WARNING: Storage Coefficient is smaller than DT!
                  Use a smaller DT or a larger area.

     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
          CN* =  76.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
          THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

 ----------------------------------------------------------------------------
 001:0013--------------------------------------------------------------------
 ---------------------
 | ADD HYD (009002) | ID: NHYD      AREA     QPEAK    TPEAK    R.V.     DWF
 ---------------------               (ha)     (cms)    (hrs)    (mm)    (cms)
                 ID1 01:0300         3.02    1.397     1.42   69.28     .000
                +ID2 05:009001      98.23    4.985     1.58   47.04     .000
                 ===================================================
                 SUM 06:009002     101.25    6.181     1.42   47.71     .000

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

 ----------------------------------------------------------------------------
 001:0014--------------------------------------------------------------------
 ****************************************************************************
 **
 **  External North East Block 400
 **
 ****************************************************************************
 ---------------------
 | CALIB STANDHYD      |    Area     (ha)=      4.66
 | 01:0400    DT= 5.00 |    Total Imp(%)=    75.00    Dir. Conn.(%)=    65.00
 ---------------------
                          IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=     3.49         1.16
     Dep. Storage     (mm)=     2.50         2.50
     Average Slope     (%)=     2.00         2.00
     Length            (m)=   152.00        40.00
     Mannings n           =     .013         .250

     Max.eff.Inten.(mm/hr)=   206.77       138.88
                over (min)      5.00        10.00
     Storage Coeff.  (min)=     1.99 (ii)    8.18 (ii)
     Unit Hyd. Tpeak (min)=     5.00        10.00
     Unit Hyd. peak  (cms)=      .31          .13
                                                        *TOTALS*
     PEAK FLOW        (cms)=     1.68          .36       1.937 (iii)
     TIME TO PEAK     (hrs)=     1.42         1.50       1.417
     RUNOFF VOLUME     (mm)=    80.12        46.77      68.445
     TOTAL RAINFALL    (mm)=    82.62        82.62      82.617
     RUNOFF COEFFICIENT    =      .97          .57        .828
     *** WARNING: Storage Coefficient is smaller than DT!
                  Use a smaller DT or a larger area.

     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
          CN* =  75.5    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
          THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

 ----------------------------------------------------------------------------
 001:0015--------------------------------------------------------------------
 ---------------------
 | ADD HYD (009003) | ID: NHYD      AREA     QPEAK    TPEAK    R.V.     DWF
 ---------------------               (ha)     (cms)    (hrs)    (mm)    (cms)
                 ID1 01:0400         4.66    1.937     1.42   68.44     .000
                +ID2 06:009002     101.25    6.181     1.42   47.71     .000
                 ===================================================
                 SUM 07:009003     105.91    8.118     1.42   48.62     .000

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

 ----------------------------------------------------------------------------
 001:0016--------------------------------------------------------------------
 ****************************************************************************
 **  SNOEK
 **  Area reduced from 10.8 hectares to 2.88 hectares as per MTM
 **  Paved/Landscape             502
 ****************************************************************************
 ---------------------
 | CALIB STANDHYD      |    Area     (ha)=      2.88
 | 02:0502    DT= 5.00 |    Total Imp(%)=    80.00    Dir. Conn.(%)=    75.00
 ---------------------
                          IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=     2.30          .58
     Dep. Storage     (mm)=     2.50         2.50
     Average Slope     (%)=     2.00         2.00
     Length            (m)=   120.00        30.00
     Mannings n           =     .013         .250

     Max.eff.Inten.(mm/hr)=   206.77       158.67
                over (min)      5.00         5.00
     Storage Coeff.  (min)=     1.73 (ii)    6.67 (ii)
     Unit Hyd. Tpeak (min)=     5.00         5.00
     Unit Hyd. peak  (cms)=      .32          .18
                                                        *TOTALS*
     PEAK FLOW        (cms)=     1.21          .17       1.386 (iii)
     TIME TO PEAK     (hrs)=     1.42         1.42       1.417
     RUNOFF VOLUME     (mm)=    80.12        44.89      71.310
     TOTAL RAINFALL    (mm)=    82.62        82.62      82.617
     RUNOFF COEFFICIENT    =      .97          .54        .863
     *** WARNING: Storage Coefficient is smaller than DT!
                  Use a smaller DT or a larger area.

     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
          CN* =  76.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
          THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

 ----------------------------------------------------------------------------
 001:0017--------------------------------------------------------------------
 ---------------------
 | ADD HYD (009004) | ID: NHYD      AREA     QPEAK    TPEAK    R.V.     DWF
 ---------------------               (ha)     (cms)    (hrs)    (mm)    (cms)
                 ID1 07:009003     105.91    8.118     1.42   48.62     .000
                +ID2 02:0502         2.88    1.386     1.42   71.31     .000
                 ===================================================
                 SUM 08:009004     108.79    9.504     1.42   49.22     .000

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

 ----------------------------------------------------------------------------
 001:0018--------------------------------------------------------------------
 ****************************************************************************
 **  Internal South East Block 600
 **  Roof                          601
 **  Paved/Landscape               602
 ****************************************************************************
 ---------------------
 | CALIB STANDHYD      |    Area     (ha)=      6.72
 | 01:0601    DT= 5.00 |    Total Imp(%)=    95.00    Dir. Conn.(%)=    90.00
 ---------------------
                          IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=     6.38          .34
     Dep. Storage     (mm)=     2.50         2.50
     Average Slope     (%)=     2.00         2.00
     Length            (m)=   211.00        30.00
     Mannings n           =     .013         .250

     Max.eff.Inten.(mm/hr)=   206.77       309.23
                over (min)      5.00         5.00
     Storage Coeff.  (min)=     2.43 (ii)    6.21 (ii)
     Unit Hyd. Tpeak (min)=     5.00         5.00
     Unit Hyd. peak  (cms)=      .30          .19
                                                        *TOTALS*
     PEAK FLOW        (cms)=     3.29          .21       3.492 (iii)
     TIME TO PEAK     (hrs)=     1.42         1.42       1.417
     RUNOFF VOLUME     (mm)=    80.12        54.50      77.555
     TOTAL RAINFALL    (mm)=    82.62        82.62      82.617
     RUNOFF COEFFICIENT    =      .97          .66        .939
     *** WARNING: Storage Coefficient is smaller than DT!
                  Use a smaller DT or a larger area.

     (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
          CN* =  76.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
          THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

 ----------------------------------------------------------------------------
 001:0019--------------------------------------------------------------------
 ****************************************************************************
 **  Control roof release to 42 l/s/ha for Area 601
 ****************************************************************************
 ---------------------
 | ROUTE RESERVOIR     |     Requested routing time step =   5.0 min.
 |  IN>01:(0601   )    |
 | OUT<03:(008601)     |     =========  OUTFLOW STORAGE TABLE  =========
 ---------------------        OUTFLOW     STORAGE    |  OUTFLOW     STORAGE
                               (cms)      (ha.m.)    |   (cms)      (ha.m.)
                                .000     .0000E+00   |    .250     .3400E+00
                                .050     .5000E-01   |    .280     .3800E+00

     ROUTING RESULTS              AREA      QPEAK     TPEAK      R.V.
     ---------------              (ha)      (cms)     (hrs)      (mm)
     INFLOW >01: (0601   )        6.72      3.492     1.417     77.555
     OUTFLOW<03: (008601)         6.72       .279     2.083     77.555

                    PEAK    FLOW    REDUCTION [Qout/Qin](%)=    8.002
                    TIME SHIFT OF PEAK FLOW           (min)=   40.00
```

```
                    MAXIMUM  STORAGE   USED        (ha.m.)=.3794E+00

 --------------------------------------------------------------------------------
 001:0020------------------------------------------------------------------------
 ---------------------
 | CALIB STANDHYD      |    Area    (ha)=     6.72
 | 02:0602   DT= 5.00 |    Total Imp(%)=    80.00    Dir. Conn.(%)=    75.00
 ---------------------
                                   IMPERVIOUS     PERVIOUS (i)
      Surface Area        (ha)=       5.38           1.34
      Dep. Storage        (mm)=       2.50           2.50
      Average Slope        (%)=       2.00           2.00
      Length               (m)=     189.00          30.00
      Mannings n              =       .013           .250

      Max.eff.Inten.(mm/hr)=        206.77         118.37
                 over (min)           5.00          10.00
      Storage Coeff.  (min)=          2.27 (ii)      7.83 (ii)
      Unit Hyd. Tpeak (min)=          5.00          10.00
      Unit Hyd. peak  (cms)=           .30            .13
                                                                 *TOTALS*
      PEAK FLOW        (cms)=         2.76            .36          3.016 (iii)
      TIME TO PEAK     (hrs)=         1.42           1.50          1.417
      RUNOFF VOLUME     (mm)=        80.12          44.89         71.310
      TOTAL RAINFALL    (mm)=        82.62          82.62         82.617
      RUNOFF COEFFICIENT   =          .97            .54           .863
      *** WARNING: Storage Coefficient is smaller than DT!
                   Use a smaller DT or a larger area.

      (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
          CN* =  76.0     Ia = Dep. Storage  (Above)
     (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
          THAN THE STORAGE COEFFICIENT.
    (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

 --------------------------------------------------------------------------------
 001:0021------------------------------------------------------------------------
 ---------------------
 | ADD HYD (000600) | ID: NHYD      AREA      QPEAK    TPEAK    R.V.     DWF
 ---------------------              (ha)      (cms)    (hrs)    (mm)    (cms)
               ID1 03:008601        6.72       .279     2.08   77.56     .000
              +ID2 02:0602          6.72      3.016     1.42   71.31     .000
               ==================================================================
               SUM 04:000600       13.44      3.181     1.42   74.43     .000

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

 --------------------------------------------------------------------------------
 001:0022------------------------------------------------------------------------
 ********************************************************************************
 **  Control release to 150 l/s/ha for Area 600
 ********************************************************************************
 ---------------------
 | ROUTE RESERVOIR   |      Requested routing time step =  5.0 min.
 | IN>04:(000600)    |
 | OUT<05:(008002)   |      =========  OUTFLOW STORAGE TABLE  =========
 ---------------------      OUTFLOW     STORAGE    |  OUTFLOW     STORAGE
                             (cms)      (ha.m.)    |   (cms)      (ha.m.)
                              .000     .0000E+00   |   1.970     .1000E+00
                              .500     .5000E-01   |   2.020     .1200E+00

    ROUTING RESULTS                 AREA      QPEAK      TPEAK        R.V.
    --------------------            (ha)      (cms)      (hrs)        (mm)
    INFLOW >04: (000600)           13.44      3.181      1.417      74.432
    OUTFLOW<05: (008002)           13.44      2.013      1.500      74.432

                    PEAK    FLOW    REDUCTION [Qout/Qin](%)=    63.287
                    TIME SHIFT OF PEAK FLOW          (min)=      5.00
                    MAXIMUM  STORAGE   USED        (ha.m.)=.1176E+00

 --------------------------------------------------------------------------------
 001:0023------------------------------------------------------------------------
 ---------------------
 | ADD HYD (009005) | ID: NHYD      AREA      QPEAK    TPEAK    R.V.     DWF
 ---------------------              (ha)      (cms)    (hrs)    (mm)    (cms)
               ID1 08:009004      108.79      9.504     1.42   49.22     .000
              +ID2 05:008002       13.44      2.013     1.50   74.43     .000
               ==================================================================
               SUM 09:009005      122.23     11.442     1.42   51.99     .000

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

 --------------------------------------------------------------------------------
 001:0024------------------------------------------------------------------------
 ********************************************************************************
 **  Internal South East Block 700
 **  Roof                          701
 **  Paved/Landscape               702
 ********************************************************************************
 ---------------------
 | CALIB STANDHYD      |    Area    (ha)=     6.63
 | 03:0701   DT= 3.00 |    Total Imp(%)=    95.00    Dir. Conn.(%)=    90.00
 ---------------------
                                   IMPERVIOUS     PERVIOUS (i)
      Surface Area        (ha)=       6.30            .33
      Dep. Storage        (mm)=       2.50           2.50
      Average Slope        (%)=       2.00           2.00
      Length               (m)=     210.00          30.00
      Mannings n              =       .013           .250

      Max.eff.Inten.(mm/hr)=        206.77         309.23
                 over (min)           5.00           5.00
      Storage Coeff.  (min)=          2.42 (ii)      6.20 (ii)
      Unit Hyd. Tpeak (min)=          5.00           5.00
      Unit Hyd. peak  (cms)=           .30            .19
                                                                 *TOTALS*
      PEAK FLOW        (cms)=         3.24            .20          3.447 (iii)
      TIME TO PEAK     (hrs)=         1.42           1.42          1.417
      RUNOFF VOLUME     (mm)=        80.12          54.50         77.555
      TOTAL RAINFALL    (mm)=        82.62          82.62         82.617
      RUNOFF COEFFICIENT   =          .97            .66           .939
      *** WARNING: Storage Coefficient is smaller than DT!
                   Use a smaller DT or a larger area.

      (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
          CN* =  76.0     Ia = Dep. Storage  (Above)
     (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
          THAN THE STORAGE COEFFICIENT.
    (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

 --------------------------------------------------------------------------------
 001:0025------------------------------------------------------------------------
 ********************************************************************************
 **  Control roof release to 42 l/s/ha for Area 701
 ********************************************************************************
 ---------------------
 | ROUTE RESERVOIR   |      Requested routing time step =  3.0 min.
 | IN>03:(0701  )    |
 | OUT<04:(008701)   |      =========  OUTFLOW STORAGE TABLE  =========
 ---------------------      OUTFLOW     STORAGE    |  OUTFLOW     STORAGE
                             (cms)      (ha.m.)    |   (cms)      (ha.m.)
                              .000     .0000E+00   |    .240     .3700E+00
                              .050     .5000E-01   |    .270     .3900E+00

    ROUTING RESULTS                 AREA      QPEAK      TPEAK        R.V.
    --------------------            (ha)      (cms)      (hrs)        (mm)
    INFLOW >03: (0701  )            6.63      3.447      1.417      77.555
    OUTFLOW<04: (008701)            6.63       .257      2.167      77.555

                    PEAK    FLOW    REDUCTION [Qout/Qin](%)=     7.443
                    TIME SHIFT OF PEAK FLOW          (min)=     45.00
                    MAXIMUM  STORAGE   USED        (ha.m.)=.3811E+00

 --------------------------------------------------------------------------------
 001:0026------------------------------------------------------------------------
 ********************************************************************************
 **  Divert Flow to Culvert 7
 **  'clean' roof runoff
 ********************************************************************************
 ---------------------
 | COMPUTE DUALHYD     |    Average inlet capacities    [CINLET] =    .080  (cms)
 | TotalHyd 04:008701 |    Number of inlets in system [NINLET] =      1
 ---------------------      Total minor system capacity          =    .080  (cms)
                            Total major system storage [TMJSTO] =      0.(cu.m.)

                  ID: NHYD       AREA      QPEAK     TPEAK      R.V.      DWF
                                 (ha)      (cms)     (hrs)      (mm)     (cms)
    TOTAL HYD.     04:008701     6.63       .257     2.167    77.555      .000
    ===========================================================================
    MAJOR SYST     02:007002     2.69       .177     2.167    77.555      .000
    MINOR SYST     10:007001     3.94       .080     1.292    77.555      .000

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

 --------------------------------------------------------------------------------
 001:0027------------------------------------------------------------------------
 ---------------------
 | CALIB STANDHYD      |    Area    (ha)=     6.62
 | 01:000702 DT= 3.00 |    Total Imp(%)=    80.00    Dir. Conn.(%)=    75.00
 ---------------------
                                   IMPERVIOUS     PERVIOUS (i)
      Surface Area        (ha)=       5.30           1.32
      Dep. Storage        (mm)=       2.50           2.50
      Average Slope        (%)=       2.00           2.00
      Length               (m)=     187.00          30.00
      Mannings n              =       .013           .250

      Max.eff.Inten.(mm/hr)=        206.77         118.37
                 over (min)           5.00          10.00
      Storage Coeff.  (min)=          2.26 (ii)      7.81 (ii)
      Unit Hyd. Tpeak (min)=          5.00          10.00
      Unit Hyd. peak  (cms)=           .30            .13
                                                                 *TOTALS*
      PEAK FLOW        (cms)=         2.72            .35          2.973 (iii)
      TIME TO PEAK     (hrs)=         1.42           1.50          1.417
      RUNOFF VOLUME     (mm)=        80.12          44.89         71.310
      TOTAL RAINFALL    (mm)=        82.62          82.62         82.617
      RUNOFF COEFFICIENT   =          .97            .54           .863
      *** WARNING: Storage Coefficient is smaller than DT!
                   Use a smaller DT or a larger area.

      (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
          CN* =  76.0     Ia = Dep. Storage  (Above)
     (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
          THAN THE STORAGE COEFFICIENT.
    (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

 --------------------------------------------------------------------------------
 001:0028------------------------------------------------------------------------
 ---------------------
 | ADD HYD (000700) | ID: NHYD      AREA      QPEAK    TPEAK    R.V.     DWF
 ---------------------              (ha)      (cms)    (hrs)    (mm)    (cms)
               ID1 01:000702        6.62      2.973     1.42   71.31     .000
              +ID2 02:007002        2.69       .177     2.17   77.56     .000
               ==================================================================
               SUM 05:000700        9.31      3.041     1.42   73.11     .000

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

 --------------------------------------------------------------------------------
 001:0029------------------------------------------------------------------------
 ********************************************************************************
 **  Control release to 150 l/s/ha for Area 700
 ********************************************************************************
 ---------------------
 | ROUTE RESERVOIR   |      Requested routing time step =  3.0 min.
 | IN>05:(000700)    |
 | OUT<06:(008003)   |      =========  OUTFLOW STORAGE TABLE  =========
 ---------------------      OUTFLOW     STORAGE    |  OUTFLOW     STORAGE
                             (cms)      (ha.m.)    |   (cms)      (ha.m.)
                              .000     .0000E+00   |   1.930     .9000E-01
                              .500     .4000E-01   |   1.980     .1100E+00

    ROUTING RESULTS                 AREA      QPEAK      TPEAK        R.V.
    --------------------            (ha)      (cms)      (hrs)        (mm)
    INFLOW >05: (000700)            9.31      3.041      1.417      73.112
    OUTFLOW<06: (008003)            9.31      1.962      1.500      73.112

                    PEAK    FLOW    REDUCTION [Qout/Qin](%)=    64.495
                    TIME SHIFT OF PEAK FLOW          (min)=      5.00
                    MAXIMUM  STORAGE   USED        (ha.m.)=.1033E+00

 --------------------------------------------------------------------------------
 001:0030------------------------------------------------------------------------
 ---------------------
 | ADD HYD (009006) | ID: NHYD      AREA      QPEAK    TPEAK    R.V.     DWF
 ---------------------              (ha)      (cms)    (hrs)    (mm)    (cms)
               ID1 06:008003        9.31      1.962     1.50   73.11     .000
              +ID2 09:009005      122.23     11.442     1.42   51.99     .000
               ==================================================================
               SUM 01:009006      131.54     13.279     1.42   53.49     .000

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

 --------------------------------------------------------------------------------
 001:0031------------------------------------------------------------------------
 ********************************************************************************
 **
 **  Internal SWM Facility Block 800
 **
 ********************************************************************************
 ---------------------
 | CALIB NASHYD        |    Area    (ha)=    2.75    Curve Number   (CN)=76.00
 | 02:0800   DT=12.00 |    Ia      (mm)=   2.500    # of Linear Res.(N)= 3.00
```

```
---------------------    U.H. Tp(hrs)=    1.000

     Unit Hyd Qpeak  (cms)=       .105

     PEAK FLOW       (cms)=       .136 (i)
     TIME TO PEAK    (hrs)=      2.500
     RUNOFF VOLUME    (mm)=     37.118
     TOTAL RAINFALL   (mm)=     82.617
     RUNOFF COEFFICIENT   =       .449

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

-------------------------------------------------------------------------------
001:0032-----------------------------------------------------------------------
--------------------
| ADD HYD (009011) | ID: NHYD      AREA      QPEAK    TPEAK    R.V.     DWF
--------------------                (ha)     (cms)    (hrs)    (mm)    (cms)
               ID1 02:0800          2.75      .136     2.50   37.12    .000
              +ID2 01:009006      131.54    13.279     1.42   53.49    .000
               ==========================================================
               SUM 04:009011      134.29    13.297     1.42   53.15    .000

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
001:0033-----------------------------------------------------------------------
--------------------
| ROUTE RESERVOIR   |       Requested routing time step =   3.0 min.
|  IN>04:(009011)   |
| OUT<05:(006000)   |       =========  OUTLFOW STORAGE TABLE  =========
--------------------        OUTFLOW    STORAGE    |   OUTFLOW    STORAGE
                             (cms)     (ha.m.)    |    (cms)     (ha.m.)
                              .000   .0000E+00    |    1.203   .2885E+01
                              .039   .2870E+00    |    1.488   .3288E+01
                              .090   .5880E+00    |    1.724   .3704E+01
                              .120   .9040E+00    |    1.929   .4133E+01
                              .144   .1234E+01    |    2.113   .4575E+01
                              .165   .1578E+01    |    4.543   .4801E+01
                              .174   .1755E+01    |    8.990   .5030E+01
                              .246   .1935E+01    |   14.930   .5263E+01
                              .394   .2118E+01    |   21.860   .5499E+01
                              .776   .2496E+01    |   29.960   .5738E+01

     ROUTING RESULTS                AREA     QPEAK      TPEAK       R.V.
     --------------------           (ha)     (cms)      (hrs)       (mm)
     INFLOW >04: (009011)         134.29    13.297      1.417     53.152
     OUTFLOW<05: (006000)         134.29     2.077      3.958     53.151

                    PEAK   FLOW   REDUCTION [Qout/Qin](%)=    15.624
                    TIME SHIFT OF PEAK FLOW          (min)=    152.50
                    MAXIMUM  STORAGE   USED       (ha.m.)=.4490E+01

-------------------------------------------------------------------------------
001:0034-----------------------------------------------------------------------
*******************************************************************************
**
**  Total controled release Diversion plus SWM Facility
**
*******************************************************************************
--------------------
| ADD HYD (009100) | ID: NHYD      AREA      QPEAK    TPEAK    R.V.     DWF
--------------------                (ha)     (cms)    (hrs)    (mm)    (cms)
               ID1 05:006000      134.29     2.077     3.96   53.15    .000
              +ID2 10:007001        3.94      .080     1.29   77.56    .000
               ==========================================================
               SUM 09:009100      138.23     2.157     3.96   53.85    .000

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
001:0035-----------------------------------------------------------------------
*******************************************************************************
**  Output Facility IN/OUT Hydrographs
*******************************************************************************
--------------------
| SAVE HYD          |     AREA        (ha)=  134.285
| ID=04 (009011)    |     QPEAK      (cms)=   13.297 (i)
| DT= 2.50 PCYC= 1  |     TPEAK      (hrs)=    1.417
--------------------      VOLUME      (mm)=   53.152
   Filename: P:\SWM\03211--1\FEB200~1\H-009011.001
   Comments: 03211 Pond In

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

TIME hrs	FLOW cms	TIME hrs	FLOW cms	TIME hrs	FLOW cms	TIME hrs	FLOW cms	TIME hrs	FLOW cms
.00	.000	7.50	.276	15.00	.031	22.50	.002	30.00	.000
.04	.000	7.54	.272	15.04	.030	22.54	.002	30.04	.000
.08	.000	7.58	.268	15.08	.030	22.58	.002	30.08	.000
.13	.000	7.62	.265	15.13	.029	22.62	.002	30.12	.000
.17	.000	7.67	.261	15.17	.029	22.67	.002	30.17	.000
.21	.000	7.71	.258	15.21	.028	22.71	.002	30.21	.000
.25	.000	7.75	.254	15.25	.028	22.75	.002	30.25	.000
.29	.005	7.79	.251	15.29	.027	22.79	.002	30.29	.000
.33	.010	7.83	.247	15.33	.027	22.83	.002	30.33	.000
.37	.133	7.87	.244	15.38	.027	22.87	.002	30.37	.000
.42	.275	7.92	.241	15.42	.026	22.92	.002	30.42	.000
.46	.349	7.96	.238	15.46	.026	22.96	.002	30.46	.000
.50	.422	8.00	.234	15.50	.025	23.00	.002	30.50	.000
.54	.489	8.04	.231	15.54	.025	23.04	.002	30.54	.000
.58	.555	8.08	.228	15.58	.025	23.08	.002	30.58	.000
.63	.621	8.12	.226	15.63	.024	23.12	.002	30.62	.000
.67	.686	8.17	.223	15.67	.024	23.17	.002	30.67	.000
.71	.756	8.21	.220	15.71	.024	23.21	.002	30.71	.000
.75	.826	8.25	.218	15.75	.023	23.25	.002	30.75	.000
.79	.904	8.29	.215	15.79	.023	23.29	.002	30.79	.000
.83	.983	8.33	.213	15.83	.023	23.33	.002	30.83	.000
.88	1.079	8.37	.211	15.88	.022	23.37	.001	30.87	.000
.92	1.178	8.42	.209	15.92	.022	23.42	.001	30.92	.000
.96	1.299	8.46	.207	15.96	.022	23.46	.001	30.96	.000
1.00	1.426	8.50	.204	16.00	.021	23.50	.001	31.00	.000
1.04	1.601	8.54	.202	16.04	.021	23.54	.001	31.04	.000
1.08	1.786	8.58	.200	16.08	.021	23.58	.001	31.08	.000
1.13	2.090	8.62	.198	16.13	.020	23.62	.001	31.12	.000
1.17	2.451	8.67	.196	16.17	.020	23.67	.001	31.17	.000
1.21	3.050	8.71	.194	16.21	.020	23.71	.001	31.21	.000
1.25	3.704	8.75	.192	16.25	.019	23.75	.001	31.25	.000
1.29	5.398	8.79	.190	16.29	.019	23.79	.001	31.29	.000
1.33	7.441	8.83	.189	16.33	.019	23.83	.001	31.33	.000
1.37	10.256	8.87	.187	16.38	.019	23.87	.001	31.37	.000
1.42	13.297	8.92	.185	16.42	.018	23.92	.001	31.42	.000
1.46	12.601	8.96	.183	16.46	.018	23.96	.001	31.46	.000
1.50	11.520	9.00	.181	16.50	.018	24.00	.001	31.50	.000
1.54	11.097	9.04	.179	16.54	.018	24.04	.001	31.54	.000
1.58	10.649	9.08	.178	16.58	.017	24.08	.001	31.58	.000
1.62	9.829	9.12	.176	16.63	.017	24.12	.001	31.62	.000
1.67	8.914	9.17	.174	16.67	.017	24.17	.001	31.67	.000
1.71	8.167	9.21	.173	16.71	.016	24.21	.001	31.71	.000
1.75	7.515	9.25	.171	16.75	.016	24.25	.001	31.75	.000
1.79	7.088	9.29	.169	16.79	.016	24.29	.001	31.79	.000
1.83	6.729	9.33	.168	16.83	.016	24.33	.001	31.83	.000
1.87	6.482	9.37	.166	16.88	.016	24.37	.001	31.87	.000
1.92	6.282	9.42	.164	16.92	.015	24.42	.001	31.92	.000
1.96	6.170	9.46	.163	16.96	.015	24.46	.001	31.96	.000
2.00	6.087	9.50	.161	17.00	.015	24.50	.001	32.00	.000
2.04	6.013	9.54	.160	17.04	.015	24.54	.001	32.04	.000
2.08	5.957	9.58	.158	17.08	.014	24.58	.001	32.08	.000
2.12	5.935	9.63	.156	17.13	.014	24.62	.001	32.12	.000
2.17	5.934	9.67	.155	17.17	.014	24.67	.001	32.17	.000
2.21	5.907	9.71	.153	17.21	.014	24.71	.001	32.21	.000
2.25	5.884	9.75	.152	17.25	.014	24.75	.001	32.25	.000
2.29	5.874	9.79	.150	17.29	.013	24.79	.001	32.29	.000
2.33	5.868	9.83	.149	17.33	.013	24.83	.001	32.33	.000
2.37	5.830	9.88	.147	17.38	.013	24.87	.001	32.37	.000
2.42	5.796	9.92	.145	17.42	.013	24.92	.001	32.42	.000
2.46	5.771	9.96	.144	17.46	.013	24.96	.001	32.46	.000
2.50	5.748	10.00	.142	17.50	.012	25.00	.001	32.50	.000
2.54	5.690	10.04	.141	17.54	.012	25.04	.001	32.54	.000
2.58	5.634	10.08	.139	17.58	.012	25.08	.001	32.58	.000
2.63	5.580	10.13	.138	17.63	.012	25.12	.001	32.62	.000
2.67	5.529	10.17	.136	17.67	.012	25.17	.001	32.67	.000
2.71	5.449	10.21	.135	17.71	.012	25.21	.001	32.71	.000
2.75	5.370	10.25	.133	17.75	.011	25.25	.001	32.75	.000
2.79	5.294	10.29	.132	17.79	.011	25.29	.001	32.79	.000
2.83	5.219	10.33	.130	17.83	.011	25.33	.001	32.83	.000
2.88	5.123	10.38	.129	17.88	.011	25.37	.001	32.87	.000
2.92	5.028	10.42	.127	17.92	.011	25.42	.001	32.92	.000
2.96	4.935	10.46	.126	17.96	.011	25.46	.001	32.96	.000
3.00	4.842	10.50	.125	18.00	.010	25.50	.001	33.00	.000
3.04	4.631	10.54	.123	18.04	.010	25.54	.001	33.04	.000
3.08	4.394	10.58	.122	18.08	.010	25.58	.001	33.08	.000
3.13	4.220	10.63	.120	18.13	.010	25.62	.001	33.12	.000
3.17	4.054	10.67	.119	18.17	.010	25.67	.001	33.17	.000
3.21	3.901	10.71	.118	18.21	.010	25.71	.001	33.21	.000
3.25	3.767	10.75	.116	18.25	.009	25.75	.001	33.25	.000
3.29	3.645	10.79	.115	18.29	.009	25.79	.001	33.29	.000
3.33	3.524	10.83	.114	18.33	.009	25.83	.001	33.33	.000
3.38	3.409	10.88	.113	18.38	.009	25.87	.001	33.37	.000
3.42	3.295	10.92	.111	18.42	.009	25.92	.001	33.42	.000
3.46	3.185	10.96	.110	18.46	.009	25.96	.001	33.46	.000
3.50	3.077	11.00	.109	18.50	.009	26.00	.001	33.50	.000
3.54	2.976	11.04	.108	18.54	.009	26.04	.001	33.54	.000
3.58	2.876	11.08	.106	18.58	.008	26.08	.001	33.58	.000
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3.67	2.681	11.17	.104	18.67	.008	26.17	.001	33.67	.000
3.71	2.592	11.21	.103	18.71	.008	26.21	.001	33.71	.000
3.75	2.504	11.25	.102	18.75	.008	26.25	.001	33.75	.000
3.79	2.417	11.29	.101	18.79	.008	26.29	.001	33.79	.000
3.83	2.330	11.33	.100	18.83	.008	26.33	.001	33.83	.000
3.88	2.253	11.38	.098	18.88	.008	26.37	.001	33.87	.000
3.92	2.176	11.42	.097	18.92	.007	26.42	.001	33.92	.000
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4.04	1.956	11.54	.094	19.04	.007	26.54	.000	34.04	.000
4.08	1.890	11.58	.093	19.08	.007	26.58	.000	34.08	.000
4.13	1.823	11.63	.092	19.13	.007	26.62	.000	34.12	.000
4.17	1.757	11.67	.091	19.17	.007	26.67	.000	34.17	.000
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4.33	1.528	11.83	.087	19.33	.006	26.83	.000	34.33	.000
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4.42	1.429	11.92	.085	19.42	.006	26.92	.000	34.42	.000
4.46	1.381	11.96	.084	19.46	.006	26.96	.000	34.46	.000
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4.75	1.095	12.25	.078	19.75	.006	27.25	.000	34.75	.000
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4.87	.996	12.38	.075	19.87	.005	27.37	.000	34.87	.000
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5.12	.833	12.63	.070	20.12	.005	27.62	.000	35.12	.000
5.17	.808	12.67	.070	20.17	.005	27.67	.000	35.17	.000
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5.67	.594	13.17	.059	20.67	.004	28.17	.000	35.67	.000
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   7.46   .279|  14.96   .031|  22.46   .002|  29.96   .000|
-----------------------------------------------------------------------------
001:0036---------------------------------------------------------------------
--------------------
| SAVE HYD           |    AREA      (ha)=    6.630
| ID=03 (0701  )     |    QPEAK     (cms)=   3.447 (i)
| DT= 5.00 PCYC= 1   |    TPEAK     (hrs)=   1.417
--------------------      VOLUME    (mm)=   77.555
  Filename: P:\SWM\03211--1\FEB200~1\H-0701.001
  Comments: 03211 Pond Out

     (i)  PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.
  TIME    FLOW |  TIME    FLOW |  TIME    FLOW |  TIME    FLOW |  TIME    FLOW
  hrs     cms  |  hrs     cms  |  hrs     cms  |  hrs     cms  |  hrs     cms
   .00    .000|    .83    .256|  1.67    .759|  2.50    .179|  3.33    .000
   .08    .000|    .92    .301|  1.75    .569|  2.58    .167|  3.42    .000
   .17    .000|   1.00    .364|  1.83    .455|  2.67    .156|  3.50    .000
   .25    .000|   1.08    .462|  1.92    .378|  2.75    .147|  3.58    .000
   .33    .005|   1.17    .630|  2.00    .325|  2.83    .139|  3.67    .000
   .42    .132|   1.25    .982|  2.08    .284|  2.92    .132|
   .50    .160|   1.33   2.081|  2.17    .254|  3.00    .126|
   .58    .178|   1.42   3.447|  2.25    .229|  3.08    .020|
   .67    .198|   1.50   1.878|  2.33    .209|  3.17    .004|
   .75    .223|   1.58   1.114|  2.42    .193|  3.25    .001|
-----------------------------------------------------------------------------
001:0037---------------------------------------------------------------------
     FINISH
-----------------------------------------------------------------------------
*****************************************************************************
     WARNINGS / ERRORS / NOTES
     -------------------------
 001:0003 CALIB STANDHYD
     *** WARNING: Storage Coefficient is smaller than DT!
                  Use a smaller DT or a larger area.
 001:0005 CALIB STANDHYD
     *** WARNING: Storage Coefficient is smaller than DT!
                  Use a smaller DT or a larger area.
 001:0010 CALIB STANDHYD
     *** WARNING: Storage Coefficient is smaller than DT!
                  Use a smaller DT or a larger area.
 001:0012 CALIB STANDHYD
     *** WARNING: Storage Coefficient is smaller than DT!
                  Use a smaller DT or a larger area.
 001:0014 CALIB STANDHYD
     *** WARNING: Storage Coefficient is smaller than DT!
                  Use a smaller DT or a larger area.
 001:0016 CALIB STANDHYD
     *** WARNING: Storage Coefficient is smaller than DT!
                  Use a smaller DT or a larger area.
 001:0018 CALIB STANDHYD
     *** WARNING: Storage Coefficient is smaller than DT!
                  Use a smaller DT or a larger area.
 001:0020 CALIB STANDHYD
     *** WARNING: Storage Coefficient is smaller than DT!
                  Use a smaller DT or a larger area.
 001:0024 CALIB STANDHYD
     *** WARNING: Storage Coefficient is smaller than DT!
                  Use a smaller DT or a larger area.
 001:0027 CALIB STANDHYD
     *** WARNING: Storage Coefficient is smaller than DT!
                  Use a smaller DT or a larger area.
  Simulation ended on 2005-02-10     at 11:27:49
=============================================================================
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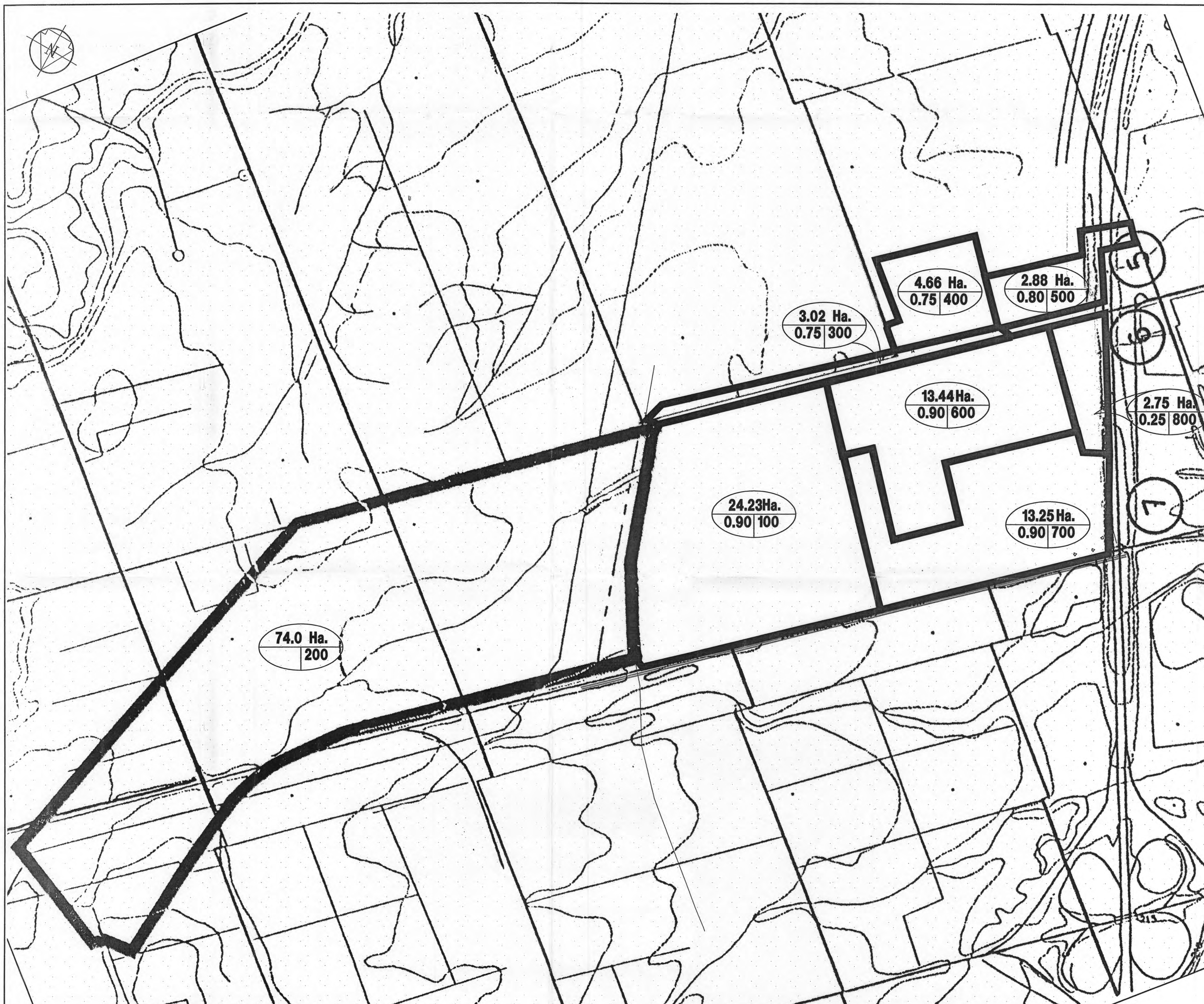
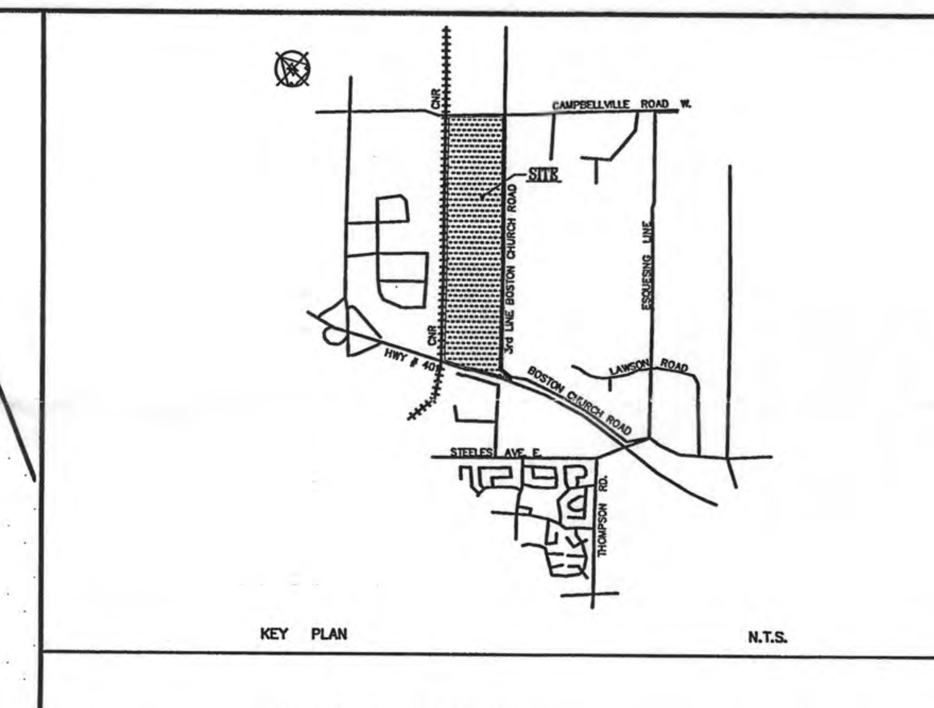




LEGEND

- 1.48 Ha. — SUB-CATCHMENT
- 0.90 | 500 — SUB-CATCHMENT ID / RUNOFF COEFFICIENT
- (5) — CULVERT NUMBER

CONTRACTOR TO BE RESPONSIBLE FOR LOCATION OF ALL EXIST. U/G & OVERHEAD UTILITIES. VARIOUS UTILITIES CONCERNED TO BE GIVEN REQUIRED ADVANCE NOTICE PRIOR TO ANY DIGGING, FOR STAKE OUT. THE CONSULTANT ASSUMES NO RESPONSIBILITY FOR THE ACCURACY OF THE LOCATION OF EXISTING UTILITIES

SUBMISSIONS

1st	____ Date ____	Preserv ____	Date ____
2nd	____ Date ____	Interim ____	Date ____
3rd	____ Date ____	Final ____	Date ____

No	DATE	BY	REVISIONS
1	SEPT. 03	D.M.E.	1ST SUBMISSION

DESIGN	D.M.E.	CHECKED	
DRAWN	S.Y.	CHECKED	

SCALE 1:4000 0 40 80 120 160 200

DATE

REFERENCES

FIELD NOTES

APPROVALS

MUNICIPAL

Design approved subject to detail construction conforming to TOWN OF MILTON Standard of Specifications.

Signed ____________ Date ____________
Town of Milton

REGIONAL

Design of sanitary and water services approved subject to detail construction conforming to HALTON REGION Standard and Specifications and location approval from area municipality.

Signed ____________ Date ____________
PLANNING AND PUBLIC WORKS DEPARTMENT – HALTON REGION

STAMP

REGISTERED PROFESSIONAL ENGINEER
K. CHOW
PROVINCE OF ONTARIO

CONSULTANT

SERNAS ASSOCIATES
141 Brunel Road
Mississauga, ON
L4Z 1X3
T 416.213.7121
F 905.890.8499
semas.com

MUNICIPALITY

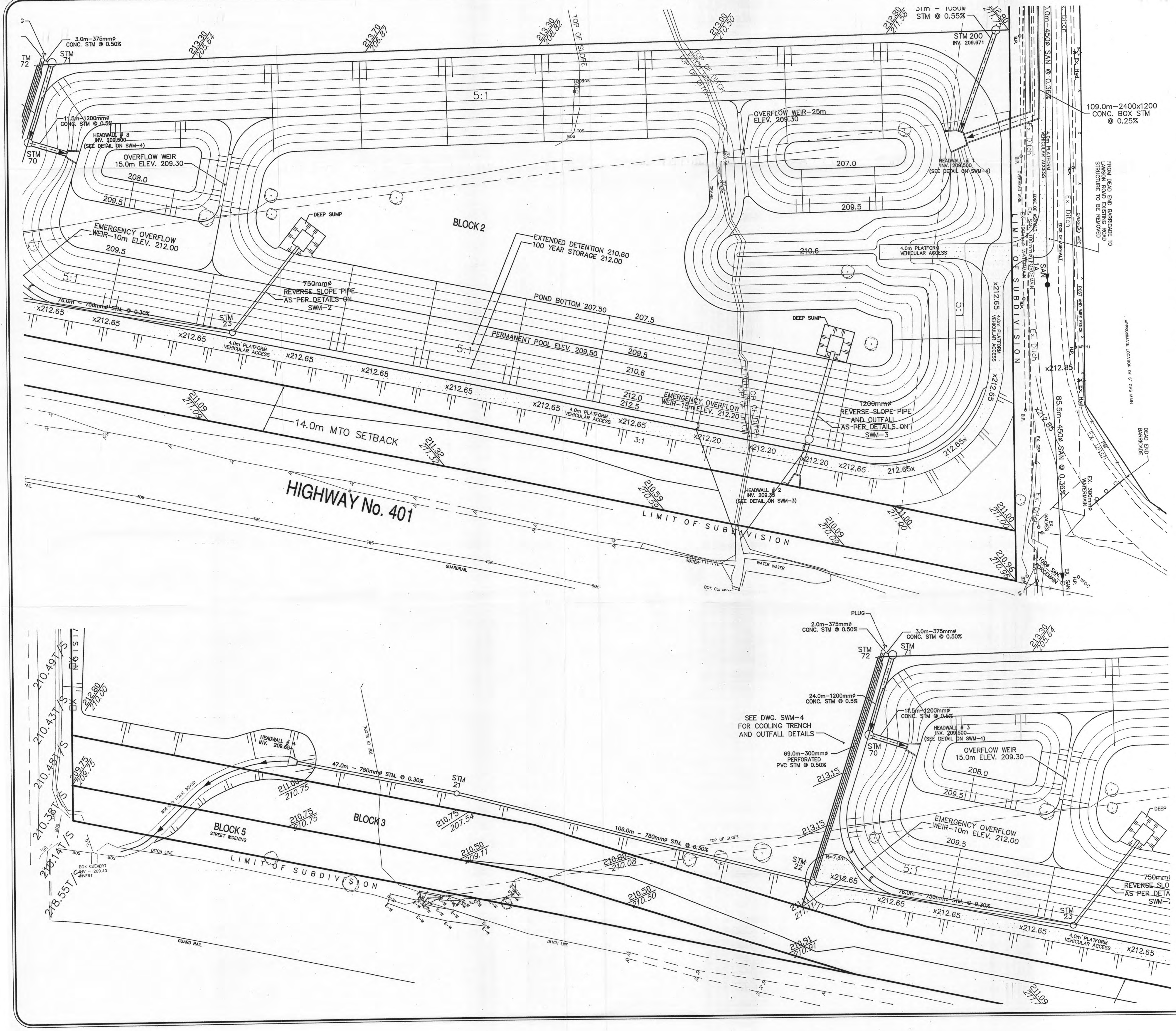
TOWN OF MILTON
PLANNING AND DEVELOPMENT
DIRECTOR OF PLANNING AND DEVELOPMENT

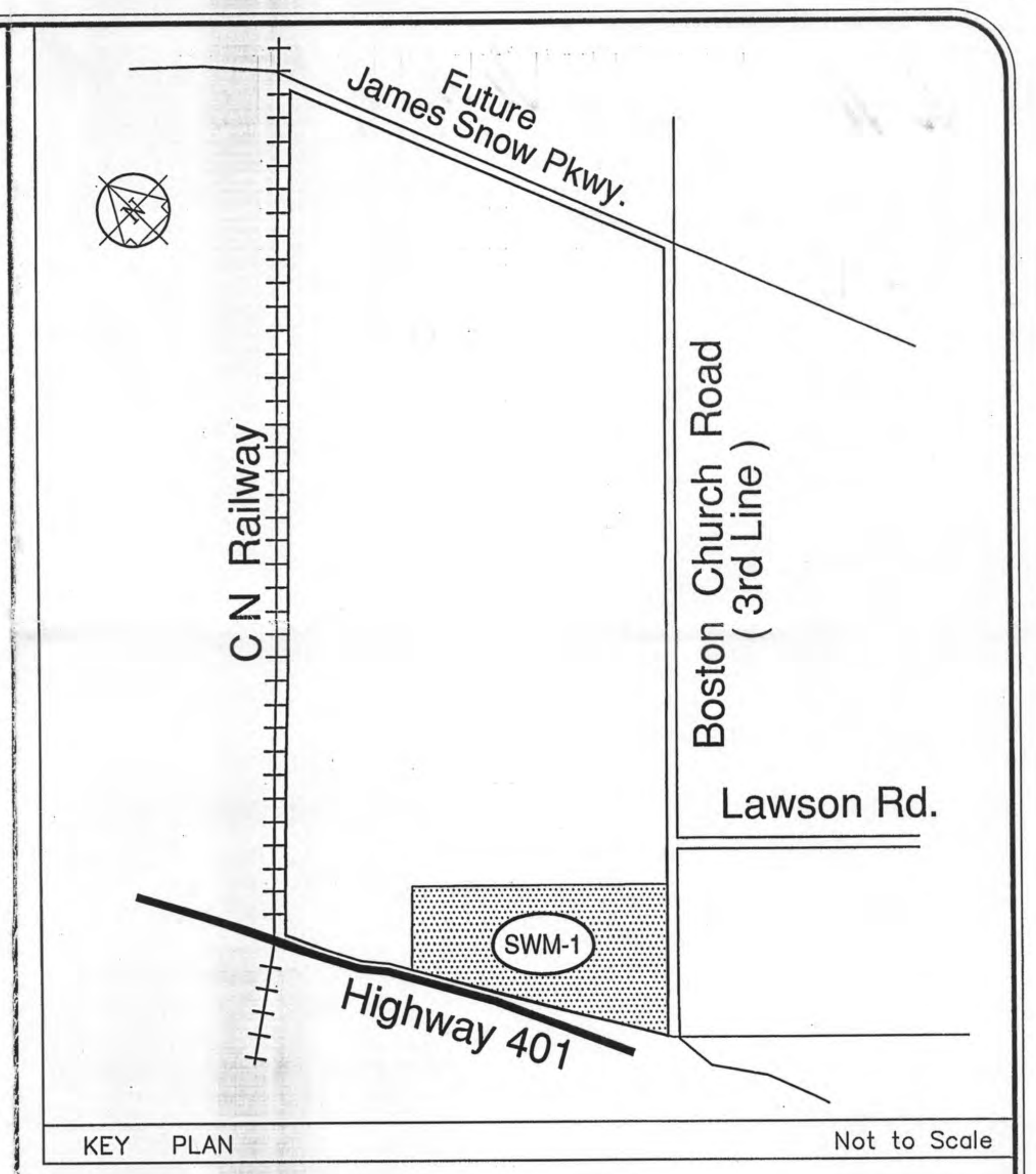
ARG MILTON
INDUSTRIAL PARK

TITLE

DRAINAGE AREA PLAN

MUNICIPAL DRAWING NO.		REGIONAL DRAWING NO.
**		****
PROJECT NO. 03211	DRAWING NO. SWM–7	SHEET OF





NOTES

1. FOR GENERAL NOTES REFER TO DWG. No. G-1

SURVEY BENCH MARK:
IS BASED ON THE MTO CONTROL POINT 880249
ELEV. 213.956m, BEING A BRASS CAP IN THE SIDEWALK AT THE SOUTHEAST CORNER OF THE JAMES SNOW PARKWAY BRIDGE OVER HIGHWAY 401.

No.	By	Date	Revision	Checked

TOWN OF MILTON
PLANNING AND DEVELOPMENT
DIRECTOR OF ENGINEERING SERVICES
REGION OF HALTON

APPROVALS

MUNICIPAL: DESIGN APPROVED SUBJECT TO DETAIL CONSTRUCTION CONFORMING TO TOWN OF MILTON STANDARDS AND SPECIFICATIONS.

DIRECTOR OF ENGINEERING SERVICES — DATE

REGIONAL: DESIGN OF SANITARY AND WATER SERVICES APPROVED SUBJECT TO DETAIL CONSTRUCTION CONFORMING TO HALTON REGION STANDARDS OF SPECIFICATION AND LOCATIONAL APPROVAL FROM THE AREA MUNICIPALITY.

PLANNING AND PUBLIC WORKS DEPARTMENT — DATE

REGISTERED PROFESSIONAL ENGINEER — ROSARIO.SACCO — PROVINCE OF ONTARIO

URBAN ECOSYSTEMS LIMITED
7050 WESTON ROAD, SUITE 705
WOODBRIDGE, ONTARIO L4L 8G7
TELEPHONE: (905)856-0629
FAX: (905)856-0698

STORM WATER MANAGEMENT POND AND DETAILS

REGIONAL FILE: DM-0154		REGION DRAWING No:	
Surveyed By	Date	Contract No.	03005
Drawn By D.J.S.	Checked By N.V.	Drawing No.	Sheet No.
Designed By D.J.S.	Checked By N.V.	SWM-1	
Scale; 1 : 500	Date 2003-06		

Drawing: D:\PROJECTS\03005\PRINTING\03005-PRINTING-SWM

CH Copy

uma

STORMWATER MANAGEMENT IMPLEMENTATION REPORT VERUS PARTNERS SITE

ESQUESING LINE

MILTON, ONTARIO

OCTOBER, 2004

STORMWATER MANAGEMENT IMPLEMENTATION REPORT VERUS PARTNERS SITE

ESQUESING LINE

MILTON, ONTARIO

PREPARED FOR:

Verus Partners, LLC

PREPARED BY:

UMA Engineering Ltd.
5080 Commerce Boulevard
Mississauga, Ontario L4W 4P2
Tel: (905) 238-0007
Fax: (905) 238-0038

and

Thompson Flow Investigations Inc.
4129 Varden Court
Mississauga, Ontario L5L 4A7

UMA File No. F168-001
Revised October, 2004

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1.0 INTRODUCTION

1.1 BACKGROUND

The Verus Partners, LLC (Verus) proposed industrial development is located in the northeast area of the Town of Milton and within the Highway No. 401 Industrial/ Business Park (see Key Plan below).

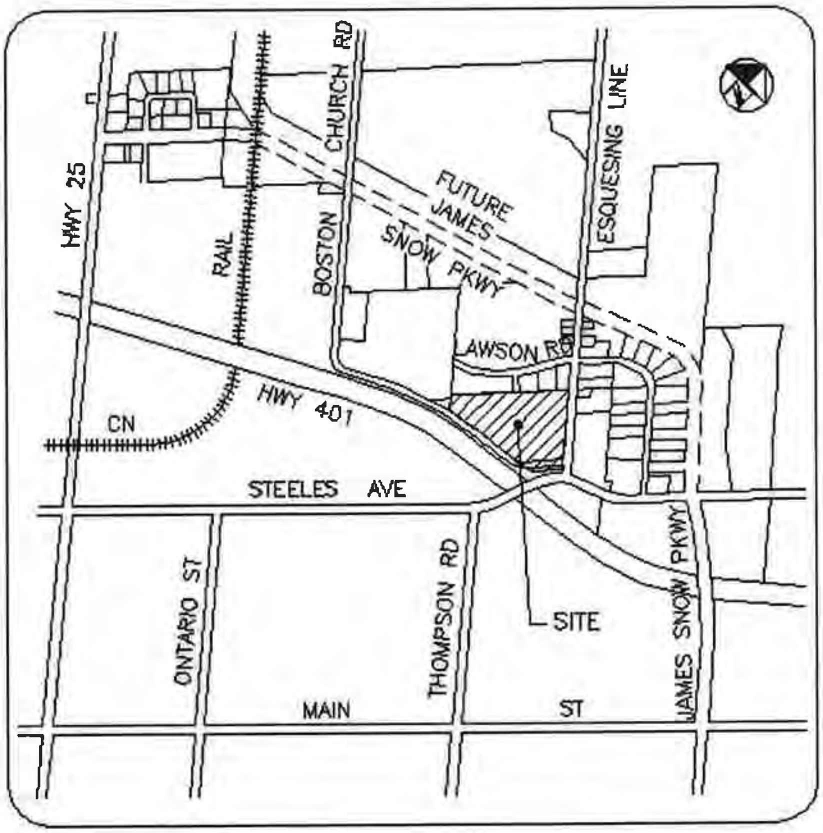

Figure No. 1 – Key Plan

The proposed development area is bounded by Esquesing Line, Boston Church Road, existing industrial development to the north and existing institutional use to the west.

The previously developed lands to the north included an existing stormwater quality and quantity control facility (pond) adjacent to the northwest area of the Verus site (see Dwg. No. SMF-01, Appendix 'D') to provide water quality treatment to a Level 1 requirement and quantity storage to control peak flows to pre-development levels. The facility was designed based on the subject lands along with the existing industrial lands south of Lawson Road and existing residential/commercial lands adjacent to Esquesing Line directing their storm drainage to the existing watercourse on the Verus lands to the east and south of the pond. As a result, these lands did not contribute to the existing facility.

The purpose of the report is to describe the design details of the proposed stormwater management facility necessary to permit development of the Verus site and that will meet the stormwater management design parameters identified for the area in previous stormwater/watershed reports. The previous reports include those completed for the design of the existing pond to the north.

The previous reports completed for the area include:

- **Hydrologic Assessment, Manheim - Snoek Stormwater Management Facility, Milton North Secondary Plan Area by Valdor Engineering Inc. dated October, 2003;**
- **Stormwater Management Facility Design Brief, Milton North Secondary Plan Area, Manheim - Snoek Property, Town of Milton dated December, 2001 by Philips Planning and Engineering Ltd.;**
- **Functional Stormwater and Environmental Management Strategy, Highway No. 401 Industrial/Business Park by Philips Planning and Engineering Ltd. dated July, 2000;**
- **Subwatershed Planning Study for Sixteen Mile Creek, Areas 2 and 7 by Philips Planning and Engineering Ltd. dated January, 2000.**

The studies identified that the Verus site could be serviced, from a stormwater management view, via the development of an independent facility for the Verus site or in conjunction with the existing pond located to the north as noted above. The Functional Stormwater and Environmental Management Strategy report identified stated the following in Table 6.2:

- **"This area has been partially developed with a "dry" SWM facility. Recent proposals for expanded industrial usage include proposal to expand the existing facility and convert to a wet pond facility".**

The Philips 2001 pond design report states the following:

- **"Under the ultimate land use conditions, the Magna International (now Verus) property south of the TAA site would be developed. At that time, the requisite additional stormwater management may be provided by a separate facility, or by expanding the proposed interim stormwater management facility".**

The strategy study also indicates that the existing watercourse across the Verus site that provides a drainage outlet for the existing pond is not required to be retained. Further to that item, the report states the following regarding the existing watercourse:

- **"No watercourses within this area have been recommended to remain as open systems however the function of the existing watercourses would need to be replicated through the design of the site drainage systems".**

- **"The upstream sections of this reach have been buried under a large lot associated with some industry. The downstream sections were ditched and dry when examined. Some water was found between the North Service Road and Highway No. 401, however, no fish could be found in this short watered section (sampling site 211). Downstream of the Highway No. 401 is an impassable barrier at the upstream end of a long buried section, thus fish could not re-colonize this reach if extirpated. This finding is substantiated by an electrofishing examination undertaken by Golder Associates in November, 1998, which also failed to collect fish".**

The items note that the existing watercourse can be removed without adverse impacts to the natural environment or existing fish habitat. In addition, **Figure No. 4, Constraint Plan** included in the report identifies that the **"watercourse may be eliminated subject to replication of function"** which supports the items presented above.

Finally, the Town of Milton has indicated a preference for a combined pond to serve the existing lands and the Verus site versus two (2) independent ponds in order to minimize the number and maintenance requirements for storm facilities in the area. Any modifications made to the existing pond to expand the facility to accommodate the Verus site should minimize changes that would result in significant impacts to the operation of the existing pond.

Along with the input of the Verus site to an expanded pond and the relocation of the existing watercourse to the pond expansion area, the existing industrial lands south of Lawson Road and the existing residential/commercial lands adjacent to Esquesing Line that drain to the system south of the existing pond must be directed to, and accommodated by, the expanded pond facility.

Another requirement of the stormwater facility will be to limit the flow rates for all storm events from the 2 Year to the Regional event that exit the Verus site and reach the Highway No. 401 culvert downstream to pre-developed conditions as per Ministry of Transportation requirements. Finally, the potential impact of tailwater that may develop at the upstream end of the existing culvert on the pond discharge must be reviewed.

Therefore, the report addresses the combined SWM facility required to service the existing pond drainage area, the Verus Partners, LLC property along with the existing industrial lands north and east of the Verus site that were not accommodated in the existing facility. The facility expansion area will be located at the west end of the Verus site, operate in conjunction with the existing facility and, along with site storm sewers will replicate the function of the existing watercourse proposed to be removed (see Dwg. No. SMF-01, Appendix 'D').

1.2 SCOPE OF REPORT

The report is intended to describe the drainage features of the Verus development including the SWM facilities necessary (both water quality and water quantity controls) to address both the Verus site and the existing industrial/ residential/commercial lands along the south side of Lawson Road and the west side of Esquesing Line that contribute uncontrolled flows to the existing drainage course.

The report will also revise the Visual OTTHYMO modelling completed for the existing pond by Valdor to address the operation of the existing pond in conjunction with the expanded pond, the adjusted drainage areas and the modified % imperviousness factors for the drainage shed. See Dwg. No. SMF-04, Appendix 'D' for an illustration of the proposed drainage areas for the revised facility.

We have reviewed the previous Valdor model and agreed with its results, however, the model required revision to update the data for the Verus site and thus, the model has been revised for the study.

The components of the report include:

- The basic criteria to be met by the drainage and SWM systems are outlined in Section 1.3;
- The method of analysis used is described in Section 2. The section includes the quality and quantity control details of the SWM facility;
- In Section 3, various hydraulic features of the SWM facility are discussed and details provided;
- Details regarding the existing watercourse relocation are provided in Section 4;
- Erosion and sediment control details are presented in Section 5;
- Supporting information, computer printouts and detailed design drawings for the expanded pond are attached as Appendices 'A' to 'D'.

It should be noted that the previous Philips and Valdor reports identified in Section 1.1 did not include the developed condition % imperviousness for the existing developed lands along the south side of Lawson Road (industrial development) or the west side of Esquesing Line (residential/commercial) north of the Verus site (Area No. 2027) within the flow rates that would reach Highway No. 401. The Verus facility design has included these lands at the required developed % imperviousness to include the increased runoff rates the post-developed flows would produce and which would reach Highway No. 401 if not regulated by the pond.

Some of the land areas employed in the design of the Verus expansion of the existing facility have been increased when compared to that used in the Valdor/Philips reviews as a result of the more accurate data available with the use of updated legal and topographic surveys prepared for the Verus site.

1.3 DRAINAGE CRITERIA

The drainage and SWM facilities for the Verus site will be developed according to the previously noted reports governing development of the area along with Town of Milton standards. The criteria noted in the reports included that required by the Ministry of Transportation (MTO), Ministry of the Environment (MOE) and Conservation Halton (CH).

Key specific criteria to be met are listed below:

1. The drainage system shall be developed according to the dual minor-major drainage concept;

2. The minor system shall consist of storm sewers and appurtenances designed to accommodate peak flows resulting from a 5 Year design storm;

3. The Verus site's major drainage system will consist of access roads and parking areas as necessary. The combined minor-major drainage system shall accommodate peak flows up to the 100 Year storm;

4. Water quality control facilities shall be designed to meet the criteria required which include a wet pond system with quality control storage (MOE Level 1 treatment for stormwater discharge) as well as, erosion control storage to address potential downstream erosion from the more frequent storms. Such erosion control requires that the outlet from the extended detention portion of the water quality control facility be sized so that at least 24 hours are required for it to drain (also allows for settling). The quality facility extended detention outlet will also assist in the maintenance of downstream base flow;

5. Water quantity control is intended to limit post-development peak discharges to pre-development levels for the 2 Year through Regional design storm events. From the Valdor report (Tables 2B and 3), the established maximum discharge rates (pre-development condition) permitted to reach the Highway No. 401 culvert south of the Verus site are to be as follows (24 hour storm);

- **2 Year storm = 3.65 cms**
- **5 Year storm = 6.42 cms**
- **10 Year storm = 8.49 cms**
- **25 Year storm = 11.28 cms**
- **50 Year storm = 13.42 cms**
- **100 Year storm = 15.62 cms**
- **Regional storm = 20.69 cms**

NOTE: The pre-development condition flows shown include all flow from all additional drainage areas identified in the report.

It should be noted that a 4.5 ha. area (Area No. 2034-2) south of the Verus site including portions of the Boston Church Road right-of-way and Highway No. 401 are included in the above noted flows but which will not pass through the pond;

6. The proposed relocation of the existing watercourse from its location within the western 1/3 of the Verus site west to the location of the new Verus stormwater facility expansion area should incorporate enhancements to increase the amount of vegetative cover;

7. All flows from the required drainage areas including those presently draining uncontrolled to the Highway No. 401 culvert (163.6 ha.) shall be accommodated within the expanded facility to increase the land area provided with stormwater quality and quantity treatment;

8. The design of the expanded pond should minimize changes that could adversely impact the operations of the existing pond and require significant alteration/reconstruction of the previously approved pond;

9. The stormwater facility will be designed with sufficient storage, a suitable outfall structure configuration and overflow weir for the Regional storm to account for submergence conditions at the facility discharge due to the Highway No. 401 culvert tailwater.

2.0 METHOD OF ANALYSIS

2.1 OVERVIEW

In this section, the methods for analysis of the drainage system for the proposed development area are presented. The operation and sizing of the water quality and quantity portions of the stormwater management (SWM) facility are also described. As noted in Section 1.0, the SWM facility to be analysed is the expanded version of the existing pond that will accommodate the addition of the proposed development area and the existing uncontrolled areas.

1. System Model

The layout of the storm sewer system for the Verus site, as well as the major system flow path, were designed to meet Town of Milton and the Functional Stormwater Strategy Report (Philips, 2000) requirements. The storm sewer system was designed using the Rational Method according to the Town of Milton storm sewer design standards. The storm sewers for the Verus site are designed to carry runoff from a 5 Year storm event.

During a major storm event, such as the 100 Year event, a portion of the flow will be carried by the minor system with the balance of the flow continuing along the major system which primarily consists of appropriately graded parking lots and access roads. A pipe system is a more efficient carrier of flow than a surface feature (major flow segment). In a pipe, the velocities are greater and storage is less than in the major flow system. As a result, there will be minimal attenuation of the peak flows which enter the sewer system. In the major system, comprised of access roads and parking areas, there can be significant attenuation ("spreading out") and lowering of peak flow rates. During a large storm, such as the 100 Year event, the major flow system itself helps to control peak rates of runoff.

The Visual OTTHYMO model has been used to design the proposed expanded facility to be consistent with the model type employed in the Valdor Engineering Ltd. report to design the most recent version of the existing facility and recently approved by the Ministry of Transportation. The Valdor model has been updated to add both the Verus lands and the adjacent uncontrolled lands to the area included in the original Valdor model with area and % imperviousness adjustments to address the revised drainage areas as necessary.

2. Water Quality Facility

The major and minor systems in the area generally drain in a south-westerly direction to outlets at the expanded facility from the Verus site and outlets to the existing facility from lands to the north and west. The major system flow is proposed to be discharged from the Verus site at the storm sewer outlet locations and from lands to the north of the existing facility via Lawson Road and the existing overland flow routes.

The existing and expanded facilities include wet ponds (permanent pool) sized as required along with an extended detention storage volume to provide erosion control for the drainage areas.

The water quality facility will include two (2) separate permanent pool areas as described in Section 2.6 but with conjoined extended detention storage areas.

The permanent pool volume was determined using the Level 1, wet pond facility and impervious parameters included in the MOE Manual which requires the provision of 150 m^3/ha. of permanent pool volume per ha. of drainage area.

Both the permanent pool and extended detention top water levels have been maintained for the existing pond area. As a result, the storage volumes available in the existing pond have been maintained with the expanded pond area volumes accommodating the added drainage areas.

The Verus site drainage system and the expanded SWM facility layouts including the permanent pool and extended detention top water levels are depicted in a series of plans enclosed with the report in Appendix 'D'.

2.2 DESIGN STORMS

We have utilized for the design of the expanded facility the design storms developed and presented in the Valdor report noted previously. These storms utilized the Chicago hyetograph method. For this analysis, the hyetographs were discretized at 5 minute time steps and a 24 hour time duration was used.

Analysis of the extended detention portion of the water quality pond involved the simulation of a 25 mm storm. It is intended that the runoff from a 25 mm storm be captured and gradually released from the extended detention storage over a period of at least 24 hours. The sizing of the outlet from the quality pond controls the duration of pond drawdown. In order to analyze the performance of this portion of the SWM facility, a 25 mm design storm was developed utilizing a mass curve (SCS, 12 hr distribution).

2.3 SUBCATCHMENT MODELLING

In hydrologic modelling, a subcatchment is an incremental portion of land from which runoff hydrographs are calculated. The hydrographs from these subcatchments are linked together through routing calculations along the flow carriers (major flow segments and pipe system) to get total flow hydrographs at various points throughout the system.

The discretization of the proposed facility drainage area into subcatchments has been developed. This discretization can be seen on the Storm Drainage Area Plan, Dwg. No. SMF-04 presented in Appendix 'D'.

There are several external previously developed, proposed to be developed and undeveloped areas that contribute to the facility and/or the Highway No. 401 culvert as follows:

- **Area 2027-2** – 2.0 ha area adjacent to Esquesing Line. This area will contribute minor flow to the Phase 1 and future Phase 2 sewers plus, major flow across the Phase 1 and 2 areas;

- **Area 2027-3** - a 7.6 ha area to the north located along the south side of Lawson Road between Esquesing Line and the existing pond. The area's flow will contribute to the western portion of the future Phase 2 minor and major systems;

- **Area 2032** - a 52.8 ha. area representing the northernmost contributory area to the existing and expanded ponds. The area is presently undeveloped and is proposed to remain so as it is located outside the present Milton urban area;

- **Area 2034-2 -** a 4.5 ha. area including the existing Boston Church Road and Highway No. 401 area contributing to the Highway No. 401 culvert. The area does not contribute to the existing or proposed ponds;

- **Areas 2046, 2047, 2048, 2049 and 2050 -** total 82.2 ha. area which is presently accommodated by the existing pond and will be included within the proposed pond drainage area.

The areas used in the updated model for the existing facility were obtained from the previous reports prepared by Valdor and Philips and adjusted to address the Verus site and the additional uncontrolled areas identified. The % imperviousness factors used have also been based on those included in the noted reports and modified as necessary for the Verus and adjacent lands.

The % imperviousness factors employed in the updated model are as noted below:

Table No. 1 – % Imperviousness

Area No.	Area (ha.)	% Imperviousness
2027-1	6.1	85
2027-2	2.0	75
2027-3	7.6	80
2027-4	2.2	16 (pond surface)
2027-5	1.4	95 (pond surface)
2032	52.8	3
2034-1	9.3	75
2034-2	4.5	50
2046	16.5	90
2047	16.3	79
2048	27.5	90
2049	9.7	68
2050	12.2	75
TOTALS	**168.1**	**56**

Please see Figure No. 2 for a schematic of the Verus facility model.

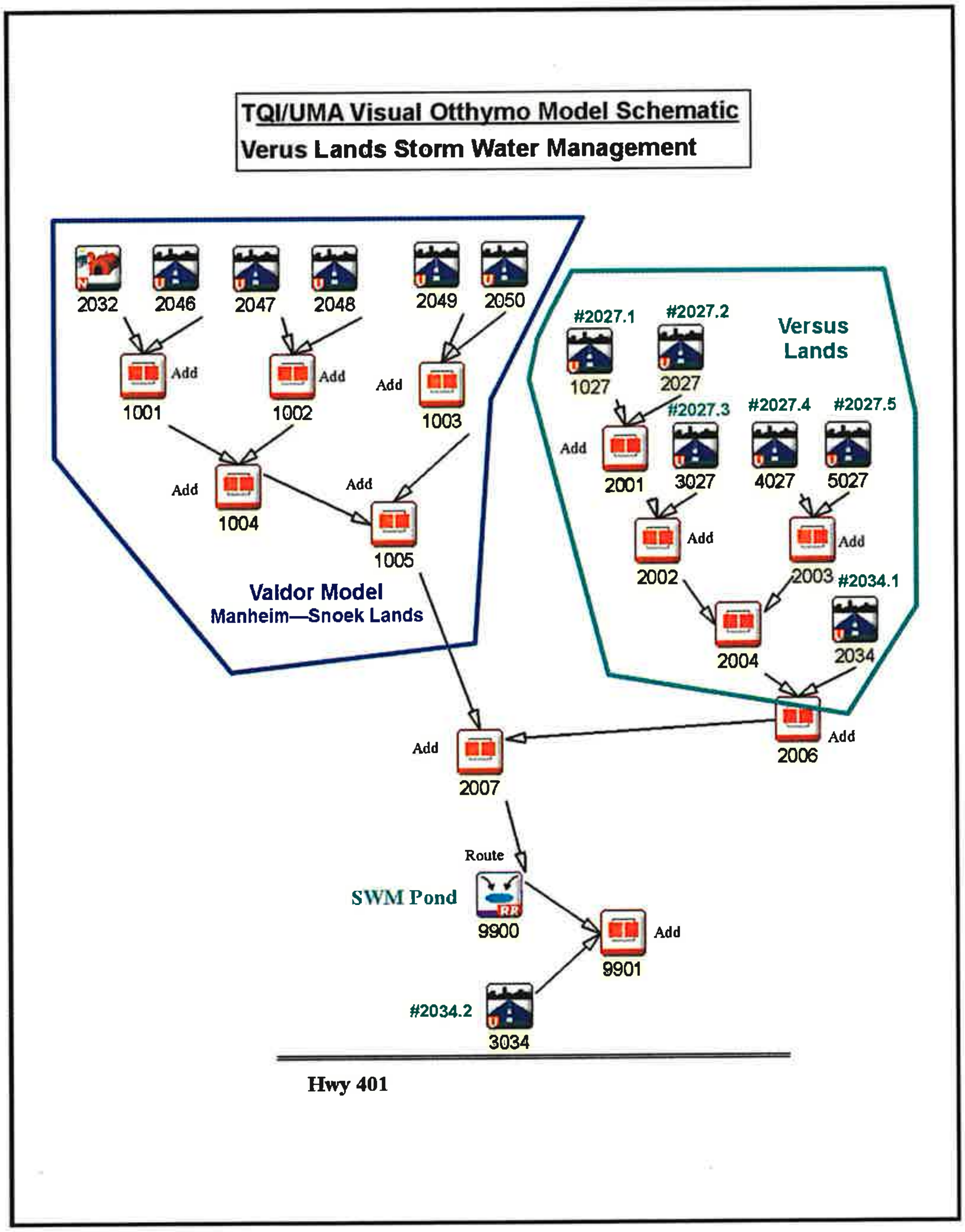

Figure No. 2 – Model Schematic

2.4 MINOR SYSTEM

All rainfall that falls within the subject drainage areas is directed to the minor drainage (sewer) system to collect and accommodate the runoff. The volume of runoff that will enter the system is determined for sewer design by the Rational Method with the 5 Year storm being the design rainfall intensity for minor systems in the Town of Milton.

The minor systems on the Verus site and adjacent lands will direct all flows that enter the systems during all storm events to the stormwater management facility for quality and quantity treatment.

2.5 MAJOR SYSTEM

Much of the subcatchment storm runoff is initially directed to the parking areas and access roads. As it flows along the routes, it encounters catchbasin inlets at which point it has an opportunity to enter the storm sewer system. At each catchbasin, some of the flow will be intercepted and some of the flow will carry on to be potentially intercepted by downstream catchbasins. All flow in excess of the intercepted flow becomes carry on major system flow.

2.6 SWM CONTROL FACILITY

The proposed SWM control facility will be located downstream of the developed areas as shown on Dwg. No. SMF-01, Appendix 'D'. The SWM facility consists of a combination pond to provide water quality treatment, erosion control plus, water quantity control.

As the existing facility was a combined pond, it was determined that the expanded facility should follow this design concept and act as an expanded area of the existing pond.

The various design features of the expanded SWM facility are described below.

1. <u>Quality Control Storage</u>

As identified in the Valdor and Philips reports noted previously, the existing facility is a wet pond type facility with specific storage volumes provided based on Level 1 treatment, etc. As a result, the expanded quality facility has been designed with similar criteria along with the requirements of the MOE's 2003 Stormwater Planning and Design Manual.

The water quality system has three components; sediment forebays, wet cells (permanent pools) and an active storage area (extended detention). The sediment forebays are designed to pre-treat storm runoff by capturing sediment and floatables. The wet cells of the quality pond are designed to provide polishing. The extended detention area of the facility is provided above the permanent pool volume and provides additional water treatment (polishing), erosion control and limited quantity control.

The expanded quality control pond has been designed according to the criteria described above including the necessary integration with the existing pond and includes the following details:

- **General:**
  - o Habitat Protection Level = 1 (based on the quality of the receiving water body, 16 Mile Creek). This level of treatment will provide enhanced protection and is the most stringent;
  - o Upstream Drainage Area - Expanded Area = 163.6 ha (>10 ha) required to sustain a wet pond;
  - o Overall Site % Imperviousness (land use) = 56%
- **Sediment Forebay**:
  - o Sediment Forebay (2 of) Storage Volume, Expansion Area = 400 m^3 (Phase 1) + 360 m^3(Phase 2) = 760 m^3;
  - o Existing Pond Sediment Forebay (2 of) Volume = 6,200 m^3;
  - o Total Sediment Forebay Volume = 6,960 m^3;
  - o Surface area is less than 33% of the combined permanent pool surface area as required;

<u>Expansion Area Details</u>

  - o Length = 45 m (Phase 1), 48 m (Phase 2); as required by settling length and dispersion length calculations;
  - o L:W ratio is 45/12 (Phase 1) and 48/10 (Phase 2) or 3.75:1 and 4.8:1 and within guidelines (see MOE Manual, Table 4.6, Length to Width Ratio Item, Min. 2:1);
  - o Side slopes = 3:1;

- Depth = 1.0 m (within guidelines and will not become anoxic and release metals and organics from pond sediments);
- Bottoms are to be lined with rip rap to facilitate maintenance and sediment removal;
- An outlet location over the forebay berms that separate the forebays from the permanent pool is set at an elevation equal to the permanent pool elevation in order to ensure that incoming sewer flows are slowed to trap coarser grit and sediment;
- The average velocity in the forebays (0.025 m/s) are within guidelines (< 0.15 m/s) to prevent erosion.

Please note that the existing pond's sediment forebays have not been reviewed in detail as their approved design conditions have not been modified as a result of the proposed expanded design.

- **Permanent Pool**
  - Expansion Area Storage Volume = 4,690 m^3 (including two (2) sediment forebays);
  - Existing Pond Storage Volume = 22,000 m^3 (including forebays and modification to integrate ponds);
  - Total Storage Volume = 26,690 m^3;

Expansion Area Details

- Depth = 1.0 m and 1.5 m.;
- L:W ratio = average 12:1;
- Side slopes = 3.1 and 5.1 (5:1 for 0.6 m of depth above and below permanent pool top water elevation).

Note: The permanent pool storage volume identified in the Philips design was 21,100 m^3 but this involved a smaller drainage area of 135.0 ha. At the present modified area of 163.6 ha. and the 150 m^3/ha requirement, the adjusted minimum storage volume for the combined pond will be 24,540 m^3 which is less than that provided as identified above.

It should be noted that a proposed berm with an elevation equal to, or greater than, the existing pond's permanent pool top water level of 209.82 will be constructed along the limit between the existing pond and the proposed pond expansion area. As a result, the existing pond's permanent pool top water elevation will remain at 209.82 while the Verus expansion area of the facility will have a lower permanent pool elevation at 209.20.

- **Extended Detention (Active) Storage**
  - Expansion Area Storage Volume = 10,085 m^3;
  - Existing Pond Storage Volume = 15,565 m^3 (including modification to integrate ponds);
  - Total Extended Detention Storage Volume = 25,650 m^3;

  Expansion Area Details
  - Depth = 1.47 m.;
  - Side slopes = 4:1 and 5:1 (5:1 for 0.6 m depth above permanent pool top water elevation);
  - L:W ratio = average 5:1;
  - Reverse sloped pipe outlet designed to release water over a 24 hour period for the extended detention volume in order to control erosion during the more frequent storm events with a discharge rate of 0.20 m^3/sec. A 290 mm orifice plate is required to discharge 0.20 m^3/sec. at a water level of 210.67 m;
  - INTERHYMO modelling shows that the 25 mm storm event (first flush) is contained within the quality pond volume.

    Note: The extended detention volume identified in the Philips design of 14,800 m^3 is for the smaller drainage area of 135.0 ha. For the larger modified drainage area for the expanded pond of 163.6 ha., the storage volume required is 21,618 m^3 which is less than that provided.

    The extended detention top water level in the existing pond has not been adjusted due to the new pond expansion area design. Both pond areas will include a 210.67 extended detention top water level.

- **Thermal Mitigation**
  - Permanent pool depths of 1.42 m and 1.5 m, the total pool surface area of 20,000 m^2 and the linear nature of the Verus permanent pool area all will provide a significant volume of water, and a configuration, that lend themselves to a reduction of the potential thermal impacts of inflows to the pond and surface area warming;
  - Planting of numerous bare root shrubs along the pond slopes adjacent to the permanent pool will assist in shading of the edges of the permanent pool area and help to reduce potential thermal impacts.

2. Quantity Control Storage

The quantity storage volume is designed to control the peak storm flows from the developed areas to pre-developed rates prior to entering the Boston Church Road and Highway No. 401 culverts. The control system consists of a storage volume in the SWM facilities and an outlet structure to control the rate of flow leaving the pond for the various storm events.

There are three (3) components to the overall quantity control system as follows, however, only the latter two (2) were modelled:

- **Surface Ponding Storage:**

When stormwater runoff exceeds the inlet capacity of the sewer system, water is temporarily ponded on the surface during storm events. While on the surface, the runoff will flow toward its gravity outlet and most of it does eventually enter the minor storm sewer system as the peak passes in the sewer. As a result, the major system flow that reaches the outlet is an overflow from the surface storage portion of the quantity control system.

- **Quality Pond Extended Detention/Erosion Control Storage which acts Dually as Quantity Storage:**

As storm flows reach this portion of the pond via both the minor and major routes, the flows go into storage as provided in the pond and are released slowly. As the initial active storage available in the facility is the quality control storage, this storage volume also acts as quantity storage for storm events beyond the first flush. As a result, this active quality storage can also be considered as a component of the quantity storage for events with flows in excess of the first flush volume.

- **Quantity Control Storage:**

The quantity control storage is the storage volume in the pond above the extended detention volume and its release rate is controlled by the weir structure to limit the pond outflow rate to below the pre-developed flow rates for the various storm events.

The quantity storage volume is added to the extended detention volume to determine the total volume available for quantity storage.

Details of the quantity storage available in the expanded facility are as follows:

- Storage Depth Available = 1.43 for 100 Year;
  = 1.58 m for Regional;
- A total quantity storage volume of 42,850 m^3 is provided up to an elevation of 212.10 m and above the quality storage volumes (i.e. above 210.67 m). An additional volume of 5,500 m^3 is available between 212.10 and 212.25;
- Total Quantity Storage Available = 74,000 m^3 (includes extended detention volume);
- An outlet structure (see Section 3.2 for description) has been designed to make effective use of this storage volume so that peak flow rates for all storms up to the Regional return period event will be less than the existing pre-developed peak flow rates documented in the Valdor report (Tables 2B and 3) at the Highway No. 401 culvert.

  Note: The Valdor report indicated a total quantity storage requirement including the quality volumes of 49,696 m^3 at the Regional level (Table 3) versus the 73,500 m^3 noted in Table No. 3, Section 3.1. The modified drainage area for the expanded pond of 163.6 ha. versus that used in the Valdor report (135.0 ha.) accounts for the difference.

The 100 Year top water elevation in the existing pond will be increased from 211.95 m to 212.10 m and reduced for the Regional event from 212.30 m to 212.25 m. The resultant minor volume reduction will be replaced within the additional quantity storage volume provided in the pond expansion area.

In addition, expected final site grades will result in a requirement for a localized on-site storage area in the southeast area of the site as overland flows cannot reach the pond. The required storage volume (630 m^3; 5 ha. area) will be included in the detailed design for the Phase 1 building however, the pond has been designed with the area included to result in a slightly conservative pond design.

The components of the SWM facility combine to treat the stormwater and to control developed peak flow rates at the exit from the pond to values within those noted in the Valdor report as the existing pre-developed peak flows (i.e. target flow rates for the development) which enter the Highway No. 401 system. See Table No. 2 for a comparison (24 hour storm)

Table No. 2

INTERHYMO Computer Results with Quantity Pond Outlet Structure

Storm (24 hour)	**Existing Peak Flow (cms)** (Valdor, Table 2B)	**Development Peak Flow (at Hwy. 401) (cms)**
2 yr	3.65	0.75
5 yr	6.42	1.89
10 yr	8.49	3.40
25 yr	11.28	6.89
50 yr	13.42	9.72
100 yr	15.62	13.00
Regional	20.69	22.03

The final configuration of the weir structure as shown in Figure No. 3 and on Dwg. No. SMF-03 in Appendix 'D' has been designed to accommodate both the Visual OTTHYMO model for the local area and the HSP-F model as developed by Philips Engineering Ltd. for the 16 Mile Creek watershed. As a result of developing a weir suitable of addressing the HSP-F model targets, the structure over controls the expected OTTHYMO flows and reduces the outflows from the pond and the resultant flows reaching the existing Hwy. No. 401 culvert to a level significantly below the pre-developed condition as illustrated in Table No. 2.

Please see the Philips Engineering Ltd. letter dated October 7, 2004 and attached memo dated October 6, 2004 in Appendix 'A' which indicates that the proposed structure was found to be acceptable following their review.

3.0 HYDRAULIC FEATURES

3.1 POND OUTLET STRUCTURE

The outlet control structure for the pond has been designed to progressively detain flows so that enough storage is utilized to control post-developed peak flows for a wide range of storms to pre-developed levels plus, detain flows to address quality treatment for the first flush storm flows and erosion control. The structure has also been designed to meet the 16 Mile Creek watershed targets. Finally, the downstream portion of the structure has been designed to provide a stilling basin and floor blocks to contain the hydraulic jump that could occur in the future if the Hwy. No. 401 culvert is expanded and the present submerged condition no longer occurs. The MTO requested these downstream structure adjustments.

It is intended that the structure be composed of reinforced concrete with a stepped, bull nosed shaped weir configuration and a reverse sloped pipe for quality control as shown conceptually in the following figure. A detailed design of the structure reflecting actual pond elevations is included with Dwg. No. SMF-03 in Appendix 'D'.

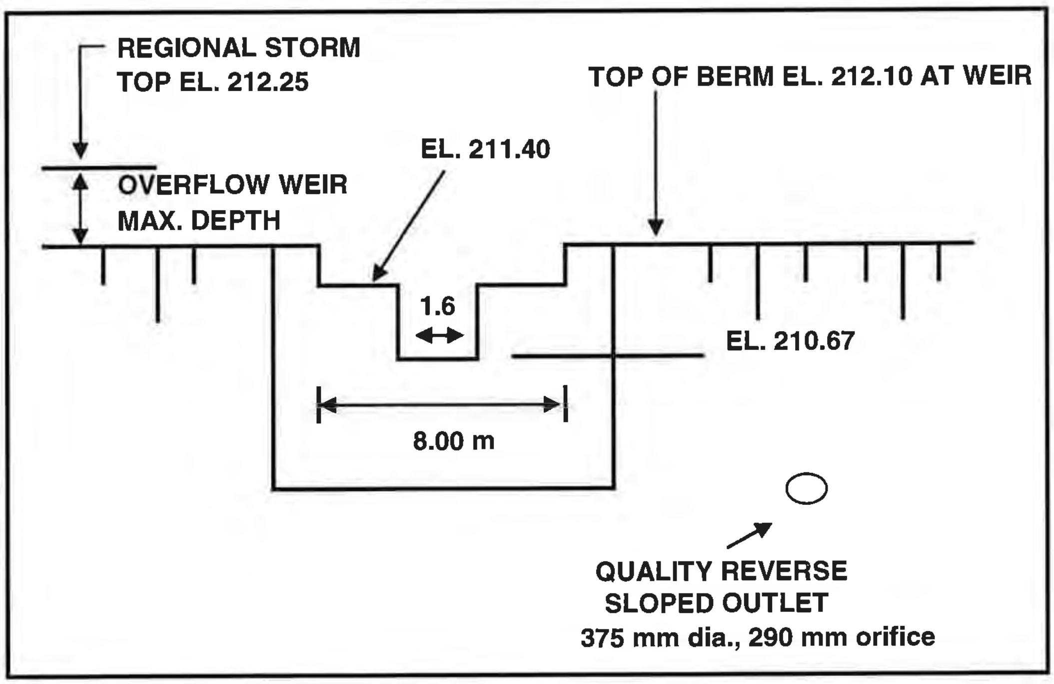

Figure No. 3 - Outlet Weir Structure Concept

During development of a rating curve for the control structure, the weir portions were analyzed as broad crested weirs with end contractions and with "C" varying with head for low heads. Storage volumes were calculated using the horizontal "mean" area approach with areas measured by CADD.

The table below provides the distribution of flow for the proposed structure plus, the associated storage.

Table No. 3 - Discharge - Storage Characteristics of Pond

Elevation	Depth	Discharge Submerged Conditions	Storage
(m)	(m)	(m^3/s)	(ha. m)
207.50	0	0	0
207.70	0.20	0	0.004
208.60	1.10	0	0.362
209.20	1.70	0	1.490
210.67	3.17	0.20	2.565*
210.81	3.31	0.32	3.000*
210.96	3.46	0.60	3.500*
211.12	3.62	1.03	4.000*
211.26	3.76	1.45	4.500*
211.40	3.90	1.89	4.950*
211.50	4.00	2.65	5.300*
211.70	4.20	4.17	5.900*
211.89	4.39	8.72	6.450*
212.10	4.60	12.07	6.950*
212.25	4.75	21.91	7.350*

Note: * = Storage volumes in addition to permanent pool volume.

The reverse sloped pipe will control the extended detention storage for quality treatment and erosion control. The weir structure will control the quantity storage volumes for the 2 Year to the Regional storm events.

The proposed pipe and structure will replace the previously proposed east and west structures of the existing pond and act as the single control for the entire expanded SWM facility.

As noted previously, the facility discharge rates needed to be reviewed against the tailwater conditions of the downstream Highway No. 401 culvert. A HEC-RAS review of the topographic and culvert conditions downstream of the pond was completed and tailwater conditions were determined for each storm event (see Appendix 'C' and 'D').

We examined the topographic plans of the area and found that the highway rises from east to west in this area (see topographic plan in Appendix 'D'). Approximately 210 m east of the Steeles Avenue overpass, the elevation is 211.5 m and just to the east (40 m) of the culvert the elevation is 212.0. By interpolation the road crest elevation at the Steeles Avenue overpass is 211.7 and it is there that water would first spill (overflow the highway) during a very large storm.

In order to analyze the impact of the Highway No. 401 on the Verus SWM facility, we first created a "model" of the Highway No. 401 culvert and embankment using the U.S. Army Corps of Engineers HEC-RAS program. The cross section layout is shown on the Cross Section Location Plan in Appendix 'C' and the top of embankment section (road profile) includes a representation of the spill that would occur under the Steeles Avenue overpass (see Appendix "C').

Regarding the calculation method used for determining the downstream starting water levels, we used the normal depth (uniform flow assumption) boundary condition for the project. To start the hydraulic calculations, we entered the slope for the MTO culvert at Hwy. No. 401 and started the calculations using two actual cross sections from the topographic plan available (see Appendix 'D') downstream of Hwy. No. 401.

The culvert opening size and upstream invert were taken from the Philips survey notes and the downstream invert was based on the slope of 0.5 % as used in their nomograph calculations (see Appendix 'C'). A rating curve of the Highway 401 culvert hydraulic performance (upstream water level versus discharge) is attached (both plot and tabular form in Appendix 'C').

The Highway 401 culvert is very close to the Verus SWM facility outlet and an examination of the VO2 hydrographs confirmed that flows occur coincidently at both locations (i.e. during a 100 year storm the peak at Highway No. 401 occurs at the same time as the peak outflow from the pond). Therefore, the peak water level upstream of Highway No. 401 for a given design storm can be used to assess submergence impacts at the Verus SWM pond outlet structure for the same storm peak.

We accounted for submergence using a procedure provided on page 5-18 to 5-19 with Figure 5-5 in Brater and King's Handbook of Hydraulics. This procedure calculates the impact of a given submergence in reducing the discharge for a given head.

Once submergence was initially allowed for, for a range of flows, a revised pond curve resulted. This was used in VO2 to get revised flows which were then used in HEC-RAS to compute new levels. The revised levels were in several cases quite different from initial levels which changed the submergence calculations. The entire process (hand calculations, VO2, HEC-RAS) had to be iterated four times to achieve good convergence.

It can be seen from the existing and developed condition profile plots in Appendix 'C' that with the Verus SWM facility in place Highway No. 401 no longer overtops with the 50 Year storm event. A HEC-RAS plot showing the Highway No. 401 culvert configuration, embankment and water levels is also provided in Appendix 'C'.

The below Table No. 4 provides a comparison of the flows and water levels at the upstream end of the existing Hwy. No. 401 culvert between the existing and developed conditions for all storm events.

Table No. 4

Existing/Developed Condition Flows & Water Levels
Upstream End of Hwy No. 401 Culvert
(STA 125.3)

Storm Event	Existing Flow (cms)	Existing Water Level (m)	Developed Flow (cms)	Developed Water Level (m)
2 Year	3.65	210.01	0.75	209.29
5 Year	6.42	210.53	1.89	209.61
10 Year	8.49	210.86	3.40	209.96
25 Year	11.28	211.42	6.89	210.61
50 Year	13.42	211.74	9.72	211.09
100 Year	15.62	211.79	13.00	211.73
Regional	20.69	211.84	22.03	211.86

The review indicated that up to the 10 Year event the culvert/highway tailwater conditions did not impact the facility outlet structure. The 25 Year to Regional events did provide tailwater conditions that resulted in submergence conditions at the facility discharge weir elevation of 210.67 m.

As a result, the weir structure was revised to the configuration shown in figure No. 3 to increase the facility water levels at the various storms to accommodate the tailwater conditions downstream.

The resultant 100 year water level has increased to 212.10 m and the Regional top water level to 212.25 m.

In addition, to pass the Regional event with a top water level of 212.25 m, an overflow weir 105 m in total length is required with a crest elevation of 212.10 m. The weir has been added to the facility design and will permit the Regional event to pass through the pond accounting for the downstream backwater impacts at Highway No. 401.

The proposed facility with increased water levels provides additional storage to offset the lower discharge rates from the pond due to the submergence conditions.

Please note that the facility discharge structure has been designed to operate adequately if the Highway No. 401 tailwater conditions are removed in the future by improvements to the existing culvert.

Finally, to contain the potential for a future hydraulic jump at the 25 Year flow event should the culvert capacity at Hwy. No. 401 be increased to eliminate the tailwater, a stilling basin and floor blocks have been added downstream of the weir. The design details for the stilling basin and blocks are included in Appendix 'A' and reflected in the detailed design of the structure in Dwg. No. SMF-03 in Appendix 'D'.

We have also reviewed the required rip rap size downstream of the weir structure at the 25 Year event (assumed no culvert tailwater) and the expected velocity of 1.16 m/sec. (free outfall; SS = 4:1; bottom width = 1.0 m; n = 0.03; slope = 0.25%; depth flow = 1.08 m; top width flow = 9.66 m) would require rip rap size of 100 - 200 mm. We have provided a rip rap size downstream of the weir of 200 - 300 mm size, 600 mm depth to be conservative (see Dwg. No. SMF-02, Appendix 'D').

4.0 WATERCOURSE RELOCATION

The proposed site design includes a requirement for the removal of the existing watercourse which crosses the Verus site in the western area in conjunction with the construction of the stormwater management facility.

The 16 Mile Creek Subwatershed and the Environmental Management Strategy reports by Philips Planning and Engineering Ltd. noted in Section 1.0 both indicate that the removal of the watercourse is permitted provided its function is replicated with other storm drainage facilities.

The function of the existing watercourse will be replicated by both the proposed site storm sewers and the stormwater management facility on-site.

The proposed site storm sewer systems will replicate the minor system function of the existing watercourse while the on-site major system will accommodate the major system function of the watercourse.

In addition, the construction of the water quality facility on-site to treat the storm flows presently directed to the watercourse to the most stringent Level 1 requirement will improve the existing quality of storm flows downstream from the Verus site while enhancing base flow by significantly extending flow periods following storm events.

A second enhancement feature will be the proposed landscape plantings within the stormwater facility and the discharge swale areas to replicate the existing vegetation to be lost due to the direction of storm flows to the pond and the loss of approximately 230 m of the existing swale. The new pond discharge swale is located between the pond outlet structure and the existing Boston Church Road culvert which will directly replace 40 m of the relocated watercourse. The SWM facility expansion area will replicate an additional 245 m of the watercourse. As a result, the proposed development will increase the effective swale length to 124% of the length of the existing watercourse.

The landscape plantings proposed for the pond and swale areas are to include native bare root shrubs (i.e., dogwood, elderberry, sumac, nannyberry, etc.), topsoil and sod plus, topsoil and seed. Plantings for inundation areas and wet pond areas will include plant materials suitable for aquatic fringe areas along the inundation zones plus, submergent materials in the permanent pool area suitable for deep water conditions (i.e. cattail, pondweed, water lilly, arrowhead, etc.). See Landscape

Plan, Dwg. No. L6 in Appendix 'D' for more details related to the proposed plantings.

The combination of the water quality treatment provided and the plantings within the stormwater facility and outlet swale areas will result in a significant enhancement to the existing conditions in the area.

5

5.0 SEDIMENT AND EROSION CONTROL PLAN

In this section of the report, we wish to provide the details for the sediment and erosion control features to be implemented for the proposed development. The design details are presented in the drawings provided in Appendix 'D'.

The details will include:

- Although erosion potential is relatively low due to the site soils types and site grades, removal of vegetative cover and the concentration of storm flows will result in increased erosion as compared to the existing condition;
- Place sediment fencing in all site areas where overland sheet flow may exit the site;
- Place rock check dams in all locations where concentrated runoff may exit the site;
- Place sediment fencing along the existing watercourse to prevent sediment entering the features during construction prior to completion of the proposed pond;
- Retain the existing watercourse and pond in operation until the new pond is ready for the connection between the two pond facilities and elimination of the drainage areas contributing to the watercourse;
- Install two (2) controlled construction vehicle crossings of the existing watercourse during grading of the site and pond construction to minimize the impact of vehicles traversing the site;
- Place sediment fence around all topsoil and earth stockpiles constructed on-site and seed the stockpiles as necessary;
- Provision of erosion protection elements (rip rap, etc.) at all sewer/pond outfalls;
- Re-vegetate the pre-graded site areas if development is not to occur within a reasonable time period;
- Monitor and inspect all sediment and erosion control facilities on an ongoing basis during development of the site to ensure the facilities are working as designed.

6.0 CONCLUSIONS

The proposed stormwater management facility will provide stormwater management for all of the required drainage areas including the proposed Verus site, all existing lands draining to the existing stormwater facility plus, the additional areas on the southside of Lawson Road and adjacent to Esquesing Line presently not contributing to the existing pond.

The proposed facility will be a combined quality and quantity facility which will provide quality treatment to Level 1, as well as, control flow rates from the contributing lands to pre-development flow rates prior to the developed flows entering the existing Highway No. 401 culvert.

The quality pond will also provide erosion control storage to reduce the potential for downstream erosion during the more frequent storm events.

The proposed expanded facility design meets or exceeds the criteria identified in the Valdor and Philips' reports noted previously as follows:

- Minor system directs all minor flows to the proposed SWM facility;
- Major system directs all flows up to the 100 Year event to the SWM facility;
- Wet pond quality control feature is provided;
- Level 1 quality control provided;
- Sediment forebays provided at all storm sewer inlets;
- Permanent pool volume provided is based upon the 150 m^3/ha requirement (163.6 ha. x 150 = 24,540 m^3 required; 26,690 m^3 provided);
- Permanent pool depths of 1.42 m and 1.5 m provided;
- Stepped, bull nose shaped weir outlet structure provided for controlled release to address the erosion control and quantity control volume storage required;
- Erosion control storage volume required = 22,140 m^3 (25,650 m^3 provided);
- Extended detention storage depths provided of 0.85 m and 1.47m;
- Quantity storage provided to reduce discharge rates below pre-development rates (73,500 m^3 required; 74,000 m^3 provided);

- The quantity storage amounts and discharge rates account for the impacts on the outlet structure of the tailwater from the Highway No. 401 culvert for the 25 Year and larger storm events;

- An overflow weir, 112 m in length, provides the facility to pass the Regional storm with a top water level of 212.25 m and exceeds the 105 m length required;

- Minimum freeboard of 0.15 m is provided at 100 Year event;

- Maintenance access locations to the pond are provided;

- Sediment and erosion control facilities are proposed to be implemented for the Verus site and for the SWM facilities both during, and following, construction;

- The existing watercourse will be filled following completion of the new pond with its function replicated via the proposed storm sewers, stormwater facility and discharge swale;

- Appropriate landscape treatments will be provided for the pond and discharge swale areas;

- The landscape plantings, the 1.5 m deep permanent pool along with the linear shape of the facility expansion area will minimize potential thermal impacts.

In summary, the proposed design of the drainage and stormwater management systems to serve the Verus Partners, LLC development and adjacent lands will meet all requirements of the previously approved reports. The stormwater facility will provide Level 1 quality control, store water to provide suitable erosion control and attenuate developed peak flows to produce release rates that will be less than the predeveloped rates at the Highway No. 401 culvert.

As a result, the proposed Verus Partners, LLC site and the existing developed areas (both controlled and uncontrolled) will be provided with the appropriate degree of stormwater management following construction of the proposed expanded facility.

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Stormwater Management and Pond Design Report

Milton Business Park
Industrial Subdivision

Part of Lots 1 & 2, Concession 4
Town of Milton
Regional Municipality of Halton

November 2004

Prepared For: **Total Developments International**

File: **03154**

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Table 4 FSEMS SWM Facility Design Requirements

Criteria	Pond Storage Volume (m^3)	Pond Discharge Rate (m^3/s)
Water Quality Control	2,620	n/a
Extended Detention Control	2,370	0.016
25 Year Flood Control	2,870	0.162
100 Year Flood Control	3,790	0.232

As outlined above, the SWM facility is located within the MTO's zone of influence that extends from the Highway 401 corridor; therefore, MTO will undertake a review of the stormwater management pond criteria and design. At present, MTO has not adopted the HSPF model approach used in the SPS or FSEMS. As a result, it must be demonstrated that post-development flows are controlled to pre-development levels using the Visual OTTHYMO model, an MTO-approved hydrologic methodology. Pre-development and post-development conditions were modeled using Version 2.0. The storage-discharge characteristics of the proposed SWM facility were modeled to demonstrate adequate storage provision and discharge control. The Visual OTTHYMO results will be discussed in Sections 4.3.3 and 4.3.4.

4.3 Pond Design Details

The proposed SWM facility has been designed as a wet pond facility to meet the criteria presented in the previous section. The SWM facility is composed of a main pool and two sediment forebays. The permanent pool level of the facility is set at 209.90 m, based on applying a 0.5% slope from the existing north invert of the Highway 401 culvert upstream to the proposed pond. The top and bottom of pond elevations are 211.50 m and 208.40 m, respectively. Side slopes internal to the facility are generally 5H:1V, except for 3H:1V within the lower depths of the permanent pool. Slopes external to the facility are proposed to be 3H:1V maximum. A 4.0 m wide access road has been provided around the facility perimeter and includes a connection to Boston Church Road. The SWM facility is located immediately north of the Union Gas Easement and is approximately 23 m from the limit of the Highway 401 corridor, which exceeds the required minimum distance of 14 m.

4.3.1 Quality Control – Permanent Pool

The SWM facility has been designed using the storage volumes outlined in Section 4.2. The permanent pool depth is set at 1.50 m. The required permanent pool volume is 2,620 m^3; the provided permanent pool volume is 3,240 m^3.

East Forebay Sizing Calculations

The proposed east forebay is approximately 38 m in length and 19 m in width, on average. The resultant length-to-width ratio is therefore 2:1. Using the methodology provided in the SWMP Manual, the recommended forebay length based on particulate settling is calculated using the following expression:

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The variable h is the maximum water elevation above the centroid of the orifice and is calculated as follows (invert of orifice set at normal water level):

$$h = HWL_{ero} - \left[NWL + \frac{D}{2}\right] = 210.50 - \left[209.90 + \frac{0.100}{2}\right] = 0.55 \cdot \text{m} \qquad [10]$$

where HWL_{ero} is the extended detention water level (210.50 m)
NWL is the normal water level (209.90 m)
D is the diameter of the orifice (0.100 m)

Solving [9] yields:

$$t_d = \frac{0.66 \cdot (2125) \cdot (0.55)^{1.5} + 2 \cdot (3669) \cdot (0.55)^{0.5}}{2.75 \cdot (0.00785)} = 278{,}590\ s = 77\ \text{h}$$

Therefore, the proposed design satisfies the detention time target of 24 hours reccommended in the SWMP Manual.

4.3.3 Flood Control

Flood control will be achieved by reducing post-development peak flow rates to at or below pre-development levels using an appropriate outlet structure design. The proposed outlet structure will consist of an orifice pipe to provide extended detention control and a weir to provide flood control up to and including the 100 year storm event.

With regards to the FSEMS criteria, Table 5 demonstrates that the prescribed release rates are achieved at the associated storage volume levels. Detailed Storage-Discharge calculations have been provided in Appendix D.

Table 5 SWM Facility Performance (FSEMS Criteria)

FSEMS CRITERIA			SWM POND DESIGN		
Criteria	Required Active Storage (m^3)	Required Discharge Rate (m^3/s)	Provided Active Storage (m^3)	Design Discharge Rate (m^3/s)	Pond Water Level (m)
Erosion	2,370	0.016	2,630	0.015	210.50
25 Year	2,870	0.162	3,140	0.036	210.60
100 Year	3,790	0.232	3,950	0.187	210.75

To satisfy MTO requirements, it is necessary to demonstrate post-to-pre peak flow control using hydrologic modelling. The 6, 12 and 24 hour Chicago design storms have been simulated using the Visual OTTHYMO model. Pre-development drainage to Culvert #5 (refer to FSEMS, Table 3.7: Culvert Summary) presently includes 35 hectares of lands northeast of Boston Church Road, plus 2.6 hectares consisting of Boston Church Road and the westbound lanes of Highway 401. A

Table 8 SWM Facility Performance – 24 Hour Chicago Storm Events

CONDITION	Event Peak Flow Rate, $Q_{CULVERT\ \#5}$ at Existing Culvert #5 under Highway 401 (m^3/s)					
	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
Pre-development	0.44	0.78	1.04	1.40	1.67	1.96
Post-development (Controlled)	0.29	0.42	0.61	1.01	1.28	1.56
SWM Facility Summary						
Inflow (m^3/s)	2.56	3.55	4.19	5.06	5.69	6.37
Outflow (m^3/s)	0.08	0.28	0.48	0.80	1.03	1.24
Elevation (m)	210.65	210.80	210.90	211.00	211.10	211.15
Storage Used (m^3)	3,457	4,293	4,801	5,487	5,982	6,534

4.3.4 Tailwater Effects

The hydrologic analyses presented in the previous section have assumed free outlet conditions are present under all storm event conditions. Typically, the free outlet condition holds true during more frequent events. Under less frequent events, the presence of a tailwater can reduce the hydraulic head across the outlet structure resulting in a lower discharge from the facility. Unless the tailwater elevations are significantly above the permanent pool elevation, the SWM facility will fill at a faster rate than the increase in the water level in the receiving tributary, therefore, there is no storage reduction in the facility from backflow. The discharge ordinates of the stage-storage-discharge curve under submerged conditions have been assessed in this section to confirm the anticipated SWM facility performance.

The tailwater elevation within the control structure is determined by considering each hydraulic element along the outlet flow path. As discussed previously, the proposed SWM facility will discharge into a proposed 730 x 1150 mm horizontal elliptical pipe under the Boston Church Road and drain into an existing ditch and Culvert #5 (refer to FSEMS, Table 3.7: Culvert Summary) within the Highway 401 corridor. The tailwater elevation at the proposed SWM facility was determined as follows:

Survey - confirm!

- It was assumed that Culvert #5 discharges to an open channel assumed to be a trapezoidal section with 1.0 m bottom width, 2H:1V side slopes and a longitudinal slope of 0.5%. The FlowMaster program was used to determine the flow depths under design storm conditions.
- The tailwater elevations at the downstream limit of Culvert #5 were calculated.
- The CulvertMaster program was used to determine the headwater elevations at the upstream limit of Culvert #5.
- The tailwater elevation at the outlet of the 730 x 1150 mm horizontal elliptical pipe was assumed to be equal to the headwater elevation at Culvert #5 (refer to Table 9).
- The CulvertMaster program was used to obtain a Headwater-Discharge curve of the 730 x 1150 mm horizontal elliptical pipe, which relates water surface elevations of the control structure and discharge rates of the 730 x 1150 mm pipe (refer to Appendix E).

Table 9 summarizes the headwater and tailwater elevations at Culvert #5 during the 5, 25 and 100 year 24 hour Chicago design storm conditions. The CulvertMaster program was used to determine the headwater elevations at the upstream limit of Culvert #5 based on the 24 hour post-development controlled peak flows (refer to Table 8). Outputs of CulvertMaster program have been included in Appendix E.

Table 9 Headwater and Tailwater Elevations at Existing Culvert #5

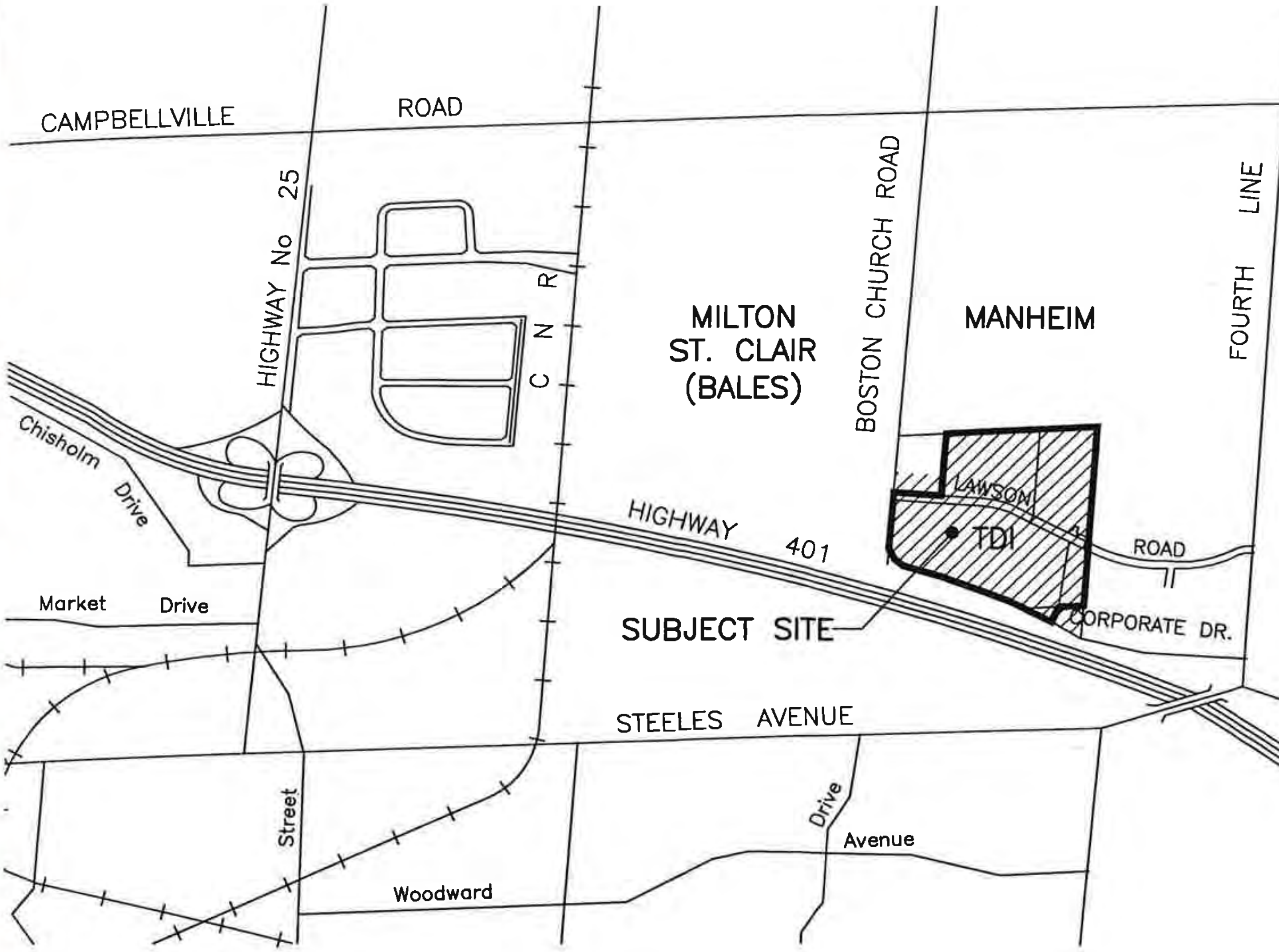
Storm Event	Post-Development Peak Flow Rate, $Q_{CULVERT\ \#5}$ (m^3/s)	Tailwater Elevation (m)	Headwater Elevation (m)
5 Year	0.4	209.4	209.7
25 Year	1.0	209.6	210.0
100 Year	1.6	209.7	210.2

The 5 year tailwater elevation of the proposed pond outlet pipe is 209.7 m, which is below the permanent pool elevation (209.90 m). The analysis indicates that there are no tailwater effects for the 5 year and less frequent design storm events. The Storage-Discharge curves were updated to reflect the potential tailwater conditions during the 25 and 100 year storm events and are included in Appendix D. These updated curves were input to the OTTHYMO model and the tailwater effects are summarized in Table 10. A summary of the post-development model summary output files has been included in Appendix C. It is expected that the SWM pond performance does not change significantly with tailwater effects.

Table 10 Revised SWM Facility Performance under Tailwater Conditions (24 Hour Chicago Storm Event)

Storm Event	Performance Parameter[1]	Tailwater (TW) Condition in Receiving Tributary[2]			Q_{target}
		Free Outlet	25-Yr TW = 240.44	100-Yr TW = 240.61	
5-Yr	S HWL Q	4,293 m^3 210.80 m 0.28m^3/s			
	Q_{MTO}	0.42			0.78
25-Yr	S HWL Q	5,487 m^3 211.00 m 0.80 m^3/s	5,516 m^3 211.00 m 0.81 m^3/s		
	Q_{MTO}	1.01	1.02		1.40
100-Yr	S HWL Q	6,534 m^3 211.15 m 1.24 m^3/s	6,564 m^3 211.20 m 1.26 m^3/s	6,590 m^3 211.20 m 1.27 m^3/s	
	Q_{MTO}	1.56	1.58	1.59	1.96

Shaded cells indicate "not applicable"
[1]S = Storage Required (m^3); HWL = High Water Level in Pond (m); Q = Peak Discharge from Pond (m^3/s), Q_{MTO} = Peak Discharge at the Upstream Limit of Culvert #5
[2]$TW_{d/s}$ = Tailwater in Receiving Tributary at Outlet #1, $Tw_{u/s}$ = Tailwater in Receiving Tributary at Outlet #2



MILTON BUSINESS PARKS (Former Kaneff Lands) TOWN OF MILTON	DRAWN BY V.L. CHECKED. BY G.W.T.	VALDOR ENGINEERING INC. Consulting Engineers - Project Managers 216 CHRISLEA ROAD, SUITE 501, WOODBRIDGE, ONTARIO, L4L 8S5 TEL (905)264-0054, FAX (905)264-0069 E-MAIL: info@valdor-engineering.com www.valdor-engineering.com		
KEY PLAN	DATE NOV 2004	SCALE N.T.S.	PROJECT 03154	DWG. FIGURE 1

APPENDIX B

Post-Development Hydrologic Modelling

B.1 Visual OTTHYMO Model – Input Parameter Assumptions

Table B-1 Parameters and Assumptions

Parameter	Assumption
CN Number	The CN number of 76 was based on the hydrologic group of the soils within the Study Area. Soil coverage was supplied by Philips Engineering Limited, and is based on Halton Region soil maps as prepared by the Ontario Soil Survey.
IA	The IA value of 4.5 mm is based on consultation with MTO for previous work completed for the Manheim-Snoek SWM Facility.
TIMP/XIMP	The subject development will be industrial; imperviousness is assumed to be 79%. The existing Boston Church Road and westbound lanes of Highway 401 are characterized by a rural roadway section; imperviousness is assumed to be 40%.
SLP	The pervious slope is based on an average lot grade of 2.0%.
SLI	The impervious slope is based on the average road slope 1.0%.
LGP	The pervious length is based on the default length of 40 m.
LGI	The impervious length is based on Equation B1, shown below. $LGI = \sqrt{\frac{A}{1.5}}$ where LGI is the impervious length (m); A is the upstream drainage area (m^2)

Table B-2 Input Parameters

Parameter	Catchment		
	1	2	3
Command	STANHYD	STANHYD	STANHYD
Area (ha)	2.6	7.25	5.85
TIMP/XIMP (%)	40/40	79/79	79/79
CN	76	76	76
I_a (mm)	4.5	4.5	4.5
DPSI (mm)	1.5	1.5	1.5
SLP/SLI (%)	2.0/1.0	2.0/1.0	2.0/1.0
LGP/LGI (m)	40.0/132.0	40.0/219.8	40.0/197.5
MNP/MNI	0.25/0.013	0.25/0.013	0.25/0.013

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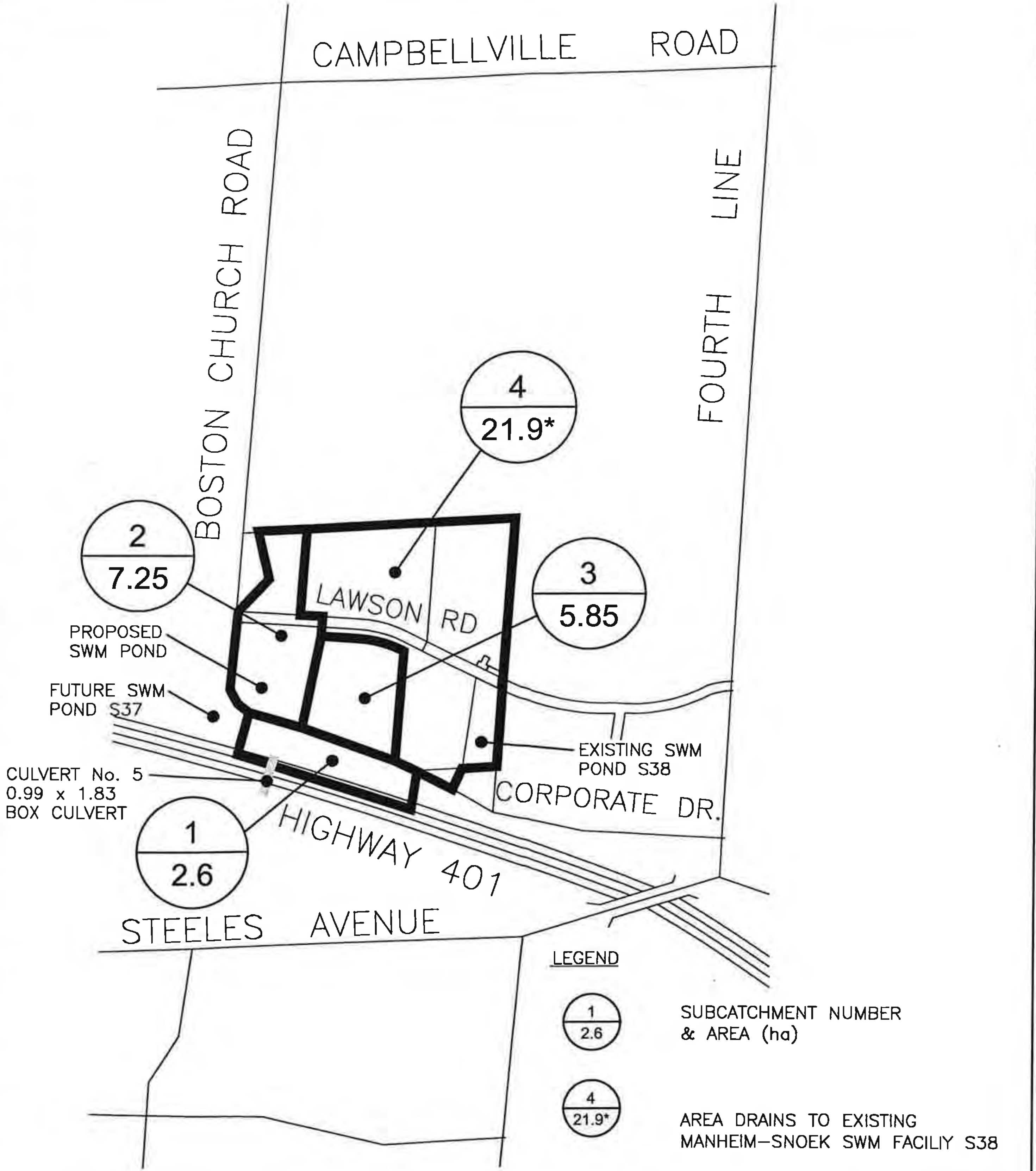

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	DATE	SCALE	PROJECT	DWG.
POST—DEVELOPMENT DRAINAGE	NOV 2004	N.T.S.	03154	FIGURE B—1

Milton Business Park Industrial Subdivision

Town of Milton
Project No.: **03154**

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Proposed Stormwater Management Facility

Elevations, Areas and Volumes

Elev. (m)	Depth (m)	Increment of Elev. (m)	Area (sq.m)	Volume (cu.m)	Cumulative Volume (cu.m)	Remarks
Active Storage						
211.20	1.30	0.10	6,525	641	6,664	H.W.L.
211.10	1.20	0.10	6,304	619	6,022	
211.00	1.10	0.10	6,084	597	5,403	
210.90	1.00	0.10	5,866	576	4,805	
210.80	0.90	0.10	5,650	554	4,230	
210.70	0.80	0.10	5,435	533	3,675	
210.60	0.70	0.10	5,221	512	3,142	
210.50	0.60	0.10	5,010	490	2,631	
210.40	0.50	0.10	4,800	469	2,140	
210.30	0.40	0.10	4,590	449	1,671	
210.20	0.30	0.10	4,384	428	1,222	
210.10	0.20	0.10	4,178	407	794	
210.00	0.10	0.10	3,970	387	387	
209.90	0.00		3,765		0	N.W.L.
Total Active Storage					**6,664**	
Permanent Stoage						
209.90	1.50	0.60	2,345	1,183	2,181	Main Pool
209.30	0.90	0.90	1,600	997	997	
208.40	0.00		616		0	Storage
209.90	1.50	0.60	1,290	602	1,055	Sediment
209.30	0.90	0.90	718	453	453	Sediment
208.40	0.00		288		0	Forebay Storage
Total Permanent Storage					**3,236**	

Milton Business Park Industrial Subdivision

Town of Milton

Proposed Stormwater Management Facility
Storage-Discharge Curves

No Tailwater Effect (Downstream of Proposed Pond Outlet Pipe = 209.7 m)

		Orifice	Front Weir	Side Weirs	Assumed WSEL Control Structure Elevation	Front Weir Correction Factor	Side Weirs Correction Factor	Orifice	Front Weir	Side Weirs	Overall Discharge	Actual WSEL Control Structure Elevation	Storage-Discharge Curve	
Invert Elevation (m)		209.90	210.55	210.75				209.90	210.55	210.75				
Diameter (mm)/ Length (m)		100	1.0	1.0				100	1.0	1.0				
Orifice Area (sq.m)		0.008						0.008						
Proposed SWM Facility		Flow	Flow	Flow				Modified Flow	Modified Flow	Modified Flow	Modified Flow		Discharge	Storage
Elevation (m)	Depth (m)	(cu.m/ s)	(cu.m/ s)	(cu.m/ s)	(m)			(cu.m/ s)	(cu.m/ s)	(cu.m/ s)	(cu.m/ s)	(m)	(cu.m/ s)	(cu.m)
211.20	1.30	0.023	0.928	0.534	210.88	0.84	0.94	0.012	0.778	0.500	1.290	210.88	1.290	6664
211.10	1.20	0.022	0.722	0.367	210.73	0.92	1.00	0.013	0.667	0.367	1.046	210.73	1.046	6022
211.00	1.10	0.021	0.534	0.221	210.58	1.00	1.00	0.014	0.532	0.221	0.767	210.58	0.767	5403
210.90	1.00	0.020	0.367	0.103	210.43	1.00	1.00	0.014	0.367	0.103	0.484	210.43	0.484	4805
210.80	0.90	0.019	0.221	0.020	210.28	1.00	1.00	0.015	0.221	0.020	0.256	210.28	0.256	4230
210.70	0.80	0.018	0.103		210.15	1.00		0.016	0.103		0.118	210.15	0.118	3675
210.60	0.70	0.017	0.020		210.03	1.00		0.016	0.020		0.036	210.03	0.036	3142
210.50	0.60	0.015			209.98			0.015			0.015	209.98	0.015	2631
210.40	0.50	0.014			209.97			0.014			0.014	209.97	0.014	2140
210.30	0.40	0.012			209.96			0.012			0.012	209.96	0.012	1671
210.20	0.30	0.010			209.95			0.010			0.010	209.95	0.010	1222
210.10	0.20	0.008			209.94			0.008			0.008	209.94	0.008	794
210.00	0.10	0.005			209.93			0.006			0.006	209.93	0.006	387
209.90	0.00	0.000						0.000					0	0

25 Year Tailwater (Downstream of Proposed Pond Outlet Pipe = 210.0 m)

		Orifice	Front Weir	Side Weirs	Assumed WSEL Control Structure Elevation	Front Weir Correction Factor	Side Weirs Correction Factor	Orifice	Front Weir	Side Weirs	Overall Discharge	Actual WSEL Control Structure Elevation	Storage-Discharge Curve	
Invert Elevation (m)		209.90	210.55	210.75				209.90	210.55	210.75				
Diameter (mm)/ Length (m)		100	1.0	1.0				100	1.0	1.0				
Orifice Area (sq.m)		0.008						0.008						
Proposed SWM Facility		Flow	Flow	Flow				Modified Flow	Modified Flow	Modified Flow	Modified Flow		Discharge	Storage
Elevation (m)	Depth (m)	(cu.m/ s)	(cu.m/ s)	(cu.m/ s)	(m)			(cu.m/ s)	(cu.m/ s)	(cu.m/ s)	(cu.m/ s)	(m)	(cu.m/ s)	(cu.m)
211.20	1.30	0.022	0.928	0.534	210.87	0.85	0.94	0.012	0.785	0.503	1.301	210.87	1.301	6664
211.10	1.20	0.021	0.722	0.367	210.73	0.92	1.00	0.013	0.667	0.367	1.046	210.73	1.046	6022
211.00	1.10	0.020	0.534	0.221	210.58	0.99	1.00	0.014	0.531	0.221	0.766	210.58	0.766	5403
210.90	1.00	0.019	0.367	0.103	210.43	1.00	1.00	0.014	0.367	0.103	0.484	210.43	0.484	4805
210.80	0.90	0.018	0.221	0.020	210.28	1.00	1.00	0.015	0.221	0.020	0.256	210.28	0.256	4230
210.70	0.80	0.017	0.103		210.15	1.00		0.016	0.103		0.118	210.15	0.118	3675
210.60	0.70	0.015	0.020		210.05	1.00		0.016	0.020		0.035	210.05	0.035	3142
210.50	0.60	0.014			210.02			0.014			0.014	210.02	0.014	2631
210.40	0.50	0.012			210.02			0.012			0.012	210.02	0.012	2140
210.30	0.40	0.010			210.01			0.010			0.010	210.01	0.010	1671
210.20	0.30	0.008			210.01			0.008			0.008	210.01	0.008	1222
210.10	0.20	0.005			210.00			0.005			0.005	210.00	0.005	794
210.00	0.10	0.000			210.00			0.000			0.000	210.00	0	387
209.90	0.00												0	0

100 Year Tailwater (Downstream of Proposed Pond Outlet Pipe = 210.2 m)

		Orifice	Front Weir	Side Weirs	Assumed WSEL Control Structure Elevation	Front Weir Correction Factor	Side Weirs Correction Factor	Orifice	Front Weir	Side Weirs	Overall Discharge	Actual WSEL Control Structure Elevation	Storage-Discharge Curve	
Invert Elevation (m)		209.90	210.55	210.75				209.90	210.55	210.75				
Diameter (mm)/ Length (m)		100	1.0	1.0				100	1.0	1.0				
Orifice Area (sq.m)		0.008						0.008						
Proposed SWM Facility		Flow	Flow	Flow				Modified Flow	Modified Flow	Modified Flow	Modified Flow		Discharge	Storage
Elevation (m)	Depth (m)	(cu.m/ s)	(cu.m/ s)	(cu.m/ s)	(m)			(cu.m/ s)	(cu.m/ s)	(cu.m/ s)	(cu.m/ s)	(m)	(cu.m/ s)	(cu.m)
211.20	1.30	0.021	0.928	0.534	210.87	0.85	0.94	0.012	0.786	0.504	1.301	210.87	1.301	6664
211.10	1.20	0.020	0.722	0.367	210.73	0.92	1.00	0.013	0.667	0.367	1.046	210.73	1.046	6022
211.00	1.10	0.019	0.534	0.221	210.58	0.99	1.00	0.014	0.531	0.221	0.766	210.58	0.766	5403
210.90	1.00	0.017	0.367	0.103	210.43	1.00	1.00	0.014	0.367	0.103	0.484	210.43	0.484	4805
210.80	0.90	0.016	0.221	0.020	210.29	1.00	1.00	0.015	0.221	0.020	0.256	210.29	0.256	4230
210.70	0.80	0.015	0.103		210.24	1.00		0.014	0.103		0.118	210.24	0.118	3675
210.60	0.70	0.013	0.020		210.21	1.00		0.013	0.020		0.033	210.21	0.033	3142
210.50	0.60	0.011			210.20			0.011			0.011	210.20	0.011	2631
210.40	0.50	0.009			210.20			0.009			0.009	210.20	0.009	2140
210.30	0.40	0.006			210.20			0.006			0.006	210.20	0.006	1671
210.20	0.30	0.000			210.20			0.000			0.000	210.20	0	1222
210.10	0.20				210.20						0.000	210.20	0	794
210.00	0.10				210.20						0.000	210.20	0	387
209.90	0.00												0	0

Headwater-Discharge Curve of 730 x 1150 mm H.E. Pipe

WSEL Control Structure Elevation	730 x 1150 mm H.E. Pipe
Headwater (m)	Discharge (cu.m/ s)
211.20	1.715
211.10	1.606
211.00	1.489
210.90	1.326
210.80	1.181
210.70	0.991
210.60	0.804
210.50	0.626
210.40	0.428
210.30	0.285
210.20	0.167
210.10	0.077
210.00	0.020
209.90	0.000

Standard Catchment Parameters - Uncalibrated

Conservation Halton Landuse	Curve Number				IA (mm)	XIMP	TIMP	Manning n	k
	A	B	C	D					
Agricultural	67	78	85	89	7	0%	0%	0.3	0.274
Agricultural Block	67	78	85	89	7	0%	0%	0.3	0.274
Agriculture/Rural Residential Block	67	78	85	89	7	0%	0%	0.3	0.274
Bare Soil	72	82	87	89	5	0%	0%	0.02	0.491
Barn	98	98	98	98	2	99%	99%	0.015	0.619
Basketball Court	98	98	98	98	2	99%	99%	0.015	0.619
Bedrock	98	98	98	98	2	99%	99%	0.015	0.305
Building	98	98	98	98	2	99%	99%	0.015	0.619
Building Block	98	98	98	98	2	99%	99%	0.015	0.619
Cemetary	49	69	79	84	5	16%	20%	0.25	0.457
Commercial	89	92	94	95	2	85%	85%	0.015	0.619
Commercial / Industrial	89	92	94	95	2	85%	85%	0.015	0.619
Commercial / Industrial Block	89	92	94	95	2	85%	85%	0.015	0.619
Confinement Yard	72	82	87	89	5	0%	0%	0.02	0.491
Dirt	72	82	87	89	5	0%	0%	0.02	0.491
Extraction	98	98	98	98	5	0%	0%	0.02	0.491
Field	49	69	79	84	5	16%	20%	0.25	0.457
Field Block	49	69	79	84	5	16%	20%	0.25	0.457
Forest	36	60	73	79	10	0%	0%	0.35	0.076
Forest Block	36	60	73	79	10	0%	0%	0.35	0.076
Future Development	77	85	90	92	5	50%	70%	0.35	0.457
Golf Course	49	69	79	84	5	0%	0%	0.25	0.457
Grass	49	69	79	84	5	0%	0%	0.25	0.457
Gravel Baseball Diamond	72	82	87	89	5	0%	0%	0.02	0.491
Greenhouse	98	98	98	98	2	99%	99%	0.015	0.619
Hedge Row	45	66	77	83	10	0%	0%	0.15	0.274
Hedge Row - Coniferous	45	66	77	83	10	0%	0%	0.15	0.274
Hedge Row - Deciduous	45	66	77	83	10	0%	0%	0.15	0.274
Hedge Row Block	45	66	77	83	10	0%	0%	0.15	0.274
High Density Residential	89	92	94	95	2	65%	85%	0.015	0.619
Highway Median Grass	49	69	79	84	2	16%	20%	0.25	0.457
Impervious	98	98	98	98	2	99%	99%	0.015	0.619
Industrial	81	88	91	93	2	90%	90%	0.015	0.619
Industrial Block	81	88	91	93	2	90%	90%	0.015	0.619
Institutional	71	80	88	90	2	60%	75%	0.015	0.619
Junk Yard	72	82	87	89	5	0%	0%	0.02	0.491
Marsh	50	50	50	50	15	0%	0%	0.13	0.076
Natural Area	49	69	79	84	10	0%	0%	0.25	0.076
Natural Area Block	49	69	79	84	10	0%	0%	0.25	0.076
Natural Area Creek Block	49	69	79	84	10	0%	0%	0.25	0.076
Nursery	45	66	77	83	10	0%	0%	0.15	0.274
Orchard	45	66	77	83	10	0%	0%	0.15	0.274
Park	49	69	79	84	5	16%	20%	0.25	0.457
Parking Lot	98	98	98	98	2	99%	99%	0.015	0.619
Pasture	49	69	79	84	8	0%	0%	0.35	0.213
Plantation	36	60	73	79	10	0%	0%	0.35	0.274
Plantation - Coniferous	36	60	73	79	10	0%	0%	0.35	0.274
Plantation - Deciduous	36	60	73	79	10	0%	0%	0.35	0.274
Playground	49	69	79	84	2	0%	0%	0.25	0.619
Private Road	98	98	98	98	2	99%	99%	0.015	0.619
Railway	98	98	98	98	2	85%	85%	0.02	0.619
Recreational	49	69	79	84	5	16%	20%	0.25	0.457
Residential	77	85	90	92	5	50%	70%	0.25	0.457
Rural Residential	61	75	83	87	5	16%	20%	0.25	0.457

SWM Pond	50	50	50	50	15	50%	50%	0.015	0.076
SWM Pond Block	50	50	50	50	15	50%	50%	0.015	0.076
Trailer Park	61	75	83	87	5	16%	20%	0.25	0.457
Transportation	98	98	98	98	2	99%	99%	0.015	0.619
Treed - Coniferous	36	60	73	79	10	0%	0%	0.35	0.076
Treed - Deciduous	36	60	73	79	10	0%	0%	0.35	0.076
Treed - Mixed	36	60	73	79	10	0%	0%	0.35	0.076
Urban Residential	77	85	90	92	5	50%	70%	0.25	0.457
Urban Residential Block	77	85	90	92	5	50%	70%	0.25	0.457
Water	98	98	98	98	15	0%	0%	0.13	0.076
Wetland	50	50	50	50	15	0%	0%	0.13	0.076

NASHYD Input Parameters - Uncalibrated, Existing Land-use

100-year Precipitation 122.4 mm

CN Conversion

Catchment	Area (ha)	CNii	Cniii	S (mm)	IA (mm)	IA* (mm)	Q	S*	CNiii*	Cnii*
110	291.95	56.76	75.12	84.12	10.41	8.41	65.59	79.23	76.22	58.23
120	110.86	63.23	79.82	64.22	10.49	6.42	74.65	55.87	81.97	66.41
130	159.51	59.53	77.18	75.08	9.98	7.51	69.48	69.48	78.52	61.38
140	144.27	65.03	81.05	59.40	10.00	8.91	74.50	57.18	81.62	65.89
150	166.06	68.28	83.20	51.31	9.20	7.70	79.25	48.49	83.97	69.49
160	111.74	61.17	78.37	70.10	11.09	7.01	71.78	61.28	80.56	64.31
170	216.86	66.06	81.74	56.75	9.24	8.51	76.01	55.30	82.12	66.63
180	221.48	56.55	74.96	84.86	11.16	8.49	65.28	78.31	76.43	58.51
210	202.82	59.71	77.32	74.52	9.34	7.45	69.74	70.24	78.34	61.12
220	143.58	54.50	73.37	92.19	11.39	9.22	62.37	86.57	74.58	56.06
230	64.00	59.35	77.06	75.62	10.91	7.56	69.24	68.04	78.87	61.88
240	265.92	63.08	79.72	64.63	9.22	6.46	74.44	58.91	81.17	65.21
250	316.66	56.01	74.54	86.75	10.55	8.68	64.51	82.08	75.58	57.36
260	292.75	57.87	75.96	80.41	10.03	8.04	67.15	75.68	77.05	59.34
270	63.88	57.51	75.69	81.58	11.26	8.16	66.65	74.19	77.39	59.81
280	243.37	55.01	73.77	90.32	10.97	9.03	63.10	85.35	74.85	56.41
290	55.36	58.52	76.44	78.28	10.98	7.83	68.07	70.95	78.16	60.88
310	264.49	61.54	78.63	69.02	10.22	6.90	72.30	61.88	80.41	64.09
320	101.17	60.80	78.10	71.21	10.86	7.12	71.26	63.05	80.11	63.66
330	183.36	61.04	78.28	70.48	9.57	7.05	71.60	64.96	79.63	62.96
340	197.16	61.54	78.64	69.01	10.83	6.90	72.30	60.59	80.74	64.57
350	169.49	54.98	73.74	90.45	10.43	9.04	63.05	86.87	74.51	55.97
360	221.71	56.29	74.76	85.75	10.78	8.58	64.92	80.29	75.98	57.90
370	33.82	60.69	78.02	71.54	12.21	7.15	71.11	60.57	80.74	64.58
380	311.59	58.05	76.09	79.82	10.47	7.98	67.40	73.96	77.45	59.89
390	121.34	61.45	78.57	69.29	10.59	6.93	72.17	61.41	80.53	64.26
410	270.12	59.05	76.83	76.60	11.47	7.66	68.81	67.92	78.90	61.92
510	425.24	64.34	80.58	61.21	8.59	9.18	73.49	62.45	80.27	63.88
520	278.91	56.06	74.58	86.58	8.77	8.66	64.58	86.30	74.64	56.14
530	34.14	64.07	80.40	61.93	7.41	9.29	73.09	65.92	79.39	62.62
540	151.94	54.40	73.29	92.56	10.14	9.26	62.23	90.24	73.79	55.03
550	112.22	56.27	74.75	85.82	7.92	8.58	64.89	87.49	74.38	55.80
560	52.81	50.79	70.36	106.99	7.29	10.70	57.05	117.14	68.44	48.53
570	151.75	57.72	75.85	80.89	7.27	8.09	66.94	82.87	75.40	57.13
580	24.79	58.86	76.70	77.18	9.37	7.72	68.55	73.33	77.60	60.10
610	167.66	50.06	69.75	110.15	8.96	7.71	58.50	106.53	70.45	50.90
710	179.17	64.79	80.89	60.01	7.77	9.00	74.16	62.56	80.24	63.84

Time of Concentration

Catchment	Length (m)	Slope (%)	k	v (m/s)	ToC (min)	Tp (hour)
110	2934.00	0.77	0.20	0.18	279.01	3.10
120	2374.00	0.45	0.20	0.14	288.42	3.20
130	4184.00	0.62	0.18	0.14	498.65	5.54
140	2408.00	0.59	0.21	0.16	245.26	2.73
150	2963.00	0.75	0.21	0.18	267.67	2.97
160	2084.00	1.09	0.12	0.13	274.67	3.05
170	3815.00	1.01	0.20	0.20	312.23	3.47
180	3874.00	1.57	0.12	0.15	420.22	4.67
210	2928.00	1.04	0.22	0.23	213.12	2.37
220	2206.00	0.49	0.16	0.11	325.35	3.61
230	1438.00	0.57	0.20	0.15	161.29	1.79
240	3278.00	0.96	0.23	0.22	245.42	2.73
250	2914.00	0.83	0.17	0.16	312.93	3.48
260	4068.00	0.70	0.17	0.14	468.35	5.20
270	1645.00	0.80	0.08	0.07	385.04	4.28
280	3777.00	0.54	0.12	0.09	700.24	7.78
290	1632.00	0.52	0.09	0.06	438.65	4.87
310	4014.00	0.45	0.20	0.13	498.86	5.54
320	1655.00	0.36	0.18	0.11	260.18	2.89
330	2603.00	0.93	0.22	0.21	208.01	2.31
340	4276.00	0.87	0.12	0.11	660.02	7.33
350	2446.00	1.00	0.12	0.12	337.46	3.75
360	2686.00	0.90	0.12	0.11	401.50	4.46
370	1253.00	1.52	0.10	0.13	166.17	1.85
380	4624.00	1.23	0.18	0.20	386.44	4.29
390	3459.00	0.48	0.13	0.09	648.87	7.21
410	4220.00	1.33	0.08	0.09	782.36	8.69
510	5426.00	1.15	0.25	0.27	334.42	3.72
520	4452.00	0.98	0.27	0.27	275.84	3.06
530	1159.00	0.48	0.33	0.23	84.20	0.94
540	2389.00	0.48	0.20	0.14	282.14	3.13
550	2727.00	1.02	0.26	0.27	171.11	1.90
560	1840.00	0.89	0.30	0.28	108.70	1.21
570	1939.00	1.92	0.33	0.45	71.38	0.79
580	964.00	1.91	0.22	0.30	52.79	0.59
610	2335.00	2.05	0.24	0.35	111.49	1.24
710	2489.00	1.25	0.28	0.32	131.50	1.46

720	180.98	66.58	82.08	55.44	9.15	8.32	76.77	53.81	82.52	67.24	2426.00	1.44	0.20	0.23	172.16	1.91
730	97.46	93.83	97.22	7.27	5.69	1.45	114.09	2.68	98.00	95.52	1636.00	1.66	0.45	0.58	47.09	0.52
740	78.00	96.88	98.00	5.18	13.81	1.04	116.39	-7.28	98.00	95.52	1329.00	2.06	0.12	0.18	124.49	1.38
750	96.13	79.99	90.19	27.63	10.01	5.53	94.53	21.24	92.28	83.87	1741.00	0.51	0.24	0.17	168.45	1.87
760	159.27	65.28	81.22	58.72	11.62	8.81	74.88	53.12	82.70	67.52	3794.00	1.10	0.10	0.11	582.77	6.48
770	42.97	61.47	78.58	69.23	7.78	6.92	72.20	67.35	79.04	62.12	1380.00	4.28	0.27	0.55	41.70	0.46
810	101.31	50.89	70.44	106.57	9.39	10.66	57.20	110.29	69.72	50.03	1419.00	2.64	0.15	0.24	98.38	1.09
820	249.57	56.41	74.85	85.34	8.61	8.53	65.09	85.16	74.89	56.46	4286.00	1.66	0.24	0.31	234.20	2.60
830	50.80	55.41	74.08	88.89	8.97	8.89	63.66	88.68	74.12	55.46	1609.00	5.18	0.23	0.52	51.89	0.58
910	115.97	89.86	95.32	12.46	5.50	2.49	108.62	8.91	96.61	92.53	1317.00	0.79	0.45	0.40	54.41	0.60
920	64.38	77.91	89.02	31.32	8.45	4.70	92.97	25.71	90.81	81.11	1493.00	4.51	0.20	0.42	59.33	0.66
1010	131.71	74.30	86.93	38.19	8.66	5.73	87.90	33.44	88.37	76.76	3030.00	2.97	0.19	0.34	150.64	1.67
1110	66.26	81.07	90.78	25.79	11.00	5.16	96.10	17.74	93.47	86.16	1283.00	2.64	0.18	0.29	73.51	0.82
1210	140.52	66.35	81.93	56.01	8.25	8.40	76.44	56.32	81.85	66.23	2603.00	3.45	0.23	0.43	101.85	1.13
1220	179.04	72.55	85.88	41.78	8.59	6.27	85.41	37.84	87.03	74.48	3077.00	4.03	0.22	0.44	116.89	1.30
1230	151.67	76.20	88.04	34.49	7.79	5.17	90.57	30.42	89.31	78.40	2997.00	3.85	0.32	0.63	79.56	0.88
1240	147.61	75.93	87.89	35.00	7.91	5.25	90.20	30.83	89.18	78.18	2164.00	3.08	0.26	0.46	78.37	0.87
1270	49.12	82.33	91.47	23.70	7.22	4.74	97.93	20.28	92.60	84.48	1550.00	1.84	0.28	0.37	68.96	0.77
1280	13.55	85.36	93.06	18.94	9.24	3.79	102.28	12.03	95.48	90.17	638.00	0.01	0.23	0.02	469.62	5.22
1310	170.98	81.53	91.04	25.01	7.57	5.00	96.78	21.42	92.22	83.75	2906.00	2.89	0.25	0.43	112.13	1.25
1320	59.21	81.56	91.05	24.98	6.85	5.00	96.81	22.36	91.91	83.16	1289.00	2.57	0.32	0.52	41.45	0.46
1330	38.22	84.48	92.60	20.29	6.60	4.06	101.02	16.94	93.75	86.70	908.00	0.84	0.32	0.29	51.41	0.57
1350	14.30	83.32	91.99	22.10	7.19	4.42	99.36	18.37	93.25	85.73	689.00	0.60	0.29	0.23	50.84	0.56
1510	190.01	79.81	90.09	27.94	7.11	5.59	94.27	25.71	90.81	81.12	3593.00	3.06	0.33	0.58	104.07	1.16
1520	204.95	80.28	90.35	27.13	7.46	5.43	94.95	24.19	91.30	82.03	3401.00	3.17	0.28	0.50	112.49	1.25
1930	11.34	78.63	89.43	30.02	6.29	4.50	93.97	27.35	90.28	80.15	349.00	2.36	0.37	0.57	10.16	0.11
2210	67.60	84.42	92.57	20.37	7.08	4.07	100.94	16.42	93.93	87.05	1306.00	0.40	0.28	0.17	124.76	1.39
3040	2.94	83.01	91.83	22.60	5.00	4.52	98.92	21.94	92.05	83.43	259.00	4.10	0.46	0.93	4.66	0.05
3050	107.73	86.37	93.58	17.43	6.90	3.49	103.71	13.13	95.08	89.37	2524.00	0.94	0.28	0.27	154.17	1.71
3110	265.18	57.26	75.50	82.43	10.00	8.24	66.29	78.18	76.47	58.55	3823.00	0.54	0.19	0.14	453.20	5.04
3120	276.19	62.27	79.15	66.91	9.58	6.69	73.32	60.78	80.69	64.50	4792.00	1.42	0.19	0.22	357.36	3.97
3210	263.35	69.55	84.01	48.36	7.98	7.25	81.09	47.02	84.38	70.14	3713.00	0.38	0.24	0.15	419.08	4.66
3220	51.73	51.67	71.09	103.30	8.36	10.33	58.32	108.97	69.98	50.33	1239.00	0.55	0.20	0.15	138.81	1.54
3230	75.80	58.18	76.19	79.37	8.64	7.94	67.59	77.69	76.58	58.70	1737.00	1.21	0.18	0.19	149.55	1.66
3240	108.32	63.04	79.69	64.74	8.68	6.47	74.38	60.14	80.85	64.74	2621.00	0.79	0.19	0.17	264.73	2.94
3250	25.00	60.44	77.85	72.29	9.74	7.23	70.76	66.71	79.20	62.34	988.00	2.01	0.09	0.13	124.89	1.39
3260	80.20	66.08	81.75	56.69	9.86	8.50	76.04	54.02	82.46	67.15	2525.00	0.89	0.09	0.08	504.96	5.61
3270	136.88	62.98	79.65	64.91	9.51	6.49	74.30	58.63	81.25	65.32	3340.00	2.11	0.11	0.16	340.35	3.78
3310	114.25	74.98	87.33	36.86	8.55	5.53	88.85	32.04	88.80	77.51	2965.00	2.89	0.20	0.34	146.91	1.63
3410	293.62	69.48	83.96	48.51	7.54	7.28	80.99	48.03	84.10	69.69	4753.00	1.43	0.27	0.32	247.57	2.75
3420	141.75	66.18	81.82	56.44	7.57	8.47	76.19	58.23	81.35	65.47	2966.00	1.52	0.24	0.29	168.12	1.87
3430	158.61	74.45	87.01	37.91	7.49	5.69	88.10	34.97	87.90	75.95	4074.00	1.82	0.25	0.34	199.99	2.22
3440	78.57	75.07	87.38	36.68	7.18	5.50	88.98	33.97	88.20	76.48	1814.00	2.37	0.26	0.41	74.13	0.82

3450	93.65	81.08	**90.79**	**25.76**	6.93	**5.15**	**96.13**	**23.24**	**91.62**	**82.61**	2073.00	0.34	0.28	**0.16**	**209.53**	**2.33**
3510	123.18	65.34	**81.26**	**58.58**	9.20	**8.79**	**74.96**	**57.73**	**81.48**	**65.67**	2644.00	2.08	0.14	**0.19**	**226.29**	**2.51**
3520	63.27	72.47	**85.82**	**41.96**	7.93	**6.29**	**85.28**	**39.17**	**86.64**	**73.82**	1914.00	2.66	0.24	**0.38**	**83.16**	**0.92**
3530	52.53	74.42	**87.00**	**37.95**	7.16	**5.69**	**88.07**	**35.55**	**87.72**	**75.65**	1068.00	3.34	0.28	**0.51**	**34.73**	**0.39**
3540	134.61	75.95	**87.90**	**34.98**	7.47	**5.25**	**90.22**	**31.48**	**88.97**	**77.82**	1763.00	1.35	0.25	**0.29**	**100.05**	**1.11**
3550	45.50	70.29	**84.48**	**46.67**	8.17	**7.00**	**82.17**	**44.58**	**85.07**	**71.24**	1568.00	2.50	0.20	**0.32**	**82.38**	**0.92**
3610	71.16	74.97	**87.32**	**36.88**	7.89	**5.53**	**88.83**	**33.09**	**88.47**	**76.94**	1725.00	2.47	0.22	**0.34**	**84.33**	**0.94**
3620	278.60	67.46	**82.66**	**53.27**	8.53	**7.99**	**78.06**	**52.24**	**82.94**	**67.89**	4091.00	2.21	0.18	**0.26**	**257.44**	**2.86**
3630	106.15	84.77	**92.75**	**19.85**	7.25	**3.97**	**101.43**	**15.57**	**94.22**	**87.64**	1371.00	0.98	0.26	**0.26**	**87.58**	**0.97**
3640	91.61	79.30	**89.81**	**28.82**	7.57	**4.32**	**94.91**	**24.10**	**91.33**	**82.09**	1848.00	2.62	0.25	**0.40**	**76.72**	**0.85**
3650	86.68	77.00	**88.51**	**32.98**	7.85	**4.95**	**91.70**	**28.53**	**89.90**	**79.47**	2482.00	2.95	0.22	**0.39**	**107.37**	**1.19**
3660	41.63	73.11	**86.21**	**40.61**	8.22	**6.09**	**86.21**	**37.05**	**87.27**	**74.88**	1383.00	3.36	0.21	**0.38**	**60.36**	**0.67**
3670	83.94	74.85	**87.26**	**37.10**	8.07	**5.56**	**88.68**	**33.08**	**88.48**	**76.95**	3164.00	2.69	0.22	**0.36**	**148.49**	**1.65**
3680	12.75	83.67	**92.18**	**21.55**	8.65	**4.31**	**99.87**	**15.82**	**94.14**	**87.47**	490.00	5.51	0.23	**0.54**	**14.99**	**0.17**
3710	190.40	81.03	**90.76**	**25.85**	8.71	**5.17**	**96.05**	**20.88**	**92.40**	**84.10**	2386.00	3.08	0.23	**0.40**	**98.42**	**1.09**
3810	82.18	76.18	**88.03**	**34.52**	8.65	**5.18**	**90.55**	**29.14**	**89.71**	**79.12**	1832.00	5.38	0.22	**0.51**	**59.48**	**0.66**
3820	171.80	62.06	**79.00**	**67.52**	11.33	**6.75**	**73.02**	**57.88**	**81.44**	**65.61**	3364.00	2.73	0.09	**0.14**	**387.78**	**4.31**
3830	157.82	74.36	**86.97**	**38.07**	8.39	**5.71**	**87.98**	**33.72**	**88.28**	**76.61**	2386.00	4.33	0.26	**0.53**	**74.69**	**0.83**
3840	53.32	76.26	**88.08**	**34.39**	7.38	**5.16**	**90.65**	**30.92**	**89.15**	**78.13**	1977.00	1.71	0.27	**0.35**	**93.14**	**1.03**
3850	37.31	83.25	**91.95**	**22.22**	7.19	**4.44**	**99.25**	**18.52**	**93.20**	**85.64**	1380.00	1.10	0.27	**0.29**	**80.27**	**0.89**
3860	61.36	82.49	**91.55**	**23.45**	7.42	**4.69**	**98.16**	**19.71**	**92.80**	**84.85**	1941.00	1.07	0.26	**0.27**	**120.12**	**1.33**

STANDHYD Input Parameters - Uncalibrated, Existing Land-use

100-year Precipitation 122.4 mm

	CN Conversion										Other				
Catchment	Area (ha)	CNii	Cniii	S (mm)	IA (mm)	IA* (mm)	Q	S*	CNiii*	Cnii*	XIMP	TIMP	Perv Type	Perv L (m)	n Perv
620	35.21	50.93	70.47	106.42	5.00	10.64	57.25	123.36	67.31	47.24	0.22	0.24	Commercial	20.00	0.25
1250	59.85	79.83	90.10	27.91	5.00	5.58	94.29	28.78	89.82	79.33	0.44	0.45	Commercial	20.00	0.25
1260	94.48	79.86	90.12	27.86	5.00	5.57	94.33	28.71	89.85	79.37	0.25	0.26	Commercial	20.00	0.25
1290	15.28	79.20	89.75	29.00	5.00	4.35	94.77	28.03	90.06	79.76	0.71	0.75	Residential	40.00	0.25
1340	56.81	79.00	89.64	29.36	5.00	4.40	94.49	28.47	89.92	79.51	0.26	0.28	Residential	40.00	0.25
1360	33.14	79.00	89.64	29.36	5.00	4.40	94.49	28.47	89.92	79.51	0.57	0.58	Commercial	20.00	0.25
1530	81.43	81.00	90.75	25.90	5.00	5.18	96.01	26.16	90.66	80.85	0.51	0.52	Commercial	20.00	0.25
1540	7.10	82.05	91.32	24.15	5.00	4.83	97.53	23.91	91.40	82.20	0.44	0.45	Commercial	20.00	0.25
1610	75.34	79.00	89.64	29.36	5.00	4.40	94.49	28.47	89.92	79.51	0.49	0.49	Commercial	20.00	0.25
1620	50.51	79.00	89.64	29.35	5.00	4.40	94.49	28.46	89.92	79.51	0.27	0.28	Commercial	20.00	0.25
1810	47.83	79.00	89.64	29.36	5.00	4.40	94.49	28.47	89.92	79.51	0.76	0.77	Commercial	20.00	0.25
1820	101.19	79.02	89.65	29.32	5.00	4.40	94.52	28.42	89.94	79.53	0.63	0.64	Commercial	20.00	0.25
1840	26.45	79.00	89.64	29.36	5.00	4.40	94.49	28.47	89.92	79.51	0.22	0.24	Commercial	20.00	0.25
1910	56.44	79.00	89.64	29.36	5.00	4.40	94.49	28.47	89.92	79.51	0.33	0.34	Commercial	20.00	0.25
1920	32.15	79.00	89.64	29.36	5.00	4.40	94.49	28.47	89.92	79.51	0.42	0.43	Commercial	20.00	0.25
2020	108.22	79.00	89.64	29.36	5.00	4.40	94.49	28.47	89.92	79.51	0.41	0.42	Commercial	20.00	0.25
2030	13.49	79.00	89.64	29.36	5.00	4.40	94.49	28.47	89.92	79.51	0.69	0.71	Commercial	20.00	0.25
2110	20.24	79.00	89.64	29.36	5.00	4.40	94.49	28.47	89.92	79.51	0.53	0.55	Commercial	20.00	0.25
2120	6.43	79.00	89.64	29.36	5.00	4.40	94.49	28.47	89.92	79.51	0.58	0.59	Commercial	20.00	0.25
2130	10.24	79.00	89.64	29.36	5.00	4.40	94.49	28.47	89.92	79.51	0.77	0.77	Commercial	20.00	0.25
2140	12.83	79.00	89.64	29.36	5.00	4.40	94.49	28.47	89.92	79.51	0.99	0.99	Commercial	20.00	0.25
2220	98.14	79.76	90.06	28.03	5.00	5.61	94.19	28.93	89.77	79.24	0.77	0.77	Commercial	20.00	0.25
2230	34.99	79.00	89.64	29.36	5.00	4.40	94.49	28.47	89.92	79.51	0.68	0.69	Commercial	20.00	0.25
2240	2.83	79.00	89.64	29.36	5.00	4.40	94.49	28.47	89.92	79.51	0.52	0.53	Commercial	20.00	0.25
2250	11.57	79.00	89.64	29.36	5.00	4.40	94.49	28.47	89.92	79.51	0.73	0.73	Commercial	20.00	0.25
2260	3.35	79.00	89.64	29.36	5.00	4.40	94.49	28.47	89.92	79.51	0.77	0.77	Commercial	20.00	0.25
2310	44.35	80.19	90.30	27.29	5.00	5.46	94.82	27.96	90.08	79.80	0.79	0.81	Commercial	20.00	0.25
2320	22.69	80.64	90.55	26.52	5.00	5.30	95.48	26.96	90.40	80.38	0.43	0.57	Residential	40.00	0.25
2330	45.58	80.25	90.34	27.17	5.00	5.43	94.92	27.81	90.13	79.88	0.50	0.68	Residential	40.00	0.25
2340	21.27	79.00	89.64	29.36	5.00	4.40	94.49	28.47	89.92	79.51	0.60	0.71	Residential	40.00	0.25
2350	59.44	79.02	89.65	29.32	5.00	4.40	94.52	28.42	89.94	79.53	0.55	0.69	Residential	40.00	0.25
2360	15.48	79.00	89.64	29.36	5.00	4.40	94.49	28.47	89.92	79.51	0.56	0.74	Residential	40.00	0.25
2370	48.17	79.00	89.64	29.36	5.00	4.40	94.49	28.47	89.92	79.51	0.67	0.70	Commercial	20.00	0.25
2410	32.64	79.00	89.64	29.36	5.00	4.40	94.49	28.47	89.92	79.51	0.57	0.59	Commercial	20.00	0.25
2420	23.76	79.00	89.64	29.36	5.00	4.40	94.49	28.47	89.92	79.51	0.50	0.53	Commercial	20.00	0.25
2430	3.51	79.00	89.64	29.36	5.00	4.40	94.49	28.47	89.92	79.51	0.50	0.52	Commercial	20.00	0.25
2510	71.40	79.06	89.67	29.25	5.00	4.39	94.57	28.33	89.96	79.58	0.51	0.53	Commercial	20.00	0.25

2520	11.79	79.00	**89.64**	**29.36**	5.00	**4.40**	**94.49**	**28.47**	**89.92**	**79.51**	0.58	0.58	**Commercial**	**20.00**	0.25
2530	15.76	79.00	**89.64**	**29.36**	5.00	**4.40**	**94.49**	**28.47**	**89.92**	**79.51**	0.53	0.54	**Commercial**	**20.00**	0.25
2610	3.69	79.00	**89.64**	**29.36**	5.00	**4.40**	**94.49**	**28.47**	**89.92**	**79.51**	0.54	0.56	**Commercial**	**20.00**	0.25
2620	16.82	79.00	**89.64**	**29.36**	5.00	**4.40**	**94.49**	**28.47**	**89.92**	**79.51**	0.51	0.64	**Residential**	**40.00**	0.25
2710	6.77	79.00	**89.64**	**29.36**	5.00	**4.40**	**94.49**	**28.47**	**89.92**	**79.51**	0.40	0.51	**Residential**	**40.00**	0.25
2720	16.65	79.00	**89.64**	**29.36**	5.00	**4.40**	**94.49**	**28.47**	**89.92**	**79.51**	0.48	0.62	**Residential**	**40.00**	0.25
2730	13.64	79.01	**89.64**	**29.34**	5.00	**4.40**	**94.50**	**28.45**	**89.93**	**79.52**	0.47	0.56	**Residential**	**40.00**	0.25
2740	7.58	79.00	**89.64**	**29.36**	5.00	**4.40**	**94.49**	**28.47**	**89.92**	**79.51**	0.49	0.54	**Commercial**	**20.00**	0.25
2810	5.63	79.00	**89.64**	**29.36**	5.00	**4.40**	**94.49**	**28.47**	**89.92**	**79.51**	0.71	0.79	**Residential**	**40.00**	0.25
2820	39.59	77.69	**88.90**	**31.71**	5.00	**4.76**	**92.67**	**31.33**	**89.02**	**77.90**	0.46	0.58	**Residential**	**40.00**	0.25
2830	33.74	75.25	**87.49**	**36.31**	5.00	**5.45**	**89.24**	**37.04**	**87.27**	**74.88**	0.37	0.47	**Residential**	**40.00**	0.25
2840	162.55	79.01	**89.64**	**29.35**	5.00	**4.40**	**94.50**	**28.46**	**89.93**	**79.51**	0.58	0.72	**Residential**	**40.00**	0.25
2850	35.64	79.60	**89.98**	**28.30**	5.00	**4.24**	**95.33**	**27.18**	**90.33**	**80.25**	0.61	0.72	**Residential**	**40.00**	0.25
2860	4.45	81.13	**90.82**	**25.69**	5.00	**5.14**	**96.19**	**25.88**	**90.75**	**81.01**	0.30	0.30	**Commercial**	**20.00**	0.25
2910	20.06	80.96	**90.73**	**25.97**	5.00	**5.19**	**95.95**	**26.25**	**90.63**	**80.80**	0.82	0.84	**Commercial**	**20.00**	0.25
2920	89.16	81.51	**91.02**	**25.06**	5.00	**5.01**	**96.74**	**25.07**	**91.02**	**81.50**	0.49	0.62	**Residential**	**40.00**	0.25
2930	110.41	79.60	**89.98**	**28.30**	5.00	**4.24**	**95.33**	**27.18**	**90.33**	**80.25**	0.56	0.63	**REsidential**	**40.00**	0.25
2940	36.64	80.77	**90.62**	**26.29**	5.00	**5.26**	**95.67**	**26.67**	**90.50**	**80.55**	0.52	0.65	**REsidential**	**40.00**	0.25
2950	64.35	79.06	**89.68**	**29.24**	5.00	**4.39**	**94.58**	**28.33**	**89.97**	**79.58**	0.51	0.62	**REsidential**	**40.00**	0.25
2960	15.95	81.23	**90.87**	**25.51**	5.00	**5.10**	**96.34**	**25.66**	**90.83**	**81.15**	0.35	0.36	**Commercial**	**20.00**	0.25
3010	39.60	80.58	**90.51**	**26.62**	5.00	**5.32**	**95.39**	**27.09**	**90.36**	**80.30**	0.26	0.32	**Commercial**	**20.00**	0.25
3020	27.45	82.17	**91.38**	**23.96**	5.00	**4.79**	**97.70**	**23.67**	**91.48**	**82.35**	0.19	0.24	**Residential**	**40.00**	0.25
3030	47.69	79.04	**89.66**	**29.29**	5.00	**4.39**	**94.54**	**28.39**	**89.95**	**79.55**	0.41	0.49	**Residential**	**40.00**	0.25

Standard Catchment Parameters - Calibrated

Conservation Halton Landuse	Curve Number				IA (mm)	XIMP	TIMP	Manning n	k
	A	B	C	D					
Agricultural	70.35	81.9	89.25	93.45	7	0%	0%	0.3	0.274
Agricultural Block	70.35	81.9	89.25	93.45	7	0%	0%	0.3	0.274
Agriculture/Rural Residential Block	70.35	81.9	89.25	93.45	7	0%	0%	0.3	0.274
Bare Soil	75.6	86.1	91.35	93.45	5	0%	0%	0.02	0.491
Barn	98	98	98	98	2	99%	99%	0.015	0.619
Basketball Court	98	98	98	98	2	99%	99%	0.015	0.619
Bedrock	98	98	98	98	2	99%	99%	0.015	0.305
Building	98	98	98	98	2	99%	99%	0.015	0.619
Building Block	98	98	98	98	2	99%	99%	0.015	0.619
Cemetary	49	69	79	84	5	16%	20%	0.25	0.457
Commercial	89	92	94	95	2	85%	85%	0.015	0.619
Commercial / Industrial	89	92	94	95	2	85%	85%	0.015	0.619
Commercial / Industrial Block	89	92	94	95	2	85%	85%	0.015	0.619
Confinement Yard	72	82	87	89	5	0%	0%	0.02	0.491
Dirt	75.6	86.1	91.35	93.45	5	0%	0%	0.02	0.491
Extraction	98	98	98	98	5	0%	0%	0.02	0.491
Field	51.45	72.45	82.95	88.2	5	16%	20%	0.25	0.457
Field Block	51.45	72.45	82.95	88.2	5	16%	20%	0.25	0.457
Forest	37.8	63	76.65	82.95	10	0%	0%	0.35	0.076
Forest Block	37.8	63	76.65	82.95	10	0%	0%	0.35	0.076
Future Development	77	85	90	92	5	50%	70%	0.35	0.457
Golf Course	51.45	72.45	82.95	88.2	5	0%	0%	0.25	0.457
Grass	51.45	72.45	82.95	88.2	5	0%	0%	0.25	0.457
Gravel Baseball Diamond	72	82	87	89	5	0%	0%	0.02	0.491
Greenhouse	98	98	98	98	2	99%	99%	0.015	0.619
Hedge Row	47.25	69.3	80.85	87.15	10	0%	0%	0.15	0.274
Hedge Row - Coniferous	47.25	69.3	80.85	87.15	10	0%	0%	0.15	0.274
Hedge Row - Deciduous	47.25	69.3	80.85	87.15	10	0%	0%	0.15	0.274
Hedge Row Block	47.25	69.3	80.85	87.15	10	0%	0%	0.15	0.274
High Density Residential	89	92	94	95	2	65%	85%	0.015	0.619
Highway Median Grass	51.45	72.45	82.95	88.2	2	16%	20%	0.25	0.457
Impervious	98	98	98	98	2	99%	99%	0.015	0.619
Industrial	81	88	91	93	2	90%	90%	0.015	0.619
Industrial Block	81	88	91	93	2	90%	90%	0.015	0.619
Institutional	71	80	88	90	2	60%	75%	0.015	0.619
Junk Yard	75.6	86.1	91.35	93.45	5	0%	0%	0.02	0.491
Marsh	50	50	50	50	15	0%	0%	0.13	0.076
Natural Area	51.45	72.45	82.95	88.2	10	0%	0%	0.25	0.076
Natural Area Block	51.45	72.45	82.95	88.2	10	0%	0%	0.25	0.076
Natural Area Creek Block	51.45	72.45	82.95	88.2	10	0%	0%	0.25	0.076
Nursery	47.25	69.3	80.85	87.15	10	0%	0%	0.15	0.274
Orchard	47.25	69.3	80.85	87.15	10	0%	0%	0.15	0.274
Park	51.45	72.45	82.95	88.2	5	16%	20%	0.25	0.457
Parking Lot	98	98	98	98	2	99%	99%	0.015	0.619
Pasture	51.45	72.45	82.95	88.2	8	0%	0%	0.35	0.213
Plantation	37.8	63	76.65	82.95	10	0%	0%	0.35	0.274
Plantation - Coniferous	37.8	63	76.65	82.95	10	0%	0%	0.35	0.274
Plantation - Deciduous	37.8	63	76.65	82.95	10	0%	0%	0.35	0.274
Playground	49	69	79	84	2	0%	0%	0.25	0.619
Private Road	98	98	98	98	2	99%	99%	0.015	0.619
Railway	98	98	98	98	2	85%	85%	0.02	0.619
Recreational	49	69	79	84	5	16%	20%	0.25	0.457
Residential	77	85	90	92	5	50%	70%	0.25	0.457
Rural Residential	64.05	78.75	87.15	91.35	5	16%	20%	0.25	0.457

SWM Pond	50	50	50	50	15	50%	50%	0.015	0.076
SWM Pond Block	50	50	50	50	15	50%	50%	0.015	0.076
Trailer Park	64.05	78.75	87.15	91.35	5	16%	20%	0.25	0.457
Transportation	98	98	98	98	2	99%	99%	0.015	0.619
Treed - Coniferous	37.8	63	76.65	82.95	10	0%	0%	0.35	0.076
Treed - Deciduous	37.8	63	76.65	82.95	10	0%	0%	0.35	0.076
Treed - Mixed	37.8	63	76.65	82.95	10	0%	0%	0.35	0.076
Urban Residential	77	85	90	92	5	50%	70%	0.25	0.457
Urban Residential Block	77	85	90	92	5	50%	70%	0.25	0.457
Water	98	98	98	98	15	0%	0%	0.13	0.076
Wetland	50	50	50	50	15	0%	0%	0.13	0.076

NASHYD Input Parameters - Calibrated, Existing Land-use

100-year Precipitation 122.4 mm

	CN Conversion										Time of Concentration					
Catchment	Area (ha)	CNii	Cniii	S (mm)	IA (mm)	IA* (mm)	Q	S*	CNiii*	Cnii*	Length (m)	Slope (%)	k	v (m/s)	ToC (min)	Tp (hour)
110	291.95	58.48	76.41	78.41	10.41	7.84	68.01	72.41	77.82	60.40	2934.00	0.77	0.20	0.18	279.01	3.10
120	110.86	65.13	81.12	59.13	10.49	8.87	74.65	55.86	81.97	66.41	2374.00	0.45	0.20	0.14	288.42	3.20
130	159.51	61.77	78.80	68.35	9.98	6.83	72.62	61.63	80.47	64.18	4184.00	0.62	0.18	0.14	498.65	5.54
140	144.27	66.83	82.25	54.81	10.00	8.22	77.15	51.36	83.18	68.26	2408.00	0.59	0.21	0.16	245.26	2.73
150	166.06	70.63	84.69	45.93	9.20	6.89	82.65	41.85	85.85	72.52	2963.00	0.75	0.21	0.18	267.67	2.97
160	111.74	63.32	79.88	63.97	11.09	6.40	74.77	54.39	82.36	67.00	2084.00	1.09	0.12	0.13	274.67	3.05
170	216.86	68.79	83.52	50.10	9.24	7.52	80.00	46.91	84.41	70.19	3815.00	1.01	0.20	0.20	312.23	3.47
180	221.48	58.76	76.62	77.49	11.16	7.75	68.41	69.64	78.48	61.33	3874.00	1.57	0.12	0.15	420.22	4.67
210	202.82	61.91	78.90	67.94	9.34	6.79	72.81	62.49	80.26	63.86	2928.00	1.04	0.22	0.23	213.12	2.37
220	143.58	55.90	74.46	87.11	11.39	8.71	64.37	80.45	75.95	57.85	2206.00	0.49	0.16	0.11	325.35	3.61
230	64.00	61.00	78.25	70.60	10.91	7.06	71.55	62.25	80.32	63.95	1438.00	0.57	0.20	0.15	161.29	1.79
240	265.92	65.55	81.40	58.04	9.22	8.71	75.27	57.01	81.67	65.95	3278.00	0.96	0.23	0.22	245.42	2.73
250	316.66	57.82	75.92	80.56	10.55	8.06	67.08	74.65	77.29	59.67	2914.00	0.83	0.17	0.16	312.93	3.48
260	292.75	60.00	77.53	73.61	10.03	7.36	70.15	67.62	78.97	62.02	4068.00	0.70	0.17	0.14	468.35	5.20
270	63.88	59.74	77.34	74.43	11.26	7.44	69.78	65.88	79.40	62.63	1645.00	0.80	0.08	0.07	385.04	4.28
280	243.37	56.93	75.24	83.57	10.97	8.36	65.82	77.22	76.69	58.85	3777.00	0.54	0.12	0.09	700.24	7.78
290	55.36	60.86	78.15	71.02	10.98	7.10	71.35	62.57	80.24	63.83	1632.00	0.52	0.09	0.06	438.65	4.87
310	264.49	63.54	80.03	63.38	10.22	9.51	72.30	61.86	80.41	64.10	4014.00	0.45	0.20	0.13	498.86	5.54
320	101.17	62.60	79.38	65.97	10.86	6.60	73.77	57.10	81.64	65.92	1655.00	0.36	0.18	0.11	260.18	2.89
330	183.36	63.21	79.81	64.27	9.57	6.43	74.62	57.77	81.47	65.66	2603.00	0.93	0.22	0.21	208.01	2.31
340	197.16	63.71	80.15	62.91	10.83	9.44	72.56	59.98	80.90	64.80	4276.00	0.87	0.12	0.11	660.02	7.33
350	169.49	57.14	75.40	82.85	10.43	8.29	66.11	77.65	76.59	58.71	2446.00	1.00	0.12	0.12	337.46	3.75
360	221.71	58.37	76.33	78.76	10.78	7.88	67.86	71.98	77.92	60.54	2686.00	0.90	0.12	0.11	401.50	4.46
370	33.82	62.18	79.08	67.18	12.21	6.72	73.18	55.73	82.01	66.46	1253.00	1.52	0.10	0.13	166.17	1.85
380	311.59	59.94	77.49	73.80	10.47	7.38	70.06	66.90	79.15	62.28	4624.00	1.23	0.18	0.20	386.44	4.29
390	121.34	63.56	80.04	63.32	10.59	9.50	72.33	61.01	80.63	64.41	3459.00	0.48	0.13	0.09	648.87	7.21
410	270.12	61.19	78.39	70.03	11.47	7.00	71.82	60.42	80.78	64.64	4220.00	1.33	0.08	0.09	782.36	8.69
510	425.24	66.37	81.94	55.97	8.59	8.40	76.47	55.58	82.05	66.52	5426.00	1.15	0.25	0.27	334.42	3.72
520	278.91	58.56	76.47	78.14	8.77	7.81	68.13	75.90	76.99	59.27	4452.00	0.98	0.27	0.27	275.84	3.06
530	34.14	66.02	81.72	56.83	7.41	8.52	75.97	59.07	81.13	65.15	1159.00	0.48	0.33	0.23	84.20	0.94
540	151.94	55.82	74.40	87.42	10.14	8.74	64.25	83.90	75.17	56.83	2389.00	0.48	0.20	0.14	282.14	3.13
550	112.22	58.79	76.64	77.42	7.92	7.74	68.44	77.00	76.74	58.92	2727.00	1.02	0.26	0.27	171.11	1.90
560	52.81	52.70	71.93	99.10	7.29	9.91	59.80	106.47	70.46	50.92	1840.00	0.89	0.30	0.28	108.70	1.21
570	151.75	59.69	77.30	74.58	7.27	7.46	69.71	75.01	77.20	59.55	1939.00	1.92	0.33	0.45	71.38	0.79
580	24.79	60.45	77.86	72.25	9.37	7.22	70.78	67.47	79.01	62.08	964.00	1.91	0.22	0.30	52.79	0.59
610	167.66	51.97	71.33	102.07	8.96	10.21	58.75	105.62	70.63	51.12	2335.00	2.05	0.24	0.35	111.49	1.24
710	179.17	66.33	81.92	56.07	7.77	8.41	76.41	57.33	81.58	65.83	2489.00	1.25	0.28	0.32	131.50	1.46

720	180.98	68.60	83.40	50.56	9.15	7.58	79.71	47.65	84.20	69.86	2426.00	1.44	0.20	0.23	172.16	1.91
730	97.46	94.17	97.38	6.83	5.69	1.37	114.57	2.19	98.00	95.52	1636.00	1.66	0.45	0.58	47.09	0.52
740	78.00	96.96	98.00	5.18	13.81	1.04	116.39	-7.28	98.00	95.52	1329.00	2.06	0.12	0.18	124.49	1.38
750	96.13	81.41	90.97	25.22	10.01	5.04	96.60	18.38	93.25	85.73	1741.00	0.51	0.24	0.17	168.45	1.87
760	159.27	67.28	82.55	53.71	11.62	8.06	77.80	46.96	84.40	70.16	3794.00	1.10	0.10	0.11	582.77	6.48
770	42.97	63.75	80.17	62.81	7.78	9.42	72.61	66.31	79.30	62.48	1380.00	4.28	0.27	0.55	41.70	0.46
810	101.31	53.19	72.33	97.17	9.39	9.72	60.51	98.07	72.14	52.96	1419.00	2.64	0.15	0.24	98.38	1.09
820	249.57	58.55	76.46	78.19	8.61	7.82	68.11	76.33	76.89	59.13	4286.00	1.66	0.24	0.31	234.20	2.60
830	50.80	57.40	75.60	81.96	8.97	8.20	66.49	80.09	76.03	57.96	1609.00	5.18	0.23	0.52	51.89	0.58
910	115.97	90.66	95.71	11.38	5.50	2.28	109.73	7.63	97.08	93.54	1317.00	0.79	0.45	0.40	54.41	0.60
920	64.38	81.52	91.03	25.03	8.45	5.01	96.76	20.24	92.62	84.51	1493.00	4.51	0.20	0.42	59.33	0.66
1010	131.71	77.66	88.88	31.77	8.66	4.77	92.62	25.94	90.73	80.98	3030.00	2.97	0.19	0.34	150.64	1.67
1110	66.26	82.60	91.61	23.27	11.00	4.65	98.32	14.82	94.49	88.17	1283.00	2.64	0.18	0.29	73.51	0.82
1210	140.52	69.16	83.76	49.24	8.25	7.39	80.53	47.65	84.20	69.86	2603.00	3.45	0.23	0.43	101.85	1.13
1220	179.04	75.64	87.72	35.57	8.59	5.34	89.78	30.45	89.29	78.39	3077.00	4.03	0.22	0.44	116.89	1.30
1230	151.67	78.61	89.42	30.05	7.79	4.51	93.95	25.21	90.97	81.42	2997.00	3.85	0.32	0.63	79.56	0.88
1240	147.61	79.34	89.83	28.75	7.91	4.31	94.96	23.54	91.52	82.43	2164.00	3.08	0.26	0.46	78.37	0.87
1270	49.12	85.98	93.38	18.01	7.22	3.60	103.16	13.43	94.98	89.16	1550.00	1.84	0.28	0.37	68.96	0.77
1280	13.55	87.61	94.21	15.62	9.24	3.12	105.47	8.25	96.85	93.05	638.00	0.01	0.23	0.02	469.62	5.22
1310	170.98	85.42	93.09	18.85	7.57	3.77	102.36	13.99	94.78	88.76	2906.00	2.89	0.25	0.43	112.13	1.25
1320	59.21	85.21	92.99	19.16	6.85	3.83	102.07	15.25	94.33	87.86	1289.00	2.57	0.32	0.52	41.45	0.46
1330	38.22	88.24	94.52	14.72	6.60	2.94	106.35	10.28	96.11	91.48	908.00	0.84	0.32	0.29	51.41	0.57
1350	14.30	87.26	94.03	16.12	7.19	3.22	104.98	11.23	95.76	90.77	689.00	0.60	0.29	0.23	50.84	0.56
1510	190.01	83.35	92.01	22.06	7.11	4.41	99.40	18.43	93.24	85.70	3593.00	3.06	0.33	0.58	104.07	1.16
1520	204.95	83.78	92.24	21.38	7.46	4.28	100.02	17.14	93.68	86.56	3401.00	3.17	0.28	0.50	112.49	1.25
1930	11.34	81.80	91.18	24.57	6.29	4.91	97.17	22.63	91.82	82.99	349.00	2.36	0.37	0.57	10.16	0.11
2210	67.60	88.52	94.66	14.32	7.08	2.86	106.75	9.26	96.48	92.27	1306.00	0.40	0.28	0.17	124.76	1.39
3040	2.94	87.16	93.98	16.26	5.00	3.25	104.84	14.07	94.75	88.70	259.00	4.10	0.46	0.93	4.66	0.05
3050	107.73	90.60	95.68	11.46	6.90	2.29	109.65	6.17	97.63	94.71	2524.00	0.94	0.28	0.27	154.17	1.71
3110	265.18	59.24	76.98	75.98	10.00	7.60	69.08	70.47	78.28	61.05	3823.00	0.54	0.19	0.14	453.20	5.04
3120	276.19	64.63	80.78	60.44	9.58	9.07	73.92	59.37	81.05	65.04	4792.00	1.42	0.19	0.22	357.36	3.97
3210	263.35	72.21	85.66	42.51	7.98	6.38	84.91	39.75	86.47	73.53	3713.00	0.38	0.24	0.15	419.08	4.66
3220	51.73	54.24	73.17	93.15	8.36	9.32	62.01	95.69	72.64	53.58	1239.00	0.55	0.20	0.15	138.81	1.54
3230	75.80	60.99	78.24	70.64	8.64	7.06	71.53	67.16	79.09	62.18	1737.00	1.21	0.18	0.19	149.55	1.66
3240	108.32	65.99	81.69	56.91	8.68	8.54	75.92	56.64	81.77	66.10	2621.00	0.79	0.19	0.17	264.73	2.94
3250	25.00	63.45	79.97	63.62	9.74	6.36	74.95	56.68	81.76	66.08	988.00	2.01	0.09	0.13	124.89	1.39
3260	80.20	69.36	83.89	48.78	9.86	7.32	80.82	44.17	85.19	71.43	2525.00	0.89	0.09	0.08	504.96	5.61
3270	136.88	66.07	81.74	56.73	9.51	8.51	76.03	54.74	82.27	66.86	3340.00	2.11	0.11	0.16	340.35	3.78
3310	114.25	78.49	89.36	30.26	8.55	4.54	93.79	24.36	91.25	81.93	2965.00	2.89	0.20	0.34	146.91	1.63
3410	293.62	72.63	85.92	41.61	7.54	6.24	85.52	39.41	86.57	73.70	4753.00	1.43	0.27	0.32	247.57	2.75
3420	141.75	69.39	83.91	48.71	7.57	7.31	80.87	48.23	84.04	69.60	2966.00	1.52	0.24	0.29	168.12	1.87
3430	158.61	78.05	89.11	31.05	7.49	4.66	93.17	26.81	90.45	80.46	4074.00	1.82	0.25	0.34	199.99	2.22
3440	78.57	78.70	89.47	29.90	7.18	4.48	94.07	25.91	90.75	81.00	1814.00	2.37	0.26	0.41	74.13	0.82

3450	93.65	85.03	**92.89**	**19.45**	6.93	**3.89**	**101.80**	**15.50**	**94.25**	**87.69**	2073.00	0.34	0.28	**0.16**	**209.53**	**2.33**
3510	123.18	68.44	**83.30**	**50.92**	9.20	**7.64**	**79.49**	**47.99**	**84.11**	**69.71**	2644.00	2.08	0.14	**0.19**	**226.29**	**2.51**
3520	63.27	75.86	**87.84**	**35.15**	7.93	**5.27**	**90.09**	**30.97**	**89.13**	**78.10**	1914.00	2.66	0.24	**0.38**	**83.16**	**0.92**
3530	52.53	78.09	**89.13**	**30.98**	7.16	**4.65**	**93.22**	**27.21**	**90.32**	**80.23**	1068.00	3.34	0.28	**0.51**	**34.73**	**0.39**
3540	134.61	79.57	**89.96**	**28.36**	7.47	**4.25**	**95.28**	**23.70**	**91.46**	**82.33**	1763.00	1.35	0.25	**0.29**	**100.05**	**1.11**
3550	45.50	73.72	**86.58**	**39.36**	8.17	**5.90**	**87.07**	**35.63**	**87.70**	**75.61**	1568.00	2.50	0.20	**0.32**	**82.38**	**0.92**
3610	71.16	78.66	**89.45**	**29.97**	7.89	**4.50**	**94.01**	**24.97**	**91.05**	**81.56**	1725.00	2.47	0.22	**0.34**	**84.33**	**0.94**
3620	278.60	70.71	**84.74**	**45.74**	8.53	**6.86**	**82.77**	**42.79**	**85.58**	**72.07**	4091.00	2.21	0.18	**0.26**	**257.44**	**2.86**
3630	106.15	88.92	**94.86**	**13.77**	7.25	**2.75**	**107.30**	**8.42**	**96.79**	**92.91**	1371.00	0.98	0.26	**0.26**	**87.58**	**0.97**
3640	91.61	83.13	**91.89**	**22.41**	7.57	**4.48**	**99.09**	**18.24**	**93.30**	**85.82**	1848.00	2.62	0.25	**0.40**	**76.72**	**0.85**
3650	86.68	80.59	**90.52**	**26.61**	7.85	**5.32**	**95.40**	**22.99**	**91.70**	**82.77**	2482.00	2.95	0.22	**0.39**	**107.37**	**1.19**
3660	41.63	76.60	**88.27**	**33.75**	8.22	**5.06**	**91.13**	**28.88**	**89.79**	**79.27**	1383.00	3.36	0.21	**0.38**	**60.36**	**0.67**
3670	83.94	78.44	**89.32**	**30.36**	8.07	**4.55**	**93.71**	**25.16**	**90.99**	**81.44**	3164.00	2.69	0.22	**0.36**	**148.49**	**1.65**
3680	12.75	86.96	**93.88**	**16.56**	8.65	**3.31**	**104.55**	**10.02**	**96.21**	**91.68**	490.00	5.51	0.23	**0.54**	**14.99**	**0.17**
3710	190.40	84.22	**92.47**	**20.70**	8.71	**4.14**	**100.65**	**14.74**	**94.52**	**88.23**	2386.00	3.08	0.23	**0.40**	**98.42**	**1.09**
3810	82.18	79.40	**89.86**	**28.65**	8.65	**4.30**	**95.05**	**22.38**	**91.90**	**83.15**	1832.00	5.38	0.22	**0.51**	**59.48**	**0.66**
3820	171.80	64.25	**80.52**	**61.44**	11.33	**9.22**	**73.36**	**57.09**	**81.65**	**65.92**	3364.00	2.73	0.09	**0.14**	**387.78**	**4.31**
3830	157.82	77.58	**88.84**	**31.92**	8.39	**4.79**	**92.50**	**26.51**	**90.55**	**80.64**	2386.00	4.33	0.26	**0.53**	**74.69**	**0.83**
3840	53.32	79.76	**90.06**	**28.02**	7.38	**5.60**	**94.20**	**25.43**	**90.90**	**81.28**	1977.00	1.71	0.27	**0.35**	**93.14**	**1.03**
3850	37.31	87.34	**94.07**	**16.01**	7.19	**3.20**	**105.08**	**11.11**	**95.81**	**90.86**	1380.00	1.10	0.27	**0.29**	**80.27**	**0.89**
3860	61.36	86.45	**93.62**	**17.31**	7.42	**3.46**	**103.83**	**12.35**	**95.36**	**89.94**	1941.00	1.07	0.26	**0.27**	**120.12**	**1.33**

STANDHYD Input Parameters - Calibrated, Existing Land-use

100-year Precipitation 122.4 mm

	CN Conversion											Other				
Catchment	Area (ha)	CNii	Cniii	S (mm)	IA (mm)	IA* (mm)	Q	S*	CNiii*	Cnii*	XIMP	TIMP	Perv Type	Perv L (m)	n Perv
620	35.21	53.47	72.55	96.09	5.00	9.61	60.90	108.91	69.99	50.35	0.22	0.24	Commercial	20.00	0.25
1250	59.85	83.82	92.26	21.32	5.00	4.26	100.07	20.33	92.59	84.45	0.44	0.45	Commercial	20.00	0.25
1260	94.48	83.85	92.27	21.27	5.00	4.25	100.12	20.26	92.61	84.50	0.25	0.26	Commercial	20.00	0.25
1290	15.28	83.16	91.91	22.36	5.00	4.47	99.14	21.63	92.15	83.62	0.71	0.75	Residential	40.00	0.25
1340	56.81	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.26	0.28	Residential	40.00	0.25
1360	33.14	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.57	0.58	Commercial	20.00	0.25
1530	81.43	85.06	92.90	19.40	5.00	3.88	101.84	17.93	93.41	86.03	0.51	0.52	Commercial	20.00	0.25
1540	7.10	86.16	93.47	17.74	5.00	3.55	103.41	15.88	94.12	87.43	0.44	0.45	Commercial	20.00	0.25
1610	75.34	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.49	0.49	Commercial	20.00	0.25
1620	50.51	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.27	0.28	Commercial	20.00	0.25
1810	47.83	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.76	0.77	Commercial	20.00	0.25
1820	101.19	82.97	91.81	22.67	5.00	4.53	98.86	22.02	92.02	83.37	0.63	0.64	Commercial	20.00	0.25
1840	26.45	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.22	0.24	Commercial	20.00	0.25
1910	56.44	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.33	0.34	Commercial	20.00	0.25
1920	32.15	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.42	0.43	Commercial	20.00	0.25
2020	108.22	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.41	0.42	Commercial	20.00	0.25
2030	13.49	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.69	0.71	Commercial	20.00	0.25
2110	20.24	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.53	0.55	Commercial	20.00	0.25
2120	6.43	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.58	0.59	Commercial	20.00	0.25
2130	10.24	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.77	0.77	Commercial	20.00	0.25
2140	12.83	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.99	0.99	Commercial	20.00	0.25
2220	98.14	83.74	92.22	21.44	5.00	4.29	99.97	20.47	92.54	84.36	0.77	0.77	Commercial	20.00	0.25
2230	34.99	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.68	0.69	Commercial	20.00	0.25
2240	2.83	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.52	0.53	Commercial	20.00	0.25
2250	11.57	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.73	0.73	Commercial	20.00	0.25
2260	3.35	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.77	0.77	Commercial	20.00	0.25
2310	44.35	84.20	92.45	20.73	5.00	4.15	100.62	19.58	92.84	84.94	0.79	0.81	Commercial	20.00	0.25
2320	22.69	84.67	92.70	19.99	5.00	4.00	101.29	18.67	93.15	85.54	0.43	0.57	Residential	40.00	0.25
2330	45.58	84.27	92.49	20.62	5.00	4.12	100.72	19.44	92.89	85.03	0.50	0.68	Residential	40.00	0.25
2340	21.27	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.60	0.71	Residential	40.00	0.25
2350	59.44	82.97	91.81	22.67	5.00	4.53	98.86	22.02	92.02	83.38	0.55	0.69	Residential	40.00	0.25
2360	15.48	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.56	0.74	Residential	40.00	0.25
2370	48.17	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.67	0.70	Commercial	20.00	0.25
2410	32.64	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.57	0.59	Commercial	20.00	0.25
2420	23.76	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.50	0.53	Commercial	20.00	0.25
2430	3.51	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.50	0.52	Commercial	20.00	0.25
2510	71.40	83.01	91.83	22.60	5.00	4.52	98.92	21.93	92.05	83.43	0.51	0.53	Commercial	20.00	0.25

2520	11.79	82.95	**91.80**	**22.70**	5.00	**4.54**	**98.83**	**22.06**	**92.01**	**83.35**	0.58	0.58	**Commercial**	**20.00**	0.25
2530	15.76	82.95	**91.80**	**22.70**	5.00	**4.54**	**98.83**	**22.06**	**92.01**	**83.35**	0.53	0.54	**Commercial**	**20.00**	0.25
2610	3.69	82.95	**91.80**	**22.70**	5.00	**4.54**	**98.83**	**22.06**	**92.01**	**83.35**	0.54	0.56	**Commercial**	**20.00**	0.25
2620	16.82	82.95	**91.80**	**22.70**	5.00	**4.54**	**98.83**	**22.06**	**92.01**	**83.35**	0.51	0.64	**Residential**	**40.00**	0.25
2710	6.77	82.95	**91.80**	**22.70**	5.00	**4.54**	**98.83**	**22.06**	**92.01**	**83.35**	0.40	0.51	**Residential**	**40.00**	0.25
2720	16.65	82.95	**91.80**	**22.70**	5.00	**4.54**	**98.83**	**22.06**	**92.01**	**83.35**	0.48	0.62	**Residential**	**40.00**	0.25
2730	13.64	82.96	**91.80**	**22.69**	5.00	**4.54**	**98.84**	**22.05**	**92.01**	**83.36**	0.47	0.56	**Residential**	**40.00**	0.25
2740	7.58	82.95	**91.80**	**22.70**	5.00	**4.54**	**98.83**	**22.06**	**92.01**	**83.35**	0.49	0.54	**Commercial**	**20.00**	0.25
2810	5.63	82.95	**91.80**	**22.70**	5.00	**4.54**	**98.83**	**22.06**	**92.01**	**83.35**	0.71	0.79	**Residential**	**40.00**	0.25
2820	39.59	81.58	**91.06**	**24.94**	5.00	**4.99**	**96.84**	**24.92**	**91.06**	**81.59**	0.46	0.58	**Residential**	**40.00**	0.25
2830	33.74	79.02	**89.65**	**29.33**	5.00	**4.40**	**94.51**	**28.43**	**89.93**	**79.53**	0.37	0.47	**Residential**	**40.00**	0.25
2840	162.55	82.96	**91.80**	**22.69**	5.00	**4.54**	**98.83**	**22.05**	**92.01**	**83.35**	0.58	0.72	**Residential**	**40.00**	0.25
2850	35.64	83.58	**92.13**	**21.69**	5.00	**4.34**	**99.74**	**20.79**	**92.43**	**84.16**	0.61	0.72	**Residential**	**40.00**	0.25
2860	4.45	85.19	**92.97**	**19.20**	5.00	**3.84**	**102.03**	**17.68**	**93.49**	**86.20**	0.30	0.30	**Commercial**	**20.00**	0.25
2910	20.06	85.01	**92.88**	**19.47**	5.00	**3.89**	**101.78**	**18.01**	**93.38**	**85.98**	0.82	0.84	**Commercial**	**20.00**	0.25
2920	89.16	85.58	**93.18**	**18.60**	5.00	**3.72**	**102.60**	**16.94**	**93.75**	**86.70**	0.49	0.62	**Residential**	**40.00**	0.25
2930	110.41	83.58	**92.13**	**21.69**	5.00	**4.34**	**99.74**	**20.79**	**92.43**	**84.16**	0.56	0.63	**REsidential**	**40.00**	0.25
2940	36.64	84.81	**92.77**	**19.78**	5.00	**3.96**	**101.49**	**18.40**	**93.25**	**85.72**	0.52	0.65	**REsidential**	**40.00**	0.25
2950	64.35	83.02	**91.83**	**22.59**	5.00	**4.52**	**98.92**	**21.93**	**92.05**	**83.43**	0.51	0.62	**REsidential**	**40.00**	0.25
2960	15.95	85.30	**93.03**	**19.04**	5.00	**3.81**	**102.19**	**17.48**	**93.56**	**86.34**	0.35	0.36	**Commercial**	**20.00**	0.25
3010	39.60	84.61	**92.67**	**20.09**	5.00	**4.02**	**101.20**	**18.79**	**93.11**	**85.46**	0.26	0.32	**Commercial**	**20.00**	0.25
3020	27.45	86.28	**93.53**	**17.56**	5.00	**3.51**	**103.59**	**15.65**	**94.19**	**87.58**	0.19	0.24	**Residential**	**40.00**	0.25
3030	47.69	82.99	**91.82**	**22.64**	5.00	**4.53**	**98.88**	**21.99**	**92.03**	**83.40**	0.41	0.49	**Residential**	**40.00**	0.25

NASHHYD Input Parameters Calibrated, Future Land-use

100-year Precipitation 122.4 mm

	CN Conversion										Time of Concentration					
Catchment	Area (ha)	CNii	Cniii	S (mm)	IA (mm)	IA* (mm)	Q	S*	CNiii*	Cnii*	Length (m)	Slope (%)	k	v (m/s)	ToC (min)	Tp (hour)
110	291.95	58.48	76.41	78.41	10.41	7.84	68.01	72.41	77.82	60.40	2934.00	0.77	0.20	0.18	279.01	3.10
120	110.86	65.13	81.12	59.13	10.49	8.87	74.65	55.86	81.97	66.41	2374.00	0.45	0.20	0.14	288.42	3.20
130	159.51	61.77	78.80	68.35	9.98	6.83	72.62	61.63	80.47	64.18	4184.00	0.62	0.18	0.14	498.65	5.54
140	144.27	66.83	82.25	54.81	10.00	8.22	77.15	51.36	83.18	68.26	2408.00	0.59	0.21	0.16	245.26	2.73
150	166.06	70.63	84.69	45.93	9.20	6.89	82.65	41.85	85.85	72.52	2963.00	0.75	0.21	0.18	267.67	2.97
160	111.74	63.32	79.88	63.97	11.09	6.40	74.77	54.39	82.36	67.00	2084.00	1.09	0.12	0.13	274.67	3.05
170	216.86	68.79	83.52	50.10	9.24	7.52	80.00	46.91	84.41	70.19	3815.00	1.01	0.20	0.20	312.23	3.47
180	221.48	58.76	76.62	77.49	11.16	7.75	68.41	69.64	78.48	61.33	3874.00	1.57	0.12	0.15	420.22	4.67
210	202.82	61.91	78.90	67.94	9.34	6.79	72.81	62.49	80.26	63.86	2928.00	1.04	0.22	0.23	213.12	2.37
220	143.58	55.90	74.46	87.11	11.39	8.71	64.37	80.45	75.95	57.85	2206.00	0.49	0.16	0.11	325.35	3.61
230	64.00	61.00	78.25	70.60	10.91	7.06	71.55	62.25	80.32	63.95	1438.00	0.57	0.20	0.15	161.29	1.79
240	265.92	65.55	81.40	58.04	9.22	8.71	75.27	57.01	81.67	65.95	3278.00	0.96	0.23	0.22	245.42	2.73
250	316.66	57.82	75.92	80.56	10.55	8.06	67.08	74.65	77.29	59.67	2914.00	0.83	0.17	0.16	312.93	3.48
260	292.75	60.00	77.53	73.61	10.03	7.36	70.15	67.62	78.97	62.02	4068.00	0.70	0.17	0.14	468.35	5.20
270	63.88	59.74	77.34	74.43	11.26	7.44	69.78	65.88	79.40	62.63	1645.00	0.80	0.08	0.07	385.04	4.28
280	243.37	56.93	75.24	83.57	10.97	8.36	65.82	77.22	76.69	58.85	3777.00	0.54	0.12	0.09	700.24	7.78
290	55.36	60.86	78.15	71.02	10.98	7.10	71.35	62.57	80.24	63.83	1632.00	0.52	0.09	0.06	438.65	4.87
310	264.49	63.54	80.03	63.38	10.22	9.51	72.30	61.86	80.41	64.10	4014.00	0.45	0.20	0.13	498.86	5.54
320	101.17	62.60	79.38	65.97	10.86	6.60	73.77	57.10	81.64	65.92	1655.00	0.36	0.18	0.11	260.18	2.89
330	183.36	63.21	79.81	64.27	9.57	6.43	74.62	57.77	81.47	65.66	2603.00	0.93	0.22	0.21	208.01	2.31
340	197.16	63.71	80.15	62.91	10.83	9.44	72.56	59.98	80.90	64.80	4276.00	0.87	0.12	0.11	660.02	7.33
350	169.49	57.14	75.40	82.85	10.43	8.29	66.11	77.65	76.59	58.71	2446.00	1.00	0.12	0.12	337.46	3.75
360	221.71	58.37	76.33	78.76	10.78	7.88	67.86	71.98	77.92	60.54	2686.00	0.90	0.12	0.11	401.50	4.46
370	33.82	62.18	79.08	67.18	12.21	6.72	73.18	55.73	82.01	66.46	1253.00	1.52	0.10	0.13	166.17	1.85
380	311.59	59.94	77.49	73.80	10.47	7.38	70.06	66.90	79.15	62.28	4624.00	1.23	0.18	0.20	386.44	4.29
390	121.34	63.56	80.04	63.32	10.59	9.50	72.33	61.01	80.63	64.41	3459.00	0.48	0.13	0.09	648.87	7.21
410	270.12	61.19	78.39	70.03	11.47	7.00	71.82	60.42	80.78	64.64	4220.00	1.33	0.08	0.09	782.36	8.69
510	425.24	66.37	81.94	55.97	8.59	8.40	76.47	55.58	82.05	66.52	5426.00	1.15	0.25	0.27	334.42	3.72
520	278.91	58.56	76.47	78.14	8.77	7.81	68.13	75.90	76.99	59.27	4452.00	0.98	0.27	0.27	275.84	3.06
530	34.14	66.02	81.72	56.83	7.41	8.52	75.97	59.07	81.13	65.15	1159.00	0.48	0.33	0.23	84.20	0.94
540	151.94	55.82	74.40	87.42	10.14	8.74	64.25	83.90	75.17	56.83	2389.00	0.48	0.20	0.14	282.14	3.13
550	112.22	58.79	76.64	77.42	7.92	7.74	68.44	77.00	76.74	58.92	2727.00	1.02	0.26	0.27	171.11	1.90
560	52.81	52.70	71.93	99.10	7.29	9.91	59.80	106.47	70.46	50.92	1840.00	0.89	0.30	0.28	108.70	1.21
570	151.75	59.69	77.30	74.58	7.27	7.46	69.71	75.01	77.20	59.55	1939.00	1.92	0.33	0.45	71.38	0.79
580	24.79	60.45	77.86	72.25	9.37	7.22	70.78	67.47	79.01	62.08	964.00	1.91	0.22	0.30	52.79	0.59
610	167.66	51.97	71.33	102.07	8.96	10.21	58.75	105.62	70.63	51.12	2335.00	2.05	0.24	0.35	111.49	1.24
710	179.17	66.33	81.92	56.07	7.77	8.41	76.41	57.33	81.58	65.83	2489.00	1.25	0.28	0.32	131.50	1.46

720	180.98	68.60	83.40	50.56	9.15	7.58	79.71	47.65	84.20	69.86	2426.00	1.44	0.20	0.23	172.16	1.91
730	97.46	94.17	97.38	6.83	5.69	1.37	114.57	2.19	98.00	95.52	1636.00	1.66	0.45	0.58	47.09	0.52
740	78.00	96.96	98.00	5.18	13.81	1.04	116.39	-7.28	98.00	95.52	1329.00	2.06	0.12	0.18	124.49	1.38
750	96.13	81.41	90.97	25.22	10.01	5.04	96.60	18.38	93.25	85.73	1741.00	0.51	0.24	0.17	168.45	1.87
760	159.27	67.28	82.55	53.71	11.62	8.06	77.80	46.96	84.40	70.16	3794.00	1.10	0.10	0.11	582.77	6.48
770	42.97	63.75	80.17	62.81	7.78	9.42	72.61	66.31	79.30	62.48	1380.00	4.28	0.27	0.55	41.70	0.46
810	101.31	53.19	72.33	97.17	9.39	9.72	60.51	98.07	72.14	52.96	1419.00	2.64	0.15	0.24	98.38	1.09
820	249.57	58.55	76.46	78.19	8.61	7.82	68.11	76.33	76.89	59.13	4286.00	1.66	0.24	0.31	234.20	2.60
830	50.80	57.40	75.60	81.96	8.97	8.20	66.49	80.09	76.03	57.96	1609.00	5.18	0.23	0.52	51.89	0.58
910	115.97	90.66	95.71	11.38	5.50	2.28	109.73	7.63	97.08	93.54	1317.00	0.79	0.45	0.40	54.41	0.60
920	64.38	81.52	91.03	25.03	8.45	5.01	96.76	20.24	92.62	84.51	1493.00	4.51	0.20	0.42	59.33	0.66
1010	131.71	77.66	88.88	31.77	8.66	4.77	92.62	25.94	90.73	80.98	3030.00	2.97	0.19	0.34	150.64	1.67
1110	66.26	82.60	91.61	23.27	11.00	4.65	98.32	14.82	94.49	88.17	1283.00	2.64	0.18	0.29	73.51	0.82
1210	140.52	69.16	83.76	49.24	8.25	7.39	80.53	47.65	84.20	69.86	2603.00	3.45	0.23	0.43	101.85	1.13
1220	179.04	77.25	88.65	32.51	8.08	4.88	92.05	27.65	90.18	79.98	3077.00	4.03	0.25	0.51	101.54	1.13
1240	147.61	80.00	90.20	27.61	7.78	5.52	94.54	24.33	91.26	81.94	2164.00	3.08	0.27	0.47	76.77	0.85
1270	49.12	86.28	93.53	17.56	7.12	3.51	103.59	13.01	95.13	89.46	1550.00	1.84	0.28	0.38	67.55	0.75
1280	13.55	87.61	94.21	15.62	9.24	3.12	105.47	8.25	96.85	93.05	638.00	0.01	0.23	0.02	469.62	5.22
1310	170.98	85.42	93.09	18.85	7.57	3.77	102.36	13.99	94.78	88.76	2906.00	2.89	0.25	0.43	112.13	1.25
1320	59.21	85.21	92.99	19.16	6.85	3.83	102.07	15.25	94.34	87.86	1289.00	2.57	0.32	0.52	41.44	0.46
1510	190.01	83.35	92.01	22.06	7.11	4.41	99.40	18.43	93.24	85.70	3593.00	3.06	0.33	0.58	104.07	1.16
1520	204.95	83.78	92.24	21.38	7.46	4.28	100.02	17.14	93.68	86.56	3401.00	3.17	0.28	0.50	112.49	1.25
1930	11.34	81.80	91.18	24.57	6.29	4.91	97.17	22.63	91.82	82.99	349.00	2.36	0.37	0.57	10.16	0.11
3110	265.18	59.24	76.98	75.98	10.00	7.60	69.08	70.47	78.28	61.05	3823.00	0.54	0.19	0.14	453.20	5.04
3120	276.19	64.63	80.78	60.44	9.58	9.07	73.92	59.37	81.05	65.04	4792.00	1.42	0.19	0.22	357.36	3.97
3210	263.35	72.21	85.66	42.51	7.98	6.38	84.91	39.75	86.47	73.53	3713.00	0.38	0.24	0.15	419.08	4.66
3220	51.73	54.24	73.17	93.15	8.36	9.32	62.01	95.69	72.64	53.58	1239.00	0.55	0.20	0.15	138.81	1.54
3230	75.80	60.99	78.24	70.64	8.64	7.06	71.53	67.16	79.09	62.18	1737.00	1.21	0.18	0.19	149.55	1.66
3240	108.32	65.99	81.69	56.91	8.68	8.54	75.92	56.64	81.77	66.10	2621.00	0.79	0.19	0.17	264.73	2.94
3250	25.00	63.45	79.97	63.62	9.74	6.36	74.95	56.68	81.76	66.08	988.00	2.01	0.09	0.13	124.89	1.39
3260	80.20	69.36	83.89	48.78	9.86	7.32	80.82	44.17	85.19	71.43	2525.00	0.89	0.09	0.08	504.96	5.61
3270	136.88	66.07	81.74	56.73	9.51	8.51	76.03	54.74	82.27	66.86	3340.00	2.11	0.11	0.16	340.35	3.78
3310	114.25	78.49	89.36	30.26	8.55	4.54	93.79	24.36	91.25	81.93	2965.00	2.89	0.20	0.34	146.91	1.63
3410	293.62	72.63	85.92	41.61	7.54	6.24	85.52	39.41	86.57	73.70	4753.00	1.43	0.27	0.32	247.57	2.75
3420	141.75	69.39	83.91	48.71	7.57	7.31	80.87	48.23	84.04	69.60	2966.00	1.52	0.24	0.29	168.12	1.87
3430	158.61	78.05	89.11	31.05	7.49	4.66	93.17	26.81	90.45	80.46	4074.00	1.82	0.25	0.34	199.99	2.22
3440	78.57	78.70	89.47	29.90	7.18	4.48	94.07	25.91	90.75	81.00	1814.00	2.37	0.26	0.41	74.13	0.82
3450	93.65	85.03	92.89	19.45	6.93	3.89	101.80	15.50	94.25	87.69	2073.00	0.34	0.28	0.16	209.53	2.33
3510	123.18	68.44	83.30	50.92	9.20	7.64	79.49	47.99	84.11	69.71	2644.00	2.08	0.14	0.19	226.29	2.51
3520	63.27	75.86	87.84	35.15	7.93	5.27	90.09	30.97	89.13	78.10	1914.00	2.66	0.24	0.38	83.16	0.92
3530	52.53	78.09	89.13	30.98	7.16	4.65	93.22	27.21	90.32	80.23	1068.00	3.34	0.28	0.51	34.73	0.39
3540	134.61	79.57	89.96	28.36	7.47	4.25	95.28	23.70	91.46	82.33	1763.00	1.35	0.25	0.29	100.05	1.11
3550	45.50	73.72	86.58	39.36	8.17	5.90	87.07	35.63	87.70	75.61	1568.00	2.50	0.20	0.32	82.38	0.92

3610	71.16	78.66	**89.45**	**29.97**	7.89	**4.50**	**94.01**	**24.97**	**91.05**	**81.56**	1725.00	2.47	0.22	**0.34**	**84.33**	**0.94**
3620	278.60	70.71	**84.74**	**45.74**	8.53	**6.86**	**82.77**	**42.79**	**85.58**	**72.07**	4091.00	2.21	0.18	**0.26**	**257.44**	**2.86**
3630	106.15	88.92	**94.86**	**13.77**	7.25	**2.75**	**107.30**	**8.42**	**96.79**	**92.91**	1371.00	0.98	0.26	**0.26**	**87.58**	**0.97**
3640	91.61	83.13	**91.89**	**22.41**	7.57	**4.48**	**99.09**	**18.24**	**93.30**	**85.82**	1848.00	2.62	0.25	**0.40**	**76.72**	**0.85**
3650	86.68	80.59	**90.52**	**26.61**	7.85	**5.32**	**95.40**	**22.99**	**91.70**	**82.77**	2482.00	2.95	0.22	**0.39**	**107.37**	**1.19**
3660	41.63	76.60	**88.27**	**33.75**	8.22	**5.06**	**91.13**	**28.88**	**89.79**	**79.27**	1383.00	3.36	0.21	**0.38**	**60.36**	**0.67**
3670	83.94	78.44	**89.32**	**30.36**	8.07	**4.55**	**93.71**	**25.16**	**90.99**	**81.44**	3164.00	2.69	0.22	**0.36**	**148.49**	**1.65**
3680	12.75	86.96	**93.88**	**16.56**	8.65	**3.31**	**104.55**	**10.02**	**96.21**	**91.68**	490.00	5.51	0.23	**0.54**	**14.99**	**0.17**
3710	190.40	84.22	**92.47**	**20.70**	8.71	**4.14**	**100.65**	**14.74**	**94.52**	**88.23**	2386.00	3.08	0.23	**0.40**	**98.42**	**1.09**
3810	82.18	79.40	**89.86**	**28.65**	8.65	**4.30**	**95.05**	**22.38**	**91.90**	**83.15**	1832.00	5.38	0.22	**0.51**	**59.48**	**0.66**
3820	171.80	64.25	**80.52**	**61.44**	11.33	**9.22**	**73.36**	**57.09**	**81.65**	**65.92**	3364.00	2.73	0.09	**0.14**	**387.78**	**4.31**
3830	157.82	77.58	**88.84**	**31.92**	8.39	**4.79**	**92.50**	**26.51**	**90.55**	**80.64**	2386.00	4.33	0.26	**0.53**	**74.69**	**0.83**
3840	53.32	79.76	**90.06**	**28.02**	7.38	**5.60**	**94.20**	**25.43**	**90.90**	**81.28**	1977.00	1.71	0.27	**0.35**	**93.14**	**1.03**
3850	37.31	87.34	**94.07**	**16.01**	7.19	**3.20**	**105.08**	**11.11**	**95.81**	**90.86**	1380.00	1.10	0.27	**0.29**	**80.27**	**0.89**
3860	61.36	86.45	**93.62**	**17.31**	7.42	**3.46**	**103.83**	**12.35**	**95.36**	**89.94**	1941.00	1.07	0.26	**0.27**	**120.12**	**1.33**

STANDHYD Input Parameters Calibrated, Future Land-use

100-year Precipitation 122.4 mm

			CN Conversion								Other				
Catchment	**Area (ha)**	**CNii**	**Cniii**	**S (mm)**	**IA (mm)**	**IA* (mm)**	**Q**	**S***	**CNiii***	**Cnii***	**XIMP**	**TIMP**	**Perv Type**	**Perv L (m)**	**n Perv**
620	35.21	53.47	72.55	96.09	5.00	9.61	60.90	108.91	69.99	50.35	0.22	0.24	Commercial	20.00	0.25
1250	59.85	83.82	92.26	21.32	5.00	4.26	100.07	20.33	92.59	84.45	0.49	0.50	Commercial	20.00	0.25
1260	94.48	83.85	92.27	21.27	5.00	4.25	100.12	20.26	92.61	84.50	0.42	0.42	Commercial	20.00	0.25
1290	15.28	83.16	91.91	22.36	5.00	4.47	99.14	21.63	92.15	83.62	0.71	0.75	Residential	40.00	0.25
1340	56.81	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.30	0.34	Residential	40.00	0.25
1360	33.14	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.57	0.58	Commercial	20.00	0.25
1530	81.43	85.06	92.90	19.40	5.00	3.88	101.84	17.93	93.41	86.03	0.65	0.66	Commercial	20.00	0.25
1540	7.10	86.16	93.47	17.74	5.00	3.55	103.41	15.88	94.12	87.43	0.44	0.45	Commercial	20.00	0.25
1610	75.34	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.82	0.82	Commercial	20.00	0.25
1620	50.51	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.65	0.66	Commercial	20.00	0.25
1810	47.83	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.76	0.77	Commercial	20.00	0.25
1820	101.19	82.97	91.81	22.67	5.00	4.53	98.86	22.02	92.02	83.37	0.63	0.64	Commercial	20.00	0.25
1840	26.45	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.22	0.24	Commercial	20.00	0.25
1910	56.44	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.33	0.34	Commercial	20.00	0.25
1920	32.15	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.42	0.43	Commercial	20.00	0.25
2020	108.22	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.74	0.74	Commercial	20.00	0.25
2030	13.49	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.69	0.71	Commercial	20.00	0.25
2110	20.24	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.53	0.55	Commercial	20.00	0.25
2120	5.54	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.65	0.66	Commercial	20.00	0.25
2130	10.24	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.77	0.77	Commercial	20.00	0.25
2140	12.83	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.99	0.99	Commercial	20.00	0.25
2220	98.14	83.74	92.22	21.44	5.00	4.29	99.97	20.47	92.54	84.36	0.77	0.77	Commercial	20.00	0.25
2230	32.60	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.71	0.72	Commercial	20.00	0.25
2240	2.83	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.52	0.53	Commercial	20.00	0.25
2250	11.57	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.73	0.73	Commercial	20.00	0.25
2260	3.35	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.77	0.77	Commercial	20.00	0.25
2310	44.35	84.20	92.45	20.73	5.00	4.15	100.62	19.58	92.84	84.94	0.79	0.81	Commercial	20.00	0.25
2320	22.69	84.67	92.70	19.99	5.00	4.00	101.29	18.67	93.15	85.54	0.43	0.57	Residential	40.00	0.25
2330	45.58	84.27	92.49	20.62	5.00	4.12	100.72	19.44	92.89	85.03	0.50	0.68	Residential	40.00	0.25
2340	21.27	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.60	0.71	Residential	40.00	0.25
2350	59.44	82.97	91.81	22.67	5.00	4.53	98.86	22.02	92.02	83.38	0.55	0.69	Residential	40.00	0.25
2360	15.48	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.56	0.74	Residential	40.00	0.25
2370	48.17	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.67	0.70	Commercial	20.00	0.25
2410	32.64	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.57	0.59	Commercial	20.00	0.25
2420	23.76	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.50	0.53	Commercial	20.00	0.25
2430	3.51	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.50	0.52	Commercial	20.00	0.25
2510	71.40	83.01	91.83	22.60	5.00	4.52	98.92	21.93	92.05	83.43	0.52	0.54	Commercial	20.00	0.25

2520	11.79	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.58	0.58	Commercial	20.00	0.25
2530	15.76	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.53	0.54	Commercial	20.00	0.25
2610	3.69	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.54	0.56	Commercial	20.00	0.25
2620	16.82	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.52	0.64	Residential	40.00	0.25
2710	6.77	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.40	0.51	Residential	40.00	0.25
2720	16.65	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.48	0.62	Residential	40.00	0.25
2730	13.64	82.96	91.80	22.69	5.00	4.54	98.84	22.05	92.01	83.36	0.49	0.58	Residential	40.00	0.25
2740	7.58	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.49	0.54	Commercial	20.00	0.25
2810	5.63	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.71	0.79	Residential	40.00	0.25
2820	39.59	81.58	91.06	24.94	5.00	4.99	96.84	24.92	91.06	81.59	0.46	0.58	Residential	40.00	0.25
2830	33.74	79.02	89.65	29.33	5.00	4.40	94.51	28.43	89.93	79.53	0.37	0.47	Residential	40.00	0.25
2840	162.55	82.96	91.80	22.69	5.00	4.54	98.83	22.05	92.01	83.35	0.58	0.72	Residential	40.00	0.25
2850	35.64	83.58	92.13	21.69	5.00	4.34	99.74	20.79	92.43	84.16	0.61	0.72	Residential	40.00	0.25
2860	4.45	85.19	92.97	19.20	5.00	3.84	102.03	17.68	93.49	86.20	0.30	0.30	Commercial	20.00	0.25
2910	20.06	85.01	92.88	19.47	5.00	3.89	101.78	18.01	93.38	85.98	0.82	0.84	Commercial	20.00	0.25
2920	89.16	85.58	93.18	18.60	5.00	3.72	102.60	16.94	93.75	86.70	0.49	0.62	Residential	40.00	0.25
2930	110.41	83.58	92.13	21.69	5.00	4.34	99.74	20.79	92.43	84.16	0.56	0.63	REsidential	40.00	0.25
2940	36.64	84.81	92.77	19.78	5.00	3.96	101.49	18.40	93.25	85.72	0.52	0.65	REsidential	40.00	0.25
2950	64.35	83.02	91.83	22.59	5.00	4.52	98.92	21.93	92.05	83.43	0.51	0.62	REsidential	40.00	0.25
2960	15.95	85.30	93.03	19.04	5.00	3.81	102.19	17.48	93.56	86.34	0.35	0.36	Commercial	20.00	0.25
3010	39.60	84.61	92.67	20.09	5.00	4.02	101.20	18.79	93.11	85.46	0.26	0.32	Commercial	20.00	0.25
3020	27.45	86.28	93.53	17.56	5.00	3.51	103.59	15.65	94.19	87.58	0.19	0.24	Residential	40.00	0.25
3030	47.69	82.99	91.82	22.64	5.00	4.53	98.88	21.99	92.03	83.40	0.41	0.49	Residential	40.00	0.25
1230	151.67	74.11	86.81	38.58	5.00	5.79	87.63	39.89	86.43	73.46	0.20	0.26	Commercial	20.00	0.25
1330	38.22	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.50	0.67	Commercial	20.00	0.25
1350	14.30	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.51	0.71	Residential	40.00	0.25
2210	67.60	82.95	91.80	22.70	5.00	4.54	98.83	22.06	92.01	83.35	0.82	0.82	Commercial	20.00	0.25
3050	107.73	84.49	92.61	20.28	5.00	4.06	101.03	19.02	93.03	85.31	0.36	0.50	Residential	40.00	0.25
3040	2.94	82.97	91.81	22.67	5.00	4.53	98.85	22.03	92.02	83.37	0.16	0.20	Residential	40.00	0.25

APPENDIX F: HYDORLOGIC MODELLING RESULTS

Future Condition - 100-year Results and Sensitivity Analysis

									NASHYD								STANDHYD								RouteChannel			
Reach	Location	HEC-RAS Section	VO Node	Areal Reduction Factor	Contributing Area (ha)	Regional (base)	Max Sens Q	Max Delta (%)	CN+10%	CN-10%	Tp+20%	Tp-20%	IA+50%	IA-50%	N+20%	N-20%	IMP+20%	IMP-20%	SLP+20%	SLP-20%	PLen+50%	PLen-50%	CN+10%	CN-10%	RCLen+20%	RCLen-20%	RC n+20%	RC n-20%
E1	Ontario Street	1463	292	100yr-100	130	33.97	36.75	8%	33.97	33.97	33.97	33.97	33.97	33.97	33.97	33.97	36.75	30.87	34.58	32.81	31.19	34.60	36.18	32.07	33.55	34.47	34.47	34.49
E1	Laurier Avenue	878	293	100yr-100	256	64.27	70.17	9%	64.27	64.27	64.27	64.27	64.27	64.27	64.27	64.27	70.17	58.90	62.42	62.41	61.15	66.41	68.91	60.10	63.00	65.63	65.63	65.71
E1	Derry Road	592	295	100yr-100	337	78.33	84.86	8%	78.33	78.33	78.33	78.33	78.33	78.33	78.33	78.33	84.53	72.61	77.86	76.47	74.94	80.84	84.86	72.34	75.07	80.75	80.75	80.31
IND1	North of 5 Side Road (at Spill Crest)	3299	1910	100yr-100	56	12.01	14.63	22%	12.01	12.01	12.01	12.01	12.01	12.01	12.01	12.01	13.17	11.55	12.26	11.81	11.91	14.63	13.56	10.96	12.01	12.01	12.01	12.01
IND1	5 Side Road	2924	192	100yr-100	89	11.06	12.38	12%	11.06	11.06	11.06	11.06	11.06	11.06	11.06	11.06	12.01	9.26	11.28	9.72	9.79	11.59	12.38	10.08	10.80	11.43	11.43	11.35
IND1	Highway 401	443	193	100yr-100	100	11.27	12.61	12%	11.75	10.90	11.26	11.28	11.23	11.31	11.42	11.09	11.96	10.37	11.38	10.85	10.79	11.78	12.61	10.28	10.60	12.21	12.21	12.17
IND12	Railway Crossing	309	223	100yr-100	264	21.21	23.16	9%	21.79	20.74	21.00	21.40	21.15	21.27	21.49	20.79	22.86	18.74	21.46	20.23	20.28	21.77	23.16	19.82	19.84	22.77	22.77	22.54
IND5	Highway 401	730	203	100yr-100	122	7.00	10.06	44%	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	8.15	5.92	7.06	6.92	6.90	7.11	10.06	5.08	6.69	7.30	7.30	7.27
IND9	Harrop Drive	527	213	100yr-100	39	5.53	6.16	11%	5.53	5.53	5.53	5.53	5.53	5.53	5.53	5.53	6.16	4.89	5.60	5.44	5.49	5.59	5.85	5.32	5.37	5.75	5.75	5.70
M1	At Confluence (south of Steeles)	1313	272	100yr-98.5	1816	131.78	146.51	11%	134.26	130.53	131.23	132.47	131.30	132.24	132.09	131.18	139.48	122.96	133.30	127.97	130.25	135.30	141.18	124.49	122.20	143.65	143.65	146.51
M1	Highside Drive	958	273	100yr-98.5	1832	135.90	150.64	11%	138.40	134.61	135.31	136.63	135.40	136.37	136.25	135.25	143.59	125.91	137.75	130.61	133.45	139.37	145.12	127.90	125.57	147.68	147.68	150.64
M1	Woodward Avenue	593	274	100yr-98.5	1942	147.21	162.75	11%	149.68	145.95	146.62	147.95	146.73	147.68	147.58	146.54	155.00	137.28	149.54	141.87	144.55	150.58	156.39	138.88	136.74	159.53	159.53	162.75
M1	Railway Crossing	304	275	100yr-98.5	1949	147.99	164.20	11%	150.51	146.71	147.38	148.77	147.49	148.47	148.40	147.30	156.35	139.07	151.07	143.34	146.19	151.59	157.57	139.44	138.70	161.27	161.27	164.20
M2	Main Street	2438	282	100yr-93.25	10979	220.30	241.75	10%	224.47	218.30	219.25	221.78	219.38	221.35	220.81	219.33	233.78	203.97	223.45	213.96	215.09	225.70	235.17	206.62	203.88	238.30	238.30	241.75
M2	Pine Street	2180	283	100yr-93	11019	221.57	242.79	10%	226.13	219.31	220.40	223.21	220.50	222.79	222.03	220.57	234.20	207.09	224.86	216.27	216.23	226.20	238.76	206.57	205.95	238.89	238.89	242.79
M2	Parkway Drive	1282	284	100yr-92.75	11215	231.74	260.79	13%	235.93	229.83	230.77	233.12	230.79	232.85	232.18	230.88	247.18	217.72	235.42	227.09	227.26	236.78	250.74	217.40	213.30	257.30	257.30	260.79
M2	Laurier Avenue	606	285	100yr-92.75	11251	226.74	254.26	12%	232.75	224.56	225.64	228.36	225.66	228.00	227.18	225.83	240.37	211.67	229.55	222.10	222.30	230.44	246.69	211.46	206.49	251.14	251.14	254.26
M2	Derry Road	315	286	100yr-91	11255	217.19	245.31	13%	221.62	214.85	216.01	218.92	216.08	218.45	217.59	216.29	230.15	203.75	218.66	212.16	212.68	220.11	235.86	202.83	198.05	242.54	242.54	245.31
M3	West of Ontario Street (25)	9241	302	100yr-91	11631	229.99	261.63	14%	234.38	227.88	228.91	231.57	228.93	231.24	230.37	229.18	244.41	216.60	230.44	227.25	227.18	232.45	250.30	212.91	205.89	261.63	261.63	260.47
M3	Ontario Street (25)	8242	303	100yr-91	11709	233.97	265.77	14%	238.16	231.87	232.64	235.73	232.89	235.22	234.33	233.12	247.74	219.66	234.13	231.00	230.90	235.53	253.84	216.41	208.97	265.77	265.77	264.63
M3	Louis St. Laurent Avenue	7809	304	100yr-91	11817	215.02	248.01	15%	219.33	212.45	213.53	216.81	213.88	216.30	215.41	214.06	226.33	202.24	214.12	213.77	213.59	215.22	233.82	198.06	189.56	248.01	248.01	245.88
N1	5 Side Road	387	1520	100yr-100	205	8.80	10.99	25%	10.99	7.03	7.65	10.43	8.59	9.00	10.31	6.78	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80
N2	5 Side Road	211	1510	100yr-100	190	8.44	10.54	25%	10.54	6.74	7.34	9.99	8.22	8.64	9.88	6.51	8.44	8.44	8.44	8.44	8.44	8.44	8.44	8.44	8.44	8.44	8.44	8.44
N3	South of 5 Side Road	2941	182	100yr-100	476	27.01	30.96	15%	28.85	26.16	26.43	27.98	26.69	27.31	26.95	26.92	30.96	24.18	29.39	26.96	26.88	29.12	28.23	26.07	26.86	27.19	27.19	27.18
N3	South of Pond Outlet	1719	183	100yr-100	483	21.07	23.47	11%	23.47	19.97	20.23	22.73	20.67	21.46	22.00	20.89	22.70	20.02	21.91	21.45	20.93	21.89	22.61	19.90	19.61	22.63	22.63	22.25
N3	Ontario Street (25)	1355	184	100yr-100	633	42.31	46.18	9%	43.91	41.49	41.83	42.94	41.89	42.68	42.39	42.07	46.18	38.46	39.70	39.41	41.96	44.29	45.09	40.09	40.08	45.28	45.28	44.29
N3	Highway 401	698	185	100yr-100	659	41.01	44.76	9%	42.85	40.12	40.42	41.95	40.61	41.37	41.03	40.79	43.65	38.57	40.48	39.96	41.11	41.86	44.23	38.42	37.97	44.76	44.76	44.40
N4	Railway Crossing	524	226	100yr-98.5	1128	66.61	71.90	8%	68.45	65.56	66.14	67.16	66.21	66.97	66.81	66.13	70.68	61.84	66.89	64.22	65.72	68.69	71.90	62.75	62.51	71.63	71.63	71.74
N4	Steeles Avenue	172	227	100yr-98.5	1131	67.29	72.61	8%	69.11	66.25	66.82	67.84	66.90	67.65	67.51	66.79	71.37	62.49	67.71	64.75	66.24	69.42	72.61	63.33	63.16	72.31	72.31	72.55
NW1	Termaine Road	3095	132	100yr-100	230	11.50	14.43	25%	14.43	9.16	10.09	13.49	11.27	11.71	12.82	9.42	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.42	11.58	11.58	11.67
NW1	Highway 401	2459	133	100yr-100	325	25.79	28.09	9%	27.06	25.20	25.45	26.30	25.64	25.93	25.86	25.59	28.01	23.54	26.29	25.17	25.29	26.49	28.09	23.89	25.63	25.99	25.99	26.03
NW1	3 Side Road	1942	134	100yr-100	340	24.11	26.59	10%	25.66	23.36	23.61	24.90	23.93	24.26	24.22	23.82	25.37	23.00	24.31	23.84	23.81	24.75	26.59	21.95	22.92	25.36	25.36	25.31
NW1	Peru Road	1339	135	100yr-100	373	22.32	24.99	12%	23.82	21.63	21.91	23.04	22.13	22.49	22.43	22.05	23.45	21.39	22.43	22.17	21.96	22.73	24.64	20.35	20.18	24.99	24.99	24.65
NW2	Pond Outlet	676	239	100yr-100	126	33.20	36.78	11%	33.20	33.20	33.20	33.20	33.20	33.20	33.20	33.20	36.78	29.67	33.95	30.82	32.46	33.45	34.76	32.08	31.84	35.00	35.00	34.52
NW3	Downstream of Highway 401	1127	242	100yr-100	531	42.70	48.93	15%	43.89	42.22	42.50	42.97	42.49	42.89	42.79	42.52	45.86	39.32	43.09	42.02	42.02	43.13	45.95	40.17	37.70	48.93	48.93	47.58
NW3	Martin Street	490	243	100yr-100	555	45.67	52.24	14%	46.83	45.22	45.48	45.93	45.46	45.86	45.76	45.50	48.89	42.09	46.08	44.66	44.90	46.12	49.20	42.86	40.41	52.24	52.24	50.93
NW3	Railway Crossing	96	244	100yr-100	558	45.31	51.51	14%	46.50	44.84	45.10	45.73	45.11	45.50	45.40	45.13	48.20	42.08	45.59	44.49	44.93	45.68	48.82	42.46	40.26	51.51	51.51	50.37
NW4	At confluence (north of Steeles Avenue)	397	262	100yr-100	661	63.61	71.19	12%	64.70	63.18	63.43	63.90	63.41	63.79	63.69	63.44	67.82	59.04	64.14	61.95	62.85	64.92	68.67	59.50	57.33	71.19	71.19	70.33
NW4	At Steeles Avenue	207	263	100yr-98.5	678	64.45	72.16	12%	65.52	64.05	64.29	64.68	64.26	64.63	64.53	64.30	68.62	59.80	64.97	63.06	63.80	65.76	69.54	60.41	58.41	72.16	72.16	72.05
NW6	Market Drive	1890	252	100yr-100	83	18.77	20.58	10%	18.77	18.77	18.77	18.77	18.77	18.77	18.77	18.77	20.38	17.10	19.04	18.53	18.54	20.58	20.43	17.50	17.87	19.66	19.66	19.57
NW6	Railway Crossing	1400	253	100yr-100	99	19.96	21.89	10%	19.96	19.96	19.96	19.96	19.96	19.96	19.96	19.96	21.39	18.40	20.16	18.98	19.74	21.27	21.89	18.44	18.44	21.29	21.29	21.11
W1	Kelso	6800	122	100yr-94	8134	64.01	75.41	18%	75.41	53.71	57.64	72.15	59.97	67.97	70.37	54.46	64.01	64.00	64.01	64.01	64.01	64.01	64.02	64.00	61.30	66.97	66.97	66.54
W1	Kelso Road	5721	123	100yr-94	8314	65.13	76.80	18%	76.80	54.60	58.91	73.16	61.06	69.16	71.27	55.97	65.13	65.12	65.13	65.13	65.13	65.13	65.14	65.12	62.16	68.51	68.51	68.03
W1	Upstream of Peru Road	3832	124	100yr-93.6	8613	66.25	78.02	18%	78.02	55.66	60.06	74.29	62.17	70.36	72.30	57.40	66.27	66.24	66.25	66.25	66.26	66.25	66.32	66.18	63.11	69.92	69.92	69.39
W1	Downstream of Peru Road	3124	126	100yr-93.6	8673	66.53	78.30	18%	78.30	55.92	60.33	74.57	62.46	70.63	72.57	57.68	66.55	66.51	66.53	66.53	66.53	66.52	66.60	66.43	63.34	70.24	70.24	69.70
W1	Steeles Avenue	1849	127	100yr-93.25	8816	66.81	78.57	18%	78.57	56.22	60.67	74.82	62.75	70.95	72.78	58.10	66.83	66.78	66.81	66.81	66.81	66.80	66.90	66.69	63.55	70.64	70.64	70.09
W1	Upstream of Mill Pond	675	129	100yr-93.25	8845	67.08	78.87	18%	78.87	56.44	60.91	75.12	63.02	71.22	73.08	58.32	67.10	67.05	67.07	67.08	67.07	67.07	67.17	66.95	63.80	70.92	70.92	70.37

Future Condition - Regional Results and Sensitivity Analysis

Reach	Location	HEC-RAS Section	VO Node	Areal Reduction Factor	Contributing Area (ha)	Regional (base)	Max Sens Q	Max Delta (%)	NASHYD CN+10%	CN-10%	Tp+20%	Tp-20%	IA+50%	IA-50%	N+20%	N-20%	STANDHYD IMP+20%	IMP-20%	SLP+20%	SLP-20%	PLen+50%	PLen-50%	CN+10%	CN-10%	RouteChannel RCLen+20%	RCLen-20%	RC n+20%	RC n-20%
E1	Ontario Street	1463	292	HH-100	130	18.31	18.55	1%	18.31	18.31	18.31	18.31	18.31	18.31	18.31	18.31	18.51	18.09	18.43	18.18	18.17	18.55	18.35	18.31	18.25	18.35	18.40	18.34
E1	Laurier Avenue	878	293	HH-100	256	35.95	36.49	2%	35.95	35.95	35.95	35.95	35.95	35.95	35.95	35.95	36.40	35.54	36.25	35.67	35.64	36.49	36.03	35.95	35.84	36.03	36.10	36.04
E1	Derry Road	592	295	HH-100	337	46.88	47.63	2%	46.88	46.88	46.88	46.88	46.88	46.88	46.88	46.88	47.52	46.47	47.31	46.65	46.47	47.63	47.12	46.88	46.69	47.12	47.11	47.05
IND1	North of 5 Side Road (at Spill Crest)	3299	191	HH-100	537	29.47	29.49	0%	29.47	29.47	29.47	29.47	29.47	29.47	29.47	29.47	29.46	29.48	29.45	29.49	29.49	29.42	29.47	29.47	29.47	29.47	29.47	29.47
IND1	5 Side Road	2924	192	HH-100	570	20.24	21.85	8%	20.24	20.24	20.24	20.24	20.24	20.24	20.24	20.24	20.22	20.25	20.22	20.26	20.26	20.17	21.81	20.24	18.91	21.81	20.24	21.85
IND1	Highway 401	443	193	HH-100	581	20.16	21.79	8%	20.16	20.16	20.16	20.16	20.16	20.16	20.16	20.16	20.15	20.17	20.14	20.18	20.18	20.10	21.76	20.16	18.81	21.76	20.17	21.79
IND12	Railway Crossing	309	223	HH-100	743	32.88	33.87	3%	32.90	32.80	32.91	32.82	32.88	32.88	32.89	32.88	33.04	32.68	33.06	32.48	32.44	33.19	33.59	32.88	32.21	33.59	33.22	33.87
IND5	Highway 401	730	203	HH-100	122	16.34	16.77	3%	16.34	16.34	16.34	16.34	16.34	16.34	16.34	16.34	16.41	16.28	16.46	16.12	16.11	16.44	16.53	16.34	16.17	16.53	16.51	16.77
IND9	Harrop Drive	527	213	HH-100	37	5.49	5.53	1%	5.49	5.49	5.49	5.49	5.49	5.49	5.49	5.49	5.53	5.44	5.50	5.47	5.44	5.51	5.51	5.49	5.45	5.51	5.53	5.51
M1	At Confluence (south of Steeles)	1313	272	HH-99.2	2219	162.50	168.61	4%	163.77	158.89	160.20	166.07	162.40	162.59	163.42	159.94	163.17	161.74	162.57	161.75	161.57	163.13	167.31	162.50	158.22	167.31	163.52	168.61
M1	Highside Drive	958	273	HH-99.2	2236	164.54	170.75	4%	165.75	160.99	162.28	168.01	164.44	164.63	165.38	162.01	165.16	163.73	164.59	163.73	163.51	165.14	169.35	164.54	160.19	169.35	165.57	170.75
M1	Woodward Avenue	593	274	HH-99.2	2354	175.63	181.92	4%	176.82	172.12	173.27	179.12	175.53	175.72	176.44	173.11	176.10	174.82	175.62	174.84	174.57	176.10	180.48	175.63	171.28	180.48	176.68	181.92
M1	Railway Crossing	304	275	HH-99.2	2362	176.47	182.79	4%	177.63	173.02	174.24	180.01	176.37	176.56	177.23	174.00	177.06	175.73	176.53	175.75	175.49	177.04	181.33	176.47	172.14	181.33	177.53	182.79
M2	Main Street	2438	282	HH-93.5	11460	387.03	430.11	11%	417.38	355.05	356.32	430.11	379.47	394.64	407.10	354.93	386.22	388.42	385.94	388.57	387.85	386.33	418.73	387.03	359.72	418.73	389.23	409.20
M2	Pine Street	2180	283	HH-92.7	11500	385.01	426.99	11%	415.08	353.51	354.57	426.99	377.63	392.50	404.15	353.41	384.15	385.90	383.80	386.25	385.73	384.30	416.55	385.01	358.11	416.55	387.12	407.13
M2	Parkway Drive	1282	284	HH-92	11696	395.12	436.76	11%	424.48	364.96	366.37	436.76	387.94	402.44	413.49	365.46	394.71	395.98	394.44	396.60	396.26	394.61	427.55	395.12	368.47	427.55	397.38	419.11
M2	Laurier Avenue	606	285	HH-92	11732	396.35	436.99	10%	427.70	368.17	369.47	436.99	390.16	404.19	416.08	369.18	398.72	399.10	395.21	399.93	399.29	395.27	428.39	396.35	371.41	428.39	399.89	420.46
M2	Derry Road	315	286	HH-89.4	11736	383.14	421.63	10%	410.06	354.20	356.58	421.63	376.93	390.13	399.02	355.89	381.61	382.09	380.24	382.55	382.27	382.54	411.40	383.14	356.91	411.40	385.48	405.94
M3	West of Ontario Street (25)	9241	302	HH-89.4	12112	411.41	447.69	9%	438.06	383.47	386.21	447.69	405.28	417.03	426.42	386.54	410.24	411.57	408.61	412.01	411.73	410.67	439.24	411.41	384.85	439.24	412.93	436.12
M3	Ontario Street (25)	8242	303	HH-89.4	12190	416.66	453.25	9%	443.27	388.93	392.55	453.25	410.80	422.62	431.88	393.03	415.35	416.92	415.17	417.39	417.15	415.91	444.84	416.66	390.23	444.84	418.49	442.07
M3	Louis St. Laurent Avenue	7809	304	HH-89.4	12298	420.44	454.89	8%	446.67	393.84	397.97	454.89	414.25	426.87	434.92	398.09	420.06	420.95	419.56	421.33	421.16	420.01	451.59	420.44	391.91	451.59	423.19	447.32
N1	5 Side Road	387	1520	HH-100	205	17.25	18.94	10%	17.52	16.14	15.87	18.94	17.23	17.26	18.77	14.81	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25	17.25
N2	5 Side Road	211	1510	HH-100	190	16.48	18.03	9%	16.76	15.44	15.20	18.03	16.46	16.49	17.90	14.21	16.48	16.48	16.48	16.48	16.48	16.48	16.48	16.48	16.48	16.48	16.48	16.48
N3	South of 5 Side Road	2941	182	HH-100	476	41.07	44.91	9%	41.68	38.87	37.98	44.91	41.04	41.11	43.81	36.75	41.06	41.10	41.06	41.16	41.10	41.05	41.19	41.07	40.96	41.19	41.10	41.21
N3	South of Pond Outlet	1719	183	HH-100	483	40.95	44.70	9%	41.53	38.70	37.85	44.70	40.91	40.98	43.46	36.71	40.89	41.01	40.92	41.07	40.98	40.90	41.25	40.95	40.60	41.25	40.97	41.01
N3	Ontario Street (25)	1355	184	HH-100	633	55.74	59.44	7%	56.34	53.58	52.79	59.44	55.70	55.78	57.92	51.88	55.71	55.81	55.69	55.85	55.82	55.68	56.26	55.74	55.20	56.26	55.83	55.74
N3	Highway 401	698	185	HH-100	659	57.90	61.56	6%	58.52	55.66	54.91	61.56	57.86	57.94	60.01	54.12	57.85	58.00	57.83	58.07	58.03	57.82	58.55	57.90	57.23	58.55	58.02	58.01
N4	Railway Crossing	524	226	HH-99.2	1531	94.14	97.56	4%	94.98	92.08	92.73	96.52	94.08	94.20	94.52	92.67	94.46	93.71	94.20	93.54	93.54	94.58	96.24	94.14	92.28	96.24	94.71	97.56
N4	Steeles Avenue	172	227	HH-99.2	1534	94.51	97.95	4%	95.35	92.49	93.14	96.91	94.45	94.57	94.88	93.08	94.84	94.08	94.60	93.92	93.91	94.97	96.63	94.51	92.65	96.63	95.08	97.95
NW1	Termaine Road	3095	132	HH-100	230	20.44	22.00	8%	20.65	19.25	19.08	22.00	20.43	20.45	21.64	18.26	20.44	20.44	20.44	20.44	20.44	20.44	20.50	20.44	20.37	20.50	20.44	20.53
NW1	Highway 401	2459	133	HH-100	325	29.93	31.65	6%	30.16	28.68	28.45	31.65	29.91	29.94	31.10	27.74	29.93	29.92	29.91	29.97	29.99	29.89	30.14	29.93	29.70	30.14	30.00	30.13
NW1	3 Side Road	1942	134	HH-100	340	31.17	32.94	6%	31.40	29.89	29.64	32.94	31.15	31.18	32.31	28.98	31.16	31.16	31.14	31.24	31.25	31.11	31.45	31.17	30.85	31.45	31.25	31.41
NW1	Peru Road	1339	135	HH-100	373	34.15	35.97	5%	34.40	32.82	32.60	35.97	34.13	34.16	35.23	32.04	34.13	34.16	34.12	34.25	34.25	34.08	34.60	34.15	33.62	34.60	34.26	34.52
NW2	Pond Outlet	676	239	HH-100	126	18.15	18.27	1%	18.15	18.15	18.15	18.15	18.15	18.15	18.15	18.15	18.27	17.89	18.19	18.04	18.05	18.18	18.20	18.15	18.07	18.20	18.23	18.19
NW3	Downstream of Highway 401	1127	242	HH-100	531	50.50	52.31	4%	50.72	49.14	49.08	52.31	50.48	50.52	51.45	48.83	50.45	50.52	50.41	50.66	50.63	50.44	52.00	50.50	49.59	52.00	50.65	51.66
NW3	Martin Street	490	243	HH-100	555	52.99	54.83	3%	53.22	51.63	51.87	54.83	52.97	53.01	53.83	51.66	52.95	53.02	52.91	53.04	53.00	52.99	54.73	52.99	51.95	54.73	53.16	54.53
NW3	Railway Crossing	96	244	HH-100	558	53.35	55.02	3%	53.59	51.98	52.14	54.96	53.33	53.37	54.25	51.93	53.32	53.39	53.32	53.44	53.40	53.33	55.02	53.35	52.39	55.02	53.54	54.90
NW4	At confluence (north of Steeles Avenue)	397	262	HH-100	661	66.22	68.46	3%	66.53	64.83	65.36	67.06	66.19	66.24	66.48	65.14	66.56	65.88	66.33	65.74	65.61	66.46	68.46	66.22	64.01	68.46	66.64	68.41
NW4	At Steeles Avenue	207	263	HH-99.2	678	67.66	69.96	3%	67.97	66.22	66.85	68.52	67.51	67.68	67.95	66.64	67.90	67.16	67.72	67.21	67.07	67.85	69.96	67.66	65.45	69.96	68.08	69.96
NW6	Market Drive	1890	252	HH-100	83	11.75	11.88	1%	11.75	11.75	11.75	11.75	11.75	11.75	11.75	11.75	11.88	11.66	11.80	11.68	11.68	11.84	11.80	11.75	11.69	11.80	11.85	11.79
NW6	Railway Crossing	1400	253	HH-100	99	13.82	13.99	1%	13.82	13.82	13.82	13.82	13.82	13.82	13.82	13.82	13.99	13.70	13.89	13.74	13.72	13.94	13.95	13.82	13.64	13.95	13.95	13.93
W1	Kelso	6800	122	HH-94.8	8134	246.98	282.99	15%	276.35	217.87	220.07	282.99	241.95	252.01	268.26	211.69	246.98	246.98	246.98	246.99	247.00	246.96	261.96	246.98	233.97	261.96	246.99	259.61
W1	Kelso Road	5721	123	HH-94.8	8314	252.69	288.42	14%	282.97	221.99	225.24	288.42	247.34	257.98	272.16	217.75	252.69	252.70	252.68	252.71	252.71	252.64	270.01	252.69	237.26	270.01	252.73	266.10
W1	Upstream of Peru Road	3832	124	HH-94.2	8613	255.50	291.54	14%	286.66	223.16	227.29	291.54	249.61	261.31	274.06	221.05	255.49	255.52	255.42	255.58	255.59	255.33	275.25	255.50	237.78	275.25	255.61	269.51
W1	Downstream of Peru Road	3124	126	HH-94.2	8673	255.34	291.37	14%	286.48	223.09	227.23	291.37	249.46	261.11	273.79	220.89	255.32	255.36	255.25	255.42	255.44	255.17	275.09	255.34	237.67	275.09	255.44	269.46
W1	Steeles Avenue	1849	127	HH-93.5	8816	253.56	289.37	14%	284.73	221.23	225.73	289.37	247.62	259.44	271.66	219.87	253.53	253.64	253.43	253.67	253.69	253.35	274.07	253.56	235.56	274.07	253.73	268.20
W1	Upstream of Mill Pond	675	129	HH-93.5	8845	253.99	289.79	14%	285.18	221.62	226.10	289.79	248.05	259.86	272.17	220.19	253.96	254.07	253.87	254.10	254.12	253.77	274.40	253.99	236.00	274.40	254.15	268.63

APPENDIX G: FLOOD FREQUENCY ANALYSIS

Flood Frequency Analysis - All

qi =	$\frac{i - a}{N + 1 - 2a}$		Xbar	19.44	$\bar{x} = \sum_{i=1}^{n} \frac{x_i}{n}$
			sx	7.27	$s_x^2 = \frac{1}{(n-1)} \sum_{i=1}^{n} (x_i - \bar{x})^2$
			alpha	5.67	
N = Count =	54		u	16.17	$u = \bar{x} - 0.5772\alpha$
a = constant for estimation =	0.44	(Gringorten Method)			$\alpha = \frac{\sqrt{6} s_x}{\pi}$

Date	Peak Flow	Rank (i)	qi	Pi	T Estimated	xi/n	(xi-xbar)2	(X-u)/alpha	P Theoretical	T Theoretical
1970-04-02 15:56	7.87	54	0.989652624	0.010347376	1.010455564	0.145740741	133.8391901	-1.463897642	0.013263023	1.013441295
2015-07-07 15:35	8.95	53	0.971175166	0.028824834	1.029680365	0.165740741	110.0167901	-1.273353375	0.028076749	1.028887825
1964-03-14 17:45	9.15	52	0.952697709	0.047302291	1.049650892	0.169444444	105.8612346	-1.2380674	0.031779254	1.032822323
1966-12-10 13:00	9.63	51	0.934220251	0.065779749	1.070411392	0.178333333	96.21430123	-1.153381059	0.042050289	1.043896134
1963-03-21 16:00	10.4	50	0.915742794	0.084257206	1.092009685	0.192592593	81.70151235	-1.017530054	0.062890914	1.067111626
1981-08-30 16:25	10.8	49	0.897265336	0.102734664	1.114497529	0.2	74.63040123	-0.946958103	0.075936627	1.08217686
2012-09-08 6:50	11.6	48	0.878787879	0.121212121	1.137931034	0.214814815	61.44817901	-0.805814201	0.106616354	1.119339944
1961-02-26 2:00	11.7	47	0.860310421	0.139689579	1.162371134	0.216666667	59.89040123	-0.788171214	0.110872923	1.124698625
2002-06-27 10:36	12.3	46	0.841832964	0.158167036	1.187884109	0.227777778	50.96373457	-0.682313288	0.138283526	1.160474507
1959-04-03 6:00	12.6	45	0.823355506	0.176644494	1.21454219	0.233333333	46.77040123	-0.629384324	0.153132007	1.180821579
1983-04-10 5:55	13.1	44	0.804878049	0.195121951	1.242424242	0.242592593	40.18151235	-0.541169386	0.179421999	1.218653192
1988-03-25 20:08	13.3	43	0.786400591	0.213599409	1.271616541	0.246296296	37.68595679	-0.505883411	0.190433931	1.235229634
1979-04-14 3:05	13.8	42	0.767923134	0.232076866	1.302213667	0.255555556	31.7970679	-0.417668472	0.21905834	1.280505383
2003-03-17 17:55	14.1	41	0.749445676	0.250554324	1.334319527	0.261111111	28.50373457	-0.364739509	0.236894872	1.310435434
1994-02-20 16:34	15.2	40	0.730968219	0.269031781	1.368048534	0.281481481	17.96817901	-0.170666645	0.305411482	1.43970131
1998-03-09 14:00	15.5	39	0.712490761	0.287509239	1.403526971	0.287037037	15.51484568	-0.117737682	0.324669032	1.480755434
2014-09-10 19:30	15.6	38	0.694013304	0.305986696	1.440894569	0.288888889	14.7370679	-0.100094694	0.331119621	1.495035632
1971-03-15 20:30	15.7	37	0.675535846	0.324464154	1.480306346	0.290740741	13.97929012	-0.082451706	0.337582205	1.509621281
1969-04-18 13:30	16.4	36	0.657058389	0.342941611	1.521934758	0.303703704	9.234845679	0.041049208	0.382976404	1.620683563
1999-07-31 14:00	17.2	35	0.638580931	0.361419069	1.565972222	0.318518519	5.012623457	0.182193109	0.434551689	1.768508244
2004-06-13 23:30	17.3	34	0.620103474	0.379896526	1.612634088	0.32037037	4.574845679	0.199836097	0.440931847	1.78869069
2005-09-16 6:50	17.5	33	0.601626016	0.398373984	1.662162162	0.324074074	3.759290123	0.235122072	0.453629566	1.830260089
1980-04-14 18:58	17.8	32	0.583148559	0.416851441	1.714828897	0.32962963	2.68595679	0.288051035	0.472497261	1.895724754
1982-04-03 11:25	17.9	31	0.564671101	0.435328899	1.770942408	0.331481481	2.368179012	0.305694023	0.478733133	1.918403149
1972-04-13 11:08	18.1	30	0.546193644	0.453806356	1.830852503	0.335185185	1.792623457	0.340979998	0.491116882	1.965087786
2007-08-25 15:15	18.4	29	0.527716186	0.472283814	1.894957983	0.340740741	1.079290123	0.393908961	0.509454134	2.038545363
1989-06-22 6:04	18.9	28	0.509238729	0.490761271	1.96371553	0.35	0.290401235	0.4821239	0.539306862	2.170642273
1965-02-10 14:30	19.2	27	0.490761271	0.509238729	2.037650602	0.355555556	0.057067901	0.535052863	0.556750357	2.256064989
1962-11-10 9:45	19.3	26	0.472283814	0.527716186	2.117370892	0.357407407	0.019290123	0.55269585	0.562481781	2.285619105
1987-07-08 15:44	19.7	25	0.453806356	0.546193644	2.203583062	0.364814815	0.068179012	0.623267801	0.584973103	2.409482389
1991-03-27 16:12	19.7	24	0.435328899	0.564671101	2.297113752	0.364814815	0.068179012	0.623267801	0.584973103	2.409482389
2006-12-01 11:31	19.9	23	0.416851441	0.583148559	2.39893617	0.368518519	0.212623457	0.658553777	0.595949494	2.474938118
1984-04-05 7:30	20	22	0.398373984	0.601626016	2.510204082	0.37037037	0.314845679	0.676196764	0.601368466	2.508582271
1976-03-19 17:32	20.6	21	0.379896526	0.620103474	2.63229572	0.381481481	1.348179012	0.78205469	0.632885919	2.723948908
1975-02-24 20:43	20.8	20	0.361419069	0.638580931	2.766871166	0.385185185	1.852623457	0.817340666	0.643003914	2.801151156
1967-04-03 2:30	21.4	19	0.342941611	0.657058389	2.915948276	0.396296296	3.84595679	0.923198592	0.672168398	3.050346561
1968-02-02 13:00	21.4	18	0.324464154	0.675535846	3.082004556	0.396296296	3.84595679	0.923198592	0.672168398	3.050346561
1997-02-20 7:00	21.7	17	0.305986696	0.694013304	3.268115942	0.401851852	5.112623457	0.976127555	0.686075713	3.185481475
1996-05-21 3:15	21.8	16	0.287509239	0.712490761	3.4781491	0.403703704	5.574845679	0.993770543	0.690611195	3.232179007
1990-12-29 13:32	21.9	15	0.269031781	0.730968219	3.717032967	0.405555556	6.057067901	1.01141353	0.695096559	3.279726847
2010-03-14 1:00	23.1	14	0.250554324	0.749445676	3.991150442	0.427777778	13.40373457	1.223129382	0.745047188	3.922294453
2009-02-12 6:01	23.6	13	0.232076866	0.767923134	4.308917197	0.437037037	17.31484568	1.311344321	0.763793683	4.233587021
1973-03-14 13:32	24.2	12	0.213599409	0.786400591	4.6816609	0.448148148	22.66817901	1.417202247	0.784749108	4.645741492
1977-03-13 3:32	24.2	11	0.195121951	0.804878049	5.125	0.448148148	22.66817901	1.417202247	0.784749108	4.645741492
1993-01-04 12:47	24.2	10	0.176644494	0.823355506	5.661087866	0.448148148	22.66817901	1.417202247	0.784749108	4.645741492
1960-04-03 17:30	25	9	0.158167036	0.841832964	6.322429907	0.462962963	30.92595679	1.558346148	0.810192105	5.268484753
1992-04-16 20:57	25.9	8	0.139689579	0.860310421	7.158730159	0.47962963	41.74595679	1.717133038	0.835620881	6.083497745
2011-05-19 0:30	26.1	7	0.121212121	0.878787879	8.25	0.483333333	44.37040123	1.752419013	0.840839829	6.282978929
1986-09-29 11:43	27.9	6	0.102734664	0.897265336	9.73381295	0.516666667	71.59040123	2.069992791	0.881450272	8.435278759
2013-06-28 13:35	28.8	5	0.084257206	0.915742794	11.86842105	0.533333333	87.63040123	2.228779681	0.897933085	9.797494105
1985-02-24 15:53	31.3	4	0.065779749	0.934220251	15.20224719	0.57962963	140.6859568	2.669854373	0.93308189	14.94363789
2008-08-05 16:00	34.9	3	0.047302291	0.952697709	21.140625	0.646296296	239.0459568	3.305001929	0.96396611	27.75165235
1995-08-14 16:45	37.8	2	0.028824834	0.971175166	34.69230769	0.7	337.1304012	3.816648572	0.978238852	45.95345837
1974-05-16 22:49	44.5	1	0.010347376	0.989652624	96.64285714	0.824074074	628.0592901	4.998728747	0.993276189	148.7251705

Flood Frequency Analysis - Post Kelso Only

$$qi = \frac{i - a}{N + 1 - 2a}$$

N = Count = 45

a = constant for estimation = 0.44 (Gringorten Method)

Xbar 20.25

sx 7.30

alpha 5.69

u 16.97

$$\bar{x} = \sum_{i=1}^{n} \frac{x_i}{n}$$

$$s_x^2 = \frac{1}{(n-1)} \sum_{i=1}^{n} (x_i - \bar{x})^2$$

$$u = \bar{x} - 0.5772\alpha$$

$$\alpha = \frac{\sqrt{6} s_x}{\pi}$$

Date	Peak Flow	Rank (i)	qi	Pi	T Estimated	xi/n	(xi-xbar)2	(X-u)/alpha	P Theoretical	Return Period
1970-04-02 15:56	7.87	45	0.987588652	0.012411348	1.012567325	0.174888889	153.302918	-1.597663431	0.007144069	1.007195474
2015-07-07 15:35	8.95	44	0.965425532	0.034574468	1.035812672	0.198888889	127.725158	-1.407957663	0.016779479	1.017065835
1981-08-30 16:25	10.8	43	0.943262411	0.056737589	1.060150376	0.24	89.33190242	-1.082998709	0.052155635	1.055025527
2012-09-08 6:50	11.6	42	0.921099291	0.078900709	1.085659288	0.257777778	74.84941353	-0.942475918	0.076817133	1.083209011
2002-06-27 10:36	12.3	41	0.89893617	0.10106383	1.112426036	0.273333333	63.22723575	-0.819518476	0.103373483	1.115291575
1983-04-10 5:55	13.1	40	0.87677305	0.12322695	1.140546006	0.291111111	51.14474686	-0.678995684	0.13919265	1.161700118
1988-03-25 20:08	13.3	39	0.854609929	0.145390071	1.170124481	0.295555556	48.32412464	-0.643864987	0.148997622	1.175084847
1979-04-14 3:05	13.8	38	0.832446809	0.167553191	1.201277955	0.306666667	41.62256909	-0.556038242	0.174863348	1.211920471
2003-03-17 17:55	14.1	37	0.810283688	0.189716312	1.234135667	0.313333333	37.84163575	-0.503342196	0.191237181	1.236456444
1994-02-20 16:34	15.2	36	0.788120567	0.211879433	1.268841395	0.337777778	25.51821353	-0.310123358	0.255740169	1.343616784
1998-03-09 14:00	15.5	35	0.765957447	0.234042553	1.305555556	0.344444444	22.5772802	-0.257427311	0.2742822	1.377946082
2014-09-10 19:30	15.6	34	0.743794326	0.256205674	1.344457688	0.346666667	21.63696909	-0.239861962	0.28053026	1.38991252
1971-03-15 20:30	15.7	33	0.721631206	0.278368794	1.385749386	0.348888889	20.71665798	-0.222296613	0.286808144	1.40214725
1969-04-18 13:30	16.4	32	0.699468085	0.300531915	1.429657795	0.364444444	14.8344802	-0.099339171	0.331396137	1.495653937
1999-07-31 14:00	17.2	31	0.677304965	0.322695035	1.476439791	0.382222222	9.311991309	0.04118362	0.38302581	1.620813345
2004-06-13 23:30	17.3	30	0.655141844	0.344858156	1.526387009	0.384444444	8.711680198	0.058748969	0.389479733	1.637947263
2005-09-16 6:50	17.5	29	0.632978723	0.367021277	1.579831933	0.388888889	7.571057975	0.093879667	0.402366342	1.673265866
1980-04-14 18:58	17.8	28	0.610815603	0.389184397	1.637155298	0.395555556	6.010124642	0.146575713	0.421615997	1.728955149
1982-04-03 11:25	17.9	27	0.588652482	0.411347518	1.698795181	0.397777778	5.529813531	0.164141062	0.428004185	1.74826454
1972-04-13 11:08	18.1	26	0.566489362	0.433510638	1.765258216	0.402222222	4.629191309	0.19927176	0.440728075	1.788038977
2007-08-25 15:15	18.4	25	0.544326241	0.455673759	1.83713355	0.408888889	3.428257975	0.251967807	0.45965928	1.850684137
1989-06-22 6:04	18.9	24	0.522163121	0.477836879	1.915110357	0.42	1.82670242	0.339794551	0.490702829	1.963490193
1987-07-08 15:44	19.7	23	0.5	0.5	2	0.437777778	0.304213531	0.480317342	0.53870506	2.167810467
1991-03-27 16:12	19.7	22	0.477836879	0.522163121	2.092764378	0.437777778	0.304213531	0.480317342	0.53870506	2.167810467
2006-12-01 11:31	19.9	21	0.455673759	0.544326241	2.194552529	0.442222222	0.123591309	0.51544804	0.550332328	2.223864561
1984-04-05 7:30	20	20	0.433510638	0.566489362	2.306748466	0.444444444	0.063280198	0.533013389	0.556085097	2.252684003
1976-03-19 17:32	20.6	19	0.411347518	0.588652482	2.431034483	0.457777778	0.121413531	0.638405482	0.589704408	2.437267225
1975-02-24 20:43	20.8	18	0.389184397	0.610815603	2.569476082	0.462222222	0.300791309	0.67353618	0.600554262	2.503468946
1968-02-02 13:00	21.4	17	0.367021277	0.632978723	2.724637681	0.475555556	1.318924642	0.778928273	0.631979981	2.71724349
1997-02-20 7:00	21.7	16	0.344858156	0.655141844	2.899742931	0.482222222	2.097991309	0.83162432	0.647043614	2.833211238
1996-05-21 3:15	21.8	15	0.322695035	0.677304965	3.098901099	0.484444444	2.397680198	0.849189669	0.651966943	2.873290277
1990-12-29 13:32	21.9	14	0.300531915	0.699468085	3.327433628	0.486666667	2.717369086	0.866755018	0.656841034	2.914101329
2010-03-14 1:00	23.1	13	0.278368794	0.721631206	3.592356688	0.513333333	8.113635753	1.077539205	0.711462741	3.465756912
2009-02-12 6:01	23.6	12	0.256205674	0.743794326	3.903114187	0.524444444	11.2120802	1.165365949	0.73212169	3.733038339
1973-03-14 13:32	24.2	11	0.234042553	0.765957447	4.272727273	0.537777778	15.59021353	1.270758042	0.755316192	4.086907131
1977-03-13 3:32	24.2	10	0.211879433	0.788120567	4.719665272	0.537777778	15.59021353	1.270758042	0.755316192	4.086907131
1993-01-04 12:47	24.2	9	0.189716312	0.810283688	5.271028037	0.537777778	15.59021353	1.270758042	0.755316192	4.086907131
1992-04-16 20:57	25.9	8	0.167553191	0.832446809	5.968253968	0.575555556	31.90492464	1.569368974	0.81206369	5.320951553
2011-05-19 0:30	26.1	7	0.145390071	0.854609929	6.87804878	0.58	34.20430242	1.604499671	0.817920536	5.492107568
1986-09-29 11:43	27.9	6	0.12322695	0.87677305	8.115107914	0.62	58.49870242	1.920675951	0.863718912	7.33777529
2013-06-28 13:35	28.8	5	0.10106383	0.89893617	9.894736842	0.64	73.07590242	2.078764091	0.882422149	8.505003241
1985-02-24 15:53	31.3	4	0.078900709	0.921099291	12.6741573	0.695555556	122.0681246	2.517897814	0.922535957	12.90921523
2008-08-05 16:00	34.9	3	0.056737589	0.943262411	17.625	0.775555556	214.5769246	3.150250374	0.958063328	23.84547806
1995-08-14 16:45	37.8	2	0.034574468	0.965425532	28.92307692	0.84	307.9479024	3.659645491	0.974586855	39.34971375
1974-05-16 22:49	44.5	1	0.012411348	0.987588652	80.57142857	0.988888889	587.987058	4.836523867	0.992096808	126.5311519

APPENDIX H: HYDRAULIC ANALYSES RESULTS

HEC-RAS Plan: 16MilkeCK-Future

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
IND9	527	100-year	5.53	207.48	208.60	208.18	208.65	0.001643	0.99	5.57	14.09	0.35
IND9	527	Regional	5.49	207.48	208.59	208.17	208.64	0.001671	0.99	5.52	11.26	0.35
IND9	520		Culvert									
IND9	508	100-year	5.53	206.68	208.39	207.75	208.43	0.001289	0.89	6.20	7.42	0.30
IND9	508	Regional	5.49	206.68	208.38	207.75	208.43	0.001287	0.89	6.18	7.41	0.30
IND9	491	100-year	5.53	206.66	208.35	207.77	208.40	0.001936	1.01	5.48	6.79	0.36
IND9	491	Regional	5.49	206.66	208.34	207.77	208.40	0.001926	1.01	5.45	6.77	0.36
IND9	384	100-year	5.53	206.54	208.10	207.63	208.16	0.002626	1.12	5.14	14.87	0.41
IND9	384	Regional	5.49	206.54	208.09	207.63	208.16	0.002631	1.12	5.10	14.46	0.42
IND9	328	100-year	5.53	206.48	207.79	207.62	207.91	0.007904	1.58	3.50	6.51	0.69
IND9	328	Regional	5.49	206.48	207.79	207.61	207.91	0.007871	1.57	3.49	6.49	0.69
IND9	294	100-year	5.53	206.44	207.65	207.33	207.72	0.003701	1.23	4.51	7.97	0.52
IND9	294	Regional	5.49	206.44	207.64	207.34	207.72	0.003657	1.22	4.50	7.96	0.52
IND9	250	100-year	5.53	206.39	207.46	207.17	207.55	0.003951	1.33	4.16	6.10	0.51
IND9	250	Regional	5.49	206.39	207.47	207.17	207.56	0.003808	1.31	4.20	6.12	0.50
IND9	211	100-year	5.53	206.35	207.27	207.06	207.37	0.005261	1.42	3.88	6.48	0.59
IND9	211	Regional	5.49	206.35	207.30	207.05	207.39	0.004486	1.34	4.09	6.60	0.55
IND9	177	100-year	5.53	206.21	207.15	206.88	207.22	0.003640	1.22	4.55	7.37	0.49
IND9	177	Regional	5.49	206.21	207.21	206.88	207.27	0.002689	1.09	5.03	7.60	0.43
IND9	163	100-year	5.53	206.12	206.86	206.86	207.08	0.016508	2.10	2.63	5.87	1.00
IND9	163	Regional	5.49	206.12	207.15	206.85	207.22	0.003473	1.21	4.54	7.13	0.48
IND9	140		Culvert									
IND9	122	100-year	5.53	205.61	206.95	206.52	207.00	0.002125	1.01	5.47	7.69	0.38
IND9	122	Regional	5.49	205.61	207.16	206.52	207.19	0.000987	0.76	7.19	8.61	0.27
IND9	110	100-year	5.53	205.61	206.91		206.97	0.002726	1.11	4.98	7.30	0.43
IND9	110	Regional	5.49	205.61	207.15		207.18	0.001125	0.80	6.83	8.31	0.28
IND5	730	100-year	7.00	209.13	209.77	209.59	209.78	0.000433	0.38	27.80	87.22	0.17
IND5	730	Regional	16.34	209.13	210.01	209.59	210.02	0.000445	0.50	50.85	107.91	0.18
IND5	716		Culvert									
IND5	700	100-year	7.00	208.56	209.75	209.44	209.76	0.000632	0.60	15.56	71.12	0.22
IND5	700	Regional	16.34	208.56	210.01	209.73	210.01	0.000271	0.47	41.58	117.96	0.15
IND5	690	100-year	7.00	208.52	209.75		209.75	0.000255	0.38	21.38	74.26	0.13
IND5	690	Regional	16.34	208.52	210.00		210.01	0.000168	0.37	43.63	111.90	0.11
IND5	489	100-year	7.00	207.90	209.65	209.25	209.66	0.000927	0.66	13.44	62.52	0.25
IND5	489	Regional	16.34	207.90	209.96	209.65	209.97	0.000237	0.43	43.56	120.93	0.14
IND5	427	100-year	7.00	207.71	209.41	209.10	209.54	0.004304	1.63	4.73	29.75	0.53
IND5	427	Regional	16.34	207.71	209.92	209.62	209.95	0.000796	0.93	28.59	39.30	0.24
IND5	375	100-year	7.00	207.66	209.21		209.30	0.004357	1.31	5.34	8.53	0.53
IND5	375	Regional	16.34	207.66	209.77		209.87	0.002871	1.39	12.27	22.13	0.46
IND5	341	100-year	7.00	207.43	209.00		209.13	0.005896	1.56	4.50	6.76	0.61
IND5	341	Regional	16.34	207.43	209.61		209.74	0.004546	1.62	10.09	12.19	0.57
IND5	314	100-year	7.00	207.29	208.88		208.99	0.003976	1.48	4.72	5.38	0.51
IND5	314	Regional	16.34	207.29	209.38		209.60	0.005186	2.06	8.08	9.23	0.61
IND5	295	100-year	7.00	207.27	208.75	208.45	208.90	0.005715	1.68	4.16	5.20	0.60
IND5	295	Regional	16.34	207.27	209.12	208.99	209.46	0.009078	2.58	6.47	9.95	0.80
IND5	265	100-year	7.00	207.22	208.64		208.74	0.004033	1.41	4.95	6.53	0.52
IND5	265	Regional	16.34	207.22	208.89	208.77	209.18	0.008784	2.40	7.03	12.23	0.79
IND5	246	100-year	7.00	207.13	208.43	208.34	208.61	0.011881	1.90	3.69	7.20	0.85
IND5	246	Regional	16.34	207.13	208.74	208.74	208.98	0.010022	2.30	8.51	33.41	0.84
IND5	225	100-year	7.00	207.05	208.31	208.23	208.41	0.006446	1.44	5.60	19.86	0.64
IND5	225	Regional	16.34	207.05	208.62	208.47	208.74	0.004449	1.64	12.45	61.15	0.57
IND5	189	100-year	7.00	206.97	207.83	207.83	208.04	0.017077	2.07	3.39	7.90	1.01

HEC-RAS Plan: 16MilkeCK-Future (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
IND5	189	Regional	16.34	206.97	208.18	208.18	208.48	0.011469	2.45	7.31	14.71	0.91
IND5	120	100-year	7.00	206.54	207.74		207.78	0.001108	0.83	9.24	17.97	0.29
IND5	120	Regional	16.34	206.54	208.00		208.08	0.002081	1.36	14.57	22.02	0.42
IND5	106	100-year	7.00	205.91	207.73	207.02	207.76	0.000859	0.81	10.05	18.47	0.25
IND5	106	Regional	16.34	205.91	207.97	207.45	208.06	0.001890	1.38	15.31	23.30	0.39
IND5	94		Culvert									
IND5	57	100-year	7.00	205.50	206.89	206.34	206.93	0.000985	1.03	8.84	13.67	0.29
IND5	57	Regional	16.34	205.50	207.12	206.69	207.25	0.002746	1.92	10.91	15.46	0.50
IND5	46	100-year	7.00	205.43	206.86		206.91	0.001111	1.08	8.16	10.49	0.31
IND5	46	Regional	16.34	205.43	206.93	206.69	207.18	0.005041	2.39	8.95	13.33	0.66
NW6	1890	100-year	18.77	205.48	206.89	206.07	206.92	0.000514	0.80	30.80	77.97	0.22
NW6	1890	Regional	11.75	205.48	206.64	205.93	206.66	0.000444	0.65	21.77	52.83	0.20
NW6	1781	100-year	18.77	205.41	206.86	205.95	206.87	0.000275	0.58	38.14	47.55	0.16
NW6	1781	Regional	11.75	205.41	206.61	205.82	206.62	0.000267	0.49	26.85	40.81	0.15
NW6	1687	100-year	18.77	205.37	206.82	205.95	206.84	0.000396	0.66	30.95	33.21	0.19
NW6	1687	Regional	11.75	205.37	206.58	205.82	206.59	0.000335	0.53	23.32	29.43	0.17
NW6	1483	100-year	18.77	204.26	206.82	205.28	206.82	0.000067	0.36	55.18	448.96	0.08
NW6	1483	Regional	11.75	204.26	206.57	205.09	206.57	0.000051	0.28	45.02	391.67	0.07
NW6	1460		Mult Open									
NW6	1400	100-year	19.96	203.80	205.90	204.58	205.92	0.000191	0.59	38.71	316.93	0.14
NW6	1400	Regional	13.82	203.80	205.83	204.46	205.84	0.000108	0.43	34.53	307.34	0.10
NW6	1000	100-year	19.96	202.82	205.91	204.08	205.91	0.000007	0.14	263.96	195.34	0.03
NW6	1000	Regional	13.82	202.82	205.83	204.08	205.83	0.000004	0.10	250.04	193.88	0.02
NW6	985		Culvert									
NW6	968	100-year	19.96	202.55	205.90	203.62	205.90	0.000007	0.15	247.72	177.94	0.03
NW6	968	Regional	13.82	202.55	205.83	203.48	205.83	0.000004	0.11	235.54	176.84	0.02
NW6	952	100-year	19.96	202.41	205.90	203.28	205.90	0.000005	0.13	213.55	110.31	0.02
NW6	952	Regional	13.82	202.41	205.83	203.19	205.83	0.000003	0.10	206.03	109.17	0.02
NW6	883	100-year	19.96	201.85	205.90	203.05	205.90	0.000005	0.15	293.01	223.10	0.03
NW6	883	Regional	13.82	201.85	205.83	202.88	205.83	0.000003	0.11	277.80	220.86	0.02
NW6	875	100-year	19.96	201.80	205.90	203.04	205.90	0.000005	0.15	263.45	226.63	0.02
NW6	875	Regional	13.82	201.80	205.83	202.84	205.83	0.000003	0.11	251.86	223.26	0.02
NW6	840		Culvert									
NW6	811	100-year	19.96	201.55	203.10	202.76	203.20	0.003077	1.43	14.96	41.59	0.49
NW6	811	Regional	13.82	201.55	203.04	202.62	203.10	0.001834	1.06	13.74	34.71	0.37
NW6	800	100-year	19.96	201.36	203.01	202.80	203.15	0.003869	1.80	14.04	27.80	0.56
NW6	800	Regional	13.82	201.36	203.01	202.54	203.08	0.001828	1.24	14.14	28.33	0.38
NW6	750	100-year	19.96	200.79	203.00	202.20	203.03	0.000893	0.93	27.02	34.93	0.27
NW6	750	Regional	13.82	200.79	203.01	201.96	203.02	0.000414	0.64	27.34	35.02	0.19
IND1	3299	100-year	12.01	222.19	223.29	223.22	223.36	0.004997	1.40	13.25	45.59	0.58
IND1	3299	Regional	29.47	222.19	223.54	223.42	223.64	0.005106	1.79	25.66	53.31	0.62
IND1	3248	100-year	12.01	222.09	222.81	222.81	222.93	0.016323	1.84	8.75	33.92	0.98
IND1	3248	Regional	29.47	222.09	223.02	223.02	223.21	0.014884	2.35	17.41	48.40	1.00
IND1	3196	100-year	12.01	221.89	222.57		222.60	0.002745	1.02	22.25	85.58	0.43
IND1	3196	Regional	29.47	221.89	222.84		222.86	0.002030	1.13	46.68	103.75	0.40
IND1	3156	100-year	12.01	221.84	222.43		222.46	0.003480	1.10	17.34	54.61	0.48
IND1	3156	Regional	29.47	221.84	222.69		222.74	0.003514	1.44	34.53	77.55	0.52
IND1	3111	100-year	12.01	221.61	222.34		222.36	0.001536	0.86	21.82	50.83	0.33
IND1	3111	Regional	29.47	221.61	222.55		222.60	0.002909	1.41	33.39	60.60	0.48
IND1	3082	100-year	12.01	221.49	222.32	221.91	222.33	0.000606	0.57	32.47	64.84	0.21
IND1	3082	Regional	29.47	221.49	222.50	222.09	222.53	0.001508	1.04	44.99	85.01	0.35

HEC-RAS Plan: 16MilkeCK-Future (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
IND1	3048	100-year	12.01	221.33	222.31	221.81	222.31	0.000342	0.48	39.31	70.71	0.16
IND1	3048	Regional	29.47	221.33	222.47	221.95	222.49	0.001011	0.92	51.08	140.16	0.29
IND1	3002	100-year	12.01	221.13	222.31	221.57	222.31	0.000038	0.18	107.88	159.13	0.06
IND1	3002	Regional	29.47	221.13	222.47	221.71	222.47	0.000123	0.36	134.30	174.13	0.10
IND1	2980	100-year	12.01	220.70	222.31	221.57	222.31	0.000030	0.18	115.51	170.86	0.05
IND1	2980	Regional	29.47	220.70	222.46	221.87	222.47	0.000109	0.37	141.78	191.31	0.10
IND1	2969		Culvert									
IND1	2946	100-year	12.01	220.30	221.22	221.22	221.45	0.011189	2.33	6.39	106.44	0.88
IND1	2946	Regional	29.47	220.30	221.49	221.49	221.51	0.001535	1.07	51.93	118.95	0.35
IND1	2924	100-year	11.06	220.29	221.15	220.98	221.17	0.002273	0.93	20.51	68.95	0.38
IND1	2924	Regional	20.24	220.29	221.24	221.06	221.28	0.004256	1.40	28.75	121.73	0.54
IND1	2896	100-year	11.06	220.29	221.10	220.87	221.11	0.001662	0.79	23.42	110.54	0.33
IND1	2896	Regional	20.24	220.29	221.09	220.96	221.14	0.006226	1.52	22.52	108.52	0.64
IND1	2842	100-year	11.06	220.28	220.79	220.79	220.90	0.015095	1.97	9.05	125.44	0.96
IND1	2842	Regional	20.24	220.28	220.87	220.82	220.88	0.003301	1.02	36.16	138.46	0.46
IND1	2788	100-year	11.06	220.20	220.63	220.45	220.64	0.001991	0.59	27.99	117.73	0.33
IND1	2788	Regional	20.24	220.20	220.72	220.51	220.74	0.002407	0.76	38.45	122.28	0.38
IND1	2709	100-year	11.06	220.07	220.39		220.40	0.003725	0.74	24.19	126.35	0.45
IND1	2709	Regional	20.24	220.07	220.51		220.52	0.002517	0.77	39.28	127.24	0.39
IND1	2629	100-year	11.06	219.57	220.28		220.30	0.001703	0.81	26.29	106.33	0.34
IND1	2629	Regional	20.24	219.57	220.43		220.45	0.001369	0.85	42.40	109.09	0.32
IND1	2577	100-year	11.06	219.30	220.08		220.17	0.006804	1.64	11.67	47.47	0.68
IND1	2577	Regional	20.24	219.30	220.29		220.35	0.004177	1.57	22.59	64.83	0.56
IND1	2531	100-year	11.06	219.06	220.02	219.81	220.04	0.001149	0.74	23.92	64.61	0.29
IND1	2531	Regional	20.24	219.06	220.23	219.90	220.25	0.001244	0.92	39.45	102.21	0.31
IND1	2481	100-year	11.06	218.66	219.89	219.56	219.95	0.002308	1.15	10.24	16.59	0.41
IND1	2481	Regional	20.24	218.66	219.89	219.79	220.11	0.007673	2.09	10.26	16.60	0.75
IND1	2438	100-year	11.06	218.35	219.89	219.22	219.90	0.000275	0.54	37.28	92.61	0.16
IND1	2438	Regional	20.24	218.35	219.91	219.43	219.94	0.000846	0.96	38.67	94.94	0.27
IND1	2415	100-year	11.06	218.36	219.40	219.40	219.77	0.012333	2.74	4.29	7.12	0.95
IND1	2415	Regional	20.24	218.36	219.76	219.76	219.87	0.003842	1.94	23.19	90.69	0.56
IND1	2335	100-year	11.06	218.14	219.64	218.69	219.64	0.000066	0.29	65.65	87.65	0.08
IND1	2335	Regional	20.24	218.14	219.74	218.82	219.75	0.000179	0.51	75.25	106.88	0.13
IND1	2319	100-year	11.06	217.95	219.64	218.74	219.64	0.000032	0.20	97.23	130.21	0.05
IND1	2319	Regional	20.24	217.95	219.74	218.94	219.74	0.000073	0.32	110.75	137.65	0.08
IND1	2302		Culvert									
IND1	2288	100-year	11.06	217.45	218.29	218.29	218.53	0.014657	2.31	5.49	51.72	0.99
IND1	2288	Regional	20.24	217.45	218.52	218.52	218.87	0.013854	2.83	8.13	86.26	1.02
IND1	2274	100-year	11.06	217.44	218.17	218.17	218.32	0.008733	1.89	8.18	31.92	0.78
IND1	2274	Regional	20.24	217.44	218.33	218.33	218.52	0.009461	2.29	13.87	42.16	0.84
IND1	2266	100-year	11.06	217.40	218.01	218.01	218.16	0.012776	1.77	7.36	168.72	0.89
IND1	2266	Regional	20.24	217.40	218.19	218.19	218.35	0.009480	1.95	14.19	192.30	0.81
IND1	2244	100-year	11.06	217.01	217.65	217.65	217.74	0.010198	1.85	12.32	66.14	0.88
IND1	2244	Regional	20.24	217.01	217.78		217.85	0.008043	1.92	20.99	75.77	0.81
IND1	2230	100-year	11.06	216.86	217.59		217.62	0.003482	1.20	19.62	79.88	0.49
IND1	2230	Regional	20.24	216.86	217.75		217.77	0.002817	1.25	32.73	94.94	0.45
IND1	2213	100-year	11.06	216.76	217.54	217.45	217.56	0.003573	1.08	19.54	129.30	0.48
IND1	2213	Regional	20.24	216.76	217.71	217.53	217.73	0.002150	1.02	35.98	143.19	0.39
IND1	2179	100-year	11.06	216.35	217.23	217.23	217.35	0.011436	1.88	9.35	37.62	0.85
IND1	2179	Regional	20.24	216.35	217.61		217.65	0.002162	1.20	27.41	66.71	0.41
IND1	2079	100-year	11.06	216.25	217.17	216.56	217.17	0.000119	0.27	55.03	97.95	0.10
IND1	2079	Regional	20.24	216.25	217.62	216.64	217.63	0.000049	0.23	122.37	234.88	0.07

HEC-RAS Plan: 16MilkeCK-Future (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
IND1	2001	100-year	11.06	215.87	217.15	216.41	217.16	0.000192	0.43	34.33	140.80	0.13
IND1	2001	Regional	20.24	215.87	217.62	216.53	217.62	0.000013	0.14	149.64	163.86	0.03
IND1	1929	100-year	11.06	215.55	217.12	216.21	217.14	0.000291	0.58	20.57	220.43	0.16
IND1	1929	Regional	20.24	215.55	217.62	216.42	217.62	0.000030	0.23	182.68	249.04	0.05
IND1	1910	100-year	11.06	215.47	216.98		217.12	0.002918	1.68	7.51	8.62	0.49
IND1	1910	Regional	20.24	215.47	217.39		217.60	0.003249	2.15	11.38	10.41	0.54
IND1	1895	100-year	11.06	215.48	216.95		217.06	0.002532	1.66	8.64	9.56	0.47
IND1	1895	Regional	20.24	215.48	217.35		217.52	0.002936	2.15	12.86	11.40	0.53
IND1	1880	100-year	11.06	215.42	216.52	216.52	216.85	0.012811	2.72	4.75	7.88	0.97
IND1	1880	Regional	20.24	215.42	216.88	216.88	217.30	0.010599	3.17	8.08	10.30	0.94
IND1	1833	100-year	11.06	215.16	215.84	215.74	215.95	0.008543	1.66	8.13	19.44	0.75
IND1	1833	Regional	20.24	215.16	216.08	215.93	216.22	0.007134	1.96	13.03	21.74	0.73
IND1	1802	100-year	11.06	214.88	215.64	215.44	215.72	0.005158	1.41	9.29	17.23	0.59
IND1	1802	Regional	20.24	214.88	215.90	215.64	216.02	0.005041	1.78	13.79	18.34	0.62
IND1	1766	100-year	11.06	214.72	215.46		215.54	0.005271	1.63	9.58	17.88	0.62
IND1	1766	Regional	20.24	214.72	215.73		215.84	0.004940	1.96	14.58	19.31	0.64
IND1	1723	100-year	11.06	214.38	215.18		215.29	0.005948	1.77	8.47	15.84	0.67
IND1	1723	Regional	20.24	214.38	215.44		215.60	0.005928	2.17	12.70	17.02	0.70
IND1	1689	100-year	11.06	214.20	215.02		215.10	0.004644	1.61	9.56	16.36	0.59
IND1	1689	Regional	20.24	214.20	215.27		215.40	0.005184	2.05	13.76	17.52	0.65
IND1	1660	100-year	11.06	214.11	214.84		214.94	0.006708	1.79	8.71	17.46	0.70
IND1	1660	Regional	20.24	214.11	215.10		215.24	0.006242	2.13	13.29	18.74	0.71
IND1	1618	100-year	11.06	213.95	214.73	214.46	214.77	0.002297	1.08	14.22	25.76	0.41
IND1	1618	Regional	20.24	213.95	215.02	214.61	215.07	0.002040	1.28	21.72	26.63	0.41
IND1	1566	100-year	11.06	213.64	214.54	214.32	214.61	0.003986	1.66	10.31	17.05	0.56
IND1	1566	Regional	20.24	213.64	214.80	214.51	214.91	0.004357	2.06	14.97	18.11	0.62
IND1	1543	100-year	11.06	213.54	214.43	214.24	214.51	0.004125	1.51	9.47	16.42	0.56
IND1	1543	Regional	20.24	213.54	214.66	214.43	214.80	0.004915	1.97	13.31	16.96	0.63
IND1	1522	100-year	11.06	213.35	214.24	214.20	214.39	0.007573	2.11	7.81	17.52	0.76
IND1	1522	Regional	20.24	213.35	214.46	214.39	214.67	0.007740	2.52	11.83	18.00	0.80
IND1	1462	100-year	11.06	213.15	214.04		214.10	0.002819	1.36	12.81	28.41	0.47
IND1	1462	Regional	20.24	213.15	214.34		214.40	0.002165	1.45	21.34	28.97	0.43
IND1	1421	100-year	11.06	213.04	213.89	213.66	213.96	0.004366	1.57	10.00	16.54	0.57
IND1	1421	Regional	20.24	213.04	214.16	213.85	214.27	0.004478	1.95	14.69	17.34	0.61
IND1	1396	100-year	11.06	212.76	213.71	213.60	213.83	0.006317	2.07	8.41	15.22	0.70
IND1	1396	Regional	20.24	212.76	213.95	213.80	214.13	0.007188	2.60	12.25	16.49	0.78
IND1	1368	100-year	11.06	212.60	213.47	213.47	213.63	0.007972	2.12	7.54	17.12	0.77
IND1	1368	Regional	20.24	212.60	213.69	213.64	213.91	0.008583	2.60	11.58	19.46	0.83
IND1	1339	100-year	11.06	212.52	213.20	213.18	213.35	0.010377	2.01	7.25	17.57	0.84
IND1	1339	Regional	20.24	212.52	213.39	213.35	213.62	0.011327	2.53	10.63	18.15	0.92
IND1	1307	100-year	11.06	212.26	212.96		213.06	0.007346	1.37	8.05	18.37	0.66
IND1	1307	Regional	20.24	212.26	213.19		213.33	0.006404	1.65	12.27	18.97	0.65
IND1	1274	100-year	11.06	211.92	212.74	212.63	212.84	0.006139	1.69	8.83	18.16	0.66
IND1	1274	Regional	20.24	211.92	212.99	212.81	213.13	0.005545	2.00	13.57	18.68	0.66
IND1	1234	100-year	11.06	211.64	212.57		212.65	0.003484	1.42	10.64	20.58	0.51
IND1	1234	Regional	20.24	211.64	212.85		212.95	0.003264	1.68	16.51	21.32	0.52
IND1	1180	100-year	11.06	211.41	212.52	212.00	212.55	0.000893	0.86	17.52	20.85	0.27
IND1	1180	Regional	20.24	211.41	212.78	212.17	212.83	0.001293	1.20	23.08	21.82	0.34
IND1	1161	100-year	11.06	211.29	212.50		212.53	0.001001	0.98	15.93	19.18	0.29
IND1	1161	Regional	20.24	211.29	212.74		212.80	0.001557	1.40	20.75	20.37	0.38
IND1	1136	100-year	11.06	211.22	212.47		212.51	0.000832	0.92	15.60	16.09	0.27
IND1	1136	Regional	20.24	211.22	212.69		212.76	0.001559	1.41	19.20	17.47	0.38
IND1	1116	100-year	11.06	211.22	212.46		212.49	0.000733	0.86	16.93	17.49	0.25

HEC-RAS Plan: 16MilkeCK-Future (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
IND1	1116	Regional	20.24	211.22	212.67		212.73	0.001373	1.31	20.66	18.29	0.36
IND1	1085	100-year	11.06	211.20	212.08	212.08	212.40	0.013944	2.52	4.50	13.05	0.99
IND1	1085	Regional	20.24	211.20	212.35	212.35	212.62	0.009139	2.56	10.37	18.24	0.85
IND1	1037	100-year	11.06	210.60	211.29	211.29	211.51	0.015639	2.08	5.31	11.80	0.99
IND1	1037	Regional	20.24	210.60	211.55	211.55	211.82	0.013302	2.32	9.00	18.76	0.96
IND1	1025	100-year	11.06	210.40	211.08	211.08	211.28	0.017115	2.00	5.53	14.00	1.02
IND1	1025	Regional	20.24	210.40	211.23	211.23	211.23	0.000054	0.13	65.91	103.45	0.06
IND1	997		Culvert									
IND1	965	100-year	11.06	209.77	210.66	210.49	210.76	0.005248	1.43	8.28	27.59	0.60
IND1	965	Regional	20.24	209.77	211.13	210.75	211.14	0.000139	0.35	54.31	86.87	0.11
IND1	958	100-year	11.06	209.67	210.54	210.45	210.71	0.008066	1.91	6.39	12.91	0.76
IND1	958	Regional	20.24	209.67	210.71	210.71	211.04	0.011569	2.67	8.80	15.50	0.94
IND1	906	100-year	11.06	209.25	210.25	210.25	210.34	0.006772	1.57	8.30	38.12	0.66
IND1	906	Regional	20.24	209.25	210.61	210.34	210.65	0.000915	0.80	22.26	39.13	0.27
IND1	790	100-year	11.06	208.93	210.06	209.72	210.07	0.000300	0.39	25.76	57.03	0.15
IND1	790	Regional	20.24	208.93	210.62	209.82	210.62	0.000056	0.25	69.90	77.31	0.07
IND1	613	100-year	11.06	208.14	210.06	208.57	210.06	0.000014	0.16	103.99	318.19	0.04
IND1	613	Regional	20.24	208.14	210.62	208.69	210.62	0.000015	0.20	158.93	330.02	0.04
IND1	553		Mult Open									
IND1	487	100-year	11.06	207.53	207.98	207.89	208.04	0.006614	1.22	10.45	148.33	0.63
IND1	487	Regional	20.24	207.53	208.17	208.01	208.25	0.005123	1.41	16.40	175.38	0.59
IND1	443	100-year	11.27	207.05	207.79		207.83	0.003781	1.09	17.07	70.19	0.50
IND1	443	Regional	20.16	207.05	208.14		208.15	0.000813	0.72	52.58	168.81	0.25
IND1	411	100-year	11.27	206.96	207.70		207.73	0.003159	1.02	20.22	105.50	0.45
IND1	411	Regional	20.16	206.96	208.13		208.13	0.000258	0.44	90.90	212.99	0.14
IND1	371	100-year	11.27	206.73	207.47		207.54	0.005415	1.52	12.21	41.07	0.61
IND1	371	Regional	20.16	206.73	208.11		208.12	0.000369	0.64	68.43	148.24	0.18
IND1	229	100-year	11.27	206.39	207.51	206.75	207.51	0.000022	0.14	197.00	343.69	0.04
IND1	229	Regional	20.16	206.39	208.11	206.82	208.11	0.000008	0.11	418.73	390.10	0.03
IND1	212	100-year	11.27	206.33	207.51		207.51	0.000080	0.27	59.41	355.94	0.08
IND1	212	Regional	20.16	206.33	208.11		208.11	0.000046	0.28	99.74	399.91	0.07
IND1	191		Culvert									
IND1	166	100-year	11.27	205.68	207.45	206.92	207.50	0.001302	1.02	12.06	18.85	0.32
IND1	166	Regional	20.16	205.68	208.00	207.19	208.04	0.000736	1.01	24.28	21.79	0.26
IND1	135	100-year	11.27	205.44	207.20		207.39	0.005749	1.93	5.85	5.93	0.62
IND1	135	Regional	20.16	205.44	207.68		207.93	0.005565	2.24	9.22	9.98	0.63
IND1	105	100-year	11.27	205.15	206.71	206.66	207.10	0.014913	2.79	4.05	4.63	0.95
IND1	105	Regional	20.16	205.15	207.15	207.15	207.65	0.013930	3.14	6.51	7.75	0.96
IND12	315	100-year	21.21	204.19	206.84		206.88	0.000520	0.93	24.48	25.49	0.22
IND12	315	Regional	32.88	204.19	206.97		207.05	0.000910	1.29	28.72	31.95	0.29
IND12	309	100-year	21.21	204.04	206.84	205.22	206.87	0.000286	0.75	31.54	87.89	0.17
IND12	309	Regional	32.88	204.04	206.99	205.49	207.03	0.000427	0.97	41.42	88.59	0.21
IND12	247		Culvert									
IND12	186	100-year	21.21	203.35	205.37	204.86	205.57	0.003279	2.01	10.54	11.47	0.53
IND12	186	Regional	32.88	203.35	205.84	205.20	205.99	0.002586	1.73	19.00	13.60	0.47
IND12	171	100-year	21.21	203.30	205.33		205.50	0.003847	1.82	11.68	10.29	0.54
IND12	171	Regional	32.88	203.30	205.70		205.92	0.004181	2.08	15.80	12.09	0.58
IND12	130	100-year	21.21	203.24	205.13		205.32	0.004859	1.96	10.83	10.35	0.61
IND12	130	Regional	32.88	203.24	205.48		205.73	0.005017	2.23	14.74	11.83	0.64
IND12	97	100-year	21.21	203.20	204.89		205.13	0.006575	2.18	9.75	10.10	0.71
IND12	97	Regional	32.88	203.20	205.24		205.54	0.006391	2.41	13.64	11.83	0.72

HEC-RAS Plan: 16MilkeCK-Future (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
IND12	75	100-year	21.21	203.05	204.79	204.45	204.99	0.005028	1.99	10.64	10.19	0.62
IND12	75	Regional	32.88	203.05	205.14	204.75	205.40	0.005200	2.27	14.46	11.59	0.65
IND12	46	100-year	21.21	202.89	204.32	204.32	204.75	0.013728	2.88	7.37	14.68	1.00
IND12	46	Regional	32.88	202.89	204.65	204.65	205.16	0.012851	3.16	10.40	18.14	1.00
IND12	24	100-year	21.21	201.29	203.65		203.70	0.000763	1.07	24.69	21.06	0.26
IND12	24	Regional	32.88	201.29	204.11		204.17	0.000704	1.21	34.63	22.83	0.26
NW1	3100	100-year	11.50	218.79	219.86	219.85	219.97	0.005311	1.78	16.99	70.18	0.63
NW1	3100	Regional	20.44	218.79	220.02	219.96	220.13	0.005262	2.00	29.21	81.47	0.64
NW1	3050	100-year	11.50	218.71	219.54		219.63	0.009091	1.91	16.54	60.03	0.78
NW1	3050	Regional	20.44	218.71	219.92		219.95	0.002212	1.30	40.60	66.12	0.42
NW1	2994	100-year	11.50	218.44	219.16		219.21	0.006476	1.43	19.38	74.34	0.65
NW1	2994	Regional	20.44	218.44	219.90		219.90	0.000333	0.60	84.11	104.15	0.17
NW1	2946	100-year	11.50	217.91	218.78	218.78	218.88	0.007298	1.85	18.97	96.33	0.72
NW1	2946	Regional	20.44	217.91	219.90		219.90	0.000071	0.35	172.56	169.24	0.08
NW1	2886	100-year	11.50	217.41	218.71		218.71	0.000280	0.47	69.36	162.40	0.15
NW1	2886	Regional	20.44	217.41	219.89		219.89	0.000016	0.19	310.63	245.84	0.04
NW1	2854	100-year	11.50	217.13	218.70		218.71	0.000125	0.39	90.15	172.10	0.11
NW1	2854	Regional	20.44	217.13	219.89		219.89	0.000011	0.17	362.71	265.00	0.03
NW1	2806	100-year	11.50	216.90	218.70	217.55	218.70	0.000014	0.15	226.22	248.34	0.04
NW1	2806	Regional	20.44	216.90	219.89	217.63	219.89	0.000003	0.10	574.97	317.40	0.02
NW1	2792	100-year	11.50	216.90	218.69	217.60	218.70	0.000212	0.56	31.41	306.98	0.14
NW1	2792	Regional	20.44	216.90	219.89	217.83	219.89	0.000002	0.09	653.92	357.26	0.02
NW1	2757		Culvert									
NW1	2635	100-year	11.50	215.57	216.52	216.48	216.80	0.012924	2.38	4.84	7.34	0.93
NW1	2635	Regional	20.44	215.57	216.90	216.90	217.19	0.010875	2.43	9.84	58.10	0.88
NW1	2459	100-year	25.79	214.40	215.70	215.44	215.85	0.003668	1.82	26.02	101.11	0.56
NW1	2459	Regional	29.93	214.40	215.76	215.59	215.91	0.003725	1.90	32.62	112.39	0.57
NW1	2269	100-year	25.79	213.57	214.58	214.58	214.65	0.012323	1.97	39.08	190.71	0.89
NW1	2269	Regional	29.93	213.57	214.59	214.59	214.68	0.013629	2.12	42.11	191.80	0.94
NW1	2050	100-year	25.79	212.72	213.28	213.15	213.28	0.000217	0.21	188.40	334.10	0.11
NW1	2050	Regional	29.93	212.72	213.31	213.15	213.31	0.000249	0.23	198.15	336.62	0.12
NW1	1997	100-year	25.79	212.48	213.27	212.92	213.27	0.000094	0.19	246.96	383.82	0.08
NW1	1997	Regional	29.93	212.48	213.30	212.92	213.30	0.000111	0.21	257.74	386.89	0.09
NW1	1986	100-year	25.79	212.43	213.27	212.54	213.27	0.000102	0.18	229.66	374.48	0.08
NW1	1986	Regional	29.93	212.43	213.30	212.54	213.30	0.000122	0.20	238.31	378.23	0.09
NW1	1973		Mult Open									
NW1	1957	100-year	25.79	212.36	212.84	212.79	212.85	0.001641	0.45	88.01	239.70	0.29
NW1	1957	Regional	29.93	212.36	212.85	212.79	212.85	0.002109	0.52	89.61	241.33	0.33
NW1	1943	100-year	24.11	212.31	212.83	212.83	212.83	0.000650	0.24	128.45	309.35	0.17
NW1	1943	Regional	31.17	212.31	212.83	212.83	212.83	0.001086	0.31	128.45	309.35	0.22
NW1	1588	100-year	24.11	210.86	211.72	211.72	211.74	0.001484	0.85	73.72	203.46	0.33
NW1	1588	Regional	31.17	210.86	211.72	211.72	211.75	0.002480	1.10	73.72	203.46	0.42
NW1	1539	100-year	24.11	210.52	211.51	211.18	211.55	0.001260	0.92	58.71	402.46	0.32
NW1	1539	Regional	31.17	210.52	211.60	211.28	211.63	0.001266	0.98	74.41	413.48	0.32
NW1	1360	100-year	24.11	210.16	211.50	210.57	211.50	0.000141	0.34	181.45	401.73	0.11
NW1	1360	Regional	31.17	210.16	211.59	210.58	211.59	0.000171	0.40	201.15	429.11	0.12
NW1	1357		Mult Open									
NW1	1344	100-year	24.11	210.05	211.29	211.07	211.30	0.000316	0.45	77.72	310.30	0.16
NW1	1344	Regional	31.17	210.05	211.49	211.07	211.50	0.000243	0.46	103.70	367.28	0.14
NW1	1339	100-year	22.32	210.02	211.17	210.88	211.27	0.002798	1.40	18.41	161.06	0.47
NW1	1339	Regional	34.15	210.02	211.29	211.07	211.45	0.004050	1.84	22.31	170.40	0.58
NW1	1303	100-year	22.32	209.97	211.06	210.96	211.14	0.005490	1.86	21.14	47.67	0.64

HEC-RAS Plan: 16MilkeCK-Future (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
NW1	1303	Regional	34.15	209.97	211.12	211.05	211.26	0.009048	2.49	23.79	48.49	0.84
NW1	1275	100-year	22.32	209.58	211.01	210.69	211.05	0.002146	1.09	28.33	201.79	0.33
NW1	1275	Regional	34.15	209.58	210.92	210.84	211.06	0.007964	1.98	24.01	181.08	0.63
NW1	1149	100-year	22.32	209.00	210.38	210.38	210.61	0.008065	2.74	13.79	96.06	0.84
NW1	1149	Regional	34.15	209.00	210.86	210.53	210.88	0.000497	0.87	79.09	106.55	0.22
NW1	1076	100-year	22.32	208.76	210.28	210.28	210.53	0.011837	2.68	11.83	103.22	0.91
NW1	1076	Regional	34.15	208.76	210.46	210.46	210.77	0.012140	3.06	15.93	107.37	0.95
NW1	993	100-year	22.32	208.45	209.93		210.00	0.002048	1.39	24.74	46.07	0.41
NW1	993	Regional	34.15	208.45	210.04		210.14	0.002990	1.78	30.25	51.92	0.50
NW1	846	100-year	22.32	207.92	209.45	209.45	209.58	0.006182	2.13	20.39	59.51	0.67
NW1	846	Regional	34.15	207.92	209.75	209.53	209.81	0.002400	1.57	38.73	62.18	0.43
NW1	690	100-year	22.32	207.36	209.11	208.65	209.13	0.000701	0.82	44.28	77.42	0.24
NW1	690	Regional	34.15	207.36	209.73	208.81	209.74	0.000178	0.55	96.92	88.43	0.13
NW1	512	100-year	22.32	206.65	208.99		209.03	0.000581	0.94	31.67	31.81	0.23
NW1	512	Regional	34.15	206.65	209.67		209.70	0.000310	0.87	56.09	40.02	0.18
NW1	508	100-year	22.32	206.63	208.97	208.09	209.02	0.000810	1.05	22.80	26.13	0.27
NW1	508	Regional	34.15	206.63	209.64	208.36	209.69	0.000477	1.03	36.34	34.35	0.22
NW1	494		Culvert									
NW1	475	100-year	22.32	207.00	208.38	208.20	208.59	0.005940	2.07	11.23	19.45	0.69
NW1	475	Regional	34.15	207.00	208.83	208.43	209.04	0.003538	2.08	17.15	29.96	0.57
NW1	469	100-year	22.32	206.95	208.37		208.54	0.004889	1.87	13.32	19.84	0.62
NW1	469	Regional	34.15	206.95	208.85		208.98	0.002315	1.70	24.21	25.37	0.46
NW1	388	100-year	22.32	206.67	208.26		208.29	0.001360	1.00	34.77	57.44	0.32
NW1	388	Regional	34.15	206.67	208.85		208.87	0.000367	0.71	70.32	62.36	0.18
NW1	328	100-year	22.32	206.28	208.16	207.26	208.23	0.000817	1.11	20.18	104.78	0.28
NW1	328	Regional	34.15	206.28	208.85	207.48	208.86	0.000058	0.37	138.42	114.42	0.08
NW1	304		Culvert									
NW1	275	100-year	22.32	206.46	207.37	207.33	207.58	0.008727	2.10	11.87	58.09	0.80
NW1	275	Regional	34.15	206.46	207.51	207.51	207.81	0.010159	2.56	15.20	62.48	0.89
NW1	265	100-year	22.32	206.44	207.34	207.29	207.46	0.007818	1.77	17.26	54.98	0.74
NW1	265	Regional	34.15	206.44	207.50		207.62	0.006030	1.83	27.37	72.46	0.67
NW2	676	100-year	33.20	210.55	211.60		211.63	0.001146	0.93	52.26	74.95	0.31
NW2	676	Regional	18.15	210.55	211.32		211.34	0.001280	0.78	33.03	64.20	0.31
NW2	604	100-year	33.20	210.04	211.24	211.14	211.45	0.009349	2.89	18.88	30.72	0.88
NW2	604	Regional	18.15	210.04	211.04	210.91	211.17	0.006943	2.19	13.38	26.30	0.74
NW2	533	100-year	33.20	209.57	210.65		210.83	0.009382	2.51	20.79	40.36	0.85
NW2	533	Regional	18.15	209.57	210.43	210.41	210.58	0.011814	2.31	12.26	33.60	0.91
NW2	502	100-year	33.20	209.44	210.45		210.61	0.005635	1.86	20.80	34.47	0.66
NW2	502	Regional	18.15	209.44	210.22		210.33	0.005677	1.50	13.47	29.58	0.63
NW2	463	100-year	33.20	208.99	210.03	210.03	210.30	0.010485	2.64	15.42	28.88	0.91
NW2	463	Regional	18.15	208.99	209.81	209.81	210.02	0.010609	2.20	9.83	23.88	0.87
NW2	398	100-year	33.20	208.37	209.55		209.65	0.002829	1.41	26.65	43.65	0.48
NW2	398	Regional	18.15	208.37	209.24		209.32	0.003890	1.24	14.96	30.80	0.52
NW2	332	100-year	33.20	207.71	208.88	208.88	209.27	0.012635	2.76	12.17	26.08	0.98
NW2	332	Regional	18.15	207.71	208.57	208.57	208.86	0.014437	2.40	7.55	12.70	1.00
NW2	267	100-year	33.20	207.06	208.40		208.45	0.002031	1.07	33.64	40.80	0.32
NW2	267	Regional	18.15	207.06	208.42		208.43	0.000569	0.57	34.42	41.15	0.17
NW2	222	100-year	33.20	206.60	208.42	207.41	208.43	0.000063	0.30	153.65	142.27	0.08
NW2	222	Regional	18.15	206.60	208.42	207.18	208.42	0.000019	0.16	153.71	142.28	0.04
NW2	105	100-year	33.20	205.39	208.42	207.12	208.42	0.000006	0.12	416.19	309.34	0.03
NW2	105	Regional	18.15	205.39	208.42	207.00	208.42	0.000002	0.07	416.28	309.38	0.01
NW2	66		Culvert									

HEC-RAS Plan: 16MilkeCK-Future (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
NW2	19	100-year	33.20	205.10	207.13	206.53	207.25	0.002001	1.56	21.23	297.00	0.42
NW2	19	Regional	18.15	205.10	207.30	206.19	207.30	0.000036	0.18	175.60	329.17	0.05
NW2	9	100-year	33.20	205.91	207.19	206.51	207.19	0.000092	0.34	202.88	338.00	0.10
NW2	9	Regional	18.15	205.91	207.30	206.40	207.30	0.000016	0.15	242.75	354.33	0.04
NW3	1127	100-year	42.70	205.15	207.15	206.23	207.16	0.000341	0.70	84.13	72.47	0.18
NW3	1127	Regional	50.50	205.15	207.27	206.30	207.29	0.000352	0.75	92.79	73.97	0.18
NW3	1018	100-year	42.70	204.70	207.13		207.14	0.000224	0.69	90.43	58.47	0.15
NW3	1018	Regional	50.50	204.70	207.25		207.26	0.000247	0.76	97.57	59.02	0.16
NW3	882	100-year	42.70	204.32	207.11	205.45	207.12	0.000102	0.52	119.03	68.07	0.11
NW3	882	Regional	50.50	204.32	207.23	205.50	207.24	0.000118	0.57	126.99	76.15	0.11
NW3	754	100-year	42.70	203.90	207.10		207.11	0.000063	0.45	147.88	112.61	0.09
NW3	754	Regional	50.50	203.90	207.22		207.23	0.000069	0.49	161.66	118.74	0.09
NW3	735	100-year	42.70	203.90	207.10	205.22	207.11	0.000057	0.42	142.05	101.70	0.08
NW3	735	Regional	50.50	203.90	207.22	205.31	207.23	0.000065	0.45	154.48	109.34	0.09
NW3	709		Culvert									
NW3	693	100-year	42.70	203.63	207.01	205.49	207.08	0.000561	1.37	46.41	105.04	0.25
NW3	693	Regional	50.50	203.63	207.15	205.65	207.21	0.000516	1.35	64.66	151.76	0.24
NW3	685	100-year	42.70	203.59	207.02	205.51	207.07	0.000503	1.26	57.27	152.64	0.23
NW3	685	Regional	50.50	203.59	207.16	205.71	207.19	0.000370	1.12	80.39	174.19	0.20
NW3	656		Culvert									
NW3	632	100-year	42.70	203.39	206.85	205.46	206.89	0.000391	1.15	55.76	96.41	0.21
NW3	632	Regional	50.50	203.39	207.16	205.64	207.18	0.000187	0.85	101.46	202.64	0.15
NW3	626	100-year	42.70	203.42	206.86	205.48	206.87	0.000221	0.79	78.90	134.74	0.15
NW3	626	Regional	50.50	203.42	207.16	205.67	207.17	0.000107	0.58	136.15	215.28	0.11
NW3	574		Culvert									
NW3	547	100-year	42.70	202.24	206.86	204.45	206.87	0.000021	0.30	253.59	265.57	0.05
NW3	547	Regional	50.50	202.24	207.16	204.60	207.16	0.000014	0.26	340.66	319.61	0.04
NW3	490	100-year	45.67	202.20	206.86		206.86	0.000019	0.31	225.60	223.27	0.05
NW3	490	Regional	52.99	202.20	207.16		207.16	0.000013	0.26	297.80	253.53	0.04
NW3	389	100-year	45.67	201.69	206.86	203.80	206.86	0.000002	0.11	426.85	278.64	0.02
NW3	389	Regional	52.99	201.69	207.16	203.92	207.16	0.000002	0.10	516.37	332.19	0.02
NW3	305	100-year	45.67	201.31	206.86	203.44	206.86	0.000003	0.13	555.78	414.73	0.02
NW3	305	Regional	52.99	201.31	207.16	203.75	207.16	0.000002	0.12	683.37	427.51	0.02
NW3	245	100-year	45.67	201.11	206.86		206.86	0.000002	0.11	648.13	403.09	0.02
NW3	245	Regional	52.99	201.11	207.16		207.16	0.000002	0.11	783.36	471.04	0.01
NW3	213	100-year	45.67	201.07	206.85		206.86	0.000037	0.49	115.02	393.38	0.07
NW3	213	Regional	52.99	201.07	207.15		207.16	0.000034	0.49	130.57	393.38	0.07
NW3	185		Mult Open									
NW3	153	100-year	45.67	200.57	202.91	202.52	203.21	0.003793	2.50	20.91	18.25	0.60
NW3	153	Regional	52.99	200.57	202.99	202.68	203.34	0.004335	2.75	22.20	18.95	0.65
NW3	96	100-year	45.31	200.31	202.82		202.99	0.001992	1.93	27.18	21.59	0.44
NW3	96	Regional	53.35	200.31	202.87		203.10	0.002508	2.20	28.26	22.19	0.50
NW3	47	100-year	45.31	200.01	202.80		202.90	0.001165	1.43	34.83	25.57	0.34
NW3	47	Regional	53.35	200.01	202.84		202.97	0.001476	1.64	36.00	25.95	0.38
NW4	397	100-year	63.61	199.88	201.90	201.90	202.55	0.008144	3.86	21.19	18.76	0.90
NW4	397	Regional	66.22	199.88	201.96	201.96	202.60	0.007872	3.87	22.21	19.34	0.89
NW4	358	100-year	63.61	199.17	201.68	201.57	202.21	0.006105	3.78	22.69	19.11	0.80
NW4	358	Regional	66.22	199.17	201.80	201.64	202.28	0.005242	3.62	25.07	20.70	0.75
NW4	293	100-year	63.61	198.77	201.91		201.97	0.000638	1.46	66.27	64.83	0.27
NW4	293	Regional	66.22	198.77	202.01		202.07	0.000551	1.39	73.01	67.54	0.25
NW4	274	100-year	63.61	198.62	201.91	200.69	201.95	0.000394	1.15	87.91	125.98	0.21

HEC-RAS Plan: 16MilkeCK-Future (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
NW4	274	Regional	66.22	198.62	202.02	200.73	202.05	0.000308	1.04	102.14	145.20	0.19
NW4	248		Culvert									
NW4	230	100-year	63.61	198.30	201.47	200.30	201.63	0.001507	1.77	35.91	45.52	0.39
NW4	230	Regional	66.22	198.30	201.85	200.34	201.92	0.000670	1.24	71.37	112.32	0.26
NW4	207	100-year	64.45	198.27	201.44	200.48	201.58	0.001384	1.89	52.00	70.81	0.38
NW4	207	Regional	67.66	198.27	201.84	200.52	201.90	0.000515	1.27	84.94	97.51	0.24
NW4	127	100-year	64.45	197.86	201.41	200.01	201.49	0.000674	1.38	62.61	78.17	0.27
NW4	127	Regional	67.66	197.86	201.82	200.05	201.86	0.000288	0.99	92.33	114.48	0.18
NW4	53	100-year	64.45	197.44	201.43	199.66	201.45	0.000144	0.68	115.67	141.76	0.13
NW4	53	Regional	67.66	197.44	201.83	199.69	201.84	0.000090	0.58	137.53	157.83	0.10
N1	387	100-year	8.80	218.49	219.08	219.08	219.19	0.012218	1.91	9.98	36.51	0.89
N1	387	Regional	17.25	218.49	219.22	219.19	219.39	0.015493	2.54	15.20	41.07	1.04
N1	274	100-year	8.80	218.07	218.61		218.63	0.002667	0.91	18.42	43.88	0.42
N1	274	Regional	17.25	218.07	219.00		219.02	0.001245	0.92	37.49	53.19	0.31
N1	256	100-year	8.80	217.98	218.45	218.36	218.53	0.008843	1.49	9.35	40.89	0.74
N1	256	Regional	17.25	217.98	218.93	218.52	218.98	0.002339	1.27	22.62	50.64	0.43
N1	230		Culvert									
N1	208	100-year	8.80	217.84	218.26	218.13	218.32	0.010090	1.48	10.20	60.00	0.78
N1	208	Regional	17.25	217.84	218.37	218.28	218.51	0.016695	2.27	13.13	62.72	1.04
N1	192	100-year	8.80	217.73	217.95	217.95	218.04	0.033993	1.80	9.35	56.40	1.29
N1	192	Regional	17.25	217.73	218.09	218.04	218.19	0.019871	1.95	17.56	61.83	1.07
N1	103	100-year	8.80	216.71	217.56	217.28	217.58	0.001229	0.78	20.88	46.86	0.30
N1	103	Regional	17.25	216.71	217.72	217.41	217.77	0.001940	1.13	28.79	48.77	0.39
N2	211	100-year	8.44	217.47	218.34		218.43	0.004683	1.35	6.32	11.33	0.56
N2	211	Regional	16.48	217.47	218.46		218.70	0.009503	2.18	7.73	11.89	0.83
N2	171	100-year	8.44	217.35	217.93	217.92	218.11	0.014367	2.04	5.83	33.59	0.96
N2	171	Regional	16.48	217.35	218.15	218.13	218.31	0.008708	2.07	15.30	39.97	0.80
N2	127	100-year	8.44	216.96	217.68		217.76	0.004472	1.39	10.56	28.59	0.56
N2	127	Regional	16.48	216.96	217.88		218.00	0.005435	1.83	16.44	31.15	0.65
N2	65	100-year	8.44	216.66	217.40	217.24	217.45	0.005380	1.37	13.87	41.87	0.60
N2	65	Regional	16.48	216.66	217.59	217.42	217.65	0.005638	1.71	22.11	46.32	0.64
N2	32	100-year	8.44	216.53	217.32		217.34	0.001954	0.97	20.45	47.48	0.38
N2	32	Regional	16.48	216.53	217.47		217.51	0.003025	1.38	28.01	50.37	0.48
N3	2941	100-year	27.01	215.82	216.73	216.67	216.84	0.010127	2.10	20.26	51.88	0.84
N3	2941	Regional	41.07	215.82	216.88	216.79	217.01	0.008694	2.24	28.36	56.91	0.81
N3	2811	100-year	27.01	214.54	215.63		215.78	0.006918	2.20	18.00	30.52	0.74
N3	2811	Regional	41.07	214.54	215.81		216.01	0.007053	2.52	23.73	31.85	0.77
N3	2703	100-year	27.01	213.73	214.72		214.92	0.009801	2.53	16.26	30.59	0.87
N3	2703	Regional	41.07	213.73	214.89		215.13	0.009850	2.86	21.46	31.46	0.90
N3	2605	100-year	27.01	212.88	214.00	213.91	214.16	0.007424	2.31	17.76	30.95	0.77
N3	2605	Regional	41.07	212.88	214.18	214.05	214.38	0.007327	2.59	23.65	32.19	0.79
N3	2491	100-year	27.01	212.00	212.94	212.94	213.17	0.011457	2.61	15.23	31.43	0.93
N3	2491	Regional	41.07	212.00	213.09	213.09	213.38	0.012138	3.00	19.89	32.34	0.99
N3	2378	100-year	27.01	210.93	212.31		212.37	0.001774	1.38	28.26	33.48	0.40
N3	2378	Regional	41.07	210.93	212.73		212.78	0.001204	1.38	42.52	35.54	0.34
N3	2273	100-year	27.01	210.62	212.26		212.28	0.000527	0.86	42.59	34.44	0.22
N3	2273	Regional	41.07	210.62	212.68		212.71	0.000489	0.98	57.61	36.80	0.22
N3	2214.61	100-year	27.01	210.34	212.24	211.18	212.26	0.000321	0.74	50.43	36.51	0.18
N3	2214.61	Regional	41.07	210.34	212.66	211.32	212.69	0.000326	0.86	66.40	38.89	0.19
N3	2170	100-year	27.01	210.31	212.21	211.21	212.24	0.000497	0.94	38.68	34.21	0.22
N3	2170	Regional	41.07	210.31	212.66	211.38	212.67	0.000142	0.58	119.62	88.85	0.12
N3	2148		Mult Open									

HEC-RAS Plan: 16MilkeCK-Future (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
N3	2124	100-year	27.01	210.19	212.02	211.15	212.03	0.000328	0.69	55.20	115.99	0.18
N3	2124	Regional	41.07	210.19	212.51	211.34	212.53	0.000271	0.76	97.72	169.03	0.17
N3	2106	100-year	27.01	210.17	212.02		212.03	0.000157	0.50	59.24	187.26	0.12
N3	2106	Regional	41.07	210.17	212.51		212.52	0.000137	0.56	81.43	194.04	0.12
N3	2002	100-year	27.01	209.90	212.02		212.02	0.000017	0.19	220.92	321.54	0.04
N3	2002	Regional	41.07	209.90	212.51		212.52	0.000019	0.23	302.34	353.90	0.05
N3	1904	100-year	27.01	209.54	212.02	210.32	212.02	0.000018	0.21	217.81	161.54	0.04
N3	1904	Regional	41.07	209.54	212.51	210.46	212.51	0.000015	0.22	298.88	199.25	0.04
N3	1760	100-year	27.01	209.34	212.00	210.37	212.01	0.000153	0.64	63.28	88.94	0.13
N3	1760	Regional	41.07	209.34	212.50	210.63	212.51	0.000115	0.63	115.91	121.70	0.12
N3	1719.38	100-year	21.07	209.12	212.00		212.00	0.000080	0.48	73.97	78.45	0.09
N3	1719.38	Regional	40.95	209.12	212.49		212.50	0.000105	0.62	132.40	174.88	0.11
N3	1701	100-year	21.07	208.98	211.99	209.80	212.00	0.000095	0.55	40.39	58.92	0.10
N3	1701	Regional	40.95	208.98	212.49	210.17	212.50	0.000096	0.62	118.76	179.51	0.11
N3	1686		Culvert									
N3	1668	100-year	21.07	208.66	210.92	209.85	210.98	0.000815	1.04	20.95	36.90	0.27
N3	1668	Regional	40.95	208.66	211.69	210.33	211.72	0.000427	0.98	59.78	53.73	0.21
N3	1651.71	100-year	21.07	208.61	210.92		210.95	0.000526	0.85	34.18	44.89	0.22
N3	1651.71	Regional	40.95	208.61	211.69		211.71	0.000291	0.83	71.55	54.50	0.17
N3	1613	100-year	21.07	208.43	210.91		210.93	0.000367	0.72	38.24	43.07	0.18
N3	1613	Regional	40.95	208.43	211.68		211.70	0.000242	0.77	75.64	55.84	0.16
N3	1567	100-year	21.07	208.22	210.90	209.61	210.92	0.000288	0.72	40.92	41.79	0.17
N3	1567	Regional	40.95	208.22	211.67	210.10	211.69	0.000232	0.81	77.78	59.54	0.16
N3	1488	100-year	21.07	207.87	210.90		210.91	0.000053	0.32	113.95	121.97	0.07
N3	1488	Regional	40.95	207.87	211.68		211.68	0.000032	0.31	228.77	180.81	0.06
N3	1451	100-year	21.07	207.73	210.89	209.12	210.90	0.000121	0.51	47.27	224.09	0.11
N3	1451	Regional	40.95	207.73	211.68	209.58	211.68	0.000009	0.17	418.70	273.47	0.03
N3	1411		Culvert									
N3	1368	100-year	21.07	207.25	209.17	208.41	209.19	0.000495	0.72	31.28	43.39	0.21
N3	1368	Regional	40.95	207.25	209.31	208.65	209.38	0.001263	1.25	35.24	51.57	0.34
N3	1355	100-year	42.31	207.18	209.06	208.71	209.15	0.003097	1.73	34.23	39.22	0.50
N3	1355	Regional	55.74	207.18	209.24	208.82	209.35	0.003072	1.89	41.42	56.46	0.51
N3	1241	100-year	42.31	206.69	208.77	208.29	208.89	0.002396	1.88	31.41	34.76	0.47
N3	1241	Regional	55.74	206.69	208.87	208.43	209.04	0.003317	2.30	34.00	36.63	0.56
N3	1126	100-year	42.31	206.20	208.61	207.80	208.70	0.001285	1.54	37.39	70.84	0.36
N3	1126	Regional	55.74	206.20	208.78	207.97	208.83	0.000926	1.38	70.79	74.49	0.31
N3	989	100-year	42.31	205.62	208.59	207.07	208.62	0.000267	0.87	74.03	90.86	0.17
N3	989	Regional	55.74	205.62	208.72	207.21	208.76	0.000369	1.05	81.08	109.53	0.20
N3	961	100-year	42.31	205.50	208.59		208.61	0.000192	0.76	96.81	67.78	0.15
N3	961	Regional	55.74	205.50	208.73		208.75	0.000257	0.91	106.03	68.96	0.17
N3	952	100-year	42.31	205.46	208.59	207.10	208.60	0.000181	0.70	103.96	73.26	0.14
N3	952	Regional	55.74	205.46	208.73	207.10	208.74	0.000241	0.84	113.94	74.43	0.16
N3	943		Culvert									
N3	930	100-year	42.31	205.36	208.59	206.83	208.60	0.000084	0.53	137.03	87.52	0.10
N3	930	Regional	55.74	205.36	208.73	206.94	208.74	0.000116	0.65	149.13	90.48	0.12
N3	913	100-year	42.31	205.26	208.59		208.60	0.000024	0.28	226.63	105.62	0.05
N3	913	Regional	55.74	205.26	208.73		208.73	0.000035	0.35	241.15	106.80	0.06
N3	866	100-year	42.31	205.00	208.59	205.91	208.59	0.000002	0.08	730.67	283.47	0.01
N3	866	Regional	55.74	205.00	208.73	205.94	208.73	0.000003	0.11	769.99	292.04	0.02
N3	838	100-year	42.31	204.82	208.52	206.61	208.58	0.000364	1.18	77.29	181.18	0.21
N3	838	Regional	55.74	204.82	208.65	206.91	208.71	0.000428	1.31	102.08	196.15	0.22

HEC-RAS Plan: 16MilkeCK-Future (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
N3	782		Culvert									
N3	732	100-year	42.31	204.44	206.86	206.02	206.97	0.001188	1.48	31.57	180.86	0.34
N3	732	Regional	55.74	204.44	207.24	206.22	207.25	0.000117	0.52	208.45	212.03	0.11
N3	698	100-year	41.01	204.20	206.88		206.91	0.000386	0.90	78.92	101.66	0.20
N3	698	Regional	57.90	204.20	207.21		207.23	0.000315	0.90	113.57	109.22	0.18
N3	618	100-year	41.01	203.82	206.85		206.89	0.000077	1.05	77.87	61.48	0.21
N3	618	Regional	57.90	203.82	207.16		207.22	0.000093	1.25	97.35	64.92	0.24
N3	585	100-year	41.01	203.65	206.85		206.89	0.000052	0.89	83.96	68.67	0.18
N3	585	Regional	57.90	203.65	207.16		207.21	0.000064	1.07	106.55	76.85	0.20
N3	365	100-year	41.01	202.76	206.87		206.88	0.000013	0.53	200.78	97.82	0.09
N3	365	Regional	57.90	202.76	207.18		207.19	0.000017	0.66	232.00	107.13	0.11
N3	236	100-year	41.01	202.34	206.87		206.87	0.000008	0.47	236.38	107.28	0.08
N3	236	Regional	57.90	202.34	207.18		207.19	0.000012	0.59	271.47	126.12	0.09
N3	71	100-year	41.01	201.62	206.87		206.87	0.000004	0.35	446.26	211.04	0.05
N3	71	Regional	57.90	201.62	207.18		207.19	0.000005	0.42	513.70	216.31	0.06
N3	61	100-year	41.01	201.54	206.85		206.87	0.000010	0.58	75.60	226.33	0.09
N3	61	Regional	57.90	201.54	207.15		207.18	0.000017	0.77	80.66	228.24	0.11
N3	34		Culvert									
N3	8	100-year	41.01	201.37	203.40	202.92	203.57	0.001416	1.93	25.50	44.42	0.50
N3	8	Regional	57.90	201.37	203.80	203.16	203.99	0.001248	2.05	34.15	54.58	0.48
N3	4	100-year	41.01	201.17	203.44		203.52	0.000698	1.63	48.36	45.55	0.37
N3	4	Regional	57.90	201.17	203.86		203.93	0.000544	1.64	69.39	63.60	0.34
N4	524	100-year	66.61	200.14	203.14		203.41	0.003201	2.31	28.89	16.32	0.54
N4	524	Regional	94.14	200.14	203.45	202.77	203.82	0.003824	2.72	37.08	39.84	0.60
N4	483	100-year	66.61	199.96	203.07		203.28	0.002414	2.01	33.16	18.07	0.47
N4	483	Regional	94.14	199.96	203.35		203.66	0.003315	2.46	38.45	22.47	0.56
N4	458	100-year	66.61	199.89	203.09	201.60	203.19	0.000933	1.40	47.61	32.33	0.30
N4	458	Regional	94.14	199.89	203.38	201.93	203.53	0.001205	1.70	58.04	62.68	0.35
N4	444		Culvert									
N4	402	100-year	66.61	199.38	202.24	201.37	202.34	0.001210	1.50	61.23	65.08	0.34
N4	402	Regional	94.14	199.38	202.49	201.89	202.60	0.001314	1.70	78.62	75.02	0.37
N4	381	100-year	66.61	199.35	202.22	201.41	202.31	0.001147	1.49	64.04	64.79	0.33
N4	381	Regional	94.14	199.35	202.47	201.84	202.57	0.001256	1.69	83.44	91.60	0.36
N4	341	100-year	66.61	199.08	202.14	201.45	202.26	0.001320	1.72	59.10	61.08	0.36
N4	341	Regional	94.14	199.08	202.37	201.83	202.51	0.001586	2.00	73.25	64.46	0.40
N4	249	100-year	66.61	198.69	202.12	200.66	202.17	0.000428	1.10	87.95	98.32	0.22
N4	249	Regional	94.14	198.69	202.36	200.99	202.41	0.000480	1.23	110.81	99.13	0.23
N4	236	100-year	66.61	198.41	201.86	201.58	202.10	0.002937	2.50	43.78	67.07	0.46
N4	236	Regional	94.14	198.41	202.19	202.00	202.36	0.002300	2.37	65.83	69.64	0.41
N4	213		Culvert									
N4	192	100-year	66.61	197.84	201.73	199.95	201.85	0.000135	1.56	61.45	76.12	0.28
N4	192	Regional	94.14	197.84	202.16	200.35	202.28	0.000129	1.66	95.94	82.12	0.28
N4	172	100-year	67.29	197.80	201.39	200.92	201.76	0.000696	2.92	36.52	43.27	0.59
N4	172	Regional	94.51	197.80	202.07	201.61	202.25	0.000324	2.34	76.45	63.58	0.42
N4	136	100-year	67.29	197.75	200.95	200.87	201.70	0.001499	3.95	21.00	17.48	0.85
N4	136	Regional	94.51	197.75	201.52	201.52	202.18	0.001100	3.93	35.48	28.44	0.75
N4	65	100-year	67.29	197.35	201.30		201.49	0.000284	2.20	47.86	32.80	0.40
N4	65	Regional	94.51	197.35	201.67		201.90	0.000320	2.52	60.14	34.13	0.43
W1	6800	100-year	64.01	219.74	221.09	221.02	221.40	0.009876	3.41	42.41	61.76	0.95
W1	6800	Regional	246.98	219.74	222.21	221.93	222.50	0.006234	4.08	167.56	122.87	0.83
W1	6725	100-year	64.01	219.00	220.82		220.91	0.004091	2.52	74.67	82.09	0.61
W1	6725	Regional	246.98	219.00	221.84		222.04	0.006182	4.23	171.60	111.07	0.82

HEC-RAS Plan: 16MilkeCK-Future (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
W1	6605	100-year	64.01	218.47	219.92	219.92	220.25	0.010090	3.57	46.93	74.01	0.97
W1	6605	Regional	246.98	218.47	220.91	220.77	221.30	0.008840	4.78	141.10	101.41	0.99
W1	6561	100-year	64.01	218.18	219.59		219.69	0.008417	2.99	59.48	72.77	0.83
W1	6561	Regional	246.98	218.18	220.62	220.04	220.84	0.009143	4.59	142.62	88.14	0.96
W1	6506	100-year	64.01	217.86	219.30		219.39	0.007007	2.82	62.55	72.78	0.76
W1	6506	Regional	246.98	217.86	220.21	219.71	220.46	0.010337	4.79	133.35	82.14	1.01
W1	6462	100-year	64.01	217.66	218.81	218.77	219.03	0.012151	3.26	50.50	83.69	1.01
W1	6462	Regional	246.98	217.66	219.76	219.51	220.08	0.009544	4.43	142.19	105.89	1.00
W1	6393	100-year	64.01	217.06	218.50	218.07	218.54	0.002204	1.66	122.23	178.93	0.45
W1	6393	Regional	246.98	217.06	219.54	218.66	219.59	0.001703	2.12	324.88	203.88	0.44
W1	6246	100-year	64.01	216.60	218.39	217.65	218.40	0.000561	0.97	196.16	184.68	0.24
W1	6246	Regional	246.98	216.60	219.40	218.08	219.43	0.000961	1.72	387.16	193.90	0.33
W1	6204	100-year	64.01	216.19	218.04	218.04	218.32	0.010435	3.80	52.33	83.64	0.96
W1	6204	Regional	246.98	216.19	218.99	218.81	219.32	0.009874	5.03	146.69	114.81	1.00
W1	6053	100-year	64.01	214.80	216.73	216.60	216.85	0.005552	2.57	71.10	105.05	0.67
W1	6053	Regional	246.98	214.80	217.63	217.21	217.84	0.006654	3.84	174.63	131.03	0.79
W1	5986	100-year	64.01	214.42	216.26	216.26	216.48	0.009542	3.21	57.75	102.10	0.87
W1	5986	Regional	246.98	214.42	216.88	216.88	217.34	0.016624	5.40	123.56	112.78	1.22
W1	5784	100-year	64.01	214.09	215.22	214.39	215.22	0.000228	0.45	300.58	286.04	0.14
W1	5784	Regional	246.98	214.09	215.90	214.52	215.92	0.000661	1.06	536.54	402.54	0.26
W1	5767	100-year	64.01	213.58	215.21	214.60	215.21	0.000232	0.57	280.00	286.80	0.15
W1	5767	Regional	246.98	213.58	215.89	214.73	215.91	0.000667	1.24	508.92	335.55	0.27
W1	5750		Mult Open									
W1	5737	100-year	64.01	213.30	214.34	214.34	214.35	0.001573	0.90	180.38	339.95	0.34
W1	5737	Regional	246.98	213.30	214.81	214.34	214.84	0.003140	1.77	335.33	355.18	0.52
W1	5721	100-year	65.13	213.25	213.90		213.90	0.001121	0.47	188.17	258.18	0.25
W1	5721	Regional	252.69	213.25	214.70		214.72	0.001333	1.09	446.46	362.63	0.34
W1	5428	100-year	65.13	211.82	213.72	213.21	213.77	0.001479	1.53	107.20	195.21	0.38
W1	5428	Regional	252.69	211.82	214.45	213.92	214.54	0.002358	2.47	309.80	250.43	0.51
W1	5373	100-year	65.13	211.56	213.46	213.23	213.60	0.006088	2.95	69.62	172.65	0.72
W1	5373	Regional	252.69	211.56	214.25	213.92	214.35	0.004538	3.29	265.73	256.66	0.67
W1	5264	100-year	65.13	211.03	213.50	212.64	213.51	0.000316	0.83	257.15	264.71	0.18
W1	5264	Regional	252.69	211.03	214.19	213.26	214.23	0.000944	1.73	456.55	309.12	0.33
W1	5197	100-year	65.13	210.70	213.48	212.25	213.49	0.000146	0.65	297.80	225.06	0.13
W1	5197	Regional	252.69	210.70	214.13	212.79	214.17	0.000708	1.65	454.61	273.06	0.29
W1	5184	100-year	65.13	210.65	213.47	212.33	213.49	0.000226	0.81	239.99	212.42	0.16
W1	5184	Regional	252.69	210.65	214.09	213.36	214.15	0.001078	2.04	395.77	278.16	0.36
W1	5161		Bridge									
W1	5149	100-year	65.13	210.54	212.16	212.08	212.50	0.006769	2.79	35.60	123.11	0.78
W1	5149	Regional	252.69	210.54	213.10	213.00	213.29	0.003575	2.91	215.88	213.97	0.62
W1	5123	100-year	65.13	210.47	212.24	211.90	212.32	0.002955	1.92	84.18	125.24	0.51
W1	5123	Regional	252.69	210.47	213.07	212.69	213.24	0.004463	3.21	218.22	179.91	0.68
W1	5102	100-year	65.13	210.38	212.11	211.96	212.25	0.005485	2.61	71.68	131.07	0.70
W1	5102	Regional	252.69	210.38	212.99	212.66	213.17	0.005228	3.52	213.60	178.17	0.74
W1	5081	100-year	65.13	210.28	212.11	211.78	212.17	0.002902	1.86	92.86	129.46	0.50
W1	5081	Regional	252.69	210.28	212.96	212.46	213.09	0.004219	3.07	224.85	165.01	0.65
W1	5056	100-year	65.13	210.19	212.05	211.73	212.11	0.002286	1.76	103.58	136.05	0.46
W1	5056	Regional	252.69	210.19	212.84	212.34	212.98	0.004054	3.11	224.36	165.79	0.65
W1	4897	100-year	65.13	209.64	211.45	211.43	211.61	0.006804	2.59	75.39	229.95	0.74
W1	4897	Regional	252.69	209.64	211.79	211.77	212.04	0.012679	4.15	187.08	247.73	1.06
W1	4542	100-year	65.13	208.39	209.77	209.51	209.85	0.004122	2.09	76.53	236.07	0.60
W1	4542	Regional	252.69	208.39	210.48	209.98	210.54	0.002849	2.36	309.68	288.40	0.54

HEC-RAS Plan: 16MilkeCK-Future (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
W1	4491	100-year	65.13	208.21	209.67	209.38	209.70	0.001700	1.34	158.26	297.80	0.39
W1	4491	Regional	252.69	208.21	210.36	209.80	210.41	0.002062	1.99	397.17	383.18	0.46
W1	4419	100-year	65.13	207.95	209.24	209.09	209.48	0.007326	2.58	50.78	202.75	0.79
W1	4419	Regional	252.69	207.95	210.13	209.77	210.24	0.003037	2.48	301.39	328.57	0.56
W1	4317	100-year	65.13	207.59	209.00	208.71	209.06	0.002647	1.75	111.70	183.89	0.49
W1	4317	Regional	252.69	207.59	209.92	209.27	210.00	0.002609	2.47	312.91	307.19	0.53
W1	4170	100-year	65.13	207.09	208.41	208.16	208.58	0.005829	2.35	66.29	127.92	0.71
W1	4170	Regional	252.69	207.09	209.55	208.97	209.68	0.002786	2.59	269.42	223.30	0.55
W1	4071	100-year	65.13	206.73	208.19	207.88	208.28	0.002122	1.54	80.00	118.27	0.44
W1	4071	Regional	252.69	206.73	209.43	208.69	209.53	0.001365	1.95	313.64	277.95	0.39
W1	3974	100-year	65.13	206.35	207.82	207.61	207.98	0.003593	2.05	60.99	95.84	0.57
W1	3974	Regional	252.69	206.35	209.10	208.47	209.30	0.002561	2.72	207.00	217.54	0.54
W1	3832	100-year	66.25	205.82	207.55	207.02	207.64	0.001941	1.76	78.08	70.05	0.44
W1	3832	Regional	255.50	205.82	208.52	207.95	208.88	0.004833	3.78	167.80	181.39	0.74
W1	3761	100-year	66.25	205.40	207.54	206.26	207.57	0.000365	0.85	85.60	51.86	0.19
W1	3761	Regional	255.50	205.40	208.45	207.23	208.69	0.001467	2.19	138.72	148.35	0.42
W1	3727	100-year	66.25	205.36	207.54	206.07	207.56	0.000168	0.58	121.56	76.69	0.13
W1	3727	Regional	255.50	205.36	208.52	206.87	208.61	0.000580	1.41	242.22	222.12	0.26
W1	3687	100-year	66.25	205.32	207.50	206.42	207.55	0.000556	1.06	96.11	67.80	0.24
W1	3687	Regional	255.50	205.32	208.26	207.33	208.55	0.002497	2.78	206.72	281.22	0.54
W1	3626	100-year	66.25	205.16	207.48	206.38	207.51	0.000403	0.93	114.75	91.90	0.21
W1	3626	Regional	255.50	205.16	208.17	207.24	208.40	0.001945	2.47	205.96	290.33	0.47
W1	3610		Bridge									
W1	3598	100-year	66.25	204.68	206.47	206.18	206.80	0.006472	2.58	28.96	62.36	0.66
W1	3598	Regional	255.50	204.68	208.03	207.43	208.20	0.002342	2.47	200.83	201.82	0.45
W1	3579	100-year	66.25	204.62	206.43	206.06	206.65	0.003973	2.15	37.63	47.71	0.60
W1	3579	Regional	255.50	204.62	207.45	207.45	208.02	0.005705	3.77	118.59	118.21	0.79
W1	3530	100-year	66.25	204.34	206.37	205.76	206.51	0.001586	1.75	50.72	71.38	0.43
W1	3530	Regional	255.50	204.34	207.47	206.89	207.70	0.001952	2.71	174.49	154.33	0.52
W1	3509	100-year	66.25	204.24	205.99	205.99	206.41	0.009003	3.17	32.49	40.47	0.89
W1	3509	Regional	255.50	204.24	207.10	207.10	207.60	0.007014	4.23	145.55	155.74	0.87
W1	3124	100-year	66.53	202.56	204.83	204.40	204.88	0.002195	1.86	102.88	112.66	0.43
W1	3124	Regional	255.34	202.56	206.43	205.04	206.49	0.001302	2.15	309.04	138.67	0.36
W1	3036	100-year	66.53	202.31	204.45		204.61	0.003928	2.53	69.46	91.92	0.60
W1	3036	Regional	255.34	202.31	206.25		206.36	0.001587	2.54	253.71	110.32	0.43
W1	2943	100-year	66.53	202.06	204.14		204.32	0.003436	2.46	66.39	83.21	0.58
W1	2943	Regional	255.34	202.06	206.21		206.27	0.000788	1.95	346.67	160.56	0.32
W1	2859	100-year	66.53	201.84	203.68	203.68	203.95	0.005926	3.03	59.50	115.34	0.75
W1	2859	Regional	255.34	201.84	206.20		206.23	0.000424	1.49	461.88	183.79	0.23
W1	2741	100-year	66.53	201.52	203.33	203.19	203.49	0.005099	2.60	72.96	113.64	0.67
W1	2741	Regional	255.34	201.52	206.19	203.92	206.21	0.000253	1.17	569.18	199.30	0.18
W1	2636	100-year	66.53	201.24	203.18		203.26	0.003061	2.17	87.39	101.15	0.53
W1	2636	Regional	255.34	201.24	206.18		206.20	0.000295	1.32	492.86	156.64	0.19
W1	2610	100-year	66.53	201.02	203.15		203.20	0.001475	1.72	104.50	99.78	0.39
W1	2610	Regional	255.34	201.02	206.17		206.19	0.000239	1.28	486.32	152.40	0.18
W1	2506	100-year	66.53	200.88	202.73	202.55	202.96	0.005628	2.88	42.12	50.46	0.72
W1	2506	Regional	255.34	200.88	206.16	203.62	206.18	0.000205	1.17	546.11	187.87	0.17
W1	2450	100-year	66.53	200.68	202.58	202.26	202.69	0.003065	2.10	77.47	101.91	0.54
W1	2450	Regional	255.34	200.68	206.16	203.14	206.17	0.000128	0.95	713.18	209.87	0.13
W1	2407	100-year	66.53	200.53	202.47	202.00	202.56	0.002043	1.86	77.30	104.81	0.45
W1	2407	Regional	255.34	200.53	206.15	202.84	206.16	0.000097	0.86	764.26	217.20	0.12
W1	2371	100-year	66.53	200.40	202.36	201.95	202.47	0.002205	1.99	66.51	91.45	0.47

HEC-RAS Plan: 16MilkeCK-Future (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
W1	2371	Regional	255.34	200.40	206.15	202.89	206.16	0.000032	0.51	795.72	248.07	0.07
W1	2323	100-year	66.53	200.23	202.31	201.80	202.39	0.001865	1.92	70.97	82.28	0.44
W1	2323	Regional	255.34	200.23	206.15	202.73	206.16	0.000041	0.59	820.96	273.92	0.08
W1	2299	100-year	66.53	200.15	202.25	201.86	202.35	0.001951	1.95	65.36	111.18	0.45
W1	2299	Regional	255.34	200.15	206.15	202.67	206.16	0.000033	0.53	818.49	257.31	0.07
W1	2274	100-year	66.53	200.06	201.41	201.41	202.19	0.019603	4.59	24.66	32.08	1.32
W1	2274	Regional	255.34	200.06	206.15	202.86	206.16	0.000046	0.64	808.15	237.52	0.08
W1	2246	100-year	66.53	200.09	201.21	201.07	201.24	0.003647	1.50	125.79	292.55	0.53
W1	2246	Regional	255.34	200.09	206.15	201.38	206.15	0.000011	0.30	1873.12	481.88	0.04
W1	2227		Bridge									
W1	2204	100-year	66.53	199.96	200.79	200.79	200.79	0.000064	0.18	500.71	343.62	0.07
W1	2204	Regional	255.34	199.96	206.15	200.79	206.15	0.000004	0.19	2680.70	566.76	0.02
W1	1849	100-year	66.81	197.15	200.68	199.16	200.71	0.000322	0.99	121.37	83.84	0.19
W1	1849	Regional	253.56	197.15	206.15	200.41	206.15	0.000005	0.26	2144.80	600.02	0.03
W1	1831	100-year	66.81	197.02	200.67	198.87	200.70	0.000282	0.89	110.09	252.76	0.18
W1	1831	Regional	253.56	197.02	206.13	200.31	206.14	0.000031	0.63	791.40	670.78	0.07
W1	1772		Mult Open									
W1	1721	100-year	66.81	196.75	199.24	198.32	199.31	0.000909	1.30	68.77	128.30	0.30
W1	1721	Regional	253.56	196.75	201.65	199.41	201.80	0.000686	1.96	185.91	208.39	0.30
W1	1685	100-year	66.81	196.75	199.23		199.27	0.000654	1.10	122.61	112.12	0.26
W1	1685	Regional	253.56	196.75	201.70		201.73	0.000239	1.17	520.17	201.03	0.18
W1	1645	100-year	66.81	196.74	199.09	198.44	199.22	0.001671	1.85	75.41	121.22	0.42
W1	1645	Regional	253.56	196.74	201.67	199.48	201.72	0.000367	1.50	517.64	282.67	0.22
W1	1630		Mult Open									
W1	1619	100-year	66.81	196.45	198.43	198.43	198.98	0.008402	3.47	26.27	195.36	0.88
W1	1619	Regional	253.56	196.45	201.69	198.69	201.70	0.000088	0.75	976.16	341.44	0.11
W1	1588	100-year	66.81	196.40	198.48		198.53	0.000894	1.28	126.59	133.56	0.30
W1	1588	Regional	253.56	196.40	201.68		201.69	0.000127	0.93	814.95	330.81	0.13
W1	1223	100-year	66.81	196.15	198.30		198.32	0.000655	1.11	154.26	117.81	0.26
W1	1223	Regional	253.56	196.15	201.67		201.68	0.000057	0.64	776.38	257.80	0.09
W1	1109	100-year	66.81	196.10	198.26		198.27	0.000251	0.68	222.55	159.16	0.16
W1	1109	Regional	253.56	196.10	201.67		201.67	0.000034	0.50	995.24	301.93	0.07
W1	1083	100-year	66.81	195.95	198.26		198.26	0.000086	0.42	368.06	250.74	0.09
W1	1083	Regional	253.56	195.95	201.67		201.67	0.000016	0.35	1455.53	396.10	0.05
W1	1053	100-year	66.81	195.91	198.21	197.14	198.25	0.000482	0.98	103.87	160.86	0.22
W1	1053	Regional	253.56	195.91	201.60	198.00	201.65	0.000193	1.21	319.37	315.19	0.17
W1	1032		Bridge									
W1	1006	100-year	66.81	195.85	197.57	197.41	197.86	0.006196	2.83	40.47	163.31	0.76
W1	1006	Regional	253.56	195.85	199.36	198.59	199.78	0.003622	3.72	122.74	236.41	0.66
W1	985	100-year	66.81	195.62	197.60		197.68	0.001866	1.73	93.21	142.79	0.43
W1	985	Regional	253.56	195.62	199.53		199.56	0.000505	1.49	477.62	245.24	0.25
W1	923	100-year	66.81	194.99	196.89	196.71	197.42	0.006751	3.29	23.60	22.06	0.81
W1	923	Regional	253.56	194.99	199.33	198.95	199.50	0.001258	2.58	319.10	249.71	0.41
W1	874	100-year	66.81	194.70	196.73	196.34	197.12	0.004315	2.79	27.69	30.31	0.66
W1	874	Regional	253.56	194.70	199.31	198.00	199.45	0.000909	2.30	326.31	211.05	0.35
W1	835	100-year	66.81	194.38	196.40	196.19	196.91	0.006152	3.25	24.16	25.80	0.78
W1	835	Regional	253.56	194.38	198.08	198.08	199.28	0.006886	5.36	81.17	149.75	0.92
W1	808	100-year	66.81	194.43	196.37	195.95	196.73	0.004111	2.69	28.69	30.36	0.64
W1	808	Regional	253.56	194.43	198.14	197.86	198.95	0.004401	4.39	115.92	104.95	0.74
W1	778	100-year	66.81	194.31	196.26	195.84	196.61	0.004036	2.69	30.18	26.34	0.63
W1	778	Regional	253.56	194.31	198.14	197.73	198.80	0.003612	4.06	125.41	95.82	0.67

HEC-RAS Plan: 16MilkeCK-Future (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
W1	741	100-year	66.81	193.95	195.96	195.79	196.42	0.005988	3.22	29.58	25.11	0.77
W1	741	Regional	253.56	193.95	197.79	197.79	198.61	0.005144	4.79	110.24	75.77	0.81
W1	722	100-year	66.81	193.94	195.90	195.71	196.26	0.005069	2.86	33.48	32.52	0.70
W1	722	Regional	253.56	193.94	197.79	197.30	198.37	0.003633	4.00	117.48	70.90	0.68
W1	705		Bridge									
W1	675	100-year	67.08	193.95	195.52	195.32	195.73	0.003189	2.04	33.79	81.42	0.54
W1	675	Regional	253.99	193.95	196.40	196.31	197.19	0.004891	3.46	66.80	104.97	0.72
W1	645	100-year	67.08	193.89	195.53	195.20	195.59	0.001547	1.41	79.49	99.97	0.37
W1	645	Regional	253.99	193.89	196.68	195.73	196.77	0.001315	1.92	204.90	159.09	0.38
W1	613	100-year	67.08	193.80	195.53	194.89	195.54	0.000401	0.77	145.29	173.40	0.19
W1	613	Regional	253.99	193.80	196.69	195.36	196.71	0.000336	1.02	385.92	234.86	0.20
W1	607		Bridge									
W1	603	100-year	67.08	193.79	195.52	194.90	195.53	0.000311	0.69	149.29	143.07	0.17
W1	603	Regional	253.99	193.79	196.67	195.23	196.71	0.000401	1.12	319.75	175.10	0.21
W1	590	100-year	67.08	193.74	195.51	194.78	195.52	0.000304	0.65	144.57	135.24	0.17
W1	590	Regional	253.99	193.74	196.65	195.20	196.69	0.000407	1.10	302.29	161.59	0.21
W1	513	100-year	67.08	192.98	195.35		195.47	0.001834	1.82	52.85	52.29	0.42
W1	513	Regional	253.99	192.98	196.04	196.04	196.58	0.006204	4.12	97.52	81.40	0.82
W1	421	100-year	67.08	192.18	195.41	194.32	195.42	0.000078	0.46	149.76	101.08	0.09
W1	421	Regional	253.99	192.18	196.19	194.80	196.26	0.000276	1.03	230.96	105.34	0.18
W1	333	100-year	67.08	191.41	195.40	193.97	195.41	0.000118	0.57	154.61	119.34	0.11
W1	333	Regional	253.99	191.41	196.17	194.94	196.23	0.000416	1.26	247.99	121.86	0.22
W1	230	100-year	67.08	190.18	195.40	192.76	195.41	0.000015	0.64	214.57	142.44	0.10
W1	230	Regional	253.99	190.18	196.16	194.79	196.21	0.000067	1.50	326.55	149.38	0.21
W1	189		Culvert									
W1	165	100-year	67.08	191.02	195.35	193.56	195.40	0.000102	1.28	98.88	93.45	0.21
W1	165	Regional	253.99	191.02	195.96	195.52	196.19	0.000454	3.00	161.02	108.57	0.46
W1	138	100-year	67.08	190.87	195.33		195.39	0.000104	1.37	99.96	106.72	0.22
W1	138	Regional	253.99	190.87	195.59	195.59	196.10	0.000886	4.17	128.20	111.65	0.66
M1	1313	100-year	131.78	196.90	201.39	200.01	201.44	0.000089	1.43	358.99	302.44	0.23
M1	1313	Regional	162.50	196.90	201.80	200.15	201.84	0.000066	1.31	485.72	317.07	0.20
M1	1302		Inl Struct									
M1	1280	100-year	131.78	196.26	200.24	199.46	200.52	0.000387	2.69	117.77	175.13	0.48
M1	1280	Regional	162.50	196.26	200.80	199.82	200.92	0.000180	2.04	305.06	301.59	0.34
M1	1263	100-year	131.78	196.08	199.87	199.41	200.42	0.000720	3.62	72.90	92.90	0.65
M1	1263	Regional	162.50	196.08	200.74	199.74	200.90	0.000218	2.35	263.86	257.96	0.37
M1	1189	100-year	131.78	195.87	199.44	199.43	200.32	0.001298	4.39	50.15	60.23	0.84
M1	1189	Regional	162.50	195.87	200.76	199.84	200.88	0.000174	2.08	282.49	237.58	0.33
M1	1139	100-year	131.78	195.70	199.57	199.13	199.69	0.000261	2.13	212.53	185.16	0.39
M1	1139	Regional	162.50	195.70	200.77	199.25	200.80	0.000056	1.22	455.22	215.94	0.19
M1	1092	100-year	131.78	195.30	199.58	198.80	199.67	0.000155	1.80	155.43	112.59	0.31
M1	1092	Regional	162.50	195.30	200.77	199.09	200.80	0.000040	1.11	297.76	126.56	0.16
M1	1010	100-year	131.78	195.15	199.61		199.65	0.000093	1.16	195.54	113.73	0.19
M1	1010	Regional	162.50	195.15	200.78		200.79	0.000030	0.79	351.29	158.87	0.11
M1	1000	100-year	131.78	194.84	199.57	198.45	199.64	0.000102	1.53	165.77	105.55	0.25
M1	1000	Regional	162.50	194.84	200.77	198.60	200.79	0.000032	1.03	313.57	136.35	0.15
M1	989		Culvert									
M1	978	100-year	131.78	194.36	199.58	198.51	199.63	0.000102	1.25	188.04	124.45	0.20
M1	978	Regional	162.50	194.36	200.76	198.68	200.78	0.000028	0.79	353.82	153.04	0.11
M1	958	100-year	135.90	194.16	199.41		199.59	0.000171	2.20	171.58	116.30	0.33
M1	958	Regional	164.54	194.16	200.70		200.76	0.000061	1.56	343.89	153.54	0.21

HEC-RAS Plan: 16MilkeCK-Future (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
M1	847	100-year	135.90	193.77	199.44		199.46	0.000024	0.85	363.02	191.61	0.13
M1	847	Regional	164.54	193.77	200.71		200.71	0.000008	0.58	641.93	252.91	0.08
M1	796	100-year	135.90	193.51	199.44	197.69	199.45	0.000018	0.73	404.90	201.53	0.10
M1	796	Regional	164.54	193.51	200.71	197.83	200.71	0.000006	0.52	684.35	240.29	0.07
M1	749	100-year	135.90	193.24	199.45	197.09	199.45	0.000010	0.56	459.75	200.28	0.08
M1	749	Regional	164.54	193.24	200.71	197.46	200.71	0.000004	0.42	724.41	224.90	0.05
M1	680	100-year	135.90	192.92	199.44	196.71	199.45	0.000024	0.46	389.65	190.98	0.07
M1	680	Regional	164.54	192.92	200.71	197.01	200.71	0.000007	0.30	645.72	218.31	0.04
M1	672	100-year	135.90	192.82	199.43	196.85	199.45	0.000028	0.92	336.96	146.19	0.13
M1	672	Regional	164.54	192.82	200.70	197.10	200.71	0.000012	0.70	546.72	199.76	0.09
M1	649	100-year	135.90	192.73	199.43	196.97	199.45	0.000023	0.90	319.17	135.29	0.12
M1	649	Regional	164.54	192.73	200.70	197.42	200.71	0.000010	0.69	539.48	210.45	0.08
M1	633	100-year	135.90	192.64	199.44	197.03	199.44	0.000012	0.61	443.16	183.92	0.08
M1	633	Regional	164.54	192.64	200.70	197.18	200.71	0.000005	0.46	692.62	224.07	0.06
M1	624		Culvert									
M1	612	100-year	135.90	192.78	199.42	196.98	199.43	0.000012	0.65	407.02	151.71	0.09
M1	612	Regional	164.54	192.78	200.70	197.17	200.71	0.000006	0.51	610.75	175.59	0.06
M1	593	100-year	147.21	192.71	199.41	196.70	199.43	0.000020	0.88	373.80	129.01	0.12
M1	593	Regional	175.63	192.71	200.69	196.87	200.70	0.000010	0.72	562.46	169.04	0.09
M1	546	100-year	147.21	192.51	199.40		199.43	0.000027	1.02	399.69	131.52	0.13
M1	546	Regional	175.63	192.51	200.69		200.70	0.000015	0.86	580.74	159.13	0.10
M1	523	100-year	147.21	192.40	199.41		199.42	0.000021	0.93	472.55	188.93	0.12
M1	523	Regional	175.63	192.40	200.69		200.70	0.000009	0.70	737.04	222.45	0.08
M1	517	100-year	147.21	192.38	199.40	196.47	199.42	0.000024	0.98	448.59	159.47	0.13
M1	517	Regional	175.63	192.38	200.69	196.64	200.70	0.000012	0.78	678.22	201.42	0.09
M1	510		Bridge									
M1	504	100-year	147.21	192.36	199.39	196.27	199.41	0.000022	0.96	459.82	170.55	0.13
M1	504	Regional	175.63	192.36	200.68	196.59	200.69	0.000011	0.75	700.89	208.00	0.09
M1	496	100-year	147.21	192.34	199.39	196.26	199.41	0.000022	0.95	465.60	172.36	0.12
M1	496	Regional	175.63	192.34	200.68	196.46	200.69	0.000010	0.74	706.83	204.97	0.09
M1	484	100-year	147.21	192.30	199.40	196.21	199.41	0.000020	0.92	481.63	178.02	0.12
M1	484	Regional	175.63	192.30	200.68	196.32	200.69	0.000009	0.71	733.30	212.61	0.08
M1	452	100-year	147.21	192.35	199.39	196.24	199.41	0.000021	0.96	473.99	193.87	0.12
M1	452	Regional	175.63	192.35	200.68	196.42	200.69	0.000009	0.71	740.85	220.55	0.08
M1	445		Bridge									
M1	441	100-year	147.21	192.33	199.38	196.19	199.40	0.000022	0.98	450.30	187.80	0.13
M1	441	Regional	175.63	192.33	200.68	196.37	200.69	0.000010	0.74	716.24	216.27	0.09
M1	409	100-year	147.21	192.30	199.38	196.20	199.40	0.000015	0.80	536.68	182.16	0.11
M1	409	Regional	175.63	192.30	200.68	196.36	200.69	0.000008	0.65	775.55	186.24	0.08
M1	388	100-year	147.21	192.17	199.38	195.70	199.40	0.000011	0.69	548.65	183.04	0.09
M1	388	Regional	175.63	192.17	200.68	195.89	200.69	0.000006	0.57	830.66	242.54	0.07
M1	374	100-year	147.21	191.96	199.33	194.55	199.38	0.000023	1.11	183.14	161.34	0.14
M1	374	Regional	175.63	191.96	200.67	194.78	200.69	0.000007	0.71	793.77	275.29	0.08
M1	353		Culvert									
M1	310	100-year	147.21	191.50	195.74	195.40	196.03	0.000461	2.89	86.35	99.52	0.51
M1	310	Regional	175.63	191.50	195.90	195.56	196.21	0.000493	3.08	97.81	117.69	0.53
M1	304	100-year	147.99	191.48	195.63	195.61	196.01	0.000634	3.35	95.46	117.17	0.60
M1	304	Regional	176.47	191.48	195.93		196.17	0.000436	2.94	134.33	141.80	0.50
M1	285	100-year	147.99	191.31	195.71		195.96	0.000448	2.87	116.84	110.11	0.50
M1	285	Regional	176.47	191.31	195.95		196.15	0.000384	2.78	144.30	129.09	0.47
M1	271	100-year	147.99	191.19	195.74	195.43	195.93	0.000363	2.56	131.76	132.77	0.45
M1	271	Regional	176.47	191.19	195.97	195.55	196.13	0.000307	2.46	163.22	137.49	0.42

HEC-RAS Plan: 16MilkeCK-Future (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
M1	246		Bridge									
M1	223	100-year	147.99	190.87	195.71	195.28	195.81	0.000208	2.09	181.68	158.67	0.34
M1	223	Regional	176.47	190.87	195.94	195.38	196.03	0.000184	2.05	218.61	159.37	0.33
M1	204	100-year	147.99	190.71	195.31	195.31	195.72	0.000649	3.48	94.64	135.92	0.60
M1	204	Regional	176.47	190.71	195.89		196.02	0.000237	2.33	182.59	160.48	0.37
M1	120	100-year	147.99	189.85	195.36	194.53	195.40	0.000101	1.42	210.40	135.19	0.23
M1	120	Regional	176.47	189.85	195.95	194.61	195.98	0.000054	1.14	299.90	157.19	0.17
M2	2447	100-year	220.30	189.39	195.32	193.11	195.38	0.000063	1.41	289.23	168.87	0.21
M2	2447	Regional	387.03	189.39	195.82	194.79	195.93	0.000105	1.95	385.92	198.36	0.27
M2	2438	100-year	220.30	189.20	195.03	194.76	195.32	0.000427	2.74	137.51	135.60	0.43
M2	2438	Regional	387.03	189.20	195.56	195.33	195.87	0.000491	3.19	230.44	239.97	0.47
M2	2426		Bridge									
M2	2409	100-year	220.30	188.85	193.26	193.26	194.74	0.002024	5.38	41.57	16.59	0.99
M2	2409	Regional	387.03	188.85	195.36	195.36	195.85	0.000484	3.74	218.05	225.35	0.53
M2	2397	100-year	220.30	188.86	192.92	192.85	194.14	0.001665	4.91	45.66	19.54	0.95
M2	2397	Regional	387.03	188.86	194.86	194.86	195.48	0.000513	3.91	181.85	186.20	0.58
M2	2385	100-year	220.30	188.81	193.09	192.69	194.04	0.001115	4.32	52.97	21.87	0.80
M2	2385	Regional	387.03	188.81	194.44	194.44	195.14	0.000616	4.12	157.88	171.56	0.63
M2	2366	100-year	220.30	188.82	193.49	192.42	193.85	0.000371	2.81	119.21	141.67	0.48
M2	2366	Regional	387.03	188.82	194.32	193.87	194.60	0.000290	2.86	253.21	173.10	0.44
M2	2347	100-year	220.30	188.70	193.54		193.81	0.000622	2.67	135.25	154.49	0.44
M2	2347	Regional	387.03	188.70	194.40		194.55	0.000347	2.30	284.34	181.29	0.34
M2	2316	100-year	220.30	188.62	193.57		193.78	0.000237	2.41	194.31	177.86	0.37
M2	2316	Regional	387.03	188.62	194.39		194.55	0.000187	2.41	348.46	196.90	0.34
M2	2288	100-year	220.30	188.57	193.59	192.78	193.76	0.000218	2.29	286.48	208.89	0.37
M2	2288	Regional	387.03	188.57	194.35	193.50	194.53	0.000233	2.66	445.33	210.00	0.39
M2	2252	100-year	220.30	188.46	193.63	192.36	193.74	0.000160	1.97	348.16	218.91	0.32
M2	2252	Regional	387.03	188.46	194.38	193.28	194.51	0.000181	2.35	542.64	285.90	0.35
M2	2232	100-year	220.30	188.40	193.56	192.78	193.72	0.000204	2.23	282.83	213.93	0.35
M2	2232	Regional	387.03	188.40	194.32	193.34	194.49	0.000223	2.61	480.62	277.29	0.38
M2	2222		Bridge									
M2	2209	100-year	220.30	188.19	193.34	192.98	193.71	0.000418	3.19	188.54	148.44	0.49
M2	2209	Regional	387.03	188.19	193.98	193.66	194.48	0.000558	4.05	288.52	198.17	0.58
M2	2180	100-year	221.57	188.09	192.99	192.99	193.62	0.000870	4.03	136.36	133.60	0.66
M2	2180	Regional	385.01	188.09	193.62	193.62	194.38	0.001034	4.86	223.36	188.12	0.74
M2	2160	100-year	221.57	188.04	192.76	192.76	193.27	0.000715	3.80	179.69	187.00	0.61
M2	2160	Regional	385.01	188.04	193.92		194.13	0.000340	3.10	426.86	239.73	0.44
M2	2124	100-year	221.57	187.89	192.73		193.08	0.000463	3.20	203.48	170.18	0.51
M2	2124	Regional	385.01	187.89	193.92		194.12	0.000273	2.92	414.02	185.50	0.41
M2	2095	100-year	221.57	187.83	192.76	191.91	193.05	0.000332	2.81	188.03	112.14	0.45
M2	2095	Regional	385.01	187.83	193.79	192.72	194.10	0.000313	3.19	309.36	119.96	0.46
M2	2021	100-year	221.57	187.62	192.47		192.92	0.000482	3.33	141.21	158.07	0.54
M2	2021	Regional	385.01	187.62	193.45		193.96	0.000472	3.83	239.69	182.72	0.56
M2	1971	100-year	221.57	187.51	192.65		192.82	0.000205	2.29	161.42	180.20	0.36
M2	1971	Regional	385.01	187.51	193.63		193.85	0.000212	2.68	240.65	190.94	0.38
M2	1952	100-year	221.57	187.46	192.61		192.81	0.000236	2.41	155.15	75.24	0.38
M2	1952	Regional	385.01	187.46	193.58		193.84	0.000255	2.89	233.48	86.53	0.41
M2	1929	100-year	221.57	187.40	192.18		192.65	0.000494	3.37	105.10	71.70	0.55
M2	1929	Regional	385.01	187.40	193.42		193.78	0.000324	3.29	206.28	94.91	0.47
M2	1907	100-year	221.57	187.32	192.28	191.76	192.59	0.000338	2.95	134.24	83.87	0.46
M2	1907	Regional	385.01	187.32	193.49		193.74	0.000238	2.93	246.60	106.21	0.40

HEC-RAS Plan: 16MilkeCK-Future (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
M2	1864	100-year	221.57	187.20	191.75	191.36	192.52	0.000793	4.03	74.58	52.82	0.69
M2	1864	Regional	385.01	187.20	192.93	192.63	193.67	0.000617	4.32	160.46	95.41	0.64
M2	1834	100-year	221.57	187.08	191.19	191.19	192.45	0.001465	5.01	51.68	37.68	0.92
M2	1834	Regional	385.01	187.08	192.83	192.50	193.64	0.000669	4.51	181.39	91.75	0.67
M2	1804	100-year	221.57	187.01	190.85	190.85	192.20	0.001565	5.18	48.07	24.42	0.95
M2	1804	Regional	385.01	187.01	192.49	192.49	193.58	0.000827	5.02	154.46	97.23	0.74
M2	1728	100-year	221.57	186.76	191.04	190.86	191.72	0.000891	3.88	93.43	80.28	0.72
M2	1728	Regional	385.01	186.76	192.42	191.74	192.91	0.000501	3.64	237.40	129.90	0.56
M2	1697.5	100-year	221.57	186.68	191.03	190.75	191.64	0.000721	3.75	107.57	80.80	0.65
M2	1697.5	Regional	385.01	186.68	192.26	191.56	192.84	0.000532	3.96	230.90	121.83	0.59
M2	1667	100-year	221.57	186.60	191.04	190.61	191.50	0.000565	3.35	133.58	90.84	0.58
M2	1667	Regional	385.01	186.60	192.28	191.38	192.70	0.000409	3.51	252.97	104.39	0.52
M2	1604	100-year	221.57	186.41	191.04		191.35	0.000405	2.90	182.84	119.77	0.49
M2	1604	Regional	385.01	186.41	192.30		192.54	0.000273	2.92	337.43	126.49	0.43
M2	1550	100-year	221.57	186.16	191.05	190.22	191.23	0.000246	2.37	247.76	144.97	0.39
M2	1550	Regional	385.01	186.16	192.30	190.83	192.46	0.000177	2.44	436.03	155.10	0.35
M2	1500	100-year	221.57	186.04	190.88	189.92	191.16	0.000351	2.79	149.13	63.77	0.46
M2	1500	Regional	385.01	186.04	192.08	190.63	192.37	0.000288	3.05	273.53	144.28	0.44
M2	1420	100-year	221.57	185.89	190.89	189.45	191.02	0.000184	2.12	234.06	127.66	0.34
M2	1420	Regional	385.01	185.89	192.10	190.13	192.24	0.000157	2.33	397.20	206.66	0.33
M2	1353	100-year	221.57	185.69	190.84	189.54	191.01	0.000202	2.27	246.29	196.03	0.36
M2	1353	Regional	385.01	185.69	192.06	190.14	192.22	0.000171	2.49	448.74	257.16	0.34
M2	1339	100-year	221.57	185.62	190.86	189.45	190.92	0.000103	1.59	422.34	223.28	0.25
M2	1339	Regional	385.01	185.62	192.08	190.01	192.14	0.000080	1.67	697.49	231.38	0.23
M2	1322		Mult Open									
M2	1312	100-year	221.57	185.56	189.71	189.71	190.74	0.001277	4.65	67.90	48.28	0.85
M2	1312	Regional	385.01	185.56	191.35	190.79	192.10	0.000633	4.36	174.70	118.43	0.64
M2	1282	100-year	231.74	185.48	189.11	189.11	190.25	0.001641	4.74	53.18	30.46	0.96
M2	1282	Regional	395.12	185.48	190.13	190.13	191.62	0.001409	5.53	87.76	37.00	0.95
M2	1267	100-year	231.74	185.45	188.99	188.99	190.12	0.001636	4.73	53.36	30.96	0.96
M2	1267	Regional	395.12	185.45	190.00	190.00	191.49	0.001409	5.52	88.27	37.96	0.95
M2	1251	100-year	231.74	185.42	188.88	188.88	190.00	0.001638	4.72	52.99	31.55	0.96
M2	1251	Regional	395.12	185.42	189.91	189.91	191.36	0.001365	5.45	89.86	39.53	0.93
M2	1228	100-year	231.74	185.35	188.79	188.79	189.73	0.001531	4.37	63.47	44.83	0.93
M2	1228	Regional	395.12	185.35	189.64	189.64	190.87	0.001369	5.12	105.70	55.53	0.92
M2	1214	100-year	231.74	185.27	188.78	188.36	189.08	0.000605	3.01	178.66	120.14	0.59
M2	1214	Regional	395.12	185.27	190.28	188.89	190.46	0.000247	2.60	379.49	158.83	0.41
M2	1197	100-year	231.74	185.24	188.81	188.10	188.89	0.001016	1.78	216.10	143.26	0.34
M2	1197	Regional	395.12	185.24	190.30	188.43	190.35	0.000340	1.36	453.79	184.26	0.21
M2	1146	100-year	231.74	185.10	188.79	188.06	188.85	0.000651	1.54	272.17	185.69	0.28
M2	1146	Regional	395.12	185.10	190.30	188.36	190.34	0.000224	1.18	561.42	206.28	0.17
M2	1035	100-year	231.74	184.79	188.70	187.28	188.77	0.000568	1.49	232.02	104.23	0.26
M2	1035	Regional	395.12	184.79	190.24	187.69	190.30	0.000331	1.45	413.01	133.59	0.21
M2	885	100-year	231.74	184.35	188.65	186.70	188.69	0.000306	1.20	283.55	103.60	0.20
M2	885	Regional	395.12	184.35	190.20	187.09	190.25	0.000232	1.31	460.96	143.94	0.18
M2	759	100-year	231.74	184.12	188.63		188.66	0.000204	1.06	331.57	113.91	0.16
M2	759	Regional	395.12	184.12	190.19		190.22	0.000155	1.14	544.40	162.98	0.15
M2	697	100-year	231.74	183.79	188.63		188.65	0.000103	0.78	447.07	144.00	0.12
M2	697	Regional	395.12	183.79	190.19		190.21	0.000087	0.87	692.66	183.19	0.11
M2	671	100-year	231.74	183.90	188.42	186.70	188.59	0.000854	2.11	138.18	159.65	0.33
M2	671	Regional	395.12	183.90	190.18	187.46	190.21	0.000116	0.98	637.74	171.86	0.13
M2	651		Bridge									

HEC-RAS Plan: 16MilkeCK-Future (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
M2	624	100-year	231.74	183.90	187.83	186.63	188.05	0.001387	2.41	122.23	150.80	0.41
M2	624	Regional	395.12	183.90	189.17	187.31	189.44	0.001077	2.64	188.20	202.91	0.39
M2	606	100-year	226.74	183.84	187.91		187.94	0.000227	1.02	340.19	139.48	0.17
M2	606	Regional	396.35	183.84	189.28		189.31	0.000173	1.10	536.59	148.21	0.16
M2	508	100-year	226.74	183.72	187.88		187.92	0.000268	1.09	275.77	89.79	0.18
M2	508	Regional	396.35	183.72	189.24		189.29	0.000248	1.30	413.78	114.94	0.19
M2	425	100-year	226.74	183.59	187.70	186.74	187.87	0.001094	2.05	155.39	89.45	0.36
M2	425	Regional	396.35	183.59	189.12		189.25	0.000620	1.96	287.52	96.67	0.29
M2	406	100-year	226.74	183.54	186.75	186.60	187.62	0.007535	4.12	56.48	35.00	0.87
M2	406	Regional	396.35	183.54	188.73	187.69	189.15	0.001863	3.11	156.81	76.42	0.48
M2	373		Bridge									
M2	339	100-year	226.74	183.40	186.28	186.28	187.13	0.007115	4.38	62.99	99.91	0.88
M2	339	Regional	396.35	183.40	187.06	187.06	188.24	0.007272	5.31	91.93	104.07	0.93
M2	315	100-year	217.19	183.35	186.16	186.16	186.63	0.004827	3.51	97.66	96.26	0.72
M2	315	Regional	383.14	183.35	187.09	186.63	187.40	0.002559	3.17	191.92	105.71	0.55
M2	194	100-year	217.19	183.10	186.21		186.31	0.001071	1.80	172.79	91.62	0.35
M2	194	Regional	383.14	183.10	187.05		187.19	0.001067	2.16	253.03	98.12	0.36
M2	87	100-year	217.19	182.87	186.11		186.22	0.000977	1.80	171.99	86.65	0.34
M2	87	Regional	383.14	182.87	186.95		187.10	0.001025	2.18	245.92	90.16	0.36
E1	1463	100-year	33.97	192.64	194.80	194.64	194.96	0.002332	2.14	24.94	32.79	0.49
E1	1463	Regional	18.31	192.64	194.38	193.93	194.59	0.003249	2.16	10.39	25.17	0.55
E1	1372	100-year	33.97	192.45	194.57	194.16	194.73	0.002579	2.11	25.30	33.25	0.49
E1	1372	Regional	18.31	192.45	194.11	193.72	194.29	0.003210	1.95	11.73	21.48	0.53
E1	1275	100-year	33.97	191.96	194.52		194.57	0.000855	1.44	43.39	41.84	0.30
E1	1275	Regional	18.31	191.96	194.06		194.11	0.000825	1.22	26.25	33.53	0.28
E1	1198	100-year	33.97	191.54	194.51	193.25	194.53	0.000276	0.90	64.58	53.76	0.17
E1	1198	Regional	18.31	191.54	194.06	192.80	194.07	0.000219	0.71	42.70	40.36	0.15
E1	1112	100-year	33.97	191.20	194.49		194.51	0.000231	0.88	64.17	44.28	0.16
E1	1112	Regional	18.31	191.20	194.04		194.06	0.000177	0.69	45.26	41.00	0.14
E1	1029	100-year	33.97	190.61	194.49	192.32	194.49	0.000084	0.60	105.17	65.19	0.10
E1	1029	Regional	18.31	190.61	194.04	191.92	194.05	0.000049	0.42	78.49	54.44	0.08
E1	964	100-year	33.97	189.97	194.48	191.70	194.49	0.000031	0.39	116.59	90.64	0.06
E1	964	Regional	18.31	189.97	194.04	191.22	194.04	0.000019	0.29	85.18	63.07	0.05
E1	947	100-year	33.97	189.79	194.48	191.65	194.49	0.000051	0.49	101.41	100.69	0.08
E1	947	Regional	18.31	189.79	194.04	191.23	194.04	0.000031	0.35	68.54	61.42	0.06
E1	922		Culvert									
E1	893	100-year	33.97	189.50	194.13	191.13	194.14	0.000053	0.51	94.20	49.37	0.08
E1	893	Regional	18.31	189.50	193.53	190.78	193.54	0.000029	0.34	71.27	34.06	0.06
E1	878	100-year	64.27	189.51	194.12		194.14	0.000098	0.71	135.26	54.49	0.11
E1	878	Regional	35.95	189.51	193.53		193.54	0.000057	0.49	104.82	46.47	0.08
E1	829	100-year	64.27	189.35	194.12	191.23	194.13	0.000053	0.55	176.15	62.30	0.08
E1	829	Regional	35.95	189.35	193.53	190.89	193.53	0.000032	0.38	140.39	58.45	0.06
E1	799	100-year	64.27	189.19	194.12	191.04	194.13	0.000043	0.50	191.33	64.38	0.08
E1	799	Regional	35.95	189.19	193.53	190.65	193.53	0.000024	0.35	154.48	60.64	0.06
E1	749	100-year	64.27	188.69	194.12	190.75	194.13	0.000027	0.42	235.97	77.09	0.06
E1	749	Regional	35.95	188.69	193.53	190.39	193.53	0.000014	0.28	193.46	69.13	0.04
E1	708	100-year	64.27	188.07	194.11	190.13	194.12	0.000052	0.62	161.49	94.73	0.09
E1	708	Regional	35.95	188.07	193.51	189.66	193.53	0.000047	0.55	68.44	69.90	0.08
E1	677		Culvert									
E1	640	100-year	64.27	188.01	190.22	189.77	190.54	0.003844	2.60	28.61	120.43	0.61
E1	640	Regional	35.95	188.01	189.89	189.36	190.05	0.002407	1.80	22.81	107.52	0.47
E1	592	100-year	78.33	188.01	190.20		190.31	0.002065	2.10	82.16	59.14	0.47

HEC-RAS Plan: 16MilkeCK-Future (Continued)

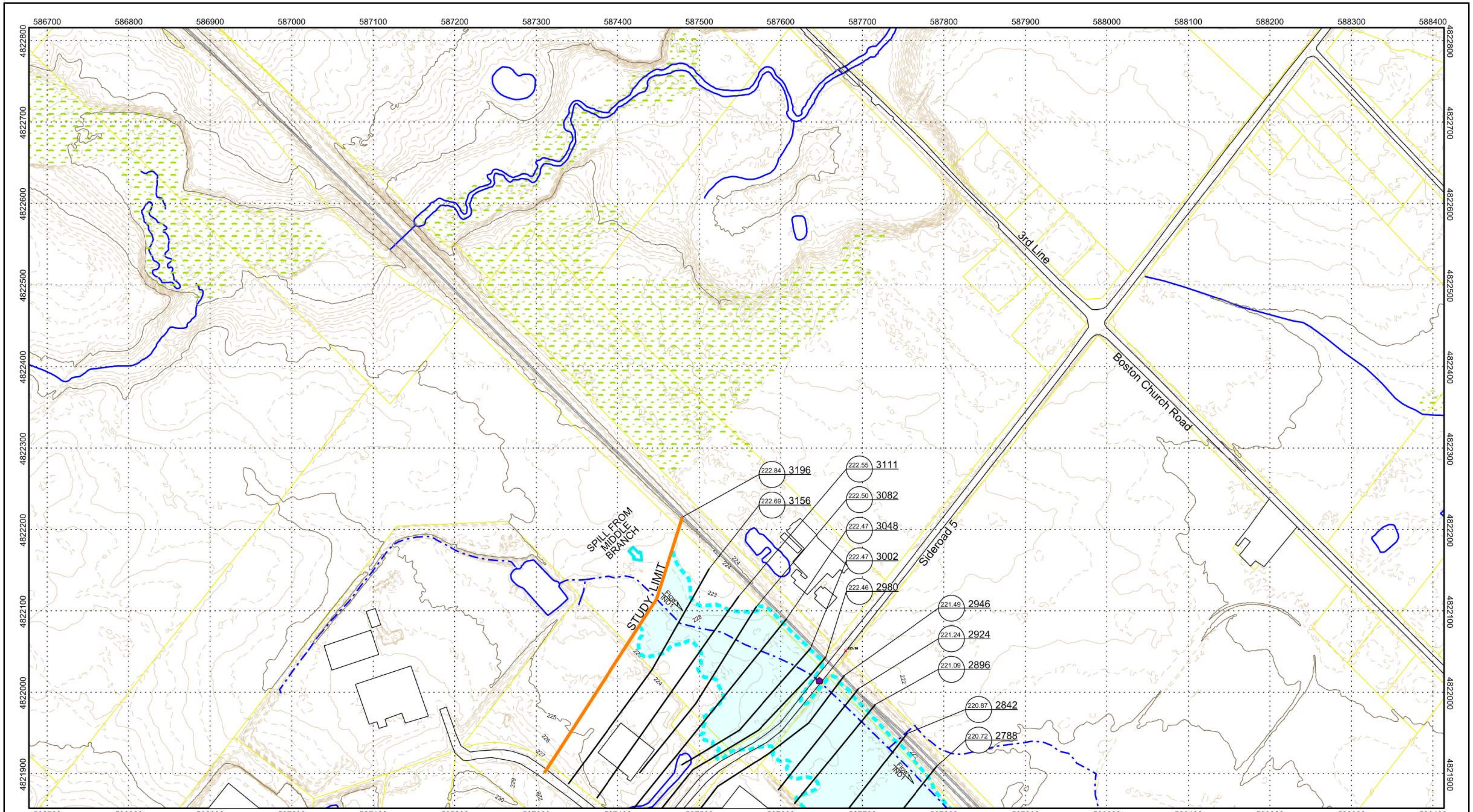
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
E1	592	Regional	46.88	188.01	189.84		189.92	0.001712	1.69	61.16	57.01	0.41
E1	523	100-year	78.33	187.13	190.20		190.23	0.000621	1.35	130.96	63.42	0.26
E1	523	Regional	46.88	187.13	189.84		189.86	0.000396	0.98	108.54	62.36	0.20
E1	445	100-year	78.33	186.58	190.19		190.21	0.000196	0.89	204.72	79.77	0.15
E1	445	Regional	46.88	186.58	189.84		189.84	0.000109	0.62	176.79	77.83	0.11
E1	303	100-year	78.33	185.68	190.18		190.19	0.000116	0.80	240.45	83.89	0.12
E1	303	Regional	46.88	185.68	189.83		189.84	0.000060	0.54	211.48	81.79	0.09
E1	220	100-year	78.33	184.94	190.19		190.19	0.000020	0.35	537.46	148.90	0.05
E1	220	Regional	46.88	184.94	189.83		189.83	0.000010	0.23	485.24	147.53	0.04
E1	154	100-year	78.33	184.22	190.18		190.19	0.000015	0.35	546.03	121.03	0.05
E1	154	Regional	46.88	184.22	189.83		189.83	0.000007	0.23	503.67	119.87	0.03
E1	87	100-year	78.33	183.46	190.17	185.65	190.18	0.000038	0.59	246.99	92.75	0.08
E1	87	Regional	46.88	183.46	189.83	185.12	189.83	0.000017	0.38	228.63	90.40	0.05
E1	65		Culvert									
E1	35	100-year	78.33	183.34	186.15	185.38	186.39	0.002341	2.53	48.57	130.11	0.51
E1	35	Regional	46.88	183.34	187.16	184.99	187.20	0.000244	1.02	72.31	134.12	0.17
M3	9241	100-year	229.99	182.28	185.46	185.05	185.80	0.003583	3.25	144.33	94.26	0.63
M3	9241	Regional	411.41	182.28	186.15	185.68	186.64	0.004157	4.08	214.84	106.92	0.71
M3	9219	100-year	229.99	182.21	185.46		185.68	0.002005	2.52	166.71	90.71	0.48
M3	9219	Regional	411.41	182.21	186.12		186.49	0.002717	3.38	228.44	95.19	0.58
M3	9078	100-year	229.99	181.79	185.19	184.33	185.43	0.001704	2.42	151.33	78.57	0.45
M3	9078	Regional	411.41	181.79	185.43	185.02	186.03	0.003997	3.90	170.25	79.55	0.69
M3	8328	100-year	229.99	180.18	184.28	182.33	184.55	0.001012	2.30	107.33	694.43	0.36
M3	8328	Regional	411.41	180.18	185.67	183.32	185.68	0.000039	0.54	2085.66	696.56	0.08
M3	8296		Mult Open									
M3	8267	100-year	229.99	180.10	183.71	183.17	184.25	0.004071	3.37	77.48	308.99	0.67
M3	8267	Regional	411.41	180.10	184.40	184.05	185.44	0.005703	4.67	102.86	455.95	0.83
M3	8242	100-year	233.97	180.05	183.88	182.49	183.98	0.000838	1.78	257.78	122.41	0.32
M3	8242	Regional	416.66	180.05	184.78	183.15	184.93	0.000948	2.23	370.57	127.33	0.35
M3	8096	100-year	233.97	179.97	183.71		183.85	0.001118	2.10	209.45	87.16	0.37
M3	8096	Regional	416.66	179.97	184.53		184.77	0.001495	2.82	283.02	92.42	0.44
M3	8042	100-year	233.97	179.89	183.55		183.77	0.001887	2.67	176.36	83.89	0.48
M3	8042	Regional	416.66	179.89	184.31		184.65	0.002463	3.51	241.09	87.30	0.56
M3	8004	100-year	233.97	179.86	183.51	182.53	183.71	0.001436	2.35	186.94	98.12	0.42
M3	8004	Regional	416.66	179.86	184.27	183.18	184.58	0.001882	3.09	264.53	108.31	0.49
M3	7994		Inl Struct									
M3	7983	100-year	233.97	179.80	183.08		183.33	0.002400	2.88	173.10	95.76	0.53
M3	7983	Regional	416.66	179.80	184.24		184.49	0.001830	3.13	289.03	104.20	0.49
M3	7929	100-year	233.97	179.73	182.98		183.20	0.002234	2.66	160.30	76.10	0.51
M3	7929	Regional	416.66	179.73	184.09		184.39	0.002005	3.14	248.00	82.47	0.51
M3	7884	100-year	233.97	179.72	182.91	182.03	183.11	0.001935	2.53	174.27	84.08	0.47
M3	7884	Regional	416.66	179.72	184.04	182.63	184.29	0.001672	2.93	271.78	87.98	0.47
M3	7860		Bridge									
M3	7817	100-year	233.97	179.50	182.52	181.95	182.83	0.002999	3.02	142.14	78.12	0.58
M3	7817	Regional	416.66	179.50	183.65	182.60	184.00	0.002361	3.37	233.78	84.29	0.55
M3	7809	100-year	215.02	179.45	182.56		182.76	0.002024	2.51	156.25	77.74	0.48
M3	7809	Regional	420.44	179.45	183.65		183.97	0.002129	3.21	244.05	82.74	0.52
M3	7768	100-year	215.02	179.35	182.45		182.68	0.001829	2.43	143.44	69.37	0.46
M3	7768	Regional	420.44	179.35	183.50		183.87	0.002124	3.23	217.83	73.17	0.52
M3	7726	100-year	215.02	179.27	182.16		182.56	0.003860	3.36	114.17	64.17	0.66
M3	7726	Regional	420.44	179.27	183.12		183.73	0.004288	4.34	177.84	68.63	0.73

HEC-RAS Plan: 16MilkeCK-Future (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
M3	7645	100-year	215.02	179.20	182.03		182.28	0.002399	2.63	139.89	76.01	0.52
M3	7645	Regional	420.44	179.20	183.01		183.40	0.002628	3.41	216.23	79.17	0.57
M3	7619	100-year	215.02	179.08	181.98		182.22	0.002045	2.48	145.96	80.13	0.48
M3	7619	Regional	420.44	179.08	182.97		183.33	0.002264	3.21	227.24	84.15	0.53
M3	7535	100-year	215.02	178.74	181.80		182.03	0.002259	2.64	151.61	80.04	0.51
M3	7535	Regional	420.44	178.74	182.76		183.13	0.002599	3.45	229.99	83.42	0.57
M3	7471	100-year	215.02	178.55	181.62		181.89	0.002138	2.49	130.47	77.88	0.49
M3	7471	Regional	420.44	178.55	182.52		182.95	0.002554	3.31	203.56	84.61	0.56
M3	7412	100-year	215.02	178.42	181.33		181.72	0.004438	3.52	123.32	76.31	0.70
M3	7412	Regional	420.44	178.42	182.17		182.76	0.005147	4.57	189.64	82.60	0.79
M3	7376	100-year	215.02	178.22	180.88	180.86	181.49	0.008071	4.13	96.62	77.85	0.91
M3	7376	Regional	420.44	178.22	181.60	181.60	182.49	0.008958	5.28	155.74	87.95	1.01
M3	7297	100-year	215.02	177.93	180.72		180.99	0.004002	3.04	143.41	99.93	0.65
M3	7297	Regional	420.44	177.93	181.52		181.90	0.004100	3.78	231.60	117.52	0.69
M3	7239	100-year	215.02	177.68	180.60		180.79	0.002636	2.55	169.40	111.91	0.53
M3	7239	Regional	420.44	177.68	181.40		181.69	0.002861	3.23	267.19	126.35	0.58
M3	7171	100-year	215.02	177.39	180.43	179.96	180.60	0.002395	2.47	196.66	143.11	0.51
M3	7171	Regional	420.44	177.39	181.26	180.46	181.48	0.002304	2.96	318.71	149.05	0.53
M3	7100	100-year	215.02	177.13	180.30		180.45	0.001751	2.28	221.69	153.48	0.44
M3	7100	Regional	420.44	177.13	181.14		181.33	0.001809	2.78	353.10	159.83	0.47
M3	7028	100-year	215.02	176.83	180.01	179.64	180.24	0.003101	2.87	168.61	123.79	0.58
M3	7028	Regional	420.44	176.83	180.79	180.19	181.11	0.003271	3.54	269.73	132.55	0.62
M3	6931	100-year	215.02	176.56	179.66		179.94	0.003433	3.11	165.51	130.19	0.61
M3	6931	Regional	420.44	176.56	180.48		180.80	0.003326	3.67	275.16	137.89	0.63
M3	6860	100-year	215.02	176.21	179.46	179.20	179.71	0.003721	3.02	167.11	133.87	0.62
M3	6860	Regional	420.44	176.21	180.33	179.71	180.60	0.003125	3.40	285.49	138.69	0.60
M3	6815	100-year	215.02	176.06	179.29		179.59	0.003189	3.02	156.14	120.03	0.59
M3	6815	Regional	420.44	176.06	180.13		180.49	0.003183	3.61	258.45	124.28	0.61
M3	6782	100-year	215.02	175.88	179.15	178.89	179.49	0.003244	3.13	146.00	112.28	0.60
M3	6782	Regional	420.44	175.88	179.93	179.53	180.38	0.003658	3.93	235.90	118.92	0.67
M3	6737	100-year	215.02	175.71	178.82	178.79	179.30	0.005142	3.60	125.84	128.47	0.74
M3	6737	Regional	420.44	175.71	179.82		180.21	0.003387	3.67	256.43	134.91	0.64
M3	6686	100-year	215.02	175.51	178.84	178.34	179.04	0.002193	2.51	189.89	140.26	0.50
M3	6686	Regional	420.44	175.51	179.80	178.93	180.01	0.001932	2.90	329.94	155.13	0.49
M3	6665	100-year	215.02	175.40	178.84	177.90	178.99	0.001145	1.95	213.92	147.35	0.36
M3	6665	Regional	420.44	175.40	179.79	178.69	179.97	0.001193	2.40	355.67	153.74	0.39
M3	6629	100-year	215.02	175.29	178.51	178.30	178.88	0.004743	3.44	130.22	94.83	0.71
M3	6629	Regional	420.44	175.29	179.41	178.92	179.86	0.004368	4.07	216.37	103.05	0.72
M3	6560	100-year	215.02	175.00	178.15	177.94	178.59	0.004514	3.54	116.99	90.39	0.70
M3	6560	Regional	420.44	175.00	178.98	178.70	179.57	0.004814	4.40	200.74	99.28	0.76
M3	6485	100-year	215.02	174.73	177.94	177.70	178.30	0.005128	3.49	127.21	94.88	0.73
M3	6485	Regional	420.44	174.73	178.76	178.22	179.29	0.005515	4.44	218.24	122.62	0.80
M3	6392	100-year	215.02	174.37	177.66	177.29	177.92	0.003845	3.11	152.87	113.18	0.63
M3	6392	Regional	420.44	174.37	178.56	177.88	178.89	0.003620	3.71	267.04	144.06	0.65
M3	6284	100-year	215.02	173.93	176.94	176.83	177.44	0.005058	3.56	107.53	90.41	0.74
M3	6284	Regional	420.44	173.93	178.04	177.55	178.53	0.003473	3.81	212.90	111.49	0.65
M3	6238	100-year	215.02	173.66	176.99	176.35	177.19	0.002338	2.47	163.78	93.60	0.50
M3	6238	Regional	420.44	173.66	178.06	176.95	178.32	0.002123	2.99	264.97	95.83	0.51
M3	6144	100-year	215.02	173.39	176.79	176.09	176.99	0.002546	2.63	158.81	85.56	0.53
M3	6144	Regional	420.44	173.39	177.85	176.73	178.14	0.002441	3.25	251.44	88.35	0.55
M3	6019	100-year	215.02	172.96	176.75	175.61	176.83	0.000722	1.65	281.39	144.09	0.29
M3	6019	Regional	420.44	172.96	177.86	176.14	177.97	0.000744	2.04	446.16	151.94	0.31
M3	5938	100-year	215.02	172.59	176.76	175.03	176.78	0.000267	1.12	490.77	195.33	0.18

HEC-RAS Plan: 16MilkeCK-Future (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
M3	5938	Regional	420.44	172.59	177.87	175.44	177.91	0.000324	1.46	711.99	200.64	0.21
M3	5849	100-year	215.02	172.23	176.73	174.53	176.75	0.000225	1.07	492.76	185.82	0.17
M3	5849	Regional	420.44	172.23	177.84	175.02	177.87	0.000300	1.46	706.77	199.82	0.21
M3	5819	100-year	215.02	172.15	176.39	174.84	176.66	0.001498	2.72	118.54	204.46	0.44
M3	5819	Regional	420.44	172.15	177.83	175.90	177.86	0.000279	1.45	767.55	231.96	0.20
M3	5805		Bridge									
M3	5787	100-year	215.02	172.10	174.40	174.40	175.21	0.009089	4.36	67.44	212.74	0.97
M3	5787	Regional	420.44	172.10	175.32	175.32	176.59	0.008969	5.55	105.26	236.45	1.03
M3	5767	100-year	215.02	172.01	173.95	173.94	174.23	0.007970	3.47	167.13	219.29	0.87
M3	5767	Regional	420.44	172.01	174.43	174.30	174.74	0.007527	4.01	274.83	229.16	0.89
M3	5737	100-year	215.02	171.95	173.82	173.70	174.03	0.005744	2.99	189.69	238.80	0.75
M3	5737	Regional	420.44	171.95	174.31	174.07	174.56	0.005494	3.49	310.05	246.84	0.76
M3	5711	100-year	215.02	171.95	173.72	173.51	173.86	0.005439	2.77	217.11	266.72	0.72
M3	5711	Regional	420.44	171.95	174.25	173.85	174.40	0.004540	3.09	358.29	270.87	0.69
M3	5679	100-year	215.02	171.81	173.60	173.33	173.70	0.003506	2.35	251.45	274.24	0.58
M3	5679	Regional	420.44	171.81	174.14	173.62	174.26	0.003269	2.73	399.72	279.39	0.59
M3	5662	100-year	215.02	171.75	173.55	173.16	173.63	0.002573	2.02	282.90	286.77	0.50
M3	5662	Regional	420.44	171.75	174.09	173.46	174.18	0.002578	2.44	438.61	293.48	0.53
M3	5648	100-year	215.02	171.70	173.49	172.97	173.56	0.002631	1.96	277.91	282.84	0.50
M3	5648	Regional	420.44	171.70	174.03	173.37	174.12	0.002631	2.38	431.62	290.32	0.53



REFER TO SIXTEEN MILE CREEK SHEET NO. 1B

REVISIONS

NO.	DESCRIPTION	BY	DATE

LEGEND

Cross-Section Label

Regional Flood Elevation (m)
Cross-Section Number 14.060 172.00 172.00
100 Year Flood Elevation (m)
Cross-Section Leader Line
Cross-Section

SQUARE BLOCK TO INDICATE 100 YEAR FLOOD ELEVATION DOMINATES, CIRCLE INDICATES REGIONAL FLOOD ELEVATION DOMINATES

LEGEND

- Contour 5 metre
- Contour 1 metre
- Contour 0.5 metre
- Parcel Fabric
- Road
- Rail Line
- Water Feature
- Hydrologic Linkage
- Bridge - Transportation
- Bridge - Pedestrian
- Culvert
- Dam
- Weir
- Other Hydraulic Structure
- Building
- Building within Floodplain
- Spill
- Spot Elevation
- Marsh
- Limit of Study
- 100 Year Floodplain Boundary
- Regional Storm (Hurricane Hazel) Floodplain Boundary
- Regional Storm (Due to Interbasin Spill)
- Flood Area
- Area of Further Study

The flood line on this map was modelled on a DEM with a grid resolution of 1.0 m. The DEM was created by Airborne Imaging using LIDAR mass points collected by Airborne Imaging in spring 2018 at a vertical accuracy of ±0.07 cm on hard surfaces.

The spot elevations shown on this map were produced by Greck and Associates Limited using an Trimble R2 RTK Rover GPS connected to the Can-Net system.

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The horizontal datum is North American Datum 1983 (CSRS), UTM Zone 17N (ESPG 2958)

PLEASE NOTE:
FLOODLINE ELEVATIONS ARE SUBJECT TO CHANGE DUE TO REVISED INFORMATION.

Engineering Consultants

Greck

5770 Highway 7, Unit 3, Woodbridge, Ontario L4L 1T8

S.M. SEXTON 100216608 2023/08/22

PLEASE NOTE: THE PROFESSIONAL ENGINEER'S STAMP VERIFIES THE FLOOD LINE AND ASSOCIATED DATA BUT NOT THE MAP DATA.

FLOODLINE APPROVED DATE:

2023-08-22

1A

INDEX MAP N.T.S.

Conservation Halton

2596 BRITANNIA ROAD WEST, BURLINGTON, ON L7P 0G3

Scale 1:2000

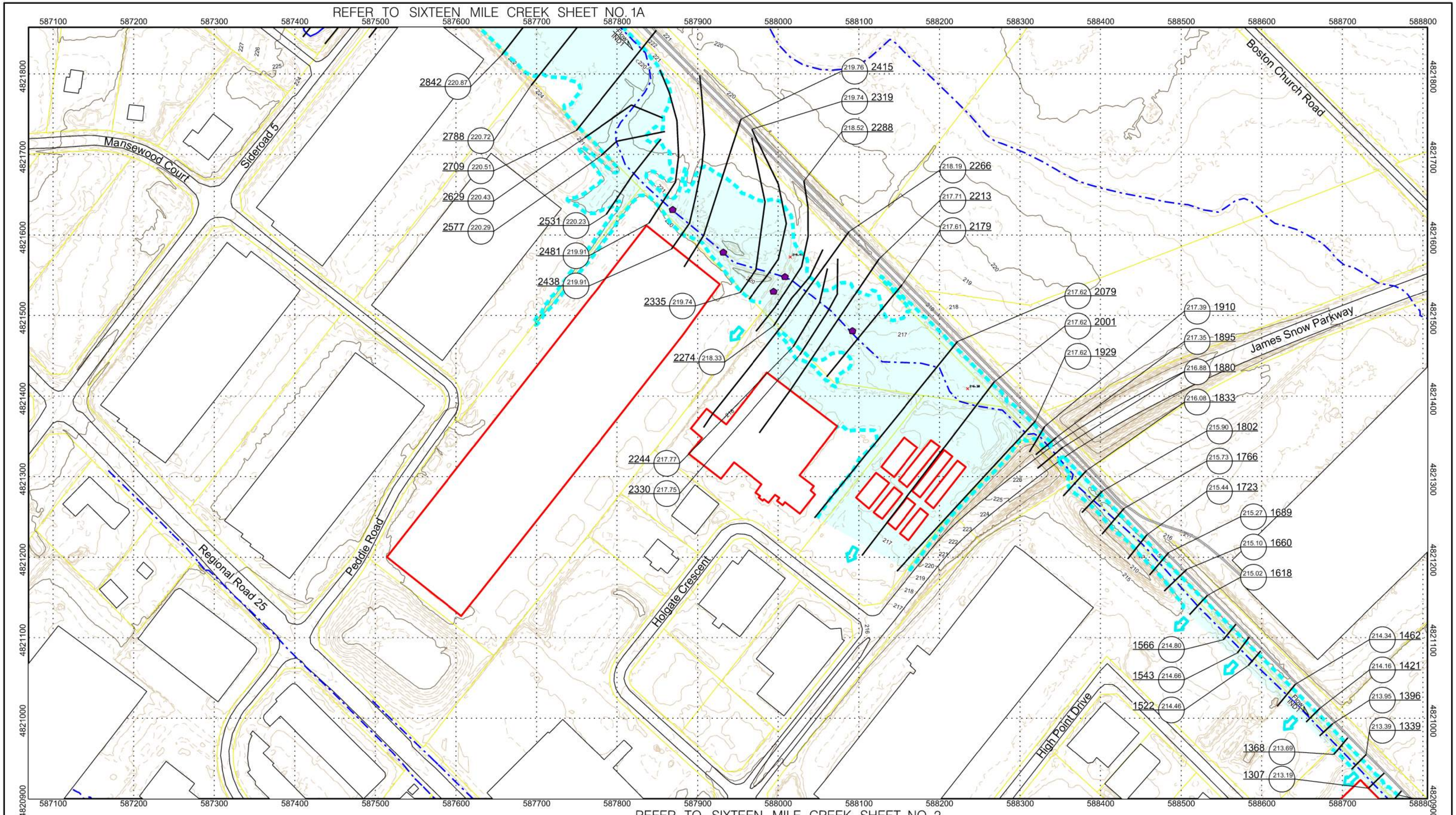
0m 100m 200m

FLOOD HAZARD MAPPING

SIXTEEN MILE CREEK WEST BRANCH

SHEET No.

1A



REVISIONS			
NO.	DESCRIPTION	BY	DATE

LEGEND
Cross-Section Label
Regional Flood Elevation (m)
Cross-Section Number 14.060 172.00
100 Year Flood Elevation (m) 172.00
Cross-Section Leader Line
Cross-Section
SQUARE BLOCK TO INDICATE 100 YEAR FLOOD ELEVATION DOMINATES, CIRCLE INDICATES REGIONAL FLOOD ELEVATION DOMINATES

LEGEND
- Contour 5 metre
- Contour 1 metre
- Contour 0.5 metre
- Parcel Fabric
- Road
- Rail Line
- Water Feature
- Hydrologic Linkage
- Bridge - Transportation
- Bridge - Pedestrian
- Culvert
- Weir
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Engineering Consultants
Greck
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LICENSED PROFESSIONAL ENGINEER
2023/08/22
S.M. SEXTON
100216608
PROVINCE OF ONTARIO

PLEASE NOTE:
THE PROFESSIONAL ENGINEER'S STAMP VERIFIES THE FLOOD LINE AND ASSOCIATED DATA BUT NOT THE MAP DATA

FLOODLINE APPROVED DATE:
2023-08-22

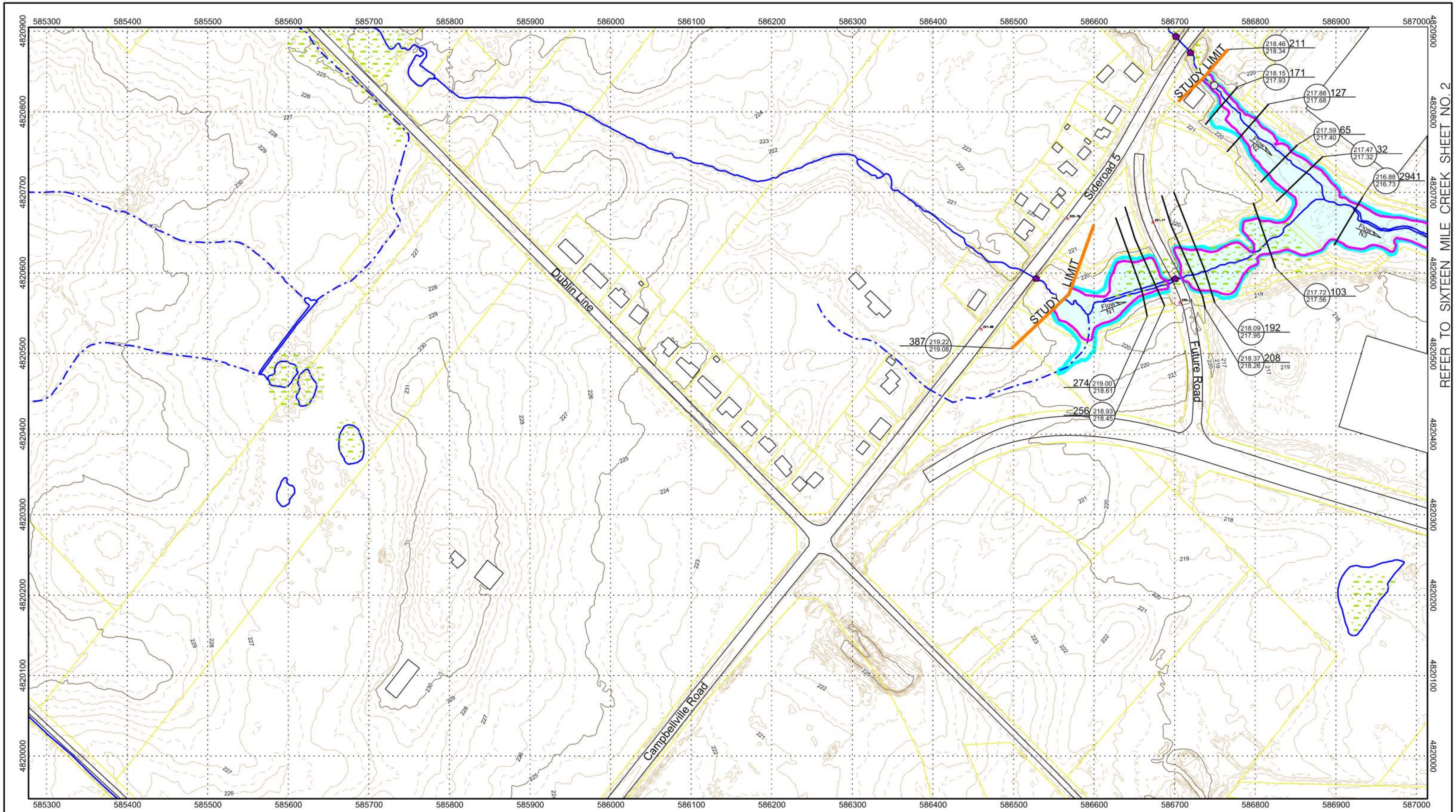
1B
INDEX MAP
N.T.S.

Conservation Halton
2596 BRITANNIA ROAD WEST, BURLINGTON, ON L7P 0G3

Scale 1:2000
0m 100m 200m

FLOOD HAZARD MAPPING
SIXTEEN MILE CREEK WEST BRANCH

SHEET No.
1B



REVISIONS			
NO.	DESCRIPTION	BY	DATE

LEGEND
Cross-Section Label

Regional Flood Elevation (m)
Cross-Section Number 14.060 172.00 172.00
100 Year Flood Elevation (m)
Cross-Section Leader Line
Cross-Section

SQUARE BLOCK TO INDICATE 100 YEAR FLOOD ELEVATION DOMINATES, CIRCLE INDICATES REGIONAL FLOOD ELEVATION DOMINATES

LEGEND

- Contour 5 metre
- Contour 1 metre
- Contour 0.5 metre
- Parcel Fabric
- Road
- Rail Line
- Water Feature
- Hydrologic Linkage
- Bridge - Transportation
- Bridge - Pedestrian
- Culvert
- Dam
- Weir
- Other Hydraulic Structure
- Building
- Building within Floodplain
- Spill
- 210.76 Spot Elevation
- Marsh
- Limit of Study
- 100 Year Floodplain Boundary
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- Regional Storm (Due to Interbasin Spill)
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Engineering Consultants

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LICENSED PROFESSIONAL ENGINEER
2023/08/22
S.M. SEXTON
100216608
PROVINCE OF ONTARIO

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FLOODLINE APPROVED DATE:

2023-08-22

INDEX MAP
N.T.S.

Conservation Halton

2596 BRITANNIA ROAD WEST, BURLINGTON, ON L7P 0G3

Scale 1:2000

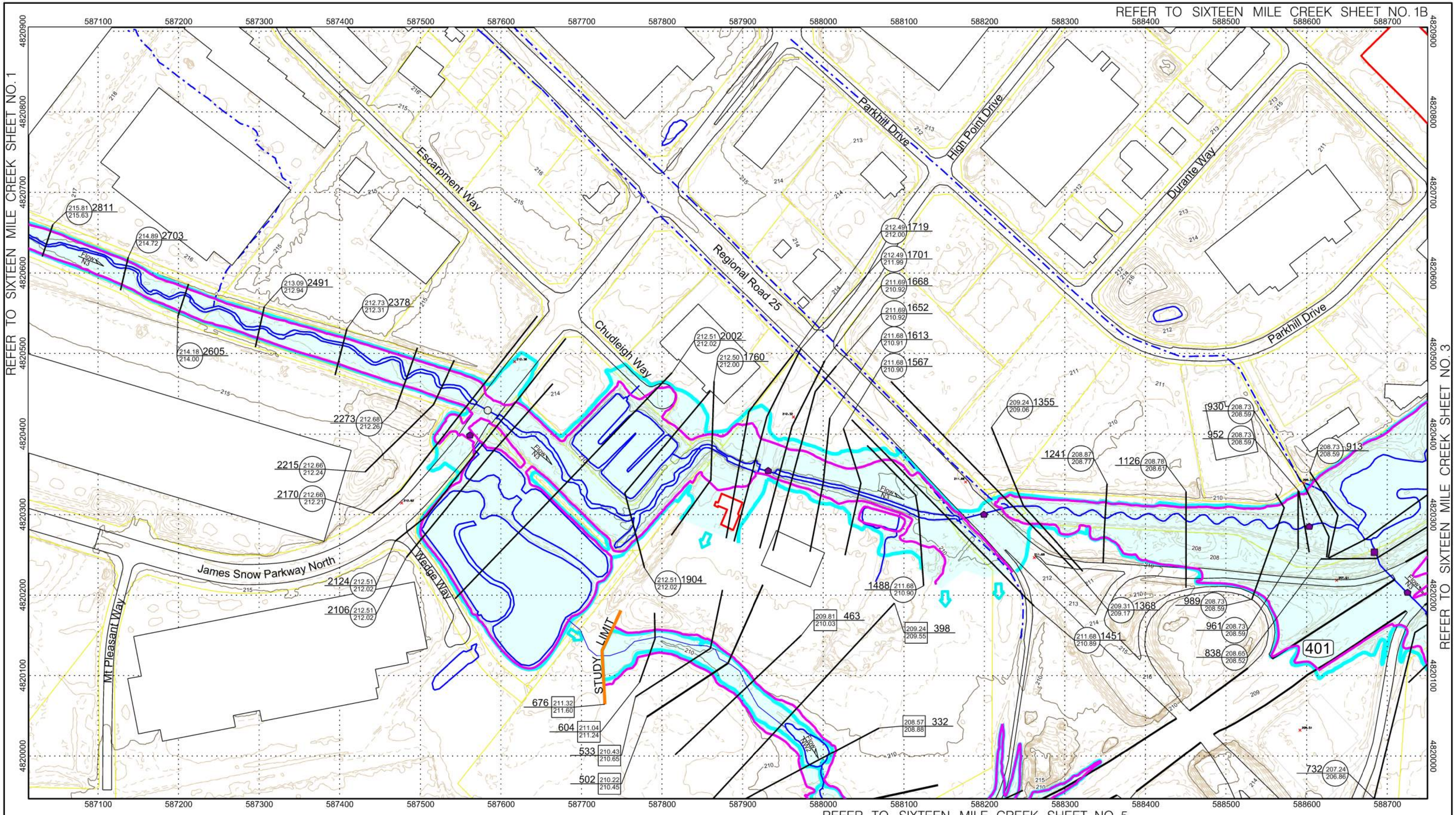
0m 100m 200m

FLOOD HAZARD MAPPING

SIXTEEN MILE CREEK WEST BRANCH

SHEET No.

1



REVISIONS			
NO.	DESCRIPTION	BY	DATE

LEGEND
Cross-Section Label

Regional Flood Elevation (m)
Cross-Section Number 14.060 172.00 172.00
100 Year Flood Elevation (m)
Cross-Section Leader Line
Cross-Section

SQUARE BLOCK TO INDICATE 100 YEAR FLOOD ELEVATION DOMINATES, CIRCLE INDICATES REGIONAL FLOOD ELEVATION DOMINATES

LEGEND

- Contour 5 metre
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LICENSED PROFESSIONAL ENGINEER
2023/08/22
S.M. SEXTON
100216608
PROVINCE OF ONTARIO

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FLOODLINE APPROVED DATE:
2023-08-22

INDEX MAP
N.T.S.

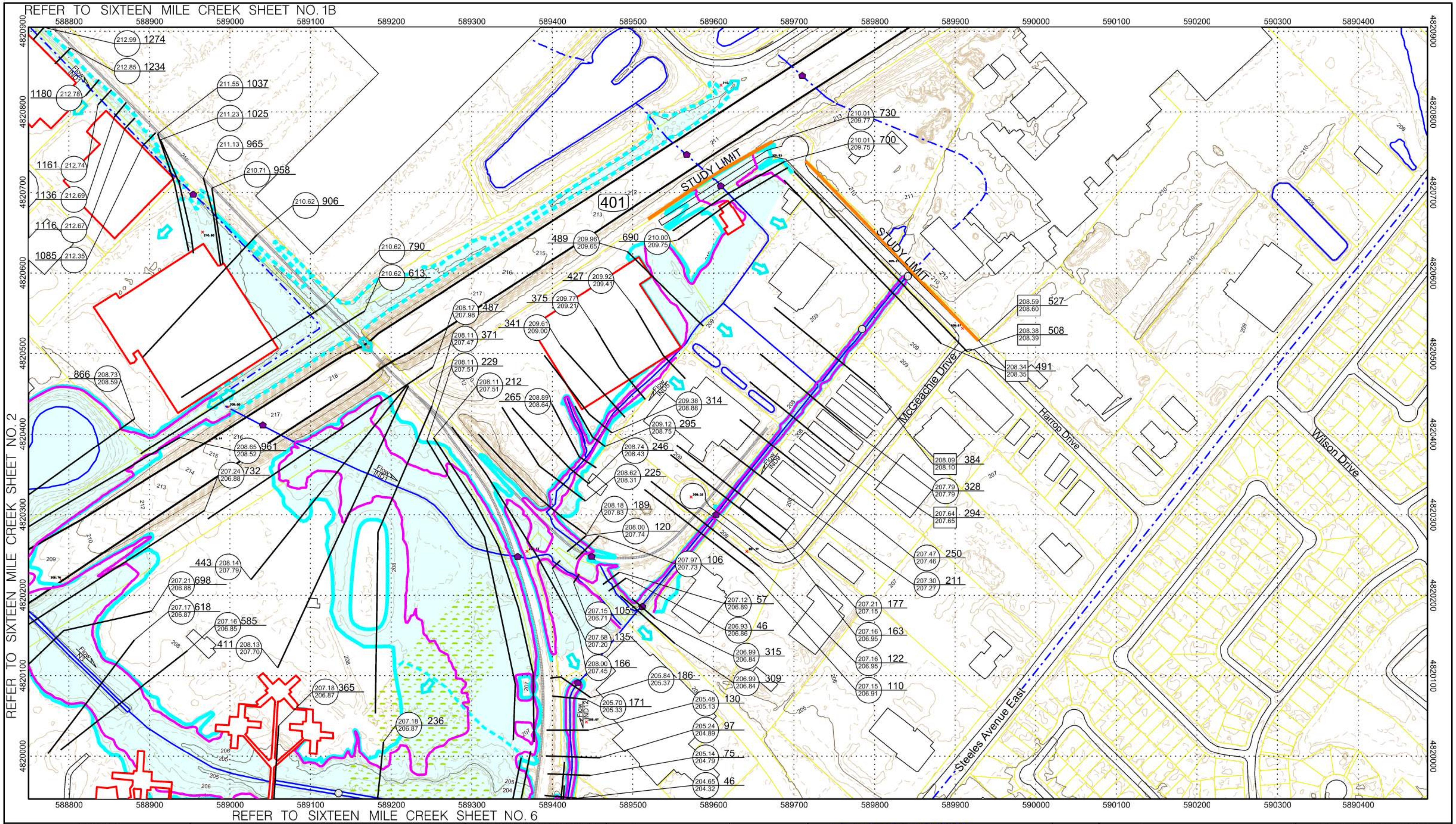
Conservation Halton
2596 BRITANNIA ROAD WEST, BURLINGTON, ON L7P 0G3

Scale 1:2000
0m 100m 200m

FLOOD HAZARD MAPPING

SIXTEEN MILE CREEK WEST BRANCH

SHEET No.
2



REVISIONS			
NO.	DESCRIPTION	BY	DATE

LEGEND
Cross-Section Label

Regional Flood Elevation (m)
Cross-Section Number 14.060 172.00 172.00
100 Year Flood Elevation (m)
Cross-Section Leader Line
Cross-Section

SQUARE BLOCK TO INDICATE 100 YEAR FLOOD ELEVATION DOMINATES, CIRCLE INDICATES REGIONAL FLOOD ELEVATION DOMINATES

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PLEASE NOTE:
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Engineering Consultants

Greck
5770 Highway 7, Unit 3, Woodbridge, Ontario L4L 1T8

LICENSED PROFESSIONAL ENGINEER
2023/08/22
S.M. SEXTON
100216608
PROVINCE OF ONTARIO

PLEASE NOTE:
THE PROFESSIONAL ENGINEER'S STAMP VERIFIES THE FLOOD LINE AND ASSOCIATED DATA, BUT NOT THE MAP DATA.

FLOODLINE APPROVED DATE:
2023-08-22

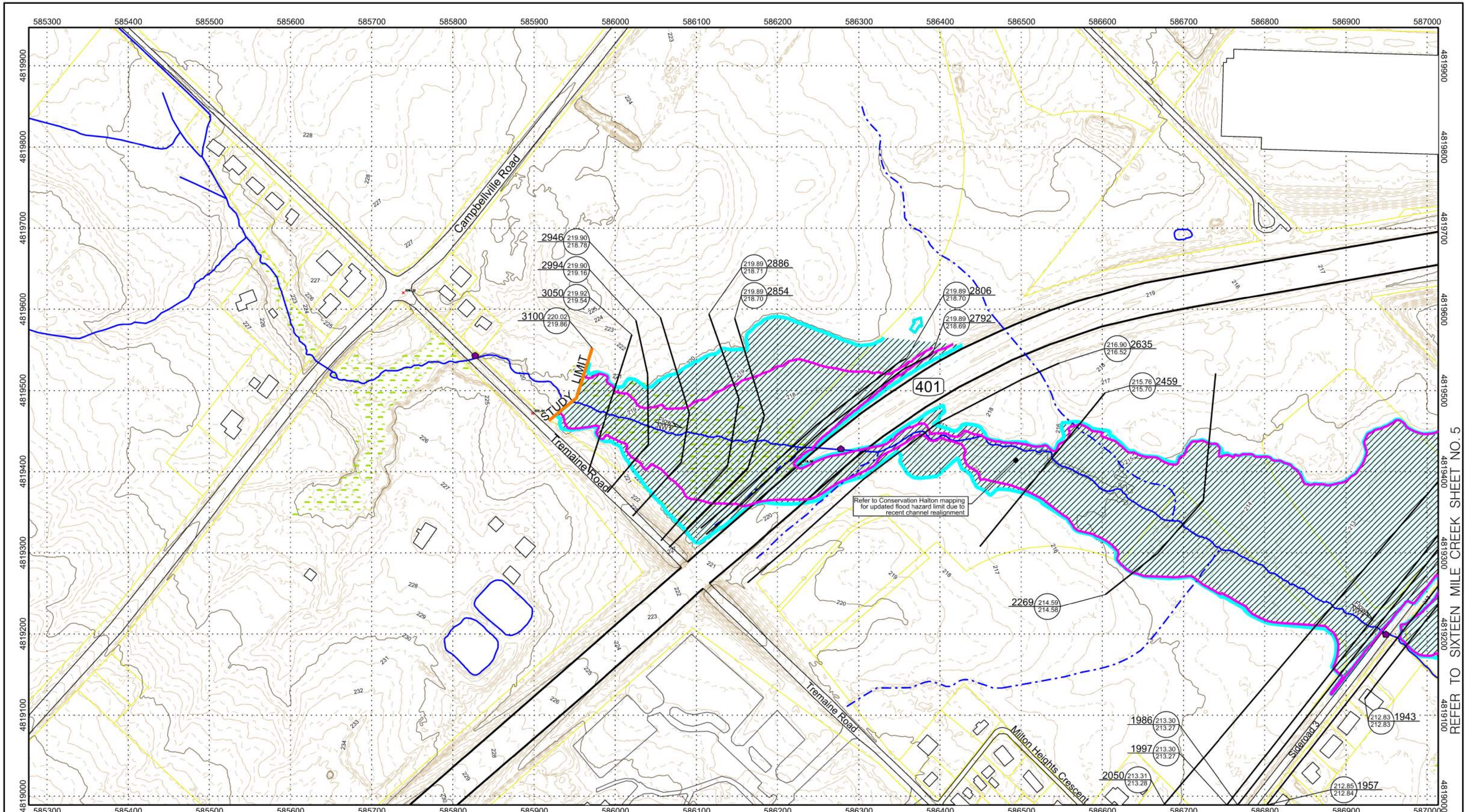
INDEX MAP
N.T.S.

Conservation Halton
2596 BRITANNIA ROAD WEST, BURLINGTON, ON L7P 0G3

Scale 1:2000
0m 100m 200m

FLOOD HAZARD MAPPING
SIXTEEN MILE CREEK WEST BRANCH

SHEET No.
3



REVISIONS			
NO.	DESCRIPTION	BY	DATE

LEGEND
Cross-Section Label
Regional Flood Elevation (m)
Cross-Section Number 14.060 172.00 172.00
100 Year Flood Elevation (m)
Cross-Section Leader Line
Cross-Section
SQUARE BLOCK TO INDICATE 100 YEAR FLOOD ELEVATION DOMINATES, CIRCLE INDICATES REGIONAL FLOOD ELEVATION DOMINATES

LEGEND
- Contour 5 metre
- Contour 1 metre
- Contour 0.5 metre
- Parcel Fabric
- Road
- Rail Line
- Water Feature
- Hydrologic Linkage
- Bridge - Transportation
- Bridge - Pedestrian
- Culvert
- Dam
- Weir
- Other Hydraulic Structure
- Building
- Building within Floodplain
- Spill
- Spot Elevation
- Marsh
- Limit of Study
- 100 Year Floodplain Boundary
- Regional Storm (Hurricane Hazel) Floodplain Boundary
- Regional Storm (Due to Interbasin Spill)
- Flood Area
- Area of Further Study

The flood line on this map was modelled on a DEM with a grid resolution of 1.0 m. The DEM was created by Airborne Imaging using LIDAR mass points collected by Airborne Imaging in spring 2018 at a vertical accuracy of ±0.07 cm on hard surfaces.

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LICENSED PROFESSIONAL ENGINEER
2023/08/22
S.M. SEXTON
100216608
PROVINCE OF ONTARIO

FLOODLINE APPROVED DATE:
2023-08-22

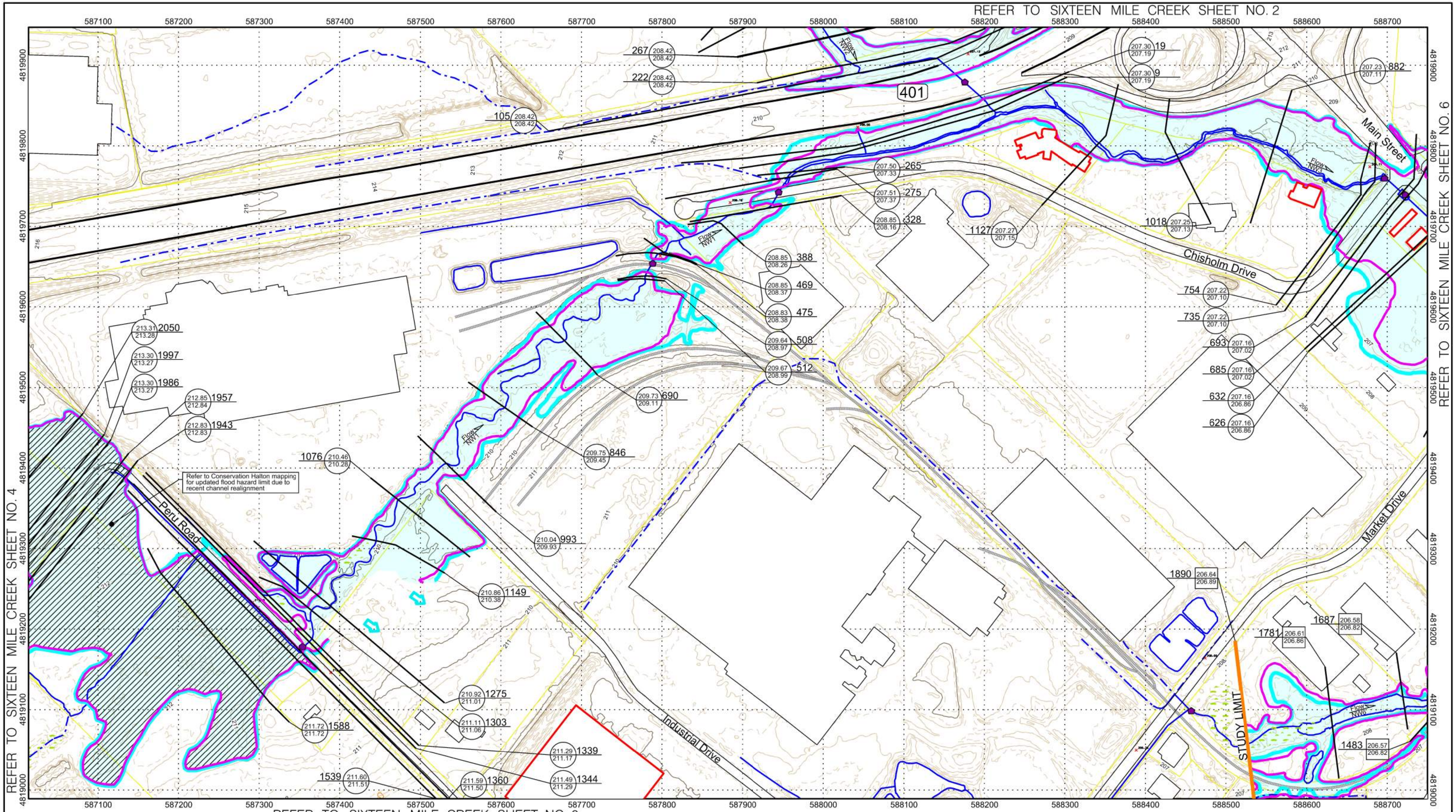
INDEX MAP
N.T.S.

Conservation Halton
2596 BRITANNIA ROAD WEST, BURLINGTON, ON L7P 0G3

Scale 1:2000
0m 100m 200m

FLOOD HAZARD MAPPING
SIXTEEN MILE CREEK WEST BRANCH

SHEET No.
4



REVISIONS			
NO.	DESCRIPTION	BY	DATE

LEGEND
Cross-Section Label

Regional Flood Elevation (m)
Cross-Section Number 14.060
100 Year Flood Elevation (m)
Cross-Section Leader Line
Cross-Section
172.00
172.00

SQUARE BLOCK TO INDICATE 100 YEAR FLOOD ELEVATION DOMINATES, CIRCLE INDICATES REGIONAL FLOOD ELEVATION DOMINATES

LEGEND

- Contour 5 metre
- Contour 1 metre
- Contour 0.5 metre
- Parcel Fabric
- Road
- Rail Line
- Water Feature
- Hydrologic Linkage
- Bridge - Transportation
- Bridge - Pedestrian
- Culvert
- Weir
- Dam
- Other Hydraulic Structure
- Building
- Building within Floodplain
- Spill
- Spot Elevation
- Marsh
- Limit of Study
- 100 Year Floodplain Boundary
- Regional Storm (Hurricane Hazel) Floodplain Boundary
- Regional Storm (Due to Interbasin Spill)
- Flood Area
- Area of Further Study

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100216608
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FLOODLINE APPROVED DATE:

2023-08-22

INDEX MAP
N.T.S.

Conservation Halton

2596 BRITANNIA ROAD WEST, BURLINGTON, ON L7P 0G3

Scale 1:2000

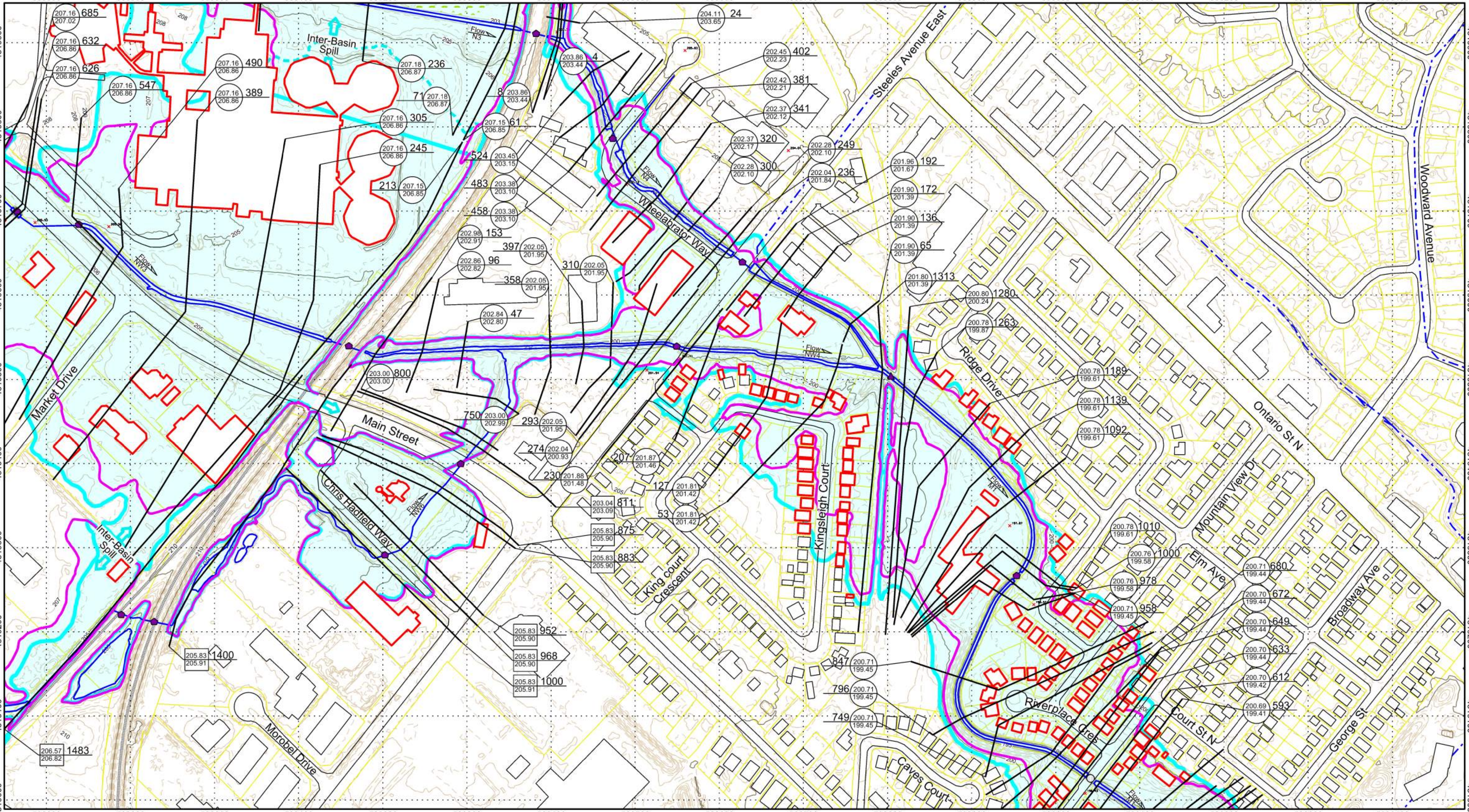
0m 100m 200m

FLOOD HAZARD MAPPING

SIXTEEN MILE CREEK
WEST BRANCH

SHEET No.
5

REFER TO SIXTEEN MILE CREEK SHEET NO. 3



REFER TO SIXTEEN MILE CREEK SHEET NO. 9

REVISIONS

NO.	DESCRIPTION	BY	DATE

LEGEND
Cross-Section Label

Regional Flood Elevation (m)
Cross-Section Number 14.060
100 Year Flood Elevation (m)
Cross-Section Leader Line
Cross-Section

SQUARE BLOCK TO INDICATE 100 YEAR FLOOD ELEVATION DOMINATES, CIRCLE INDICATES REGIONAL FLOOD ELEVATION DOMINATES

LEGEND

- Contour 5 metre
- Contour 1 metre
- Contour 0.5 metre
- Parcel Fabric
- Road
- Rail Line
- Water Feature
- Hydrologic Linkage
- Bridge - Transportation
- Bridge - Pedestrian
- Culvert
- Dam
- Weir
- Other Hydraulic Structure
- Building
- Building within Floodplain
- Spill
- 210.76 Spot Elevation
- Marsh
- Limit of Study
- 100 Year Floodplain Boundary
- Regional Storm (Hurricane Hazel) Floodplain Boundary
- Regional Storm (Due to Interbasin Spill)
- Flood Area
- Area of Further Study

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Engineering Consultants

Greck
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Woodbridge, Ontario L4L 1T8

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LICENSED PROFESSIONAL ENGINEER
2023/08/22
S.M. SEXTON
100216608
PROVINCE OF ONTARIO

FLOODLINE APPROVED DATE:
2023-08-22

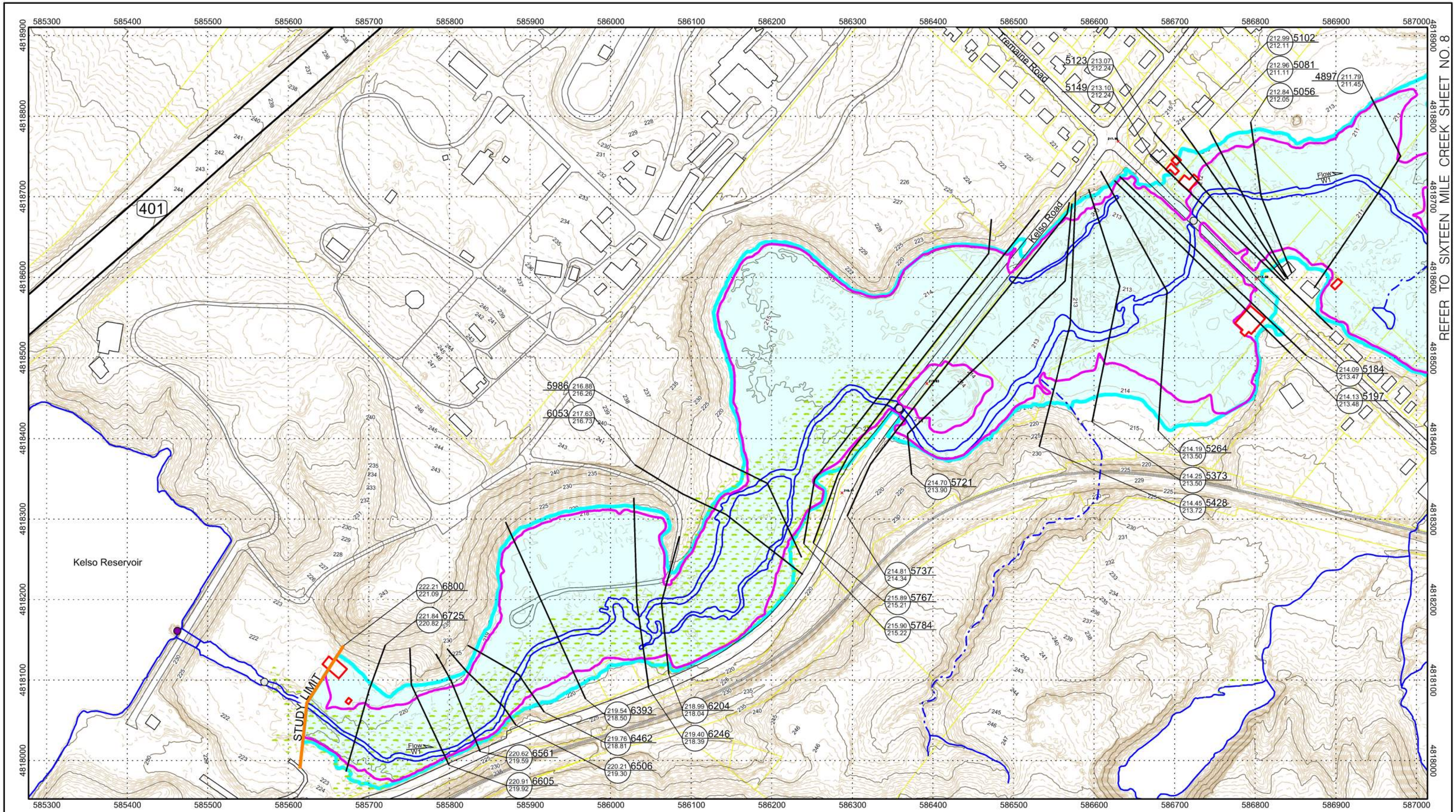
INDEX MAP
N.T.S.

Conservation Halton
2596 BRITANNIA ROAD WEST, BURLINGTON, ON L7P 0G3

FLOOD HAZARD MAPPING
SIXTEEN MILE CREEK
WEST BRANCH

Scale 1:2000
0m 100m 200m

SHEET No.
6



REVISIONS

NO.	DESCRIPTION	BY	DATE

LEGEND
Cross-Section Label

Regional Flood Elevation (m)
Cross-Section Number 14.060 172.00 172.00
100 Year Flood Elevation (m)
Cross-Section Leader Line
Cross-Section

SQUARE BLOCK TO INDICATE 100 YEAR FLOOD ELEVATION DOMINATES, CIRCLE INDICATES REGIONAL FLOOD ELEVATION DOMINATES

LEGEND

- Contour 5 metre
- Contour 1 metre
- Contour 0.5 metre
- Parcel Fabric
- Road
- Rail Line
- Water Feature
- Hydrologic Linkage
- Bridge - Transportation
- Bridge - Pedestrian
- Culvert
- Dam
- Weir
- Other Hydraulic Structure
- Building
- Building within Floodplain
- Spill
- 210.16 Spot Elevation
- Marsh
- Limit of Study
- 100 Year Floodplain Boundary
- Regional Storm (Hurricane Hazel) Floodplain Boundary
- Regional Storm (Due to Interbasin Spill)
- Flood Area
- Area of Further Study

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LICENSED PROFESSIONAL ENGINEER
2023/08/22
S.M. SEXTON
100216608
PROVINCE OF ONTARIO

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FLOODLINE APPROVED DATE:
2023-08-22

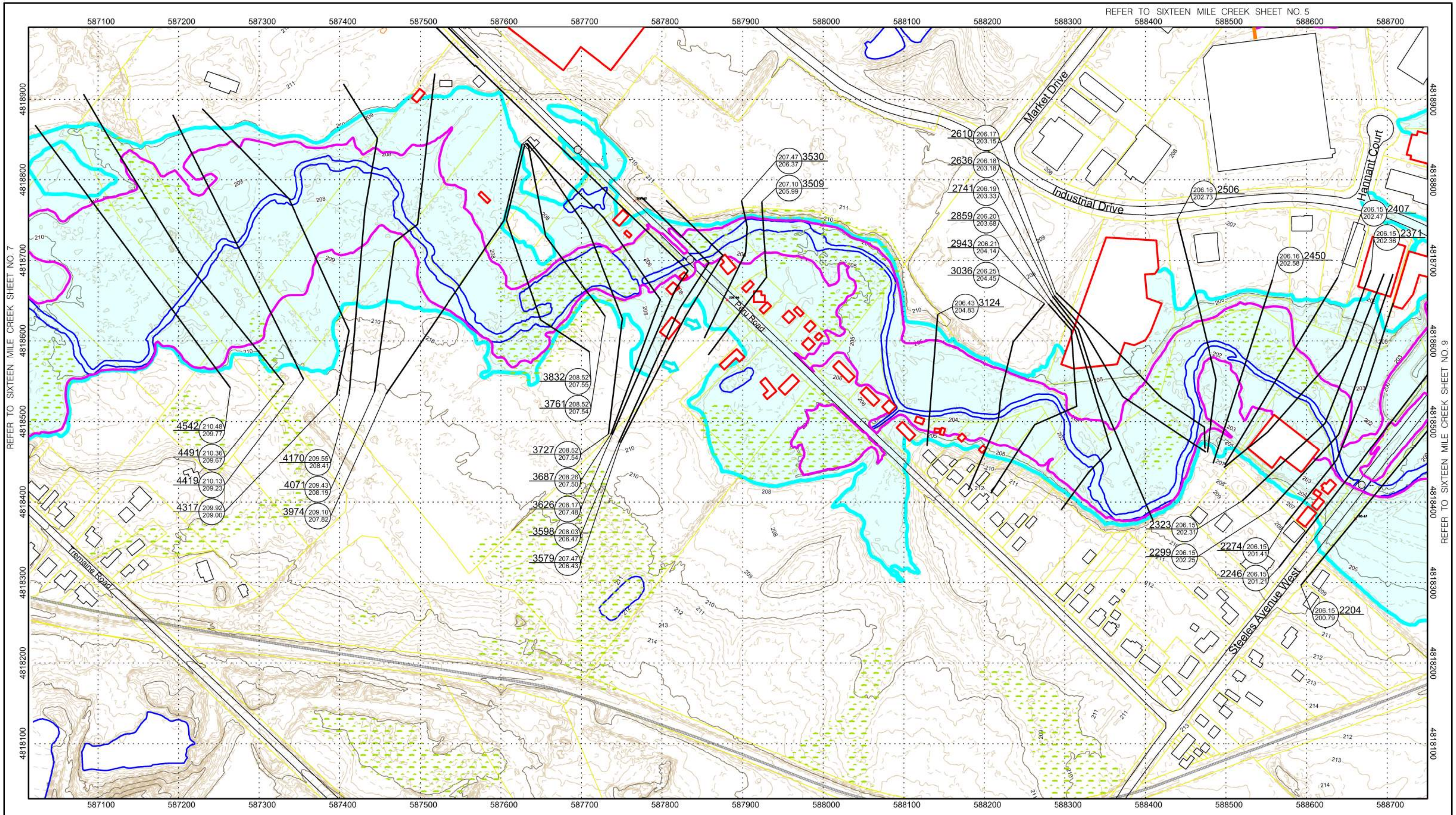
INDEX MAP
N.T.S.
7

Conservation Halton
2596 BRITANNIA ROAD WEST, BURLINGTON, ON L7P 0G3

Scale 1:2000
0m 100m 200m

FLOOD HAZARD MAPPING
SIXTEEN MILE CREEK WEST BRANCH

SHEET No.
7



REVISIONS			
NO.	DESCRIPTION	BY	DATE

LEGEND Cross-Section Label

Regional Flood Elevation (m)
Cross-Section Number 14.060
100 Year Flood Elevation (m)
Cross-Section Leader Line

SQUARE BLOCK TO INDICATE 100 YEAR FLOOD ELEVATION DOMINATES, CIRCLE INDICATES REGIONAL FLOOD ELEVATION DOMINATES

LEGEND

- Contour 5 metre
- Contour 1 metre
- Contour 0.5 metre
- Parcel Fabric
- Road
- Rail Line
- Water Feature
- Hydrologic Linkage
- Bridge - Transportation
- Bridge - Pedestrian
- Culvert
- Weir
- Building
- Building within Floodplain
- Marsh
- Limit of Study
- 100 Year Floodplain Boundary
- Regional Storm (Hurricane Hazel) Floodplain Boundary
- Regional Storm (Due to Interbasin Spill)
- Flood Area
- Area of Further Study
- Spill
- Spot Elevation
- Dam
- Other Hydraulic Structure

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Engineering Consultants

Greck

S.M. SEXTON 100216608

FLOODLINE APPROVED DATE: 2023-08-22

INDEX MAP N.T.S.

Conservation Halton

2596 BRITANNIA ROAD WEST, BURLINGTON, ON L7P 0G3

Scale 1:2000

0m 100m 200m

FLOOD HAZARD MAPPING

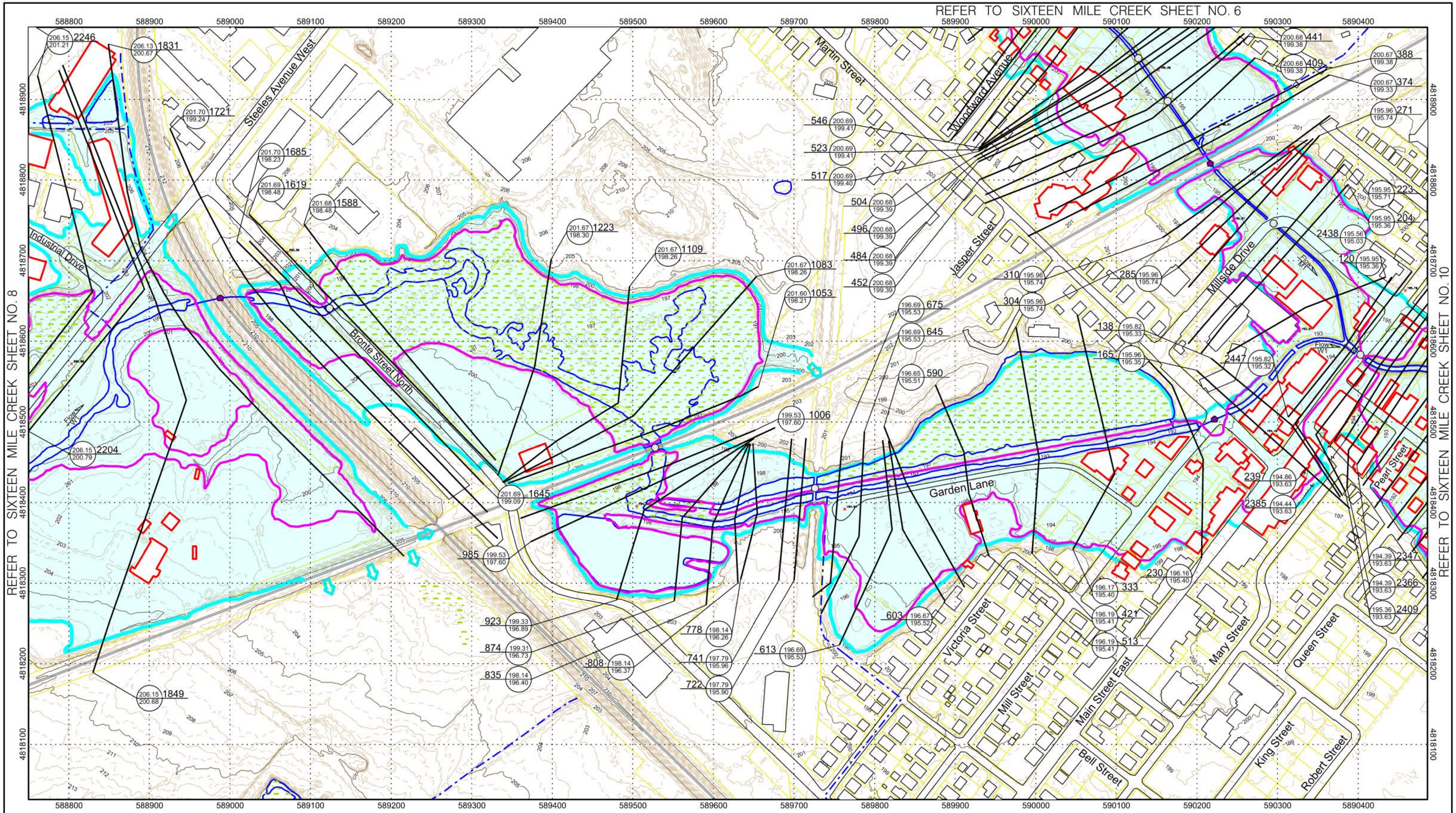
SIXTEEN MILE CREEK WEST BRANCH

SHEET No. 8

REFER TO SIXTEEN MILE CREEK SHEET NO. 6

REFER TO SIXTEEN MILE CREEK SHEET NO. 8

REFER TO SIXTEEN MILE CREEK SHEET NO. 10



REVISIONS			
NO.	DESCRIPTION	BY	DATE

LEGEND
Cross-Section Label

Regional Flood Elevation (m)
Cross-Section Number 14.060 172.00 172.00 Cross-Section Leader Line
100 Year Flood Elevation (m)

SQUARE BLOCK TO INDICATE 100 YEAR FLOOD ELEVATION DOMINATES, CIRCLE INDICATES REGIONAL FLOOD ELEVATION DOMINATES

LEGEND

- Contour 5 metre
- Contour 1 metre
- Contour 0.5 metre
- Parcel Fabric
- Road
- Rail Line
- Water Feature
- Hydrologic Linkage
- Bridge - Transportation
- Bridge - Pedestrian
- Culvert
- Dam
- Weir
- Other Hydraulic Structure
- Building
- Building within Floodplain
- Spill
- Spot Elevation
- Marsh
- Limit of Study
- 100 Year Floodplain Boundary
- Regional Storm (Hurricane Hazel) Floodplain Boundary
- Regional Storm (Due to Interbasin Spill)
- Flood Area
- Area of Further Study

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Engineering Consultants

Greck

5770 Highway 7, Unit 3, Woodbridge, Ontario L4L 1T8

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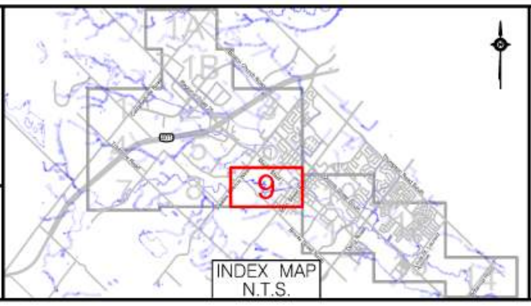
LICENSED PROFESSIONAL ENGINEER
2023/08/22
S.M. SEXTON
100216608
PROVINCE OF ONTARIO

FLOODLINE APPROVED DATE:

2023-08-22



INDEX MAP
N.T.S.

Conservation Halton

2596 BRITANNIA ROAD WEST, BURLINGTON, ON L7P 0G3

Scale 1:2000

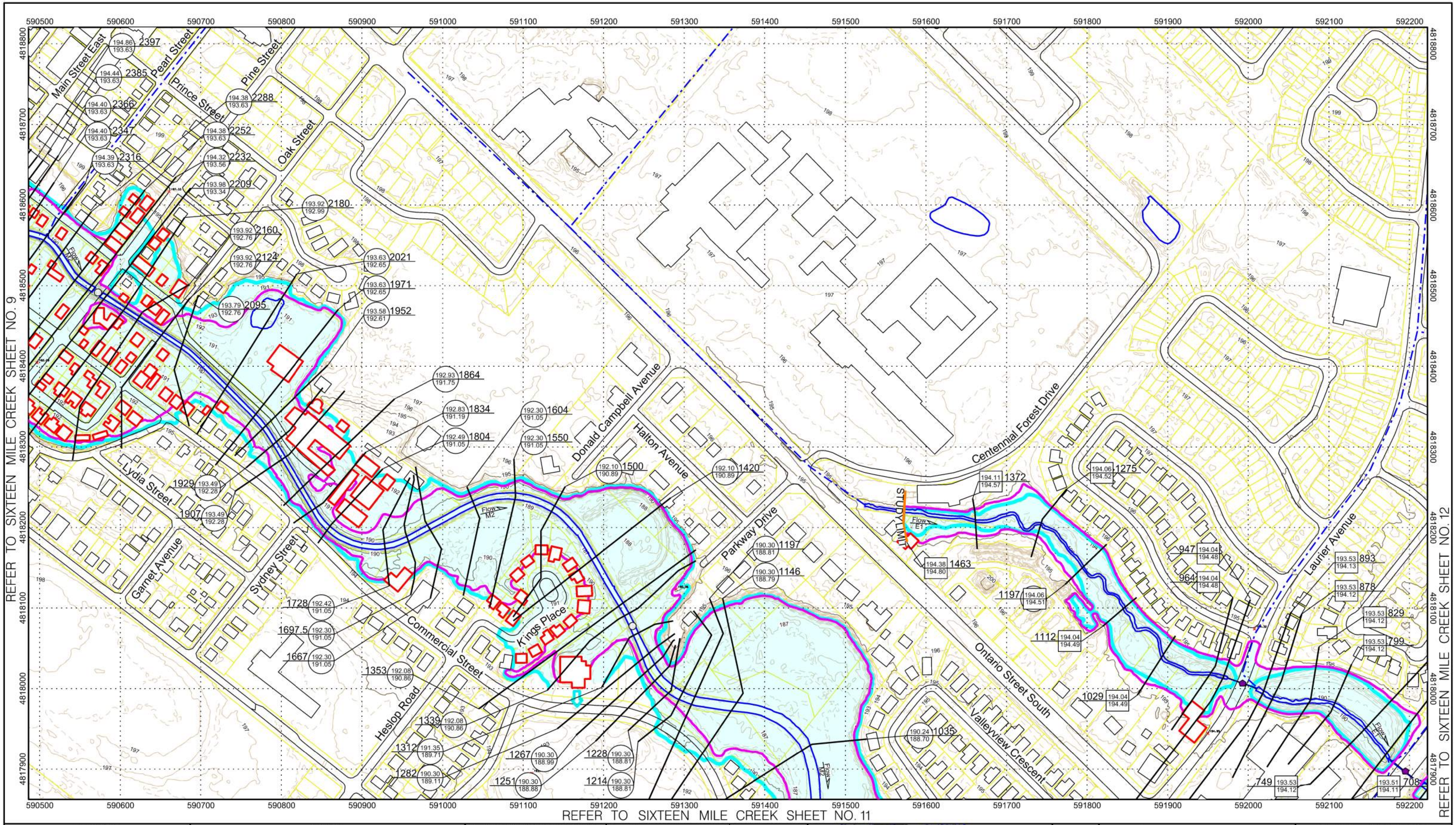
0m 100m 200m

FLOOD HAZARD MAPPING

SIXTEEN MILE CREEK WEST BRANCH

SHEET No.

9



REVISIONS			
NO.	DESCRIPTION	BY	DATE

LEGEND
Cross-Section Label
Regional Flood Elevation (m)
Cross-Section Number — 14.060
100 Year Flood Elevation (m)
Cross-Section Leader Line
Cross-Section
SQUARE BLOCK TO INDICATE 100 YEAR FLOOD ELEVATION DOMINATES. CIRCLE INDICATES REGIONAL FLOOD ELEVATION DOMINATES.

LEGEND
- Contour 5 metre
- Contour 1 metre
- Contour 0.5 metre
- Parcel Fabric
- Road
- Rail Line
- Water Feature
- Hydrologic Linkage
- Bridge - Transportation
- Bridge - Pedestrian
- Culvert
- Dam
- Weir
- Other Hydraulic Structure
- Building
- Building within Floodplain
- Spill
- Spot Elevation
- Marsh
- Limit of Study
- 100 Year Floodplain Boundary
- Regional Storm (Hurricane Hazel) Floodplain Boundary
- Regional Storm (Due to Interbasin Spill)
- Flood Area
- Area of Further Study

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Engineering Consultants
Greck
5770 Highway 7, Unit 3, Woodbridge, Ontario L4L 1T8

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LICENSED PROFESSIONAL ENGINEER
2023/08/22
S.M. SEXTON
100216608
PROVINCE OF ONTARIO

FLOODLINE APPROVED DATE:
2023-08-22

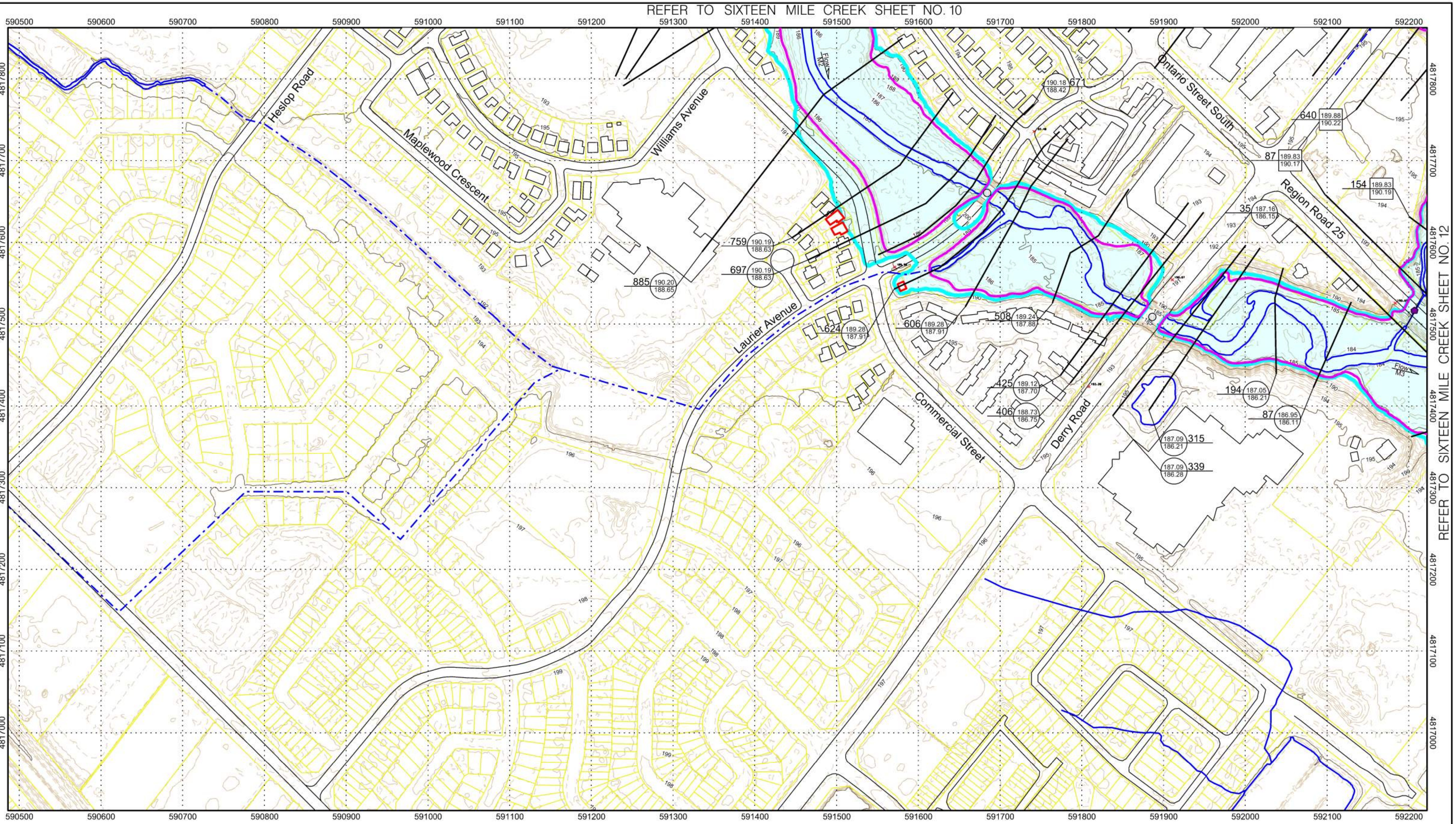
INDEX MAP
N.T.S.

Conservation Halton
2596 BRITANNIA ROAD WEST, BURLINGTON, ON L7P 0G3

Scale 1:2000
0m 100m 200m

FLOOD HAZARD MAPPING
SIXTEEN MILE CREEK
WEST BRANCH

SHEET No.
10



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REVISIONS

NO.	DESCRIPTION	BY	DATE

LEGEND
Cross-Section Label

Regional Flood Elevation (m)
Cross-Section Number — 14.060 — 172.00 / 172.00
100 Year Flood Elevation (m)
Cross-Section Leader Line
Cross-Section

SQUARE BLOCK TO INDICATE 100 YEAR FLOOD ELEVATION DOMINATES, CIRCLE INDICATES REGIONAL FLOOD ELEVATION DOMINATES

LEGEND

- Contour 5 metre
- Contour 1 metre
- Contour 0.5 metre
- Parcel Fabric
- Road
- Rail Line
- Water Feature
- Hydrologic Linkage
- Bridge - Transportation
- Bridge - Pedestrian
- Culvert
- Dam
- Weir
- Other Hydraulic Structure
- Building
- Building within Floodplain
- Spill
- Spot Elevation (210.16)
- Marsh
- Limit of Study
- 100 Year Floodplain Boundary
- Regional Storm (Hurricane Hazel) Floodplain Boundary
- Regional Storm (Due to Interbasin Spill)
- Flood Area
- Area of Further Study

Engineering Consultants
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Woodbridge, Ontario L4L 1T8

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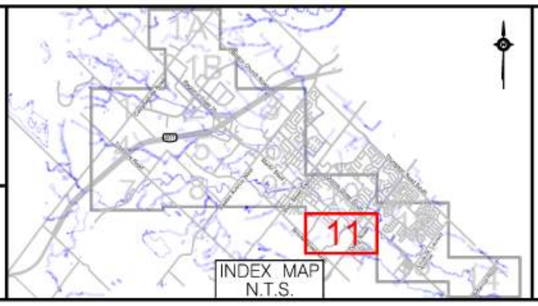
LICENSED PROFESSIONAL ENGINEER
2023/08/22
S.M. SEXTON
100216608
PROVINCE OF ONTARIO

FLOODLINE APPROVED DATE:
2023-08-22

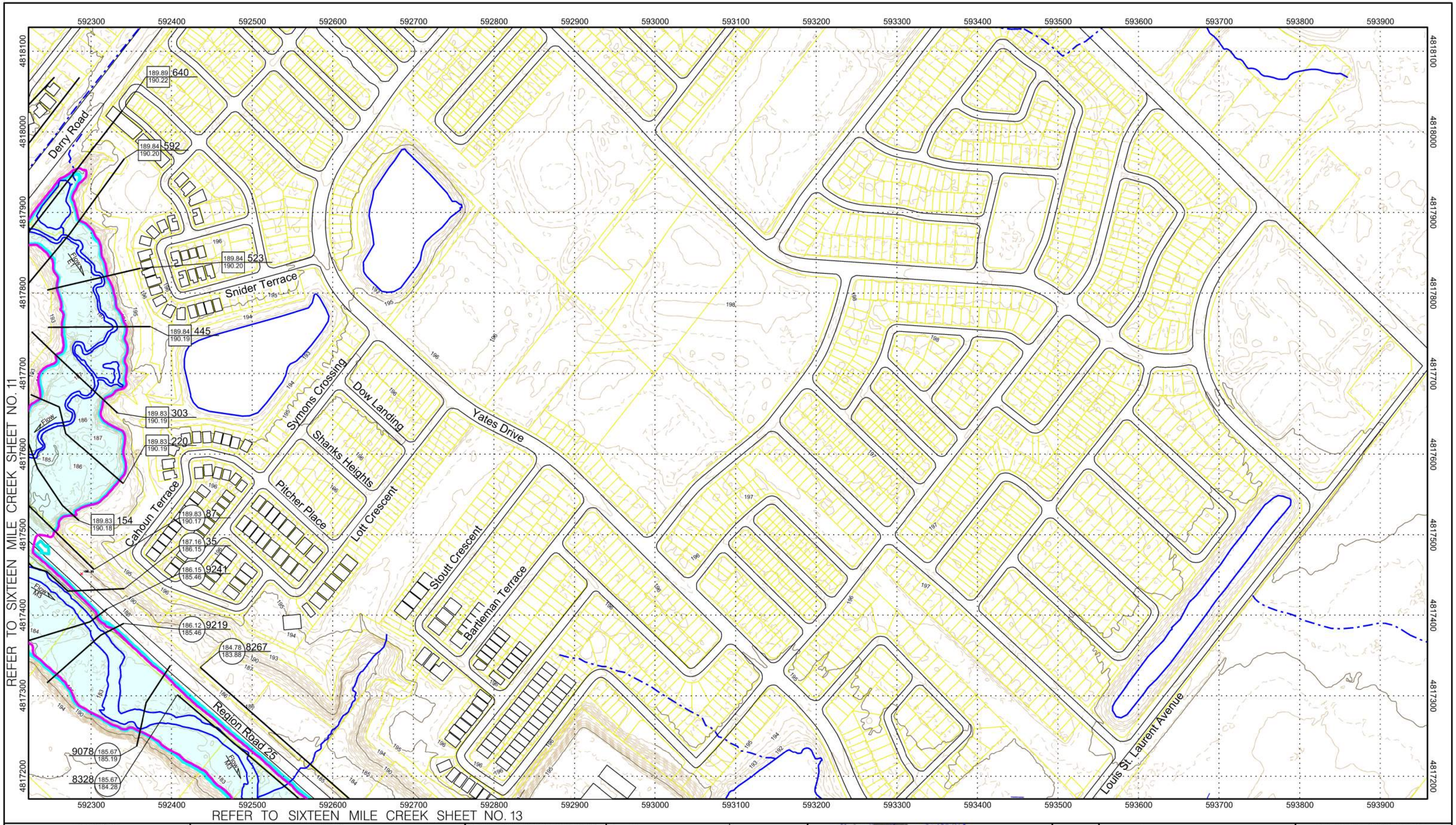


Conservation Halton
2596 BRITANNIA ROAD WEST, BURLINGTON, ON L7P 0G3

Scale 1:2000
0m 100m 200m

FLOOD HAZARD MAPPING
SIXTEEN MILE CREEK
WEST BRANCH

SHEET No.
11



REVISIONS

NO.	DESCRIPTION	BY	DATE

LEGEND
Cross-Section Label

Regional Flood Elevation (m)
Cross-Section Number 14.060
100 Year Flood Elevation (m)
Cross-Section Leader Line
Cross-Section

SQUARE BLOCK TO INDICATE 100 YEAR FLOOD ELEVATION DOMINATES, CIRCLE INDICATES REGIONAL FLOOD ELEVATION DOMINATES.

LEGEND

- Contour 5 metre
- Contour 1 metre
- Contour 0.5 metre
- Parcel Fabric
- Road
- Rail Line
- Water Feature
- Hydrologic Linkage
- Bridge - Transportation
- Bridge - Pedestrian
- Culvert
- Weir
- Dam
- Other Hydraulic Structure
- Building
- Building within Floodplain
- Spill
- Spot Elevation
- Marsh
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The planimetric data on this map was acquired from the Conservation Halton in 2019. The vintage of the data may not match with the elevation dataset and is for reference only.

Elevations are in metres above mean sea level and are based on the Canadian Geodetic Vertical Datum of 2013 (CGVD2013) as established by NRCAN.

The horizontal datum is North American Datum 1983 (CSRS), UTM Zone 17N (ESPG 2958)

PLEASE NOTE:
FLOODLINE ELEVATIONS ARE SUBJECT TO CHANGE DUE TO REVISED INFORMATION.

Engineering Consultants

Greck

S.M. SEXTON 100216608 2023/06/22

FLOODLINE APPROVED DATE:
2023-08-22

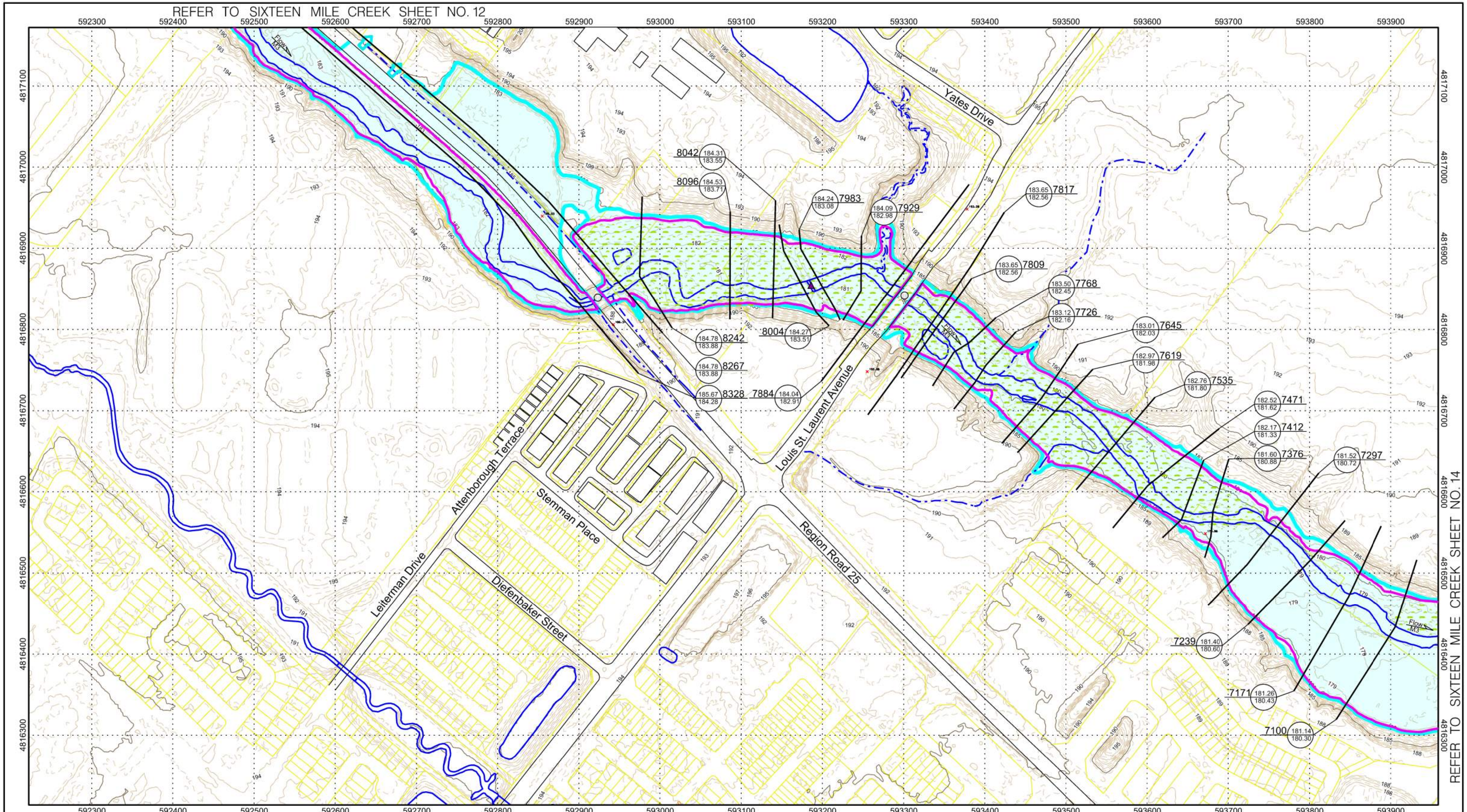
INDEX MAP N.T.S.

Conservation Halton
2596 BRITANNIA ROAD WEST, BURLINGTON, ON L7P 0G3

Scale 1:2000
0m 100m 200m

FLOOD HAZARD MAPPING
SIXTEEN MILE CREEK WEST BRANCH

SHEET No. 12



REVISIONS			
NO.	DESCRIPTION	BY	DATE

LEGEND
Cross-Section Label
Regional Flood Elevation (m)
Cross-Section Number 14.060 172.00 / 172.00
100 Year Flood Elevation (m)
Cross-Section Leader Line
Cross-Section
SQUARE BLOCK TO INDICATE 100 YEAR FLOOD ELEVATION DOMINATES, CIRCLE INDICATES REGIONAL FLOOD ELEVATION DOMINATES

LEGEND
- Contour 5 metre
- Contour 1 metre
- Contour 0.5 metre
- Parcel Fabric
- Road
- Rail Line
- Water Feature
- Hydrologic Linkage
- Bridge - Transportation
- Bridge - Pedestrian
- Culvert
- Weir
- Dam
- Other Hydraulic Structure
- Building
- Building within Floodplain
- Spill
- Spot Elevation
- Marsh
- Limit of Study
- 100 Year Floodplain Boundary
- Regional Storm (Hurricane Hazel) Floodplain Boundary
- Regional Storm (Due to Interbasin Spill)
- Flood Area
- Area of Further Study

The flood line on this map was modelled on a DEM with a grid resolution of 1.0 m. The DEM was created by Airborne Imaging using LIDAR mass points collected by Airborne Imaging in spring 2018 at a vertical accuracy of ±0.07 cm on hard surfaces.

The spot elevations shown on this map were produced by Greck and Associates Limited using an Trimble R2 RTK Rover GPS connected to the Can-Net system.

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PLEASE NOTE:
FLOODLINE ELEVATIONS ARE SUBJECT TO CHANGE DUE TO REVISED INFORMATION.

Engineering Consultants
Greck
5770 Highway 7, Unit 3, Woodbridge, Ontario L4L 1T8

LICENSED PROFESSIONAL ENGINEER
2023/08/22
S.M. SEXTON
100216608
PROVINCE OF ONTARIO

PLEASE NOTE:
THE PROFESSIONAL ENGINEER'S STAMP VERIFIES THE FLOOD LINE AND ASSOCIATED DATA BUT NOT THE MAP DATA.

FLOODLINE APPROVED DATE:
2023-08-22

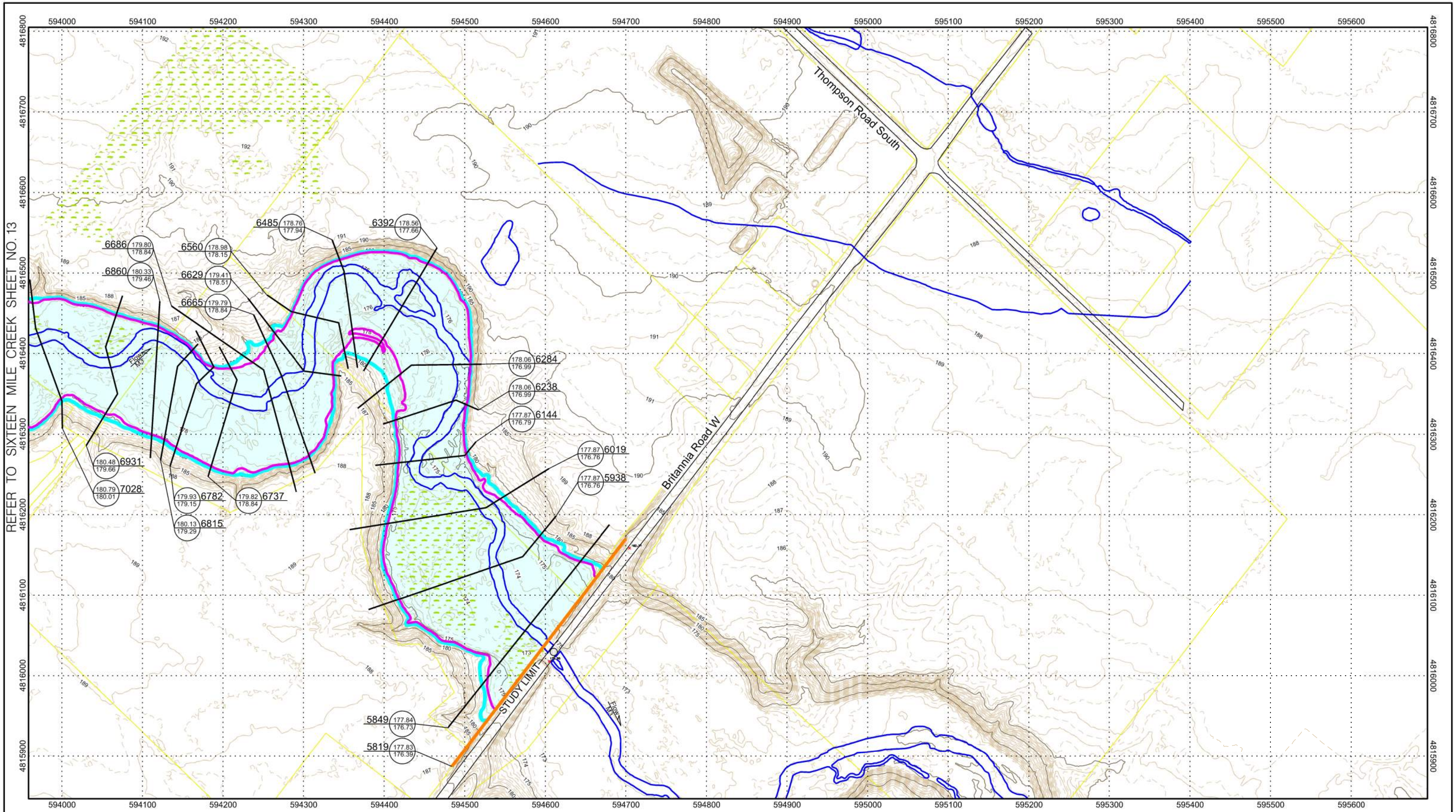
INDEX MAP
N.T.S.
13

Conservation Halton
2596 BRITANNIA ROAD WEST, BURLINGTON, ON L7P 0G3

Scale 1:2000
0m 100m 200m

FLOOD HAZARD MAPPING
SIXTEEN MILE CREEK WEST BRANCH

SHEET No.
13



REVISIONS			
NO.	DESCRIPTION	BY	DATE

LEGEND
Cross-Section Label

Regional Flood Elevation (m)
Cross-Section Number — 14.060 — Cross-Section Leader Line
100 Year Flood Elevation (m)
172.00 / 172.00
Cross-Section

SQUARE BLOCK TO INDICATE 100 YEAR FLOOD ELEVATION DOMINATES, CIRCLE INDICATES REGIONAL FLOOD ELEVATION DOMINATES

LEGEND

- Contour 5 metre
- Contour 1 metre
- Contour 0.5 metre
- Parcel Fabric
- Road
- Rail Line
- Water Feature
- Hydrologic Linkage
- Bridge - Transportation
- Bridge - Pedestrian
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FLOODLINE APPROVED DATE:

2023-08-22

INDEX MAP
N.T.S.

Conservation Halton

2596 BRITANNIA ROAD WEST, BURLINGTON, ON L7P 0G3

Scale 1:2000

0m 100m 200m

FLOOD HAZARD MAPPING

SIXTEEN MILE CREEK WEST BRANCH

SHEET No.

14

APPENDIX I: Rainfall Variability & Wetland Storage Assessment

Amy Mayes

Subject: RE: Meeting Follow-up - Urban Milton Flood Hazard Technical Meeting

Hi Everyone - Further to our Technical Meeting on May 26th, CH has reviewed the similarities and differences between HSPF flows reported in the FSEMS for the Highway 401 Industrial Park Secondary Plan Area (Philips, July 2000) relative to the VO5.1 flows generated by Greck and Associates for the Urban Milton Flood Hazard Mapping Study. Conservation Halton has also compared and reviewed rainfall distributions for each of the storms previously identified by Greck and Associates for calibration and or validation. The findings of these reviews are summarized below, with the attached spreadsheets providing more detailed information. I've also re-attached a third spreadsheet which summarizes the pond data referenced in my previous June 23rd e-mail, as I understand this spreadsheet may have been corrupted or mis-linked in my previous e-mail.

Flow and Drainage Node Comparison

- Drainage areas and flows were compared relative to the following studies:
  - FSEMS Highway 401 Industrial Area (Philips, Jul. 2000) and
  - Flood Hazard Mapping Study - Urban Milton (Greck, Mar. 2020)
- It was not possible to directly compare flow nodes at all locations. The closest comparative point has been reported along with corresponding drainage areas to support interpretation of the data. Generally speaking, drainage areas and connections were comparable apart from a few key considerations:
  - Spill flows from the Middle Branch of Sixteen Mile Creek have been added into the Greck Analysis.
  - There are key differences in the drainage connections identified for a 160 ha catchment area associated with Philips Catchments 2030, 2031 and 2033. In the 2000 model, these catchments drained southerly adjacent to Ontario Court of Justice Property towards Ontario Street. The LiDAR data however, indicates a positive drainage outlet to the west. In the Greck Study, this area outlets to the tributary immediately east of Wheelabrator Way. This accounts for the substantial difference in flow at Node O. (See the attached excel sheet for a flow node comparison).
  - At drainage node C, the Philips model indicates a significantly larger drainage area.
- Flow comparisons were made relative to the Regional Storm only, as the July 2000 Report did not include the additional event based modelling work completed per MTO's request. The following summarized key findings related to the Regional flow comparison:
  - There was greater variability associated with Regional flows in the Industrial Area, as compared to the previous comparison points indicated (Kelso, WSC Gauge near Pine Street & at Britannia Road), however unitary discharge rates were quite similar, generally within +/- 15%.
  - Where the difference in catchment area associated with the two models was within +/-10%, the average difference in reported flow rate between the two models was 4% (excluding Node G - as discussed below). (See the spreadsheet for specifics related to nodes A, B, C, D, I, G, O, J, M & L.)
  - At Node G, the Philips 2000 report indicates a decrease in flow (as compared to upstream node I), despite the addition of new industrial area. The HSPF flows at Node G have a substantially

lower unitary discharge rate as compared to other reported flows. As no physical reason for the lowered flows was evident, this node was excluded from the analysis.

Comparison of Rainfall Distribution - Calibration/Validation Events

- The following distributions were considered (and with the exception of the 2000 events have been presented by Greck and Associates in previous iterations of the report:
  - May 12/13, 2000,
  - May 18/19, 2000,
  - August 5/6, 2008,
  - May 17-19, 2011,
  - June 28, 2013, and
  - January 10-11th 2020.

  Note – The May 2000 reservoir data only became available late in the study, and so this data was not previously included.

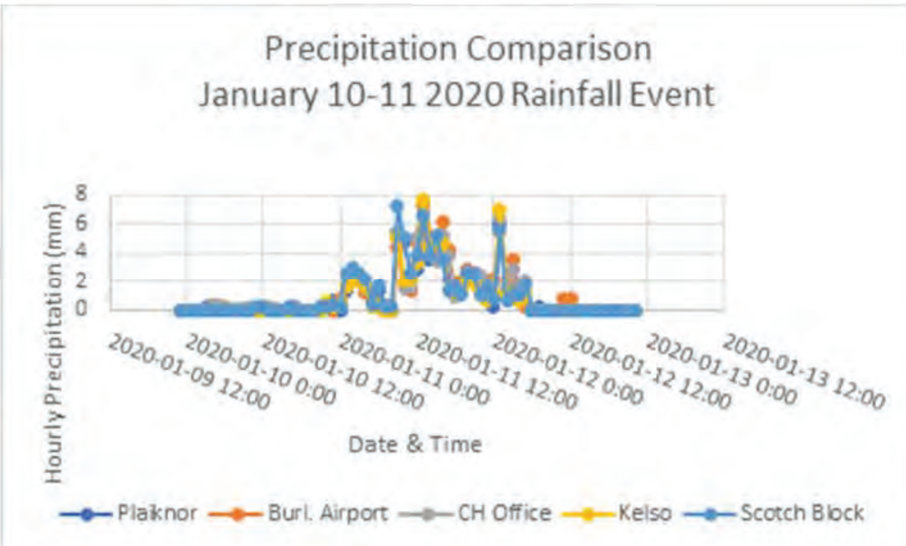
- The January 10-11th, 2020 rainfall represented the most consistent rainfall distribution – across all five stations measuring precipitation during the winter months, with the May 17-19, 2011 represented the second most consistent rainfall pattern. These were the rainfall distributions Greck and Associates relied upon to support calibration decisions. The table and graphs below summarize the differences relative to all of the rainfall.
- For the year 2000 storms, only Kelso data is available within the actchment area. Rainfall variability was elvaluated relative to additional stations in Oakville, and Hamilton.
  - The May 12-13th event generated significant variability in rainfall, with Kelso reporting 130 mm - the highest rainfall in Ontario - per the Environment Canada Report on the spring 2000 storms). The only other gauges in CH's jurisdiction for which records are available were located in Oakville – and recorded rainfall depths of 84mm. Rainfall Gauges from the surrounding area (Guelph Dam – 38 mm, Valens – 56 mm, Shades Mill – 21.5 mm) support an expectation that rainfall across the study area would have been highly variable.
  - Flow at the WSC Gauge near Pine Street measured a peak flow just before the May 18-19th flow event. This is believed to be as a result of reservoir operations in preparation for the subsequent rain event, and not reflective of watershed response to the May 18-19th flow event.

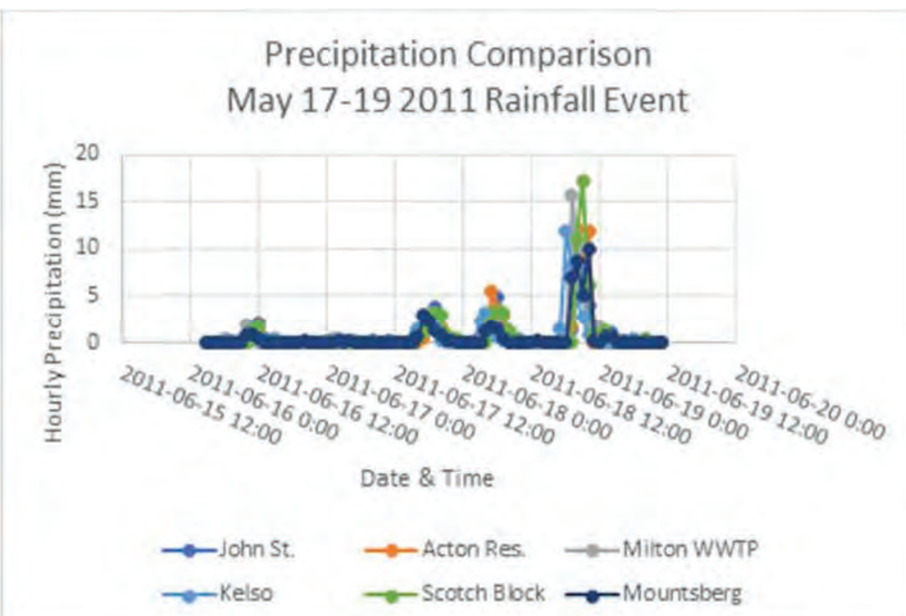
  Based on the variability associated with the May 12-13th event minimal precipitation depths and variability associated with the May 18-19th events, Conservation Halton does not intend to model these events as part of calibration/validation efforts.

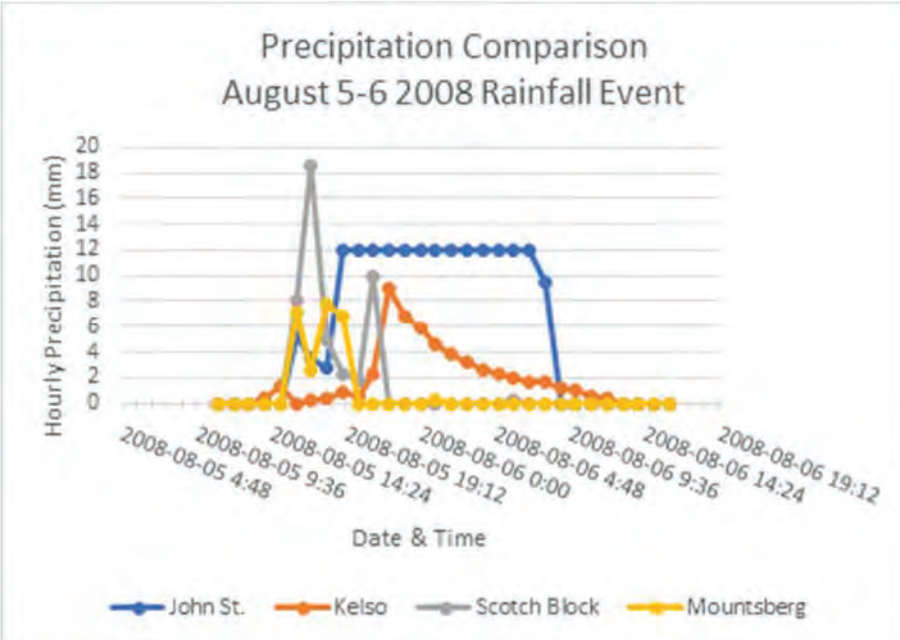
Event	Gauges	Min.	Max.	Median	Ave.	St. Dev.
2000 May 12-13th*	4	56	130.6	84.1	88.7	26.8
2000 May 18-19th*	4	0	34	11.6	14.3	13.6
2008 August 5-6	4	24.6	171.8	49.1	63.8	66.5
2008 Aug. 5-6 (excluding John St.)	3	24.6	52.4	45.8	40.9	14.5
2011 May 17-19	6	43	58.8	50.5	49.7	6.2
2013 June 28	7	1.2	67	34	27.2	23.5

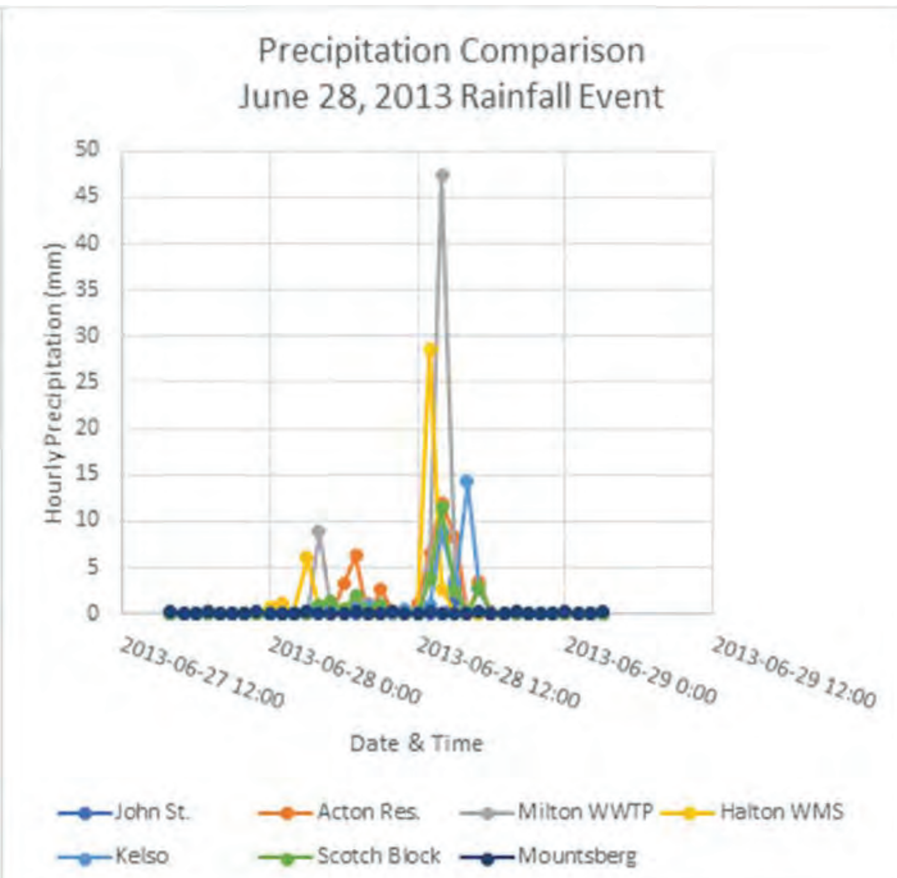
2020 January 10-12th	5	64.6	76.3	74.8	71.0	5.0

*Data has been pulled from Kelso, 14 Mile, Oakville WWTP, and Valens









<u>SWM Ponds</u>

After sharing the SWM Pond data, I realized an omission related to areas that are planned but not yet developed. To address uncertainties with respect to planned pond design, Conservation Halton proposes that the 1:100 year floodplain be established based on existing conditions (incorporating the modelling of existing off-line publicly owned quantity control ponds), as opposed to future condition flows. (As there are no regulatory control ponds located within the study area, it is proposed that the Regional Storm model run be based on future land use conditions without ponds.)

I trust that this additional information in conjunction with the model and report refinements that will be incorporated into the final submission (as discussed during the two May meetings) will enable the Town to support the final Flood Hazard Study. We look forward to receiving Town comments on the Stormwater Management pond submission (requested by July 21st) and advancing work with Greck and Associates to complete this study.

Thanks to all for your support and interest in making this a stronger and more defensible study.

Amy

Amy Mayes, P.Eng.
Coordinator, Floodplain Mapping

Conservation Halton
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905.336.1158 ext. 2302 | Cell 905.805.9874 | amayes@hrca.on.ca
conservationhalton.ca

Memorandum

Conservation Halton

ENGINEERING MEMO TO FILE

Date: 26 May 2020
To: Amy Mayes
C.C.: Janette Brenner
From: David Irwin
Regarding: *Urban Milton – Floodplain Mapping Project*
Sixteen Mile Creek

The purpose of this high-level modelling exercise was to review findings from the Urban Milton Floodplain Mapping Study; specifically, within the headwater areas which contain numerous wetlands. As the hydrologic and hydraulic properties of these wetlands is difficult to quantify, this modelling was advanced to garner a better understanding of their effects, particularly with respect to a large-scale event (e.g. Regional Storm) and to support Conservation Halton's independent evaluation of the hydrologic model.

Background:
There are a lot of wetlands within the headwaters of Sixteen Mile Creek (West Branch). Using traditional forms of analysis, it is difficult and costly to characterize these features. None the less, it is pertinent that FPM studies account for these features in their modelling. The Urban Milton Floodplain Mapping study accounted for these features via adjustment of subcatchment parameters using an aerial weighting technique based on wetland area and via adjustment of subcatchments' time-to-peak parameters based on ground cover.

As calibration efforts proved difficult, internal questions arose surrounding wetland parameterization and the model's calibration. As there were numerous challenges and uncertainties concerning input data (precipitation and reservoir levels); Conservation Halton opted to conduct a high-level internal review of the model's findings via a different approach. The approach for this high-level review was scoped considering:

- Detailed review of the wetlands' properties would not be possible for this scale of project, considering budget constraints, and the compressed timeline.
- Rainfall is spatially variable.
- Rainfall gauges are capture a point of data. Application of a data point across a watershed is only valid where the precipitation is spatially and temporarily uniform. These such events are uncommon, particularly those of the scale recommended for calibrating a Regulatory hydrologic model.
- Calibrating with radar rainfall data was considered; however due to the project's constraints, availability of data, and model limitations; this approach was ruled out.
- Detailed topographic data (2018 LIDAR) was available; this data's accuracy has been demonstrated to be of high quality.

Considering the above, staff elected to test the model's findings using a HEC-RAS 2D Model using a rain on grid analysis. This approach makes use of the detailed topographic data available, takes into consideration flow routing over the topography and in general wetland storage, and the approach does not rely upon observed rainfall data as rainfall becomes an input parameter.

HEC- RAS 2D Model Development:
The following summarizes the general approach to preparing the modelling.

- Subcatchments Boundaries from the hydrologic model were input into the HECRAS Model as 2D Flow Area Perimeters.
- A mesh was generated for each subcatchment using an approximately 40-meter x 40-meter mesh size. This mesh size is relatively large; however, it is staff's experience that the larger mesh size does not necessarily reduce quality of results. Good quality results have been obtained using larger mesh sizes; so long as key features (e.g. roads, banks, etc.) are refined, as necessary. The advantage of this larger mesh size is a reduced number of cells, which reduces computational requirements. An adaptive timestep was utilized which ranged between 60 and 3.75 seconds based upon the courant condition. It was observed that the model ran using a 3.75 second time step for the majority of the analysis.
- Breaklines were placed along key features, and areas of interest had refined mesh sizing.
- All subcatchments were connected using 2D Area Connections. Some catchment boundaries were refined at this stage such that 2D Area Connections were between two subcatchments. Notably, subcatchments with boundaries abutting through wetlands were generally merged into a single catchment; or the catchment was refined.
- As wetland storage was of interest, and due to time/data constraints; culverts were not added into the model at roadway crossing structures. In general, break lines were added along roadway crowns (approximately). This forced runoff to pond behind crossing structures until roadways would overtop; this should maximize the effects of storage.
- The rain on Grid Simulation assumes that all precipitation turns into runoff. In this regard the peak flows generated are conservative. The 12-hour Regional Storm was run for this assessment. The model was run using the full momentum equations.
- The model utilizes CH's Lidar Data (2018 Spring) for determining mesh properties.
- Model differences: Runoff from several of the gravel extraction pit subcatchments was excluded for the purposes of this analysis; based on the size of these pits there is likely storage in these extraction areas for the regional storm.

Model Details:
The following files were used for the purposes of this review. Other plan files are included with the modelling which were generally used for separate tests. As part of a follow up meeting staff will demonstrate the model and can answer the Study Team's questions.

Geometry File: HiltonFalls_Test
Unsteady Flow Title: US-HiltonFallsTest

Modelling Results:

The following summarizes the key findings from the modelling exercise. Both models are available for the study teams review and comment. Images are included on the following pages for reference purposes.

Table 1: Modelling Results Summary

Parameter Simulated	HEC-RAS 2D Rain on Grid Analysis			Hydrologic Model		
	Hilton Falls	Node 16	Total	Hilton Falls	Node 16	Total
Rainfall Volume (1 000 m^3)	N/A	N/A	10 814[1]	1 677	10 484	12 161
Flow Volume (1 000 m^3)	3 060	5 342	8 402	1 407	7 543	8 950
Peak Flow (m^3/s)	113	162		44	181	

- Peak flows rates determined by the hydrologic model exceed those of the HEC RAS Model at Node 16. Considering the HEC-RAS model allows the spill at beaver dams trail to occur; a higher peak flow rate (hydrologic model) at this location was expected. The difference in peak flow rates is not considered unreasonable.
- Peak flows rates determined by the hydrologic model at the inflow to Hilton Falls are less than those suggested by the HEC RAS Model. Considering the HEC-RAS model allows the spill at beaver dams trail to occur; the higher peak flow rate (HEC-RAS model) at this location was expected. The difference in peak flow rates is not considered unreasonable.
- Total Runoff volumes determined via the analysis are generally similar to the HEC RAS Model. Considering the HEC-RAS Model retains water behind roadway embankments, because culverts were not included, higher volumes from the hydrologic model would be expected. The differences were considered reasonable.

Conclusion:
The HEC-RAS 2D model suggests that the Regional Storm is to expect inundate the wetland areas and suggests runoff volumes and peak flow rates suggested by the hydrologic model are not unreasonable.

[1] This volume is less than the Hydrologic models because several gravel extraction pits were excluded from the analysis.

Figures:

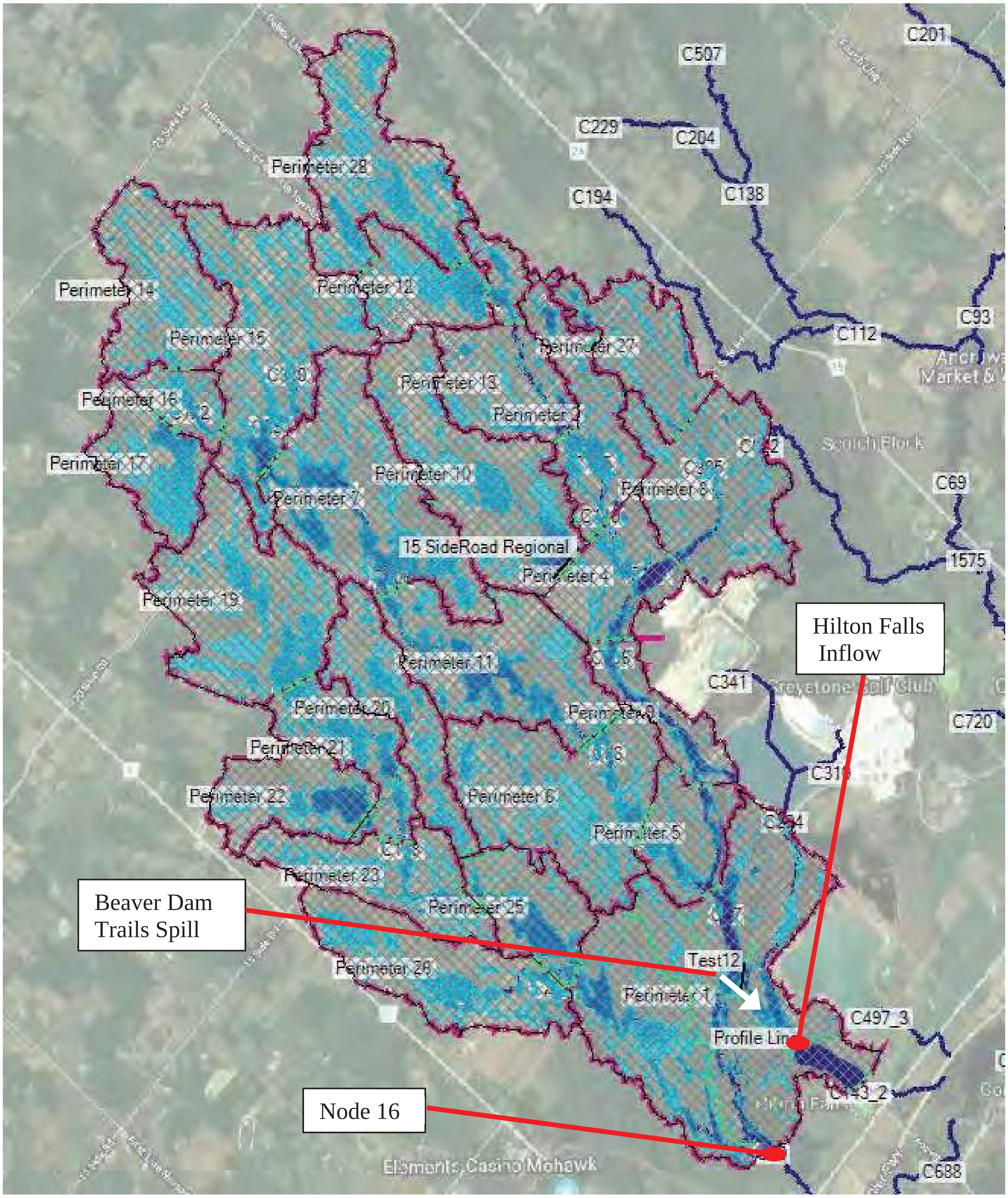

Figure 1: Model Geometry Overview

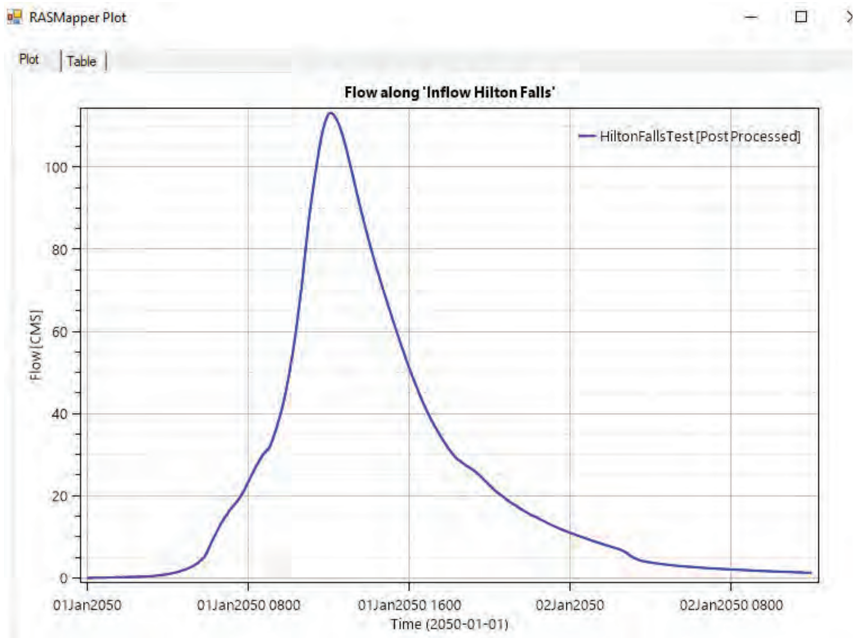

Figure 2: Peak Inflow into Hilton Falls Reservoir (Includes Spill)

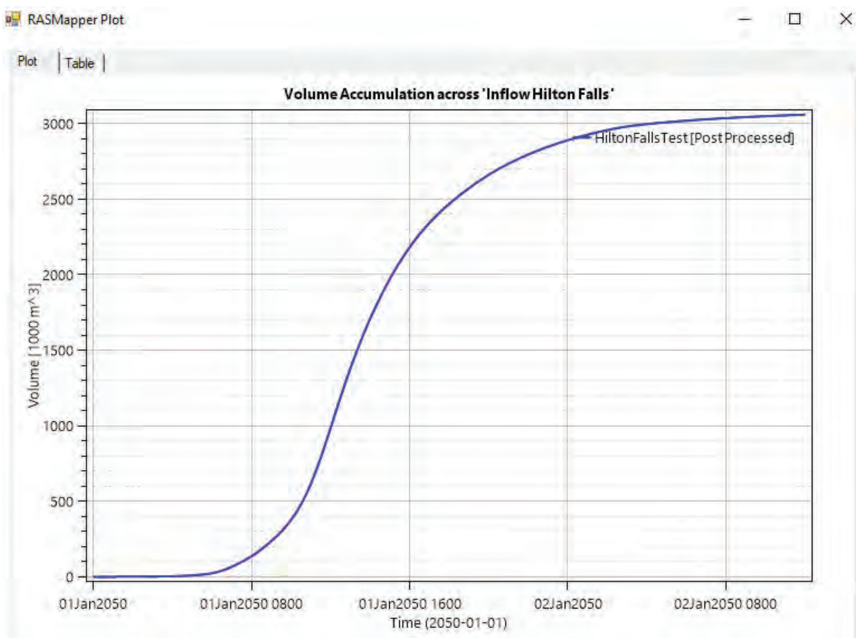

Figure 3: Total Volume inflow into Hilton Falls Reservoir (Includes Spill) – Runoff Volume (3 000 000)

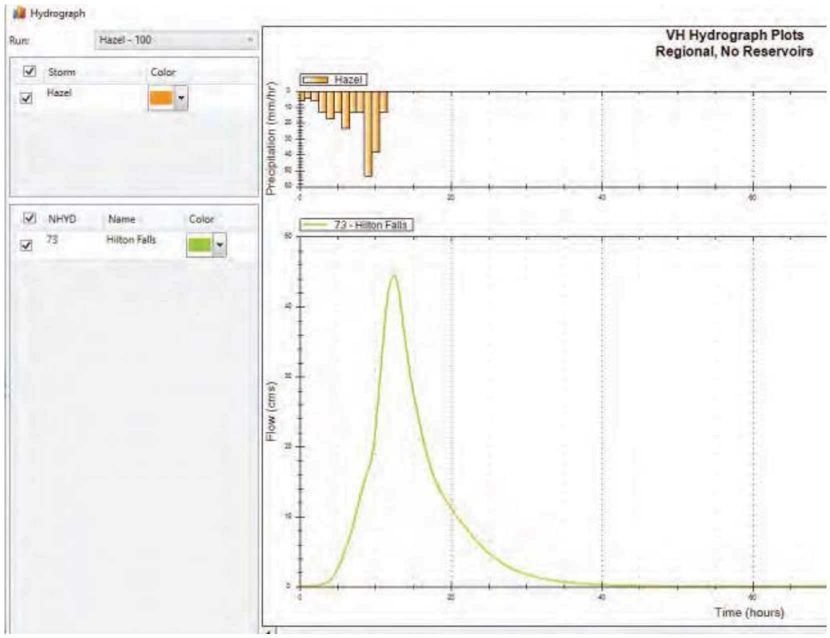

Figure 4: VO Model Output at Hilton Falls (No Spill Modelled) 45 m^3/s

Regional, No Reservoirs ✕

Schematic | Detail - All Runs | Detail - All Runs ✕

```
**********************************
** SIMULATION:Hazel - 100       **
**********************************

--------------------
| ADD HYD  (  0073)|
|   1 +  2 =  3    |          AREA     QPEAK     TPEAK      R.V.
--------------------          (ha)     (cms)     (hrs)      (mm)
      ID1= 1 (  0760):      159.27     4.660     16.92    161.30
    + ID2= 2 (  0972):      631.74    41.509     12.33    182.03
      ======================================================
      ID = 3 (  0073):      791.01    44.388     12.42    177.86

   NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

----------------------------------------------------------------------------
```

Figure 5: VO Model Output at Hilton Falls (Runoff Volume 1 406 873 m^3)

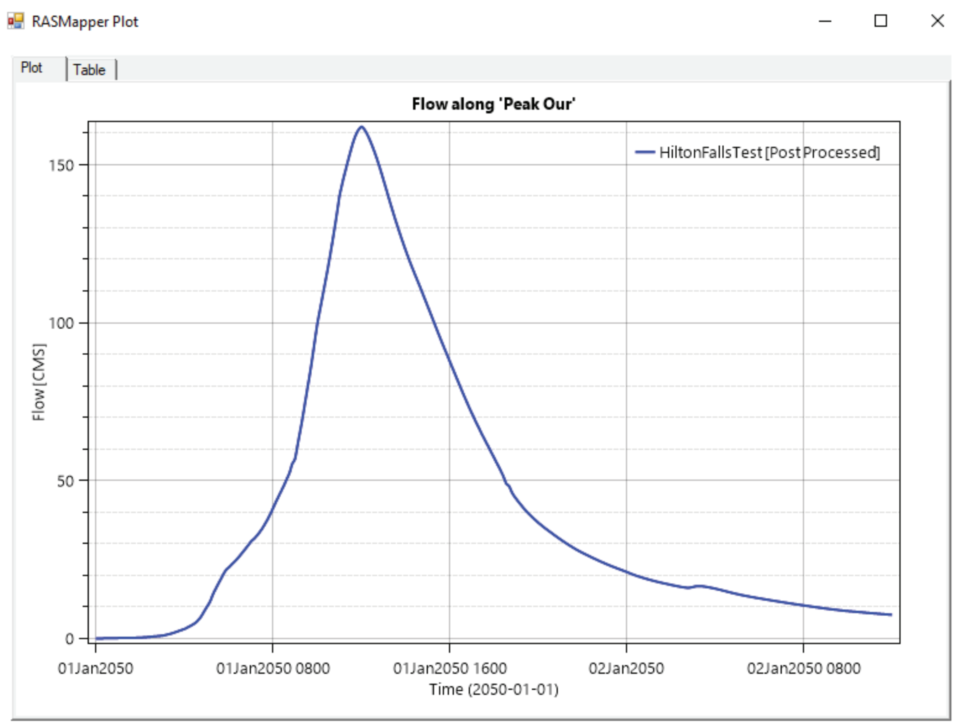

Figure 6: Peak Flow Down Tributary C44 (Node 16) Peak Flow 160 m^3/s

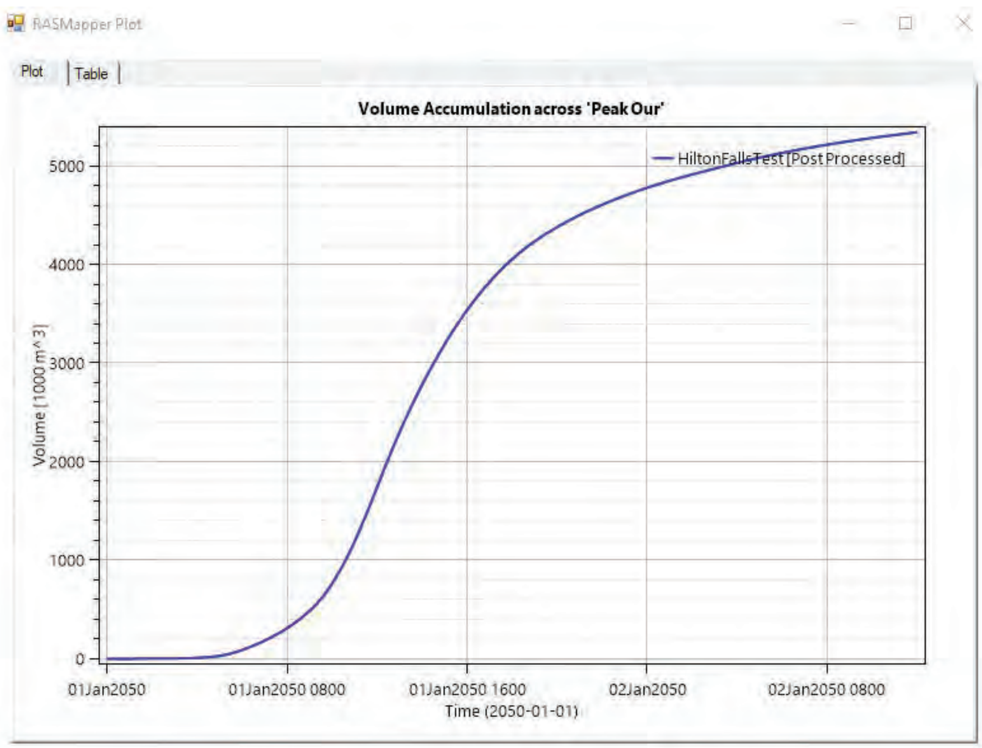

Figure 7: Total Runoff Volume (Node 16) Total Volume 5 400 000 m^3

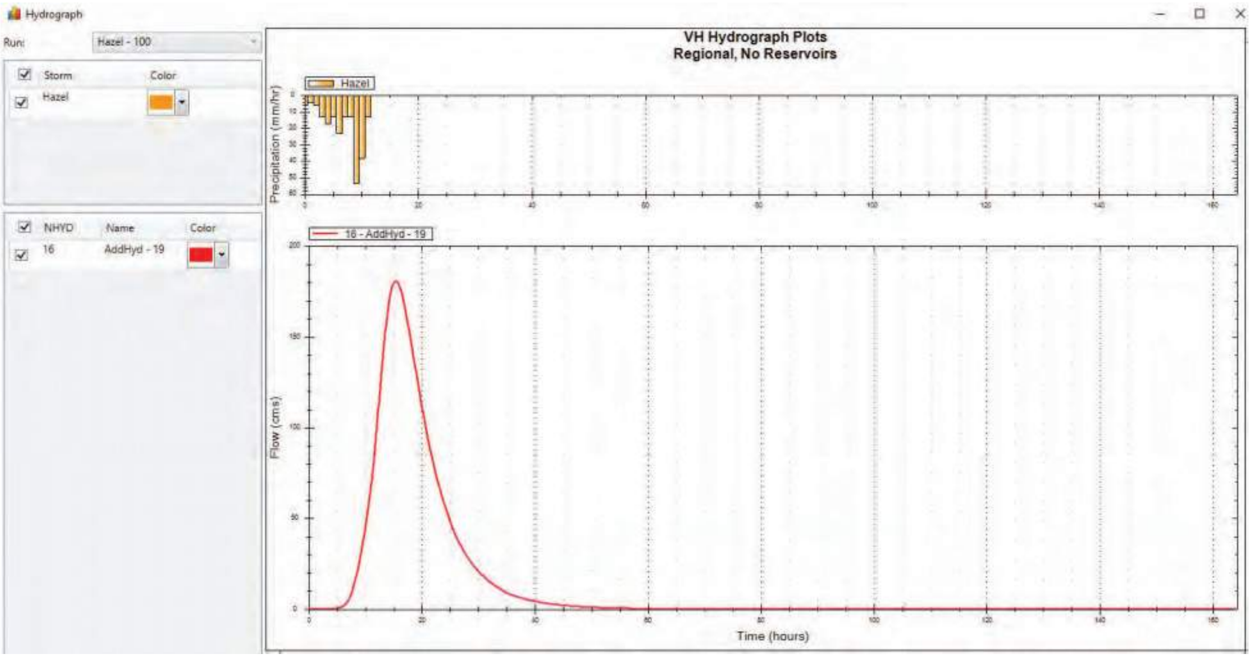

Figure 8: Visual Otthymo Output (Node 16) Peak Flow 180 m^3/s

Regional, No Reservoirs ✕

Schematic | Detail - All Runs ✕

```
 ** SIMULATION:Hazel - 100     **
 ********************************

 --------------------
 | ADD HYD   (  0016)|
 |   1 +  2 =  3     |       AREA     QPEAK     TPEAK      R.V.
 --------------------        (ha)     (cms)     (hrs)      (mm)
         ID1= 1 (  0180):   221.50    7.434     15.33    146.96
       + ID2= 2 (  0410):   270.13    5.606     19.75    153.37
         ==================================================
         ID = 3 (  0016):   491.63   12.222     16.50    150.49

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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

 --------------------
 | ADD HYD   (  0016)|
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 --------------------        (ha)     (cms)     (hrs)      (mm)
         ID1= 3 (  0016):   491.63   12.222     16.50    150.49
       + ID2= 2 (  0915):  1201.19   51.882     15.00    156.72
         ==================================================
         ID = 1 (  0016):  1692.82   63.658     15.17    154.91

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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

 --------------------
 | ADD HYD   (  0016)|
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 --------------------        (ha)     (cms)     (hrs)      (mm)
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       + ID2= 2 (  0927):  3252.51  117.328     15.50    151.31
         ==================================================
         ID = 3 (  0016):  4945.33  180.845     15.42    152.54

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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```

Figure 9: Visual Otthymo Output (Node 16) Runoff Volume 7 543 103 m^3