Township of Springwater

Midhurst Secondary Plan Area

COMPREHENSIVE STORMWATER MANAGEMENT PLAN

FINAL REPORT

Volume 4 of 4

Appendix H-1 to N

June 2020

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CONSULTING
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Appendix H-1

Stormwater Outlet Assessment for Matheson Creek

File: 213115
June 2020

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MIDHURST MASTER DRAINAGE PLAN TECHNICAL MEMO #1:

DATE May 20, 2016 **FILE NO.** 845-3675

RE Pre-development Watershed Modeling &
Proposed Terms of Reference for Completion of Stage 2 MDP for Matheson Creek

1.0 INTRODUCTION

The Midhurst Heights Development forms part of the Midhurst Secondary Plan (MSP) development area in the Township of Springwater, Ontario.

The subject lands currently consist of agricultural land with some wooded and pasture area. Simcoe County Soils Mapping identifies the soils onsite as Vasey sandy loam and Dundonald sandy loam, which are classified by MTO Design Charts as AB type soils. The site currently drains to the north and west property lines via several drainage draws across the site. Overall site drainage is from southeast to northwest.

The Midhurst Heights Development lands lie within the Matheson Creek Subwatershed, as shown on Figure 1. Matheson Creek forms part of the Nottawasaga River Watershed, and is thus under the jusrisdiction of the Nottawasaga Valley Conservation Authority (NVCA). Matheson Creek was previously studied as part of the Willow Creek Subwatershed Plan (NVCA, 2001), as it is a tributary of Willow Creek. Matheson Creek has been identified as having significant reaches of cold and cool water fish habitats, and supports both brook and brown trout fisheries (NVCA, 2001). The Matheson Creek Subwatershed (Tributary to Willow Creek) encompasses approximately 9,250 ha of land, pre-dominantly pasture, meadow and forested land uses, extending from Midhurst to the Horseshoe Valley area. The outlet of the Matheson Creek Subwatershed to Willow Creek is located just west of Wilson Drive and north of Hwy 26. The nature and sensitivity of Matheson and Willow Creeks have bearing on the stormwater management strategies for developments within the MSP.

Preliminary SWM targets and a preliminary proposed SWM design for the Midhurst Heights Development were presented in Stage 1 of the Midhurst Secondary Plan Master Drainage Plan (MDP). This work was summarized in *Summary Document for OMB Proceedings* (Crozier, August 2014).

To achieve the SWM targets identified in the Stage 1 MDP, it is proposed that the runoff generated by the proposed development will be collected and treated in a stormwater management "end-of-pipe" facility constructed in the northwest portion of the Midhurst Heights Development. Low Impact Development (LID) stormwater management practices will also be implemented throughout the subdivision to assist in meeting water balance objectives, mitigate erosion impacts and to provide primary water quality controls.

The existing site outlets do not exhibit defined bed and banks and are not permanently flowing watercourses. As such, they are not considered to be appropriate stormwater outlets by NVCA. A preferred outlet for the pond consisting of the Matheson Creek Tributary at Gill Road, located approximately 3 km north of the site, was subsequently deemed acceptable by the NVCA through the Stage 1 MDP Work.

1.1 Stage 2 MDP Objectives

The second stage (Stage 2) of the Midhurst Secondary Plan MDP will be prepared by the Township, with input from MSP developers, to expand upon the analysis completed in Stage 1 to include all future development lands within the MSP area. Stage 2 will confirm that development within the MSP area will have no negative impact on the receiving waters.

The following issues are to be addressed with Stage 2 of the Midhurst MDP:

1. Confirm no increase in peak flows downstream of the MSP development areas;
2. Confirm no increase in runoff volumes downstream of the MSP development areas for frequent events;
3. Confirm no net erosion impacts downstream of the MSP development areas;
4. Confirm no additional nutrient loading downstream of the MSP development areas (including the wastewater treatment plant).

Stormwater management criteria and methods will be confirmed through the Stage 2 MDP to ensure that the above-noted objectives are met on a watershed basis by the proposed development within the MSP. Further to these criteria, the MDP will:

5. Present an Adaptive Management Plan (AMP) that will provide a framework for ongoing monitoring of the developments, and implement changes if necessary to meet the above noted objectives.

Another objective: "*Provide for best efforts to minimize or eliminate thermal impacts to receiving waters as a result of development*", has been previously addressed through the MDP Stage 1, and is thus considered complete.

1.2 Stage 2 MDP Process and Terms of Reference

In the absence of formal Terms of Reference from the Township as to the required format and content of the MDP work, we propose to assist with addressing the MDP requirements through a series of Technical Memos with respect to the Matheson Creek focus area that will be submitted to the Township and Nottawasaga Valley Conservation Authority (NVCA) for review. This format will allow flexibility for the Township in preparing the ultimate MDP for the entire MSP area.

While the overall MDP to be prepared by the Township will examine the entire MSP area, Crozier will contribute the study specifically of Matheson Creek, which is the outlet for the Midhurst Heights Development lands.

Our work on the MDP will directly address issues one (1), two (2) and five (5) noted above. Our work will provide supporting material to assist GEOmorphix and Hutchison Environmental to address issues three (3) and four (4), respectively.

Our MDP work will be structured in the following steps:

1. Collection of data, consisting of streamflow and rainfall data;
2. Processing of data for use during the modeling stage;
3. Determining the model inputs for pre-development model;

4. Calibration and validation of the pre-development model, comparing observed and simulated data;
5. Using the calibrated pre-development model, simulate pre-development watershed response to a variety of rainfall events (2 year through 100 year, 4-hour Chicago and 24-hour SCS, Regional);
6. Prepare post-development model based on the calibrated pre-development model to reflect proposed conditions on subject site and other development properties within the MSP and Matheson Creek Subwatershed;
7. Size SWM facilities and LID controls to reduce post-development runoff flows and volumes to have no negative peak flow and volume impacts on downstream reaches of Matheson Creek;
8. Confirm that proposed SWM targets respect the erosion and nutrient management objectives;
9. Prepare an AMP reflecting a monitoring and management plan to ensure that the established targets are met, and remain suitable throughout buildout of the MSP.

We have prepared this Technical Memo #1 to document steps 1 to 5 of the MDP work related to Matheson Creek; the establishment and calibration of an existing conditions model of the Matheson Creek Subwatershed. This will be an important tool moving forward to confirm the Stormwater Management (SWM) criteria for the Midhurst Heights development. This memo also presents the proposed Terms of Reference for the completion of steps 5 through 8 for Township and NVCA consideration.

2.0 STREAMFLOW MONITORING PROGRAM

Commencing April 15th, 2015 and ending October 14th, 2015, streamflow data was collected at three (3) separate locations within the Matheson Creek Subwatershed. The following locations were used for streamflow monitoring (refer to Figure 2):

1. Tributary to Matheson Creek along Gill Road (Small Tributary);
2. Tributary to Matheson Creek along Gill Road just north of location 1 (Large Tributary);
3. Matheson Creek at Wilson Drive.

These sites were established to capture flow conditions as two (2) potential future site outlets (the Gill Road sites) and at the downstream limit of the watershed. Using data at these sites post-to-pre comparisons can be made locally at the proposed discharge location(s), and on a net watershed basis. NVCA and the Township were made aware of these monitoring locations via email November 11, 2015, and were provided the opportunity to comment.

Streamflow monitoring was completed using both automated and manual practices. Automated monitoring was completed using Solinst Leveloggers (Model 3001) at each location to record water levels. Water level data recorded by the Leveloggers was corrected using Solinst Barologgers (Model 3001). Barologgers were located only at location 3 and location 2 due to the proximity of locations 1 and 2. All loggers recorded data at 5 minute intervals.

Manual stream gauging was undertaken in order to develop rating curves for each location shown in Appendix A (A-1 to A-3). Rating curves are used in order to estimate the flow rate at a recorded water level. The process used to determine the rating curves for each location was:

1. Water level was recorded at the time of manual stream gauging using a staff-gauge measurement reading;
2. The staff gauge reading was correlated to the documented Levelogger data;

3. Manual stream gauging was performed at a pre-selected cross section for each location in order to determine the flow rate of the watercourse at a given water level.

The velocity-area method of manual stream gauging was used in order to determine the watercourse flow rate at a particular time for multiple rainfall events during the course of the monitoring period. Velocity measurements were taken using a Swoffer (Model 3000). This method was used for each location mentioned (See Appendix A, A-1 to A-3). Due to the depth of flows of Location 3, assistance was provided by NVCA during large runoff events. NVCA provided flow rate measurements using depth sounding to measure flow depths. During larger events, data collected from Location 3 by the NVCA and Crozier was combined to develop the rating curve for this location. This was completed on two (2) occasions.

A minimum of five (5) manual stream gauging points were obtained at each monitoring location with which to develop a rating curve. Data logger downloads were completed seven (7) times over the course of the monitoring work.

The equations produced for each rating curve were used in combination with the relevant corrected water level data recorded from each location to obtain a continuous streamflow record at each location. Refer to Appendix A (A-4 to A-6) for the derived continuous streamflow data at each location.

2.1 Streamflow Data Processing

Processing of streamflow data collected from all locations consisted of the following steps:

- Selection of appropriate events to use for modeling;
- Baseflow separation for selected events; and,
- Hydrograph timestep alignment corresponding to the beginning of the rainfall event.

Selected flow events for modeling comparison purposes were chosen based on the following attributes:

1. The event peak flow rate compared to the maximum rating curve limit
    - It was important to select sample events that exhibited peak flows within a reasonable range of the maximum observed rating curve flow rate, such that streamflow data was not extrapolated too far beyond the observed rating curve flows.
2. Antecedent moisture conditions
    - Best to avoid the use of rainfall events immediately following other rainfall events, or during spring conditions.
3. Spatial distribution of rainfall
    - Select sample events that exhibited uniform rainfall across the entire watershed.
4. Size of events
    - Modeling appropriately sized events to ensure an appropriate range of rainfall volumes

Based on these criteria, nine (9) candidate events were selected for further assessment. From the candidate events, events 3, 4, 5 and 8 shown in Appendix A (A-7) were selected for calibration and validation purposes. Refer to Section 3.1 for a discussion of the review of rainfall data and selection of the events. Events 3 and 4 were used for calibration purposes, while events 5 and 8 were used for validation purposes.

Baseflow separation of the streamflow data for the selected events was completed in order to eliminate flow resulting from baseflow/groundwater, and obtain a direct runoff hydrograph for calibration. The method used for baseflow separation was adapted from *Hydrology: An Introduction* by Philip B. Bedient et al. This method included the following procedure (refer to Appendix A, A-16):

1. Identify beginning of direct runoff (Point A);
2. Draw a vertical axis through the hydrograph peak (Peak Flow Line);
3. Draw a horizontal line from point A to the peak flow line (Point B);
4. Identify the point of inflection on the falling limb of the hydrograph (Point C);
5. Connect point B to point C;
6. Subtract the calculated baseflow hydrograph (points A-B-C) from the total hydrograph to obtain a direct runoff hydrograph.

Baseflow separation results of events 3, 4, 5 and 8 are shown in Appendix A (A-8 to A-15).

3.0 RAINFALL MONITORING

Rainfall monitoring data was retrieved from the following external sources:

- Environment Canada;
- NVCA; and,
- City of Barrie.

Environment Canada rain gauges record daily precipitation and were located in Collingwood, Midland, Barrie, and Coldwater. Rainfall data from these rain gauges were used to get a sense of the general rainfall patterns across the watershed and was used only for preliminary selection of calibration events. It was important to select rainfall events that were well distributed across the watershed, as only a single representative rainfall distribution/volume was applied to the OTTHYMO model across all catchment areas.

NVCA rain gauges recorded rainfall data every 15 minutes. NVCA rain gauges were located south of Minesing, Ontario and in Horseshoe Valley, Ontario. City of Barrie rain gauges recorded in 5 minute intervals and were located within the City of Barrie limits. The NVCA rain gauges and City of Barrie rain gauge #3 were used in the final selection of modeling events and preparation of rainfall data for modeling purposes.

Refer to Figure 3 for modeling rain gauge locations and Appendix B (Table B-1) for rainfall data comparison between rain gauges for each selected event. The observations noted in Table B-1 describe the rationale for selection of calibration and validation events.

3.1 Rainfall Data Processing

Rainfall data used for the selected modeling events was processed into modeling storm files. Refer to Appendix B (Table B-2 to B-9). The following steps were undertaken to produce these storm files:

- Realign data to have 15 minute interval data for all rain gauges;
- Determine the representative rainfall amount at an ungauged location, located at the centroid of the watershed; and,
- Extract selected calibration and validation rainfall events.

As mentioned in Section 3.0, the recording intervals of the NVCA and the City of Barrie data were 15 minute and 5 minute intervals, respectively. Since the NVCA's rainfall data was recorded at a greater time interval, the rainfall data for City of Barrie rain gauge #3 was manipulated from 5 minute to 15 minute interval rainfall data to match the NVCA's rainfall data intervals.

In order to represent the entire watershed with a single rainfall event, a representative ungauged location was selected at the centroid of the watershed. Rainfall from the aforementioned rain gauges was used in order to create an estimated rainfall record at this location for each event. Refer to Appendix B (Tables B-2 to B-5) for ungauged rainfall amounts for the selected events. This estimated rainfall record was used to model the watershed response for the various calibration and validation events. Refer to Table 1 for the corresponding estimated rainfall amounts for the selected modeling events.

Table 1: Estimated Rainfall Amounts for Selected Model Events

Event #	Event Type	Calibration or Validation	Estimated Rainfall Depth at Ungauged Location (mm)
3	Large	Calibration	34.1
4	Small	Calibration	27.4
5	Large	Validation	41.7
8	Small	Validation	26.6

The centroid of the watershed was determined by using a trapezoidal approximation as shown in Figure 3. The ungauged rainfall amounts were determined by inverse distance weighting method, which required the straight line distance of each rain gauge to the centroid and the rainfall amount for each rain gauge at a given time. Distances of the rain gauges to the centroid and the watershed centroid location are shown in Figure 3 and Appendix B (Tables B-2 to B-5). Storm files for the selected storms were created using the ungauged rainfall data calculated for each selected event and are shown in Appendix B (Tables B-6 to B-9).

4.0 HYDROLOGIC PARAMETERS

Baseline input values representing watershed physical characteristics, were established using a number of sources:

- NVCA Topographic maps (NVCA, 2012);
- NVCA Land Use maps (NVCA, 2008);
- Willow Creek Sub-Watershed Plan (high-level catchment delineation) (NVCA, 2001);
- Land Information Ontario (LIO) (Soil Types map) (LIO, 2014);
- NVCA Technical SWM Guidelines (NVCA, 2013);
- MTO Drainage Manual (MTO, 1997); and,
- HEC RAS Hydraulic Reference Manual (HEC-RAS, 2010).

4.1 Hydrologic Parameterization

The physical watershed characteristics were analyzed and processed in order create the uncalibrated hydrologic model (Base Model). The following watershed characteristics were determined:

- Delineation of Catchment areas;
- Composite Curve Number (CN) value for each catchment;
- Composite Initial Abstraction (IA) value for each catchment;
- Time of Peak; and,
- Cross sections for use in ROUTECHANNEL Commands.

Delineation of catchment areas were completed considering the previously completed delineations in the Willow Creek Sub-Watershed Plan (NVCA, 2001), DEM topographic mapping from NVCA and ground-truthing completed by our office. The following factors were taken into consideration when delineating the catchment areas:

1. Topographic features
2. Obstructing drainage features (i.e. railroad lines, roads)
3. Catchment size consistency between watersheds
4. Points of interest (i.e. monitoring locations)

Provided these factors, Matheson Creek Subwatershed was divided into eighteen (18) catchment areas as shown in Figure 4.

Characterization of each catchment area included the use of NVCA Technical SWM Guidelines, NVCA land use and topographic maps and Land Information Ontario's soil maps. NVCA land use map was combined with the soils map produced by Land Information Ontario in order to determine a baseline composite CN value for each catchment. A total of six (6) land uses and fifteen (15) soil types were evaluated in the Matheson Creek Subwatershed. A composite CN value was calculated based on an area-weighted method for each land use/soil type combination shown in the NVCA Technical SWM Guideline. Refer to Figure 5 for more information regarding land use and soil types.

Similarly, an area-weighted method was used to determine the baseline composite IA value for each catchment. IA values were obtained from NVCA Technical SWM Guideline.

Time of concentration (T_c) was calculated for each catchment based on the lengths of sheet flow, shallow concentrated flow and streamflow to a specified outlet. The Airport and Uplands Methods were used to calculate T_c for each catchment area. In each case, the Uplands method provided the longest T_c, and thus was applied to the uncalibrated model. Refer to Appendix C (C-16) for travel paths used for T_c calculations. The T_c for each catchment was converted to Time of Peak (T_p) in hours for input into the model. The following methods, perhaps more suitably for large, undeveloped watersheds were used to check T_p calculated from the Uplands Method:

- California Culvert Practice Method; and,
- Kerby-Kerpich Method.

Refer to Appendix C (Tables C-1 to C-3) for the uncalibrated model hydrologic parameters and the calculated T_p for each catchment using the aforementioned methods.

To represent long reaches of channelized flow, cross sections were required for input into ROUTECHANNEL commands in OTTHYMO. Cross sections were developed using NVCA Digital Elevation Model (DEM) and air photo observations/field observations. For each cross section a Manning's value for the floodplain and the

main channel was visually determined, cross referenced with the HEC-RAS Hydraulic Reference Manual (HEC-RAS, 2010). In order to accurately model low flow conditions, a small low flow channel was also included for each cross section based on air photo and field observation. Refer to Appendix C (C-4 to C-15), visually showing the cross sections used in OTTHYMO. Model cross sections are also shown in Appendix C (C-16).

Refer to Appendix D (D-1) to view the OTTHYMO model layout schematic.

This model was run using the selected calibration rainfall events to establish the uncalibrated rainfall/runoff relationship for the watershed.

5.0 CALIBRATION & VALIDATION

The model selected for the MDP work was Visual OTTHYMO Version 3.0. This model simulates direct runoff during a rainfall event. This model was selected by the Master Drainage Plan Steering Group consisting of engineering consultants for Geranium and Midhurst Rose Alliance, Ainley Group (acting for the Township) and NVCA staff. The model was selected for the following reasons:

- The OTTHYMO modeling platform is an industry standard model that is familiar to all involved parties and is relatively simple to parameterize;
- Previous work done for the Geranium and Midhurst Heights developments were completed in OTTHYMO;
- OTTHYMO modeling could be readily integrated into existing and future models on the Willow Creek system by NVCA; and,
- OTTHYMO effectively models both urban and rural catchment areas.

The OTTHYMO model is traditionally applied as a single-event hydrologic model which has the capability to model rainfall, infiltration, runoff, channel routing and storage routing. Various hydrograph routines can be used to model both rural and urban catchment areas.

Calibration of a model involves the comparison of observed streamflow data and simulated streamflow data to assess and improve the performance of the hydrologic model. Systematic modification of input parameters within acceptable ranges allows the user to adjust the inputs to an uncalibrated model until the outputs more closely reflect observed data.

Typically, observed data is broken into two portions: calibration data, and validation data. Calibration data is used to calibrate the model as described above. The independent validation data is then used to confirm the performance of the calibrated model. This ensures that the calibration exercise did not simply represent "curve fitting" of the calibration data, but rather results in a model that reliably predicts watershed response over a range of data.

Calibration and validation of the Matheson Creek hydrologic model was performed considering the following hydrograph characteristics:

1. Time of peak (T_p);
2. Direct Runoff Volume;
3. Peak flow rate;
4. General hydrograph shape.

In order to determine if the simulated results accurately represented the observed watershed response, a number of statistics and metrics were assessed. These statistics are shown below with brief explanations of their purpose:

- **Nash-Sutcliffe Efficiency (NSE):** Normalized statistic that determines the relative magnitude of the residual variance compared to the measured data variance. This is used to determine goodness of fit between the simulated and observed data, with NSE = 1 being the optimal value.
- **Mean Square Error (MSE):** Error index that indicates the error in the units of the constituent of interest. This is used to determine goodness of fit between simulated and observed data, with MSE = 0 being the optimal value.
- **Difference in Simulated and Observed Time of Peak:** The difference between the simulated and observed time of peaks, with difference of zero (0) minutes being the optimal value. This is used to determine goodness of fit and how close time to peak is between simulated and observed data.
- **Ratio of Peak Flow Simulated ($Q_{peak,sim}$) to Peak Flow Observed ($Q_{peak,observed}$):** The ratio of the simulated peak flow rate to the observed peak flow rate, with $Q_{peak,sim}/Q_{peak,observed}$ = 1 being the optimal value. This is used to determine goodness of fit and if peak flow rate between simulated and observed data match.
- **Ratio of Simulated Runoff Volume ($V_{sim,runoff}$) to Observed Runoff Volume ($V_{observed,runoff}$):** The ratio of simulated runoff volume to the observed runoff volume, with $V_{sim,runoff}/V_{observed,runoff}$ = 1 being the optimal value. This is used to determine goodness of fit and if runoff volume between simulated and observed data match.

An additional method that was used was a visually graphical comparison of the simulated and observed data, which was a preliminary indicator of error between the simulated and observed data for all four (4) hydrograph characteristics. Table 2 displays the purpose of each statistic for each hydrograph characteristic.

Table 2: Methods of Comparison for Simulated and Observed Data

		Statistics/Methods of Comparison				
		NSE	MSE	Simulated vs Observed T_p	$Q_{peak,sim}/Q_{peak,observed}$	$V_{runoff,sim}/V_{runoff,observed}$
Hydrograph Characteristics	T_p			X		
	Volume					X
	Peak Flow Rate				X	
	General Shape	X	X	X	X	X

5.1 Calibration Process & Results

The model was calibrated based on the manipulation of four (4) input parameters in the order shown below:

1. Time to Peak (T_p);
2. Curve Number (CN);
3. Initial Abstraction (IA);
4. N value.

Data comparison for the purposes of calibration was completed at Location 3 (Matheson Creek at Willow Drive) to compare the full Matheson Creek Subwatershed response. The observed and simulated results at Location 2 were also compared for confirmation/discussion.

The final calibrated model represented the following changes from the baseline parameters:

- Time to Peak for each catchment was decreased by 40% of uncalibrated values;
- Curve Number for each catchment was increased by 15% of uncalibrated values;
- Initial Abstraction for each catchment was decreased by 30% of uncalibrated values; and,
- N value for each catchment was set to 1.07 (Uncalibrated value = 3).

Refer to Appendix D (D-2 and D-3) regarding the comparison of the simulated and observed hydrographs for the uncalibrated and calibrated models. Refer to Appendix D (D-6 to D-9) for the OTTHYMO summary output files for the uncalibrated and calibrated model. Refer to Table 3 for the summarized statistical analysis of the simulated and observed data for the uncalibrated and calibrated models for calibration events 3 and 4. Refer to Appendix D (Tables D-12 and D-13) for additional data regarding the calibrated hydrologic parameters and the statistical analysis of the calibration events, respectively.

Table 3: Summarized Statistical Analysis for Calibration Events at Location 3

Statistical Parameters	Average Uncalibrated Model Values	Average Calibrated Model Values	Net Change
Nash-Sutcliffe Efficiency	-0.52	0.94	1.46
Mean Square Error	0.96	0.03	-0.94
Qpeak Modeled/Qpeak Observed	1.80	1.01	-0.79
Runoff Volume Modeled/Runoff Volume Observed	0.63	1.04	0.41

As shown in Table 3 and the detailed results (Appendix D, Table D-13), the calibration exercise greatly improved the modeling results relative to the observed data at Location 3. Particularly important was the significant improvement to the simulation of peak flow values (ratios of modeled to observed runoff between 0.96-1.05), which will be critical to the accurate assessment of flooding impacts. Hydrograph volumes and general shapes were also fairly well represented in the calibrated model, with the ratios of modeled runoff volume to observed runoff volume between 0.85 and 1.23.

Appendix D (D-14, D-15 & Table D-18) also includes comparison of the observed and simulated flows at Location 2 for the two calibration events. The contributing area to Location 2 is significantly smaller than that of Location 3. As a result, there is more opportunity for localized error in modeling results. In general, the calibrated model results show significant improvement over the uncalibrated model results for the calibration rainfall events, particularly for peak flow (one of the most important parameters). Total hydrograph volume, however, was not represented well by the model at this location. Specifically, the falling limbs of the modeled hydrographs did not fall as sharply as those of the observed hydrographs, resulting in more flow volume modeled than observed. This could be due to a number of factors, such as:

- Localized variation in rainfall patterns not captured in the estimated rainfall record at the watershed centroid;
- Effects of catchment storage present within catchment 7 and 8, such as quarries, reservoirs, significant wetland areas, presence of flow barriers such as Highway 400 and the rail corridor;

- Model scaling issues (i.e. the model, having been calibrated to simulate runoff volumes for a large catchment area, may not accurately simulate runoff volumes for a smaller catchment area).

The overall results of the calibration process indicate the following:

- The calibrated model provides a reasonable estimate of peak flows at multiple locations in the watershed and at a variety of catchment scales, making it suitable for use in the assessment of peak flow impacts;
- The calibrated model may not be appropriate for modeling of runoff volumes at small scales, although it represents total runoff volumes on a watershed basis relatively well.

These conclusions are further examined through the validation process, discussed below.

5.2 Validation Process & Results

Validation was undertaken using events 5 and 8. It is important to note that these events represented slightly less desirable candidates, as they were subject to antecedent conditions associated with small rainfall events the day previous. Furthermore, the rainfall distributions during the events were somewhat irregular. Attempts to correct for this were accounted for during baseflow separation, however it was anticipated that there would be some inconsistency with the calibrated model.

At Location 3 (the watershed outlet), the simulated peak flow for event 5 was larger than the observed peak flow, while the simulated peak flow for event 8 was smaller than the observed peak flow (ratios of modeled to observed runoff between 0.74-1.32). Both simulated events resulted in similar runoff volumes as the observed data (±7%).

Refer to Appendix D (D-4 and D-5) regarding the comparison of the simulated and observed hydrographs for the calibrated model. Refer to Appendix D (D-10 and D-11) for the OTTHYMO summary output files for the calibrated model. Refer to Table 4 for the summarized statistical analysis of the simulated and observed data for the calibrated model for all modeled events. Refer to Appendix D (Table D-13) for additional data regarding the statistical analysis of the validation events.

Table 4: Summarized Statistical Analysis for Calibration & Validation (Location 3)

Statistical Parameters	Calibrated Model Values*	Validated Model Values**
Nash-Sutcliffe Efficiency	0.94	0.86
Mean Square Error	0.03	0.10
Qpeak Modeled/Qpeak Observed	1.01	1.03
Runoff Volume Modeled/Runoff Volume Observed	1.04	1.03

* Results shown are average between events 3 and 4
** Results shown are average between events 5 and 8

The validation results at Location 3 are (as expected) slightly less accurate than those achieved in the calibration process, however both the calibration and validation testing show that the performance of the calibrated model is significantly improved relative to the uncalibrated model.

Appendix D (D-16, D-17 and Table D-18) also includes comparison of the observed and simulated flows at Location 2 for the two validation events. In general, the calibrated model results show fair results for the

validation rainfall event 8 (ratio of modeled to observed peak flow 0.89). Similar to the calibration event results, total hydrograph volume was not represented well by the model at this location (ratio of modeled to observed runoff volume 1.59).

The results of validation event 5 at Location 2 appeared to be incongruent with the results at all locations and for all other events. Based on the review of the observed hydrographs at Locations 2 and 3, it is clear that some kind of localized error was present at Location 2 for event 5; the observed watershed response at Location 2 for event 5 was significantly less than what would be expected. In fact, although event 5 represented a rainfall amount of 42mm, while event 8 was only 27mm, the observed peak flow at Location 2 was lower for event 5 than for event 8. The results at Location 3 were as expected (the response to event 5 was greater than that for event 8). This error could result from a number of sources such as local rainfall irregularities not reflected in the observed rainfall records, or from data logger malfunction. As such, the results of event 5 at Location 2 have been reviewed and discussed, but are not considered representative of the performance of the model and were not considered in the formulations of conclusions and recommendations.

The overall results of the validation process confirm the conclusions from the calibration exercise.

6.0 PRE-DEVELOPMENT CONDITIONS MODELING

The calibrated model developed through this study is suitable for use in the comparison of pre- and post-development peak flow rates at a number of locations in the Matheson Creek Watershed. As such, the calibrated model was used to develop existing conditions peak flows at locations of interest in the Matheson Creek Watershed for the assessment of peak flow impacts associated with the Midhurst Secondary Plan Developments within Matheson Creek Subwatershed:

- Location 2 (Matheson Creek Tributary at Gill Road) to assess the local impacts of the proposed flow diversion; and,
- Location 3 (Matheson Creek Outlet) to assess the net watershed impacts of the proposed developments.

These pre-development peak flows are provided in Table 5 below:

Table 5: Pre-Development Peak Flows

Storm Event	Location 3 Peak Flow (m^3/s)		Location 2 Peak Flow (m^3/s)	
	Chicago Storm	SCS Storm	Chicago Storm	SCS Storm
2 year	2.3	5.1	0.4	0.8
5 year	5.2	11.1	0.9	1.8
10 year	7.4	15.9	1.3	2.6
25 year	10.7	23.1	1.9	3.8
50 year	13.4	29.1	2.5	4.8
100 year	16.3	35.6	3.0	5.9
Regional	89.2		15.7	

7.0 CONCLUSIONS

Through the above analysis, the following items (Steps 1 to 5) of Phase 2 of the Midhurst MDP included the completion of the following:

1. Collection of data, consisting of streamflow and rainfall data;
2. Processing of data for use during the modeling stage;
3. Determining the model inputs for pre-development model;
4. Calibration and validation of the pre-development model, comparing observed and simulated data;
5. Using the calibrated pre-development model, simulate pre-development watershed response to a variety of rainfall events (2 year through 100 year, 4-hour Chicago and 24-hour SCS, Regional).

A variety of rainfall events were used to calibrate and validate a pre-development watershed model in order to create an accurate and robust model for use in modeling the post-conditions of the Matheson Creek Subwatershed. The final model was calibrated and validated for large (34.1mm-41.7mm) and small (26.6mm-27.4mm) events. Calibration was performed at the downstream limit of the model (Location 3), however the results at Location 2 were also reviewed and discussed.

8.0 RECOMMENDATIONS

Based on the results, the calibrated model of the watershed will form a good basis for future peak flow impact assessments associated with the MSP development within the Matheson Creek Subwatershed. We note that this model has been established on an event basis for events of 26.6mm to 41.7mm total rainfall volume. As initial abstraction values in the calibrated model are within 5.8mm to 7.1mm, we recommend use of the model for assessment of events larger than 20mm for peak flow and total volume. It is not recommended that the model be used in the assessment of runoff volumes for small catchment areas, although it is appropriate for use of comparison of total runoff volumes on a watershed basis.

Using the established model as a basis, we recommend the following approach to finalize the MDP for Matheson Creek, as related to the five (5) objectives identified at the beginning of this memo.

Objective #1: *Confirm no increase in peak flows downstream of the MSP development areas.*

Crozier will undertake post-development modeling of the Midhurst Heights Development and other MSP development areas within Matheson Creek, including proposed SWM facilities. Modeling will be based on the following considerations:

- Simulation of development areas will be based on work previously submitted through the Stage 1 MDP, but expanded to include all offsite development areas using similar principles and modeling techniques;
- Watershed model will be based on the calibrated watershed model presented in this memo;
- Post-development simulation will be undertaken using IDF curves and total rainfall volumes increased by 15%, per Stage 1 MDP, to account for climate change impacts;
- Peak flow assessment model will neglect the impact of LIDs (conservative);
- Flow assessment will be completed at Locations 2 and 3 on Matheson Creek, to illustrate no negative impacts at the proposed diversion outlet location and on a watershed basis; and,

- Additional commentary and analysis regarding existing site outlets will be provided to assess local peak flow contributions at the existing site outlets.

The results of the model will be used to establish the quantity control requirements for all of the MSP development areas within the Matheson Creek Watershed. The quantity control criteria will be presented in unit flow rate format ($m^3/s/ha$ to each outlet, for each storm event). It will be the responsibility of the proponent of each development within the study area to demonstrate adherence to these unit flow rates through their Draft Plan and detailed design submissions, as they come forward.

Objective #2: *Confirm no increase in runoff volumes downstream of the MSP development areas for frequent events.*

An annual water balance analysis of the MSP development areas within the Matheson Creek Watershed will be undertaken per the Stormwater Management Planning and Design Guidelines (MOE, 2003). The pre-development and post-development (with climate change) assessments will be compared to establish additional infiltration criteria that will be required to be accomplished through implementation of LIDs (LIDs to be assessed as 25% blocked).

"Frequent events" may be defined as events less than the 4 hour, 25mm event rainfall. Events less than 25mm represent more than 95% of all rainfall events and approximately 76% of the annual volume (Hutchinson, 2014). As such we will also confirm that the infiltration targets maintain or reduce runoff volumes for the development areas in the 25mm event.

- **ACTION: Crozier will complete a Technical Memo #2 to present work and findings related to Objectives #1 and #2.**

Objective #3: *Confirm no net erosion impacts downstream of the MSP development areas.*

Crozier is coordinating with GEOmorphix to establish extended detention requirements and infiltration targets to meet erosion objectives. It is understood that these targets may exceed those established to meet Objective #2, and thus may govern the final SWM targets presented in the Township's MDP.

- **ACTION: Crozier will collaborate with GEOmorphix to prepare a Technical Memo #3 to address Objective #3.**

Objective #4: *Confirm no additional nutrient loading downstream of the MSP development areas (including the wastewater treatment plant).*

Crozier is coordinating with Hutchison Environmental to confirm that the use of LIDs will address nutrient loading issues and ensure no negative downstream impact.

- **ACTION: Hutchison Environmental to address Objective #4 per TOR established with NVCA and Township.**

Objective #5: *Present an Adaptive Management Plan (AMP) that will provide a framework for ongoing monitoring of the developments, and implement changes if necessary to meet the above noted objectives.*

Crozier will coordinate with SCS Consulting to prepare an AMP for the Midhurst Heights Development that is similar in nature to that proposed for the Geranium Developments, but modified to suit the specific stormwater management strategy for the site.

- **ACTION: Crozier will present AMP in Technical Memo #4.**

Once the Township and Conservation Authority have indicated acceptance of the pre-development modeling work presented in this Memo, and the Terms of Reference above, we will proceed to complete the balance of the Stage 2 MDP for Matheson Creek.

C.F. CROZIER & ASSOCIATES INC.

Kaitlin Wilmshurst, P.Eng.
Project Engineer

C.F. CROZIER & ASSOCIATES INC.

Austin Spencer, E.I.T.

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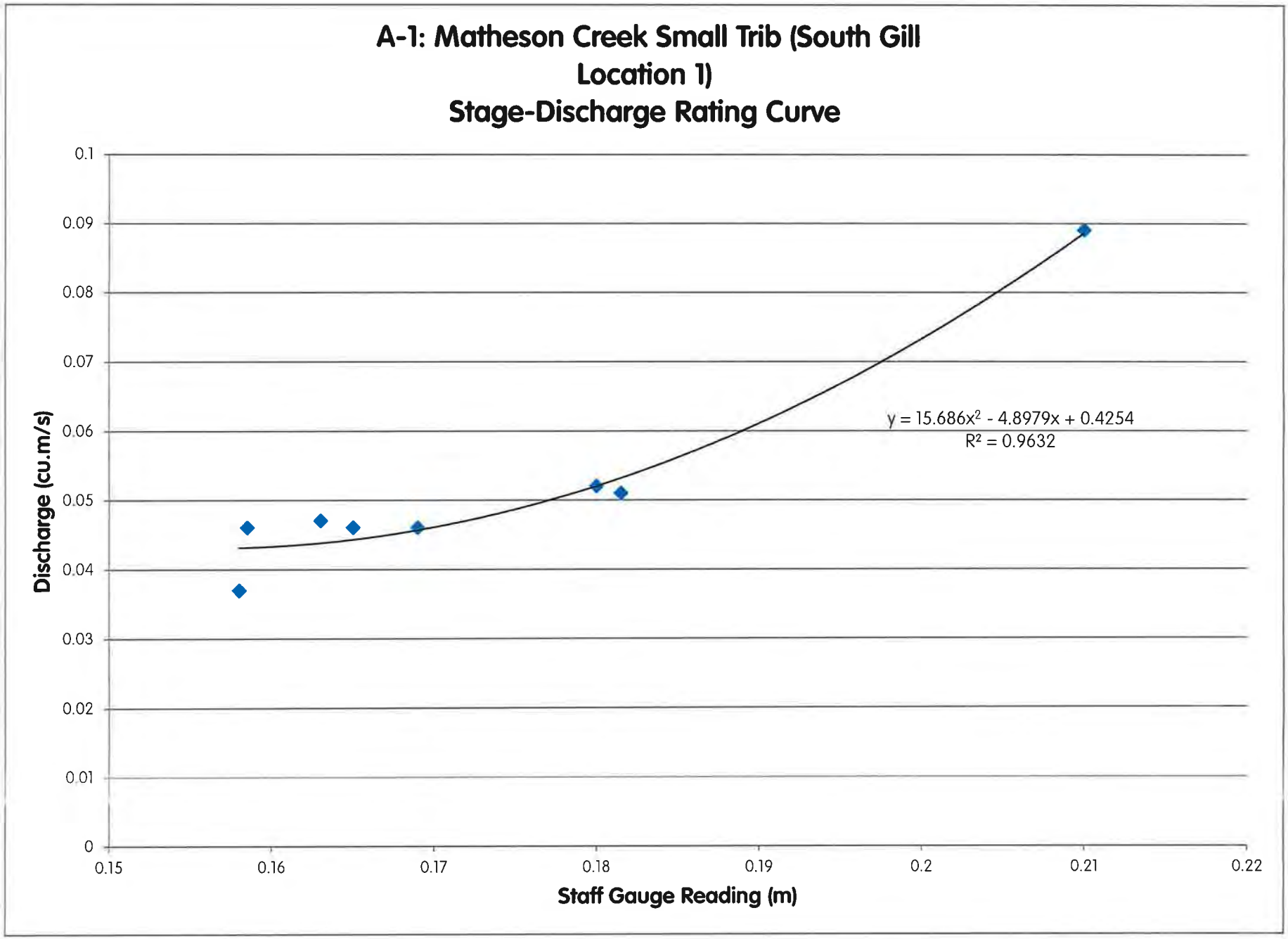
APPENDIX A

Streamflow Data & Baseflow Analysis



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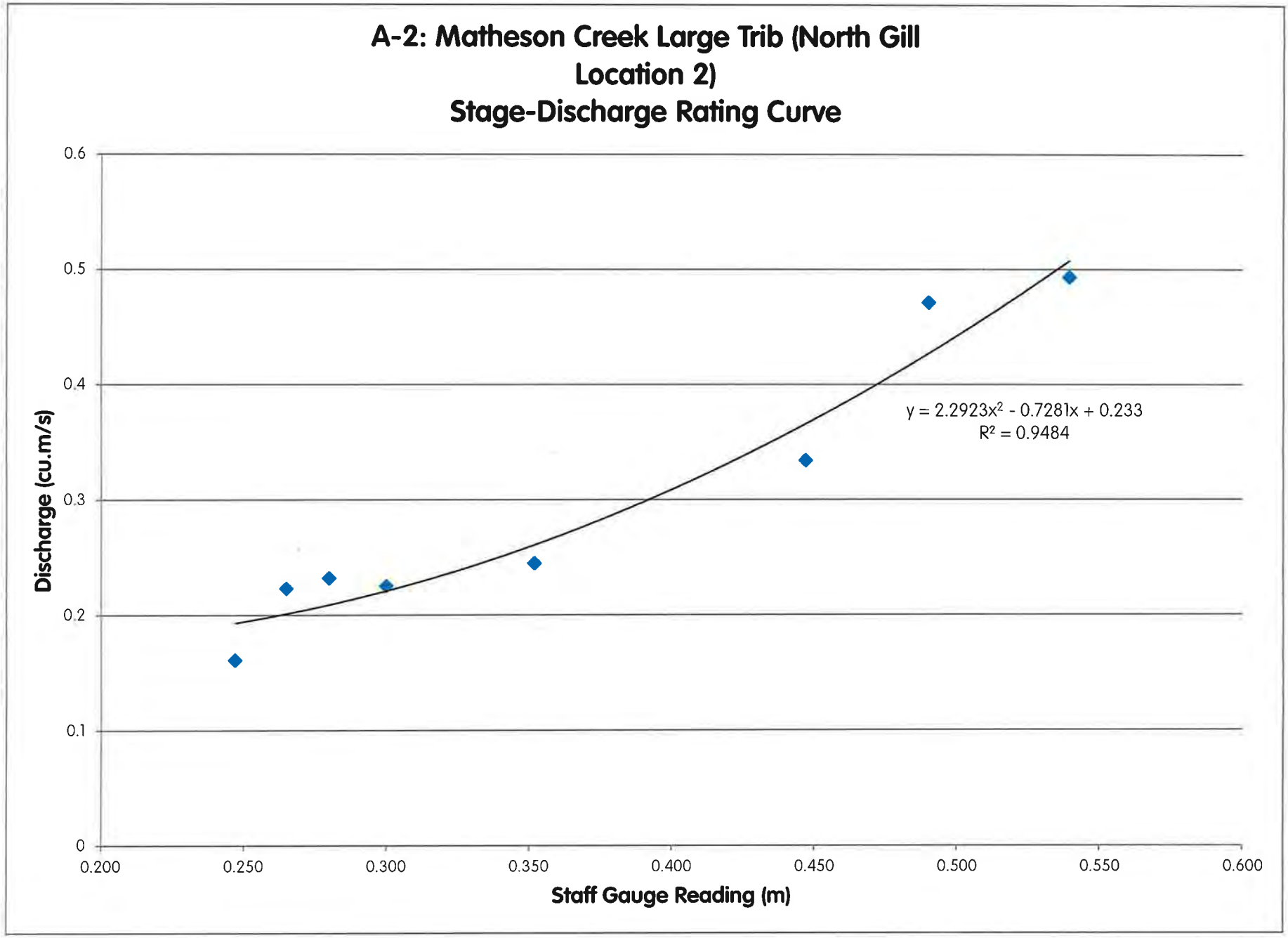
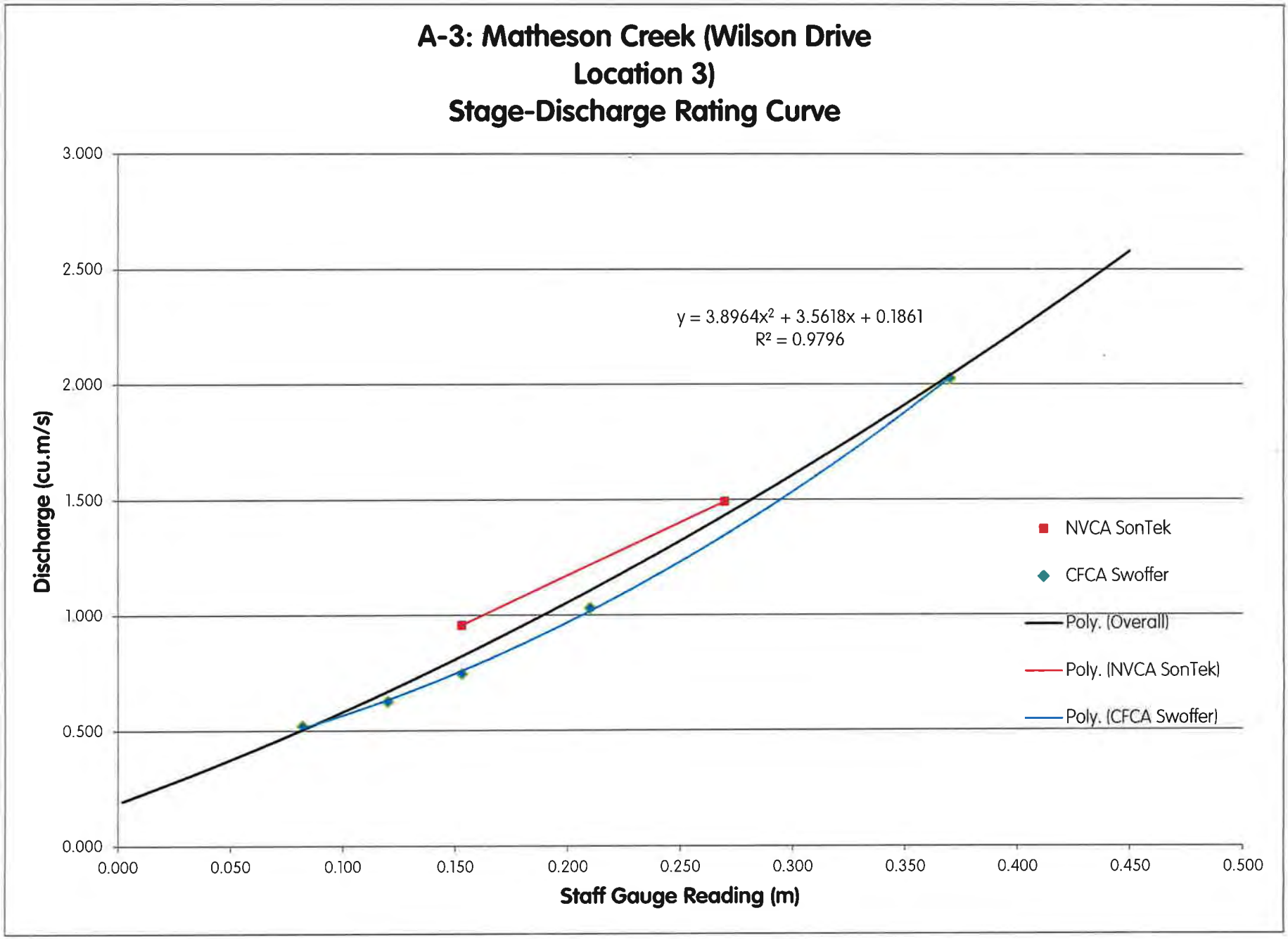

A-2: Matheson Creek Large Trib (North Gill Location 2)
Stage-Discharge Rating Curve
Discharge (cu.m/s)
Staff Gauge Reading (m)
y = 2.2923x² - 0.7281x + 0.233
R² = 0.9484
0
0.1
0.2
0.3
0.4
0.5
0.6
0.200
0.250
0.300
0.350
0.400
0.450
0.500
0.550
0.600



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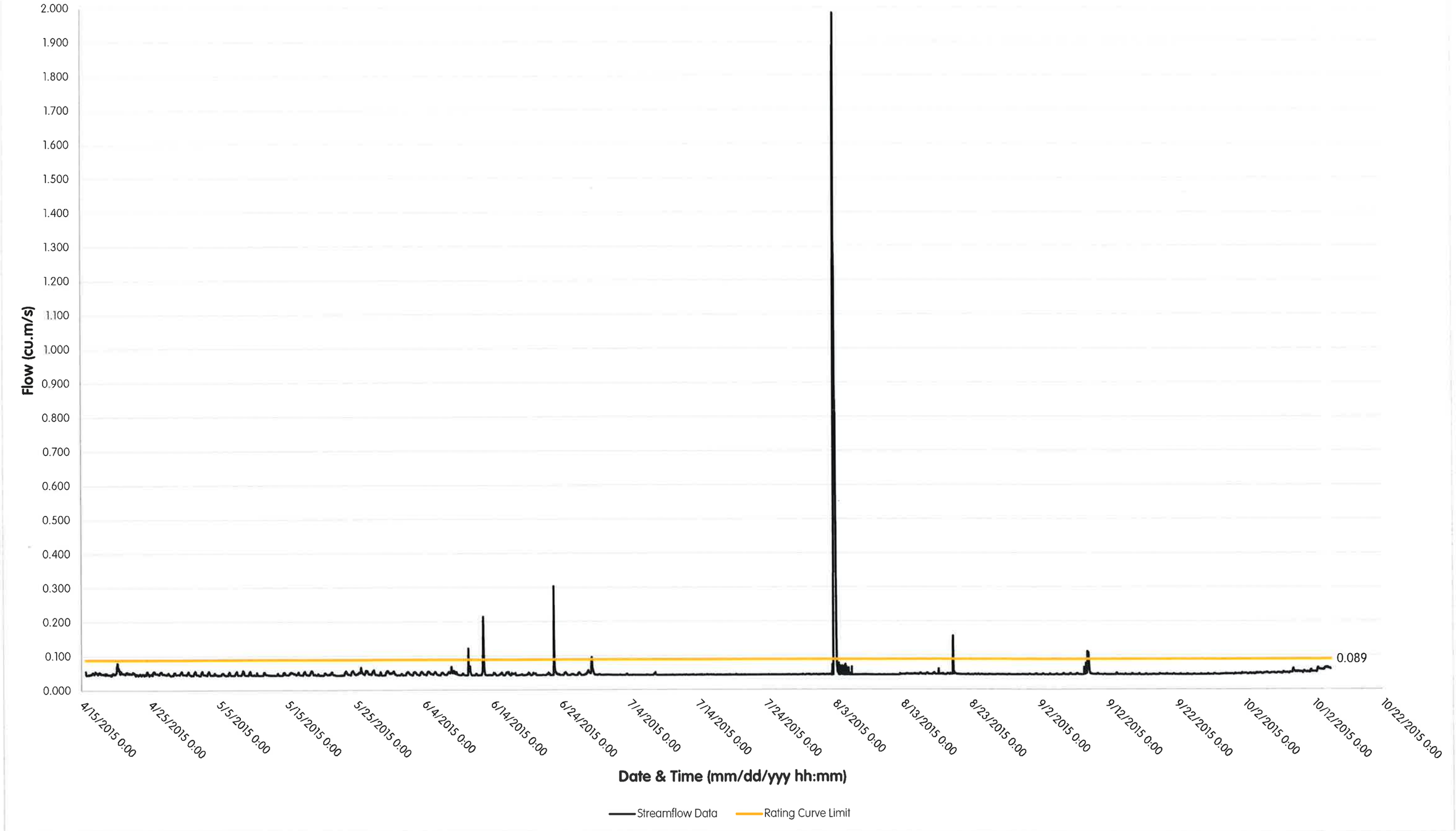
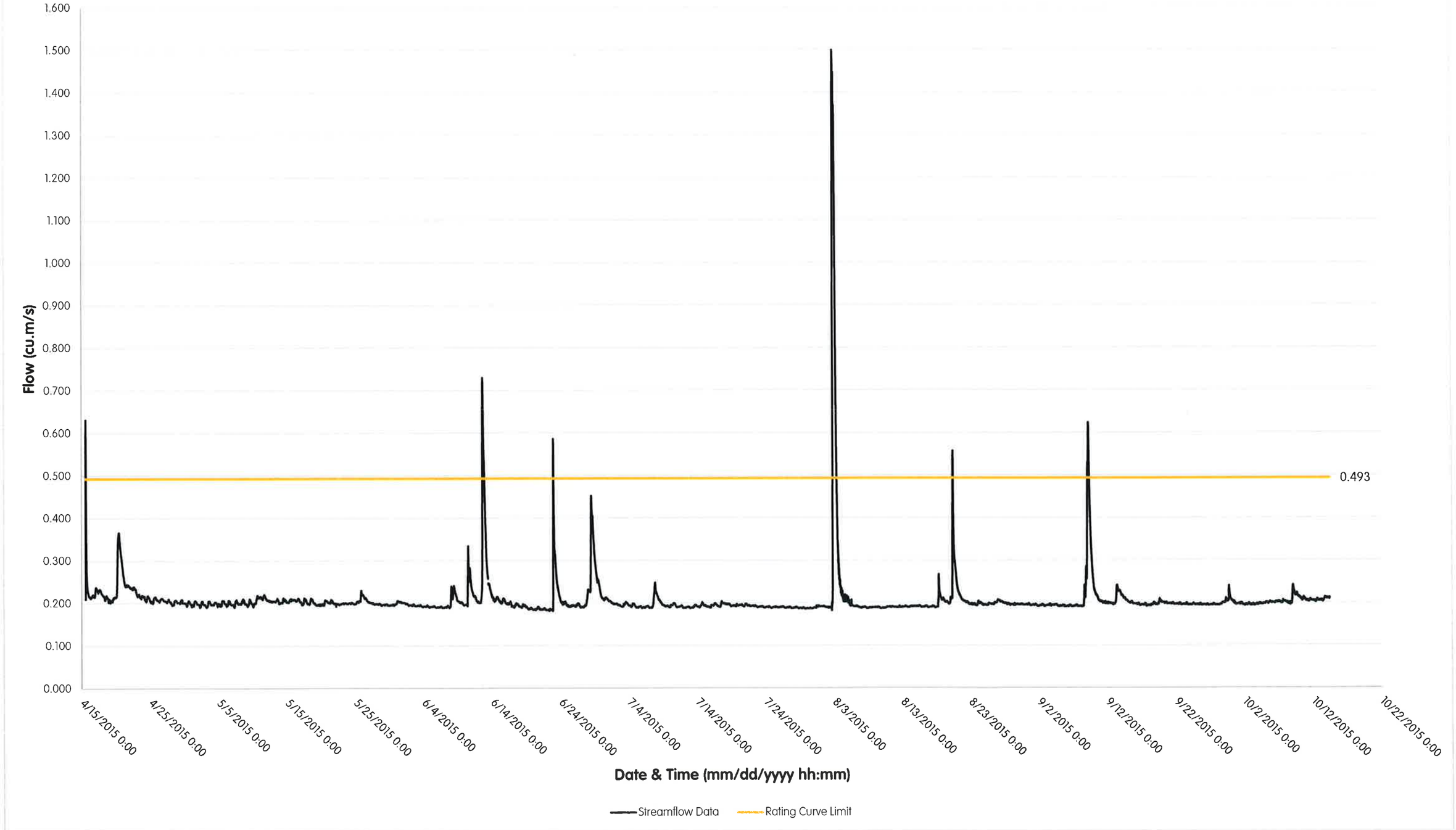
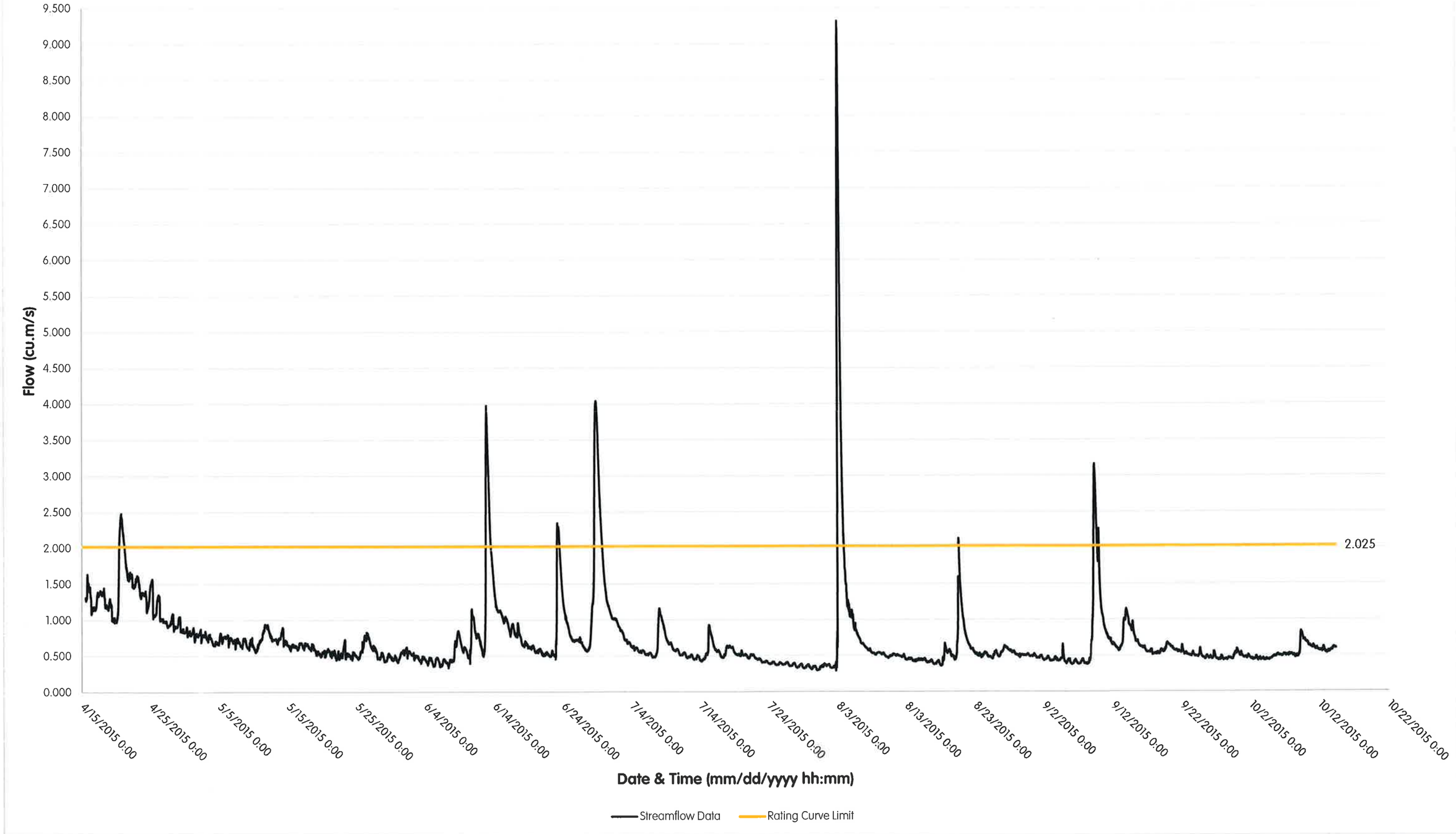
A-4: Streamflow Data for Location 1 (Small Tributary of Matheson Creek - South Gill Rd.)

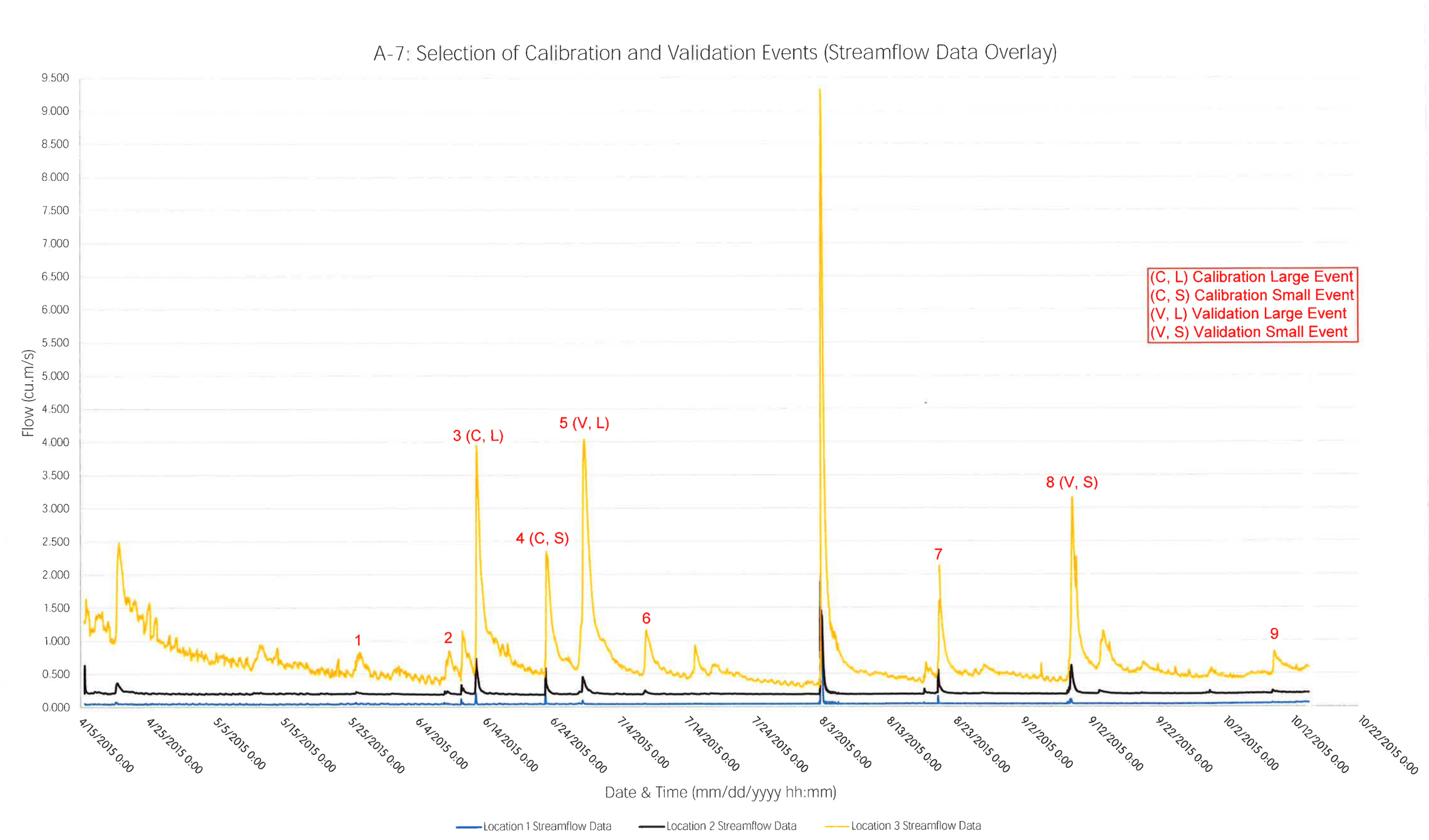


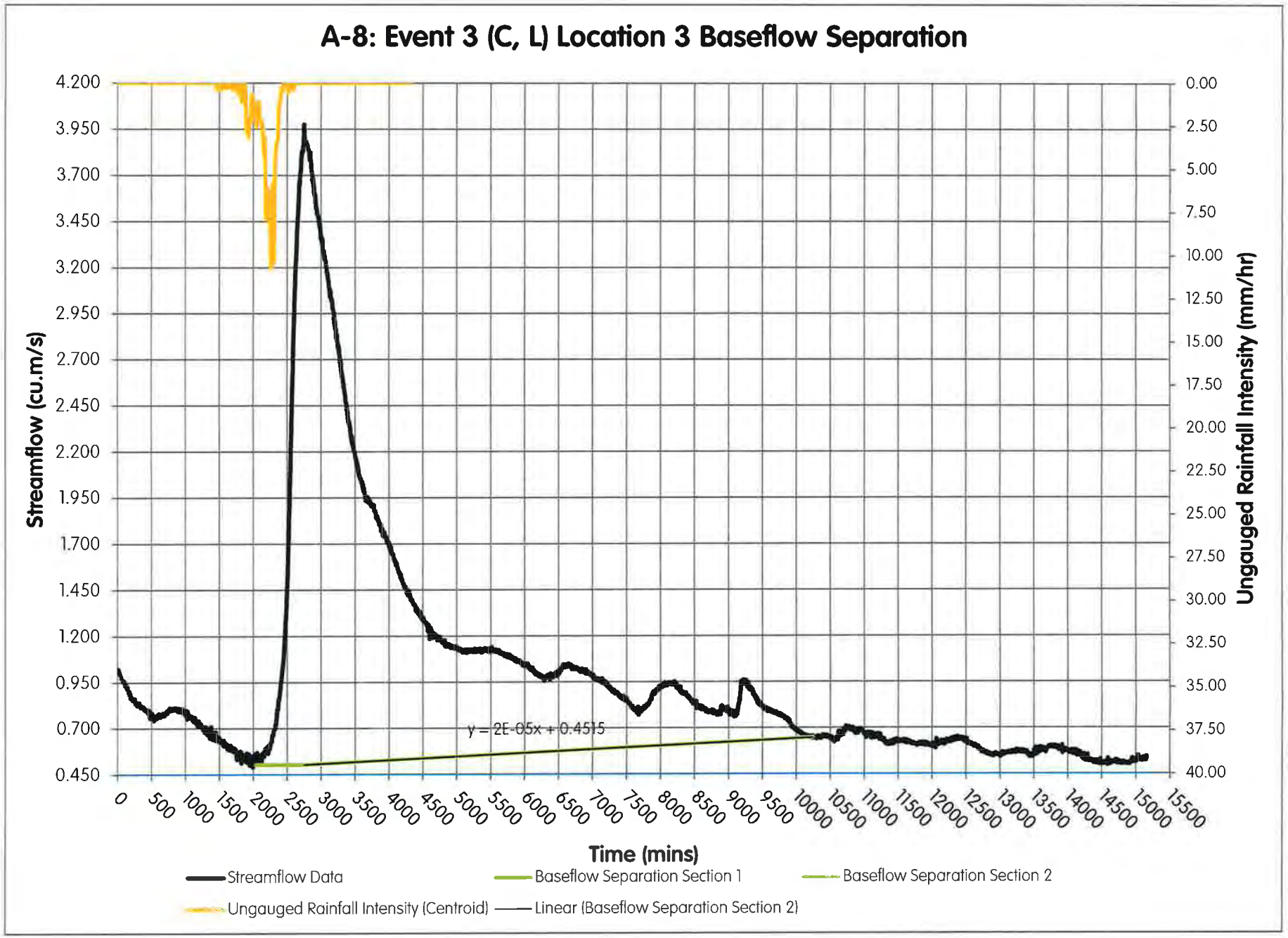
A-5: Streamflow Data for Location 2 (Large Tributary of Matheson Creek - North Gill Rd.)



A-6: Streamflow Data for Location 3 (Matheson Creek at Wilson Dr.)




A-7: Selection of Calibration and Validation Events (Streamflow Data Overlay)
Flow (cu.m/s)
9.500
9.000
8.500
8.000
7.500
7.000
6.500
6.000
5.500
5.000
4.500
4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
(C, L) Calibration Large Event
(C, S) Calibration Small Event
(V, L) Validation Large Event
(V, S) Validation Small Event
1
2
3 (C, L)
4 (C, S)
5 (V, L)
6
7
8 (V, S)
9
4/15/2015 0:00
4/25/2015 0:00
5/5/2015 0:00
5/15/2015 0:00
5/25/2015 0:00
6/4/2015 0:00
6/14/2015 0:00
6/24/2015 0:00
7/4/2015 0:00
7/14/2015 0:00
7/24/2015 0:00
8/3/2015 0:00
8/13/2015 0:00
8/23/2015 0:00
9/2/2015 0:00
9/12/2015 0:00
9/22/2015 0:00
10/2/2015 0:00
10/12/2015 0:00
10/22/2015 0:00
Date & Time (mm/dd/yyyy hh:mm)
Location 1 Streamflow Data
Location 2 Streamflow Data
Location 3 Streamflow Data



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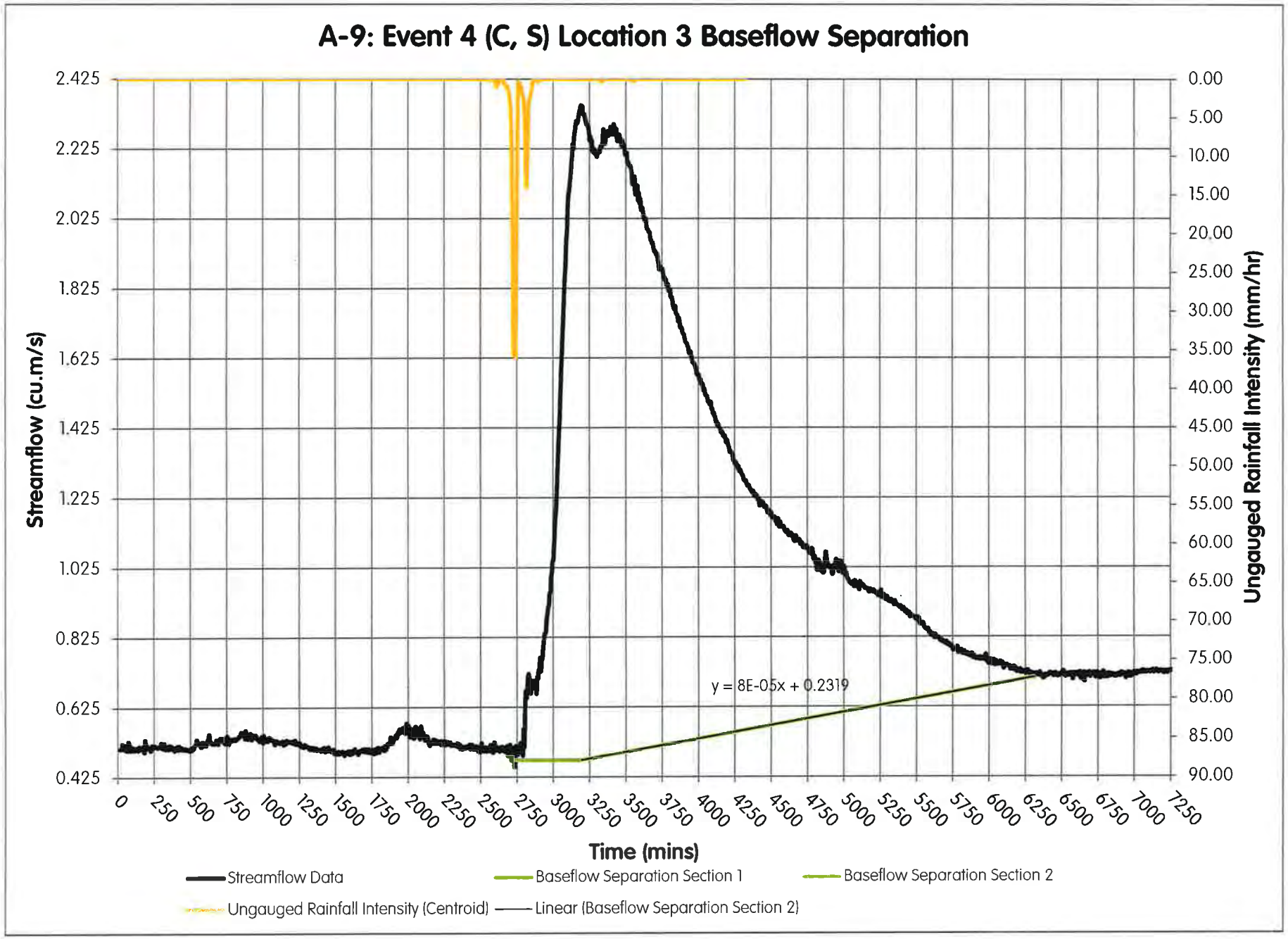

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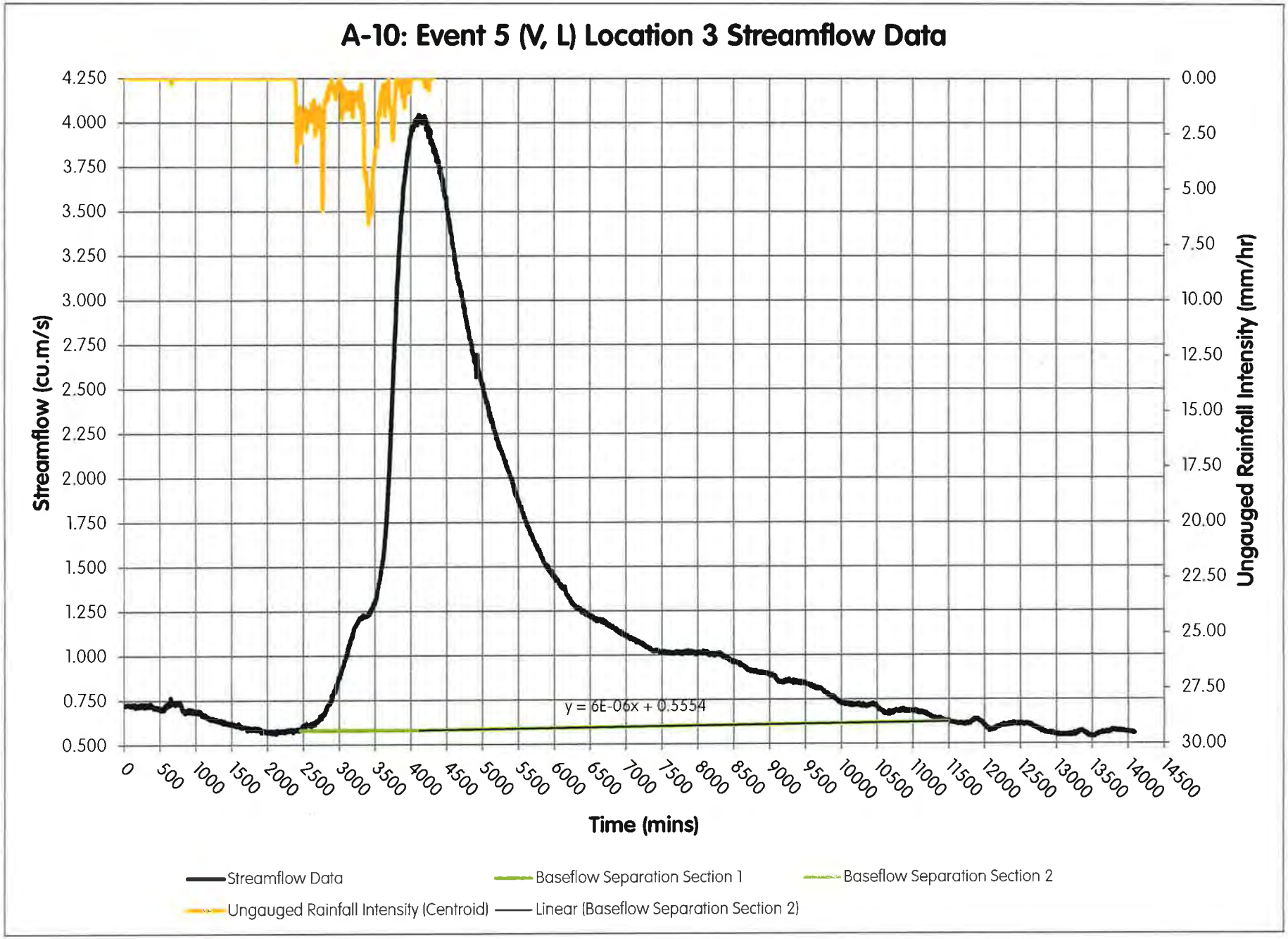

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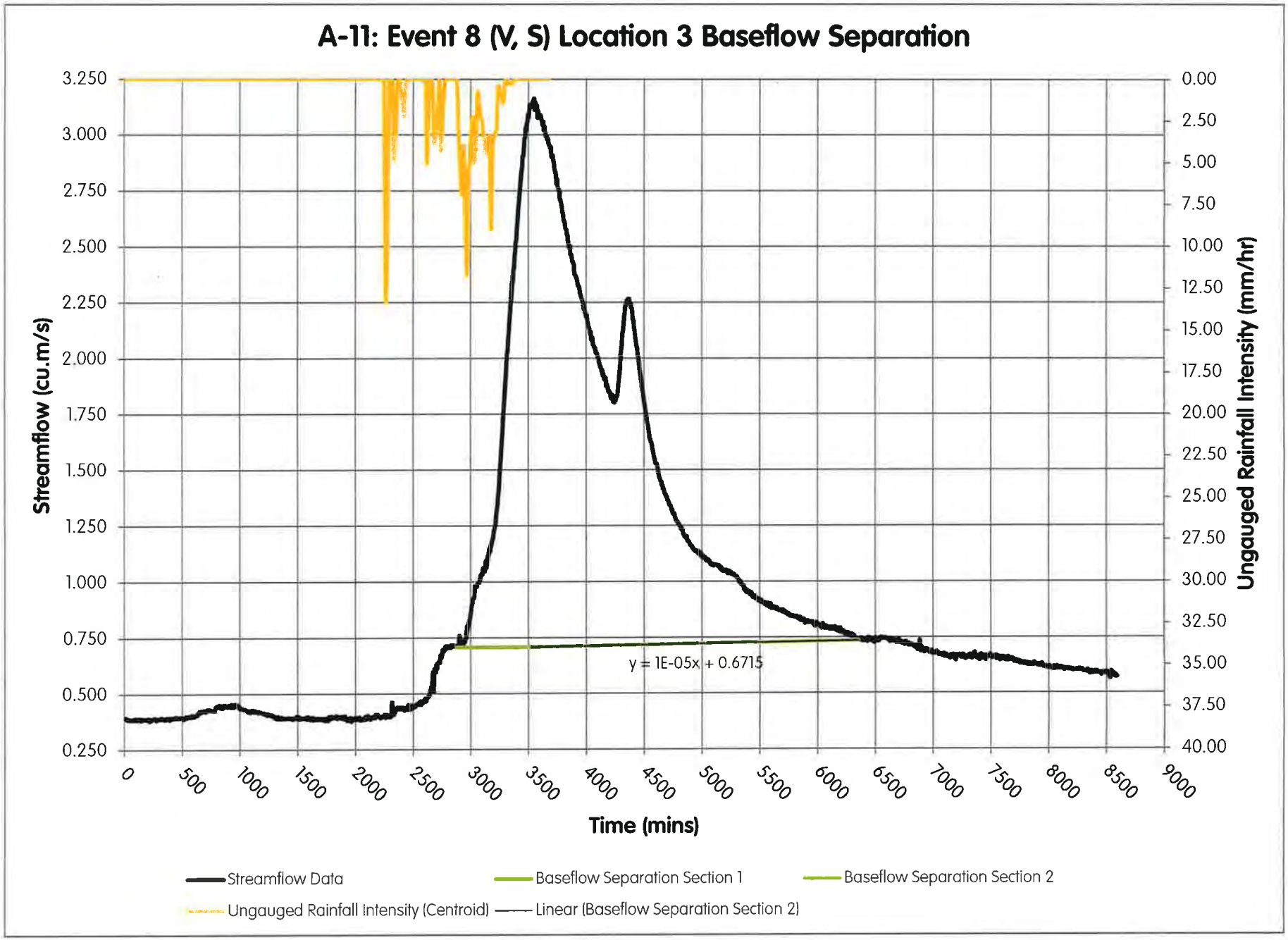

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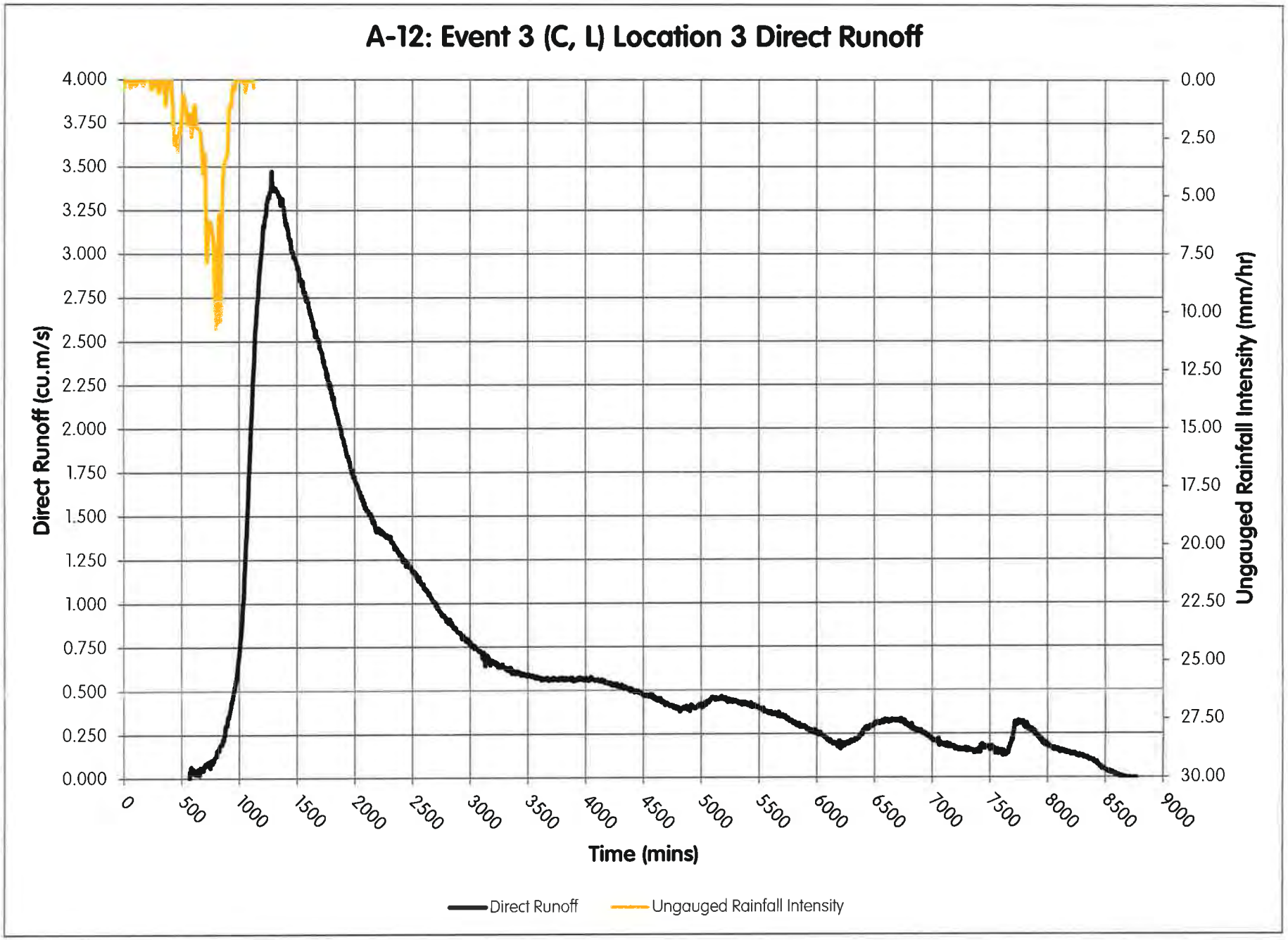

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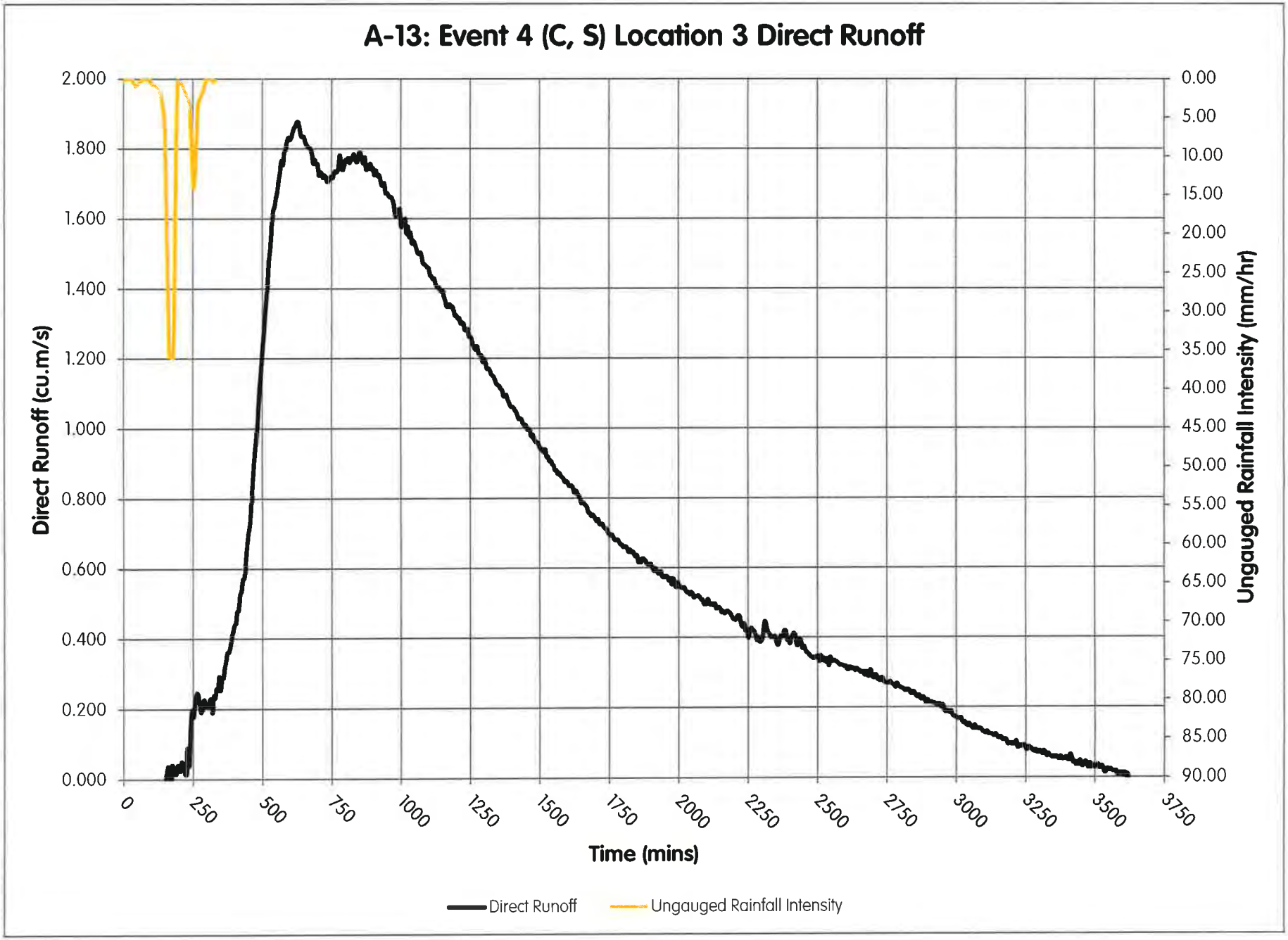

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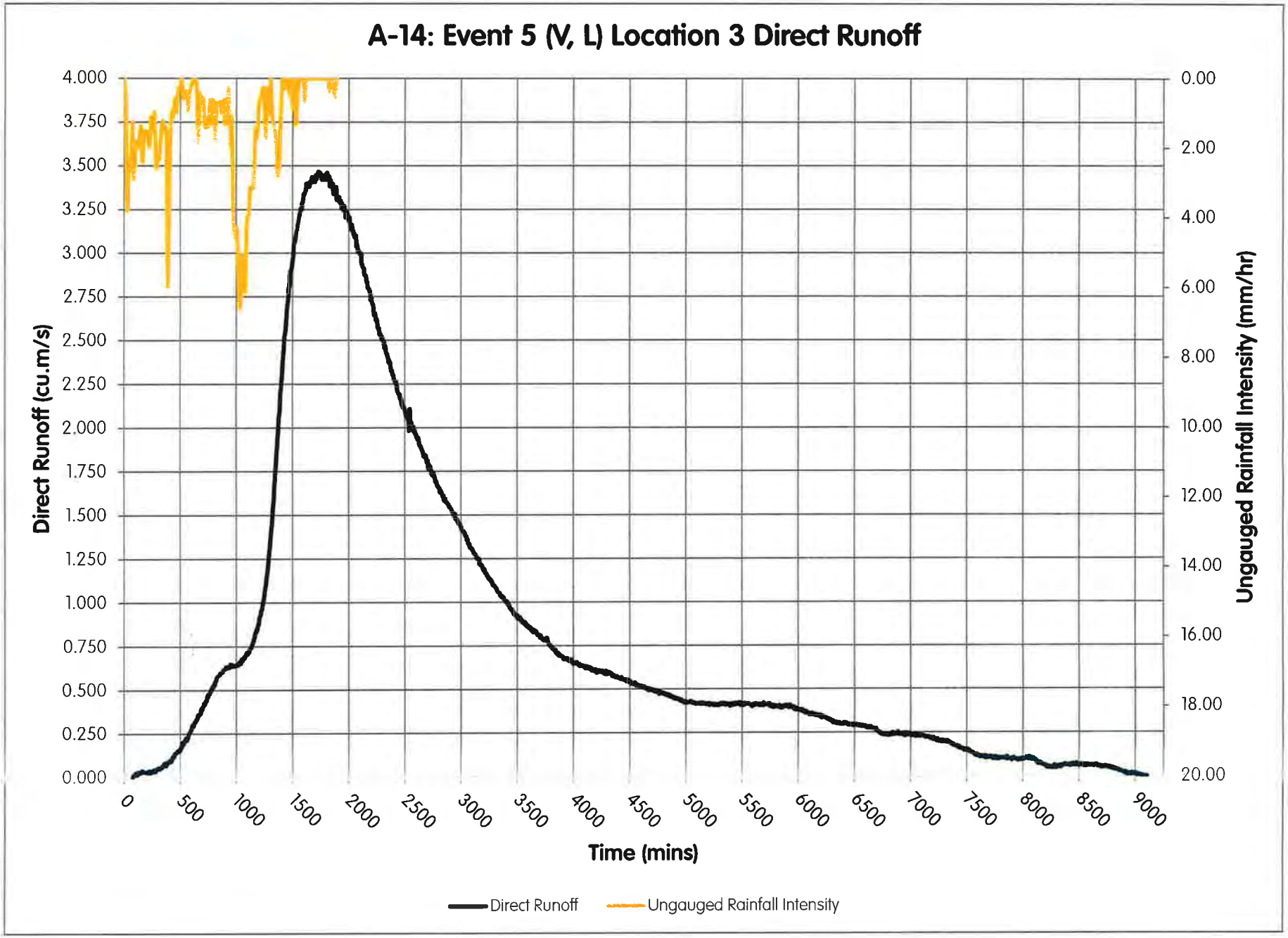

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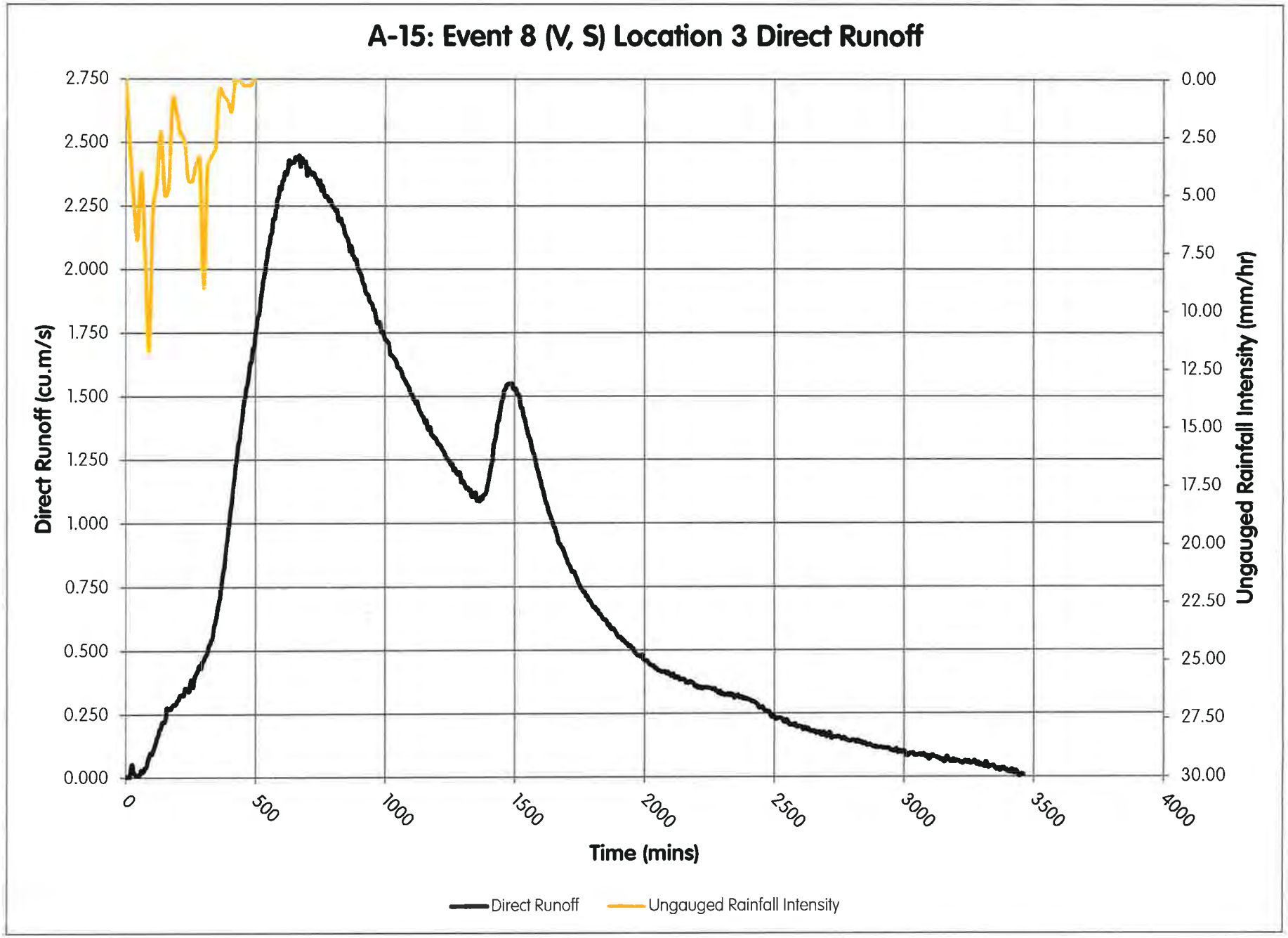

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APPENDIX B

Rainfall Data

CROZIER & ASSOCIATES Consulting Engineers

The City of BARRIE

Table B-1: Rain Gauge Precipitation Comparison for Candidate Flow Events

Project Midhurst Heights MDP
Project No. 845-3675
By A.Spencer
Date January 28, 2016
Revision Date February 29, 2016
Revised By A.Spencer

Event	Time Period	Period of Rainfall		Precipitation (mm/24 hours)						Statistics			Comments
		Start Time (dd/mm/yyyy hh:mm)	End Time (dd/mm/yyyy hh:mm)	Coldwater	Collingwood	Midland	Minesing*	Oro-Medonte*	COB Rain Gauge 3*	Average	Min.	Max.	
Event 1	Day Before	5/24/2015 0:00	5/25/2015 0:00	4	0	N/A	N/A	0	0	1.00	0.00	4.00	Missing rainfall data at the Minesing rain gauge. Not selected for modelling purposes.
	Day Occurring	5/25/2015 0:00	5/26/2015 0:00	9.4	8.1	3	N/A	15.2	12	9.54	3.00	15.20	
	Day After	5/26/2015 0:00	5/27/2015 0:00	0.2	0	0	0.2	0.2	0.25	0.14	0.00	0.25	
	Total Precipitation (72 hours)	5/24/2015 0:00	5/27/2015 0:00	13.6	8.1	3	0.2	15.4	12.25	8.76	0.20	15.40	
Event 2	Day Before	6/7/2015 0:00	6/8/2015 0:00	7.2	5.9	N/A	N/A	10.8	1.25	6.29	1.25	10.80	Patchy/Isolated rainfall. Missing rainfall data at Minesing rain gauge. Not selected for modelling purposes.
	Day Occurring	6/8/2015 0:00	6/9/2015 0:00	3.4	0.6	N/A	N/A	6	19.5	7.38	0.60	19.50	
	Day After	6/9/2015 0:00	6/10/2015 0:00	0	0	N/A	0	0.4	0.75	0.23	0.00	0.75	
	Total Precipitation (72 hours)	6/7/2015 0:00	6/10/2015 0:00	10.6	6.5	0	0	17.2	21.5	9.30	0.00	21.50	
Event 3	Day Before	6/11/2015 0:00	6/12/2015 0:00	2.00	0.30	N/A	0.00	0.00	0.00	0.46	0.00	2.00	Rainfall distribution watershed wide. No missing data for modelling rain gauges. Selected for modelling purposes (Calibration).
	Day Occurring	6/12/2015 0:00	6/13/2015 0:00	22.00	30.80	N/A	37.00	30.40	33.25	30.69	22.00	37.00	
	Day After	6/13/2015 0:00	6/14/2015 0:00	1.00	0.00	N/A	0.00	0.00	0.00	0.20	0.00	1.00	
	Total Precipitation (72 hours)	6/11/2015 0:00	6/14/2015 0:00	25.00	31.10	0.00	37.00	30.40	33.25	26.13	0.00	37.00	
Event 4	Day Before	6/21/2015 0:00	6/22/2015 0:00	0.6	0	N/A	0	0	0	0.12	0.00	0.60	Rainfall distribution lower in northern stations. Rainfall isolated to a certain corridor. Selected for modelling purposes (Calibration).
	Day Occurring	6/22/2015 0:00	6/23/2015 0:00	8	17.9	12	33.8	19.2	25.5	19.40	8.00	33.80	
	Day After	6/23/2015 0:00	6/24/2015 0:00	0	0	0	0.4	0.2	0.25	0.14	0.00	0.40	
	Total Precipitation (72 hours)	6/21/2015 0:00	6/24/2015 0:00	8.6	17.9	12	34.2	19.4	25.75	19.64	8.60	34.20	
Event 5	Day Before	6/26/2015 0:00	6/27/2015 0:00	0	0	N/A	0	0.2	0	0.04	0.00	0.20	Rainfall distribution watershed wide. No missing data for modelling rain gauges. Selected for modelling purposes (Validation).
	Day Occurring	6/27/2015 0:00	6/28/2015 0:00	14.8	17.1	N/A	13	16	17.75	15.73	13.00	17.75	
	Day After	6/28/2015 0:00	6/29/2015 0:00	27.2	15.7	N/A	25	30.4	25	24.66	15.70	30.40	
	Total Precipitation (72 hours)	6/26/2015 0:00	6/29/2015 0:00	42	32.8	0	38	46.6	42.75	33.69	0.00	46.60	
Event 6	Day Before	7/6/2015 0:00	7/7/2015 0:00	0	0	N/A	0	0	0	0.00	0.00	0.00	Rainfall distribution watershed wide. No missing data for modelling rain gauges. Small rainfall volume. Not selected for modelling purposes.
	Day Occurring	7/7/2015 0:00	7/8/2015 0:00	16	N/A	14	15.6	19	17.5	16.42	14.00	19.00	
	Day After	7/8/2015 0:00	7/9/2015 0:00	0	0	0	0.2	0.2	0	0.07	0.00	0.20	
	Total Precipitation (72 hours)	7/6/2015 0:00	7/9/2015 0:00	16	0	14	15.8	19.2	17.5	13.75	0.00	19.20	
Event 7	Day Before	8/19/2015 0:00	8/20/2015 0:00	3.2	0	N/A	N/A	0.2	1.25	1.16	0.00	3.20	Patchy/Isolated rainfall. Missing rainfall data at Minesing rain gauge. Not selected for modelling purposes.
	Day Occurring	8/20/2015 0:00	8/21/2015 0:00	20.2	6.6	5	N/A	22.4	15.25	13.89	5.00	22.40	
	Day After	8/21/2015 0:00	8/22/2015 0:00	1	0	5	N/A	1	0	1.40	0.00	5.00	
	Total Precipitation (72 hours)	8/19/2015 0:00	8/22/2015 0:00	24.4	6.6	10	N/A	23.6	16.5	16.22	6.60	24.40	
Event 8	Day Before	9/7/2015 0:00	9/8/2015 0:00	N/A	0	N/A	N/A	0	0	0.00	0.00	0.00	Rainfall distribution watershed wide. Some missing data at the Minesing rain gauged (assumed 0mm of rainfall). Selected for modelling purposes (Validation).
	Day Occurring	9/8/2015 0:00	9/9/2015 0:00	N/A	20	40	17.8	12.2	9.75	19.95	9.75	40.00	
	Day After	9/9/2015 0:00	9/10/2015 0:00	N/A	3.5	0	23.8	32.4	23	16.54	0.00	32.40	
	Total Precipitation (72 hours)	9/7/2015 0:00	9/10/2015 0:00	0	23.5	40	41.6	44.6	32.75	30.41	0.00	44.60	
Event 9	Day Before	10/8/2015 0:00	10/9/2015 0:00	8.4	2.3	8	8.2	4.4	10.25	6.93	2.30	10.25	Rainfall distribution watershed wide. No missing data for modelling rain gauges. Small rainfall volume. Not selected for modelling purposes.
	Day Occurring	10/9/2015 0:00	10/10/2015 0:00	0	0.2	0	2	3.8	0.75	1.13	0.00	3.80	
	Day After	10/10/2015 0:00	10/11/2015 0:00	0	0	N/A	0	0.2	0	0.04	0.00	0.20	
	Total Precipitation (72 hours)	10/8/2015 0:00	10/11/2015 0:00	8.4	2.5	8	10.2	8.4	11	8.08	2.50	11.00	
Recording Interval of Gauge				24 hours	24 hours	24 hours	15min	15min	5min				

* Rain gauges selected for modelling purposes

CROZIER & ASSOCIATES
Consulting Engineers

The City of BARRIE

Project Midhurst MDP
Project No. 845-3675
Date January 4, 2016
Name A. Spencer
Date Revised March 23, 2016

Table B-2: Event 3 Rainfall Data

Calibration, Large Event

Minesing (mm)	Oro-Medonte (mm)	COB RG 3 (mm)	Rainfall Period (mins)	Date & Time (mm/dd/yyyy hh:mm)	Ungauged Watershed Centroid (mm)	Rainfall Intensity (mm/hr)
0.2	0	0	0	6/12/2015 0:30	0.10	0.39
0	0	0	15	6/12/2015 0:45	0.00	0.00
0	0	0	30	6/12/2015 1:00	0.00	0.00
0	0	0	45	6/12/2015 1:15	0.00	0.00
0.2	0	0	60	6/12/2015 1:30	0.10	0.39
0	0	0	75	6/12/2015 1:45	0.00	0.00
0	0	0	90	6/12/2015 2:00	0.00	0.00
0	0.2	0	105	6/12/2015 2:15	0.07	0.29
0	0	0	120	6/12/2015 2:30	0.00	0.00
0	0	0	135	6/12/2015 2:45	0.00	0.00
0	0	0	150	6/12/2015 3:00	0.00	0.00
0	0.2	0	165	6/12/2015 3:15	0.07	0.29
0	0	0	180	6/12/2015 3:30	0.00	0.00
0	0	0	195	6/12/2015 3:45	0.00	0.00
0	0	0	210	6/12/2015 4:00	0.00	0.00
0	0	0	225	6/12/2015 4:15	0.00	0.00
0.2	0	0	240	6/12/2015 4:30	0.10	0.39
0	0.2	0	255	6/12/2015 4:45	0.07	0.29
0	0	0	270	6/12/2015 5:00	0.00	0.00
0	0	0	285	6/12/2015 5:15	0.00	0.00
0	0.4	0	300	6/12/2015 5:30	0.14	0.57
0	0.2	0	315	6/12/2015 5:45	0.07	0.29
0	0	0	330	6/12/2015 6:00	0.00	0.00
0	0	0	345	6/12/2015 6:15	0.00	0.00
0.4	0	0.5	360	6/12/2015 6:30	0.27	1.09
0.2	0	0.25	375	6/12/2015 6:45	0.14	0.55
0	0	0	390	6/12/2015 7:00	0.00	0.00
0	0	0	405	6/12/2015 7:15	0.00	0.00
0.4	0	0	420	6/12/2015 7:30	0.19	0.78
1.2	0.2	0.25	435	6/12/2015 7:45	0.69	2.77
0.4	0.6	1.25	450	6/12/2015 8:00	0.61	2.42
1.6	0	0	465	6/12/2015 8:15	0.78	3.10
0.6	0.2	1	480	6/12/2015 8:30	0.52	2.08
0.4	0.6	1	495	6/12/2015 8:45	0.57	2.27
0.2	0.2	0	510	6/12/2015 9:00	0.17	0.67
0.2	0.2	0.25	525	6/12/2015 9:15	0.21	0.83
0	0.8	0.25	540	6/12/2015 9:30	0.32	1.30
0.4	0.8	0	555	6/12/2015 9:45	0.48	1.92
0.6	0	0.5	570	6/12/2015 10:00	0.37	1.48
0.6	0.6	0.75	585	6/12/2015 10:15	0.62	2.50
0.6	0.2	0.25	600	6/12/2015 10:30	0.40	1.61
0.4	0	0.5	615	6/12/2015 10:45	0.27	1.09
0.4	0.8	0.25	630	6/12/2015 11:00	0.52	2.08
0.4	0.6	0.75	645	6/12/2015 11:15	0.53	2.11
0.4	0.8	0.5	660	6/12/2015 11:30	0.56	2.23
0.8	0.6	0.75	675	6/12/2015 11:45	0.72	2.88
1	0.4	2.5	690	6/12/2015 12:00	1.02	4.10
1	0.6	0.75	705	6/12/2015 12:15	0.82	3.27
3	0.6	1.75	720	6/12/2015 12:30	1.95	7.78
2.2	0.4	2	735	6/12/2015 12:45	1.53	6.11
2	0.8	1.75	750	6/12/2015 13:00	1.53	6.13
2	1.2	1.5	765	6/12/2015 13:15	1.64	6.54
2.2	1.2	2	780	6/12/2015 13:30	1.81	7.25
2.8	2	3.75	795	6/12/2015 13:45	2.67	10.66
2.8	2.4	2.25	810	6/12/2015 14:00	2.57	10.28
1.4	1.6	1.25	825	6/12/2015 14:15	1.45	5.79
4.2	1	1.25	840	6/12/2015 14:30	2.59	10.37
0.8	1.4	2.5	855	6/12/2015 14:45	1.28	5.13
0.4	1.8	0.5	870	6/12/2015 15:00	0.92	3.66
0.2	2	0.25	885	6/12/2015 15:15	0.85	3.40
0	2.2	0	900	6/12/2015 15:30	0.78	3.14
0	0.8	0	915	6/12/2015 15:45	0.29	1.14
0	0.8	0	930	6/12/2015 16:00	0.29	1.14
0	0.2	0	945	6/12/2015 16:15	0.07	0.29
0	0.2	0.25	960	6/12/2015 16:30	0.11	0.44
0	0	0	975	6/12/2015 16:45	0.00	0.00
0	0	0	990	6/12/2015 17:00	0.00	0.00
0	0	0	1005	6/12/2015 17:15	0.00	0.00
0	0	0	1020	6/12/2015 17:30	0.00	0.00
0	0	0	1035	6/12/2015 17:45	0.00	0.00
0	0.4	0	1050	6/12/2015 18:00	0.14	0.57
0	0	0	1065	6/12/2015 18:15	0.00	0.00
0	0	0	1080	6/12/2015 18:30	0.00	0.00
0	0	0	1095	6/12/2015 18:45	0.00	0.00
0	0	0	1110	6/12/2015 19:00	0.00	0.00
0.2	0	0	1125	6/12/2015 19:15	0.10	0.39
Sum (mm)	37.0	30.4	33.3		34.1	

Rain Gauge Distance to Watershed Centroid

Minesing	7460 m
Oro Medonte	8700 m
COB RG 3	13050 m

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Name A. Spencer
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Table B-3: Event 4 Rainfall Data

Calibration, Small Event

	Minesing (mm)	Oro-Medonte (mm)	COB RG 3 (mm)	Rainfall Period (mins)	Date & Time (mm/dd/yyyy hh:mm)	Ungauged Watershed Centroid (mm)	Rainfall Intensity (mm/hr)
	0	0	0.25	0	6/22/2015 18:45	0.04	0.16
	0	0	0	15	6/22/2015 19:00	0.00	0.00
	0	0	0	30	6/22/2015 19:15	0.00	0.00
	0	0.6	0.25	45	6/22/2015 19:30	0.25	1.01
	0.2	0	0	60	6/22/2015 19:45	0.10	0.39
	0	0	0	75	6/22/2015 20:00	0.00	0.00
	0	0	0	90	6/22/2015 20:15	0.00	0.00
	0.2	0.2	0.25	105	6/22/2015 20:30	0.21	0.83
	0.2	0.4	0	120	6/22/2015 20:45	0.24	0.96
	0.8	0.2	0.5	135	6/22/2015 21:00	0.54	2.15
	2.2	0.8	1.75	150	6/22/2015 21:15	1.63	6.52
	15.6	0.8	6.25	165	6/22/2015 21:30	8.84	35.36
	13.4	0.4	14.5	180	6/22/2015 21:45	8.94	35.76
	0.2	0	0	195	6/22/2015 22:00	0.10	0.39
	0	0.4	0.25	210	6/22/2015 22:15	0.18	0.73
	0	1.4	0	225	6/22/2015 22:30	0.50	2.00
	0.2	2.4	0	240	6/22/2015 22:45	0.95	3.81
	0	9.8	0	255	6/22/2015 23:00	3.49	13.98
	0.4	1.6	0.25	270	6/22/2015 23:15	0.80	3.22
	0.4	0.2	1.25	285	6/22/2015 23:30	0.46	1.85
	0	0	0	300	6/22/2015 23:45	0.00	0.00
	0	0	0	315	6/23/2015 0:00	0.00	0.00
	0.2	0	0	330	6/23/2015 0:15	0.10	0.39
Sum (mm)	34.0	19.2	25.5			27.4	

Rain Gauge Distance to Watershed Centroid

Minesing	7460 m
Oro Medonte	8700 m
COB RG 3	13050 m

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Name A. Spencer
Date Revised March 23, 2016

Table B-4: Event 5 Rainfall Data

Validation, Large Event

Minesing (mm)	Oro-Medonte (mm)	COB RG 3 (mm)	Rainfall Period (mins)	Date & Time (mm/dd/yyyy hh:mm)	Ungauged Watershed Centroid (mm)	Rainfall Intensity (mm/hr)
0	0	0	0	6/27/2015 15:45	0.00	0.00
0.2	0	0.5	15	6/27/2015 16:00	0.18	0.70
1.2	0	2.25	30	6/27/2015 16:15	0.94	3.75
0.8	0	1.25	45	6/27/2015 16:30	0.59	2.34
1.2	0	0.5	60	6/27/2015 16:45	0.66	2.64
0.4	0	0.75	75	6/27/2015 17:00	0.31	1.25
1	0	1.5	90	6/27/2015 17:15	0.72	2.89
0.4	0.4	0.75	105	6/27/2015 17:30	0.46	1.82
0.2	1	0.25	120	6/27/2015 17:45	0.49	1.97
0.4	0.6	0.25	135	6/27/2015 18:00	0.45	1.79
0.4	0.2	0.5	150	6/27/2015 18:15	0.34	1.38
0.4	0.8	0.75	165	6/27/2015 18:30	0.60	2.39
0.2	0.8	0	180	6/27/2015 18:45	0.38	1.53
0.4	0.4	0.25	195	6/27/2015 19:00	0.38	1.50
0.4	0.2	0.75	210	6/27/2015 19:15	0.38	1.54
0.4	0.6	0.5	225	6/27/2015 19:30	0.49	1.95
0.2	0.4	0.25	240	6/27/2015 19:45	0.28	1.12
0.4	0.4	0.25	255	6/27/2015 20:00	0.38	1.50
0.2	0.2	0.5	270	6/27/2015 20:15	0.25	0.99
0.4	0.8	1	285	6/27/2015 20:30	0.64	2.55
0.2	0.8	1.25	300	6/27/2015 20:45	0.58	2.32
0.8	0.2	0.75	315	6/27/2015 21:00	0.58	2.31
0.4	0.4	0.25	330	6/27/2015 21:15	0.38	1.50
0.4	0.2	0.25	345	6/27/2015 21:30	0.30	1.22
0.2	0.6	0.5	360	6/27/2015 21:45	0.39	1.56
0.2	0.4	0.75	375	6/27/2015 22:00	0.36	1.43
0.6	3	0.75	390	6/27/2015 22:15	1.48	5.92
0.4	1.6	0.25	405	6/27/2015 22:30	0.80	3.22
0.2	0.4	0	420	6/27/2015 22:45	0.24	0.96
0.2	0.4	0.25	435	6/27/2015 23:00	0.28	1.12
0	0.4	0	450	6/27/2015 23:15	0.14	0.57
0.2	0.4	0	465	6/27/2015 23:30	0.24	0.96
0	0.2	0	480	6/27/2015 23:45	0.07	0.29
0	0.2	0	495	6/28/2015 0:00	0.07	0.29
0	0	0	510	6/28/2015 0:15	0.00	0.00
0	0.4	0	525	6/28/2015 0:30	0.14	0.57
0.2	0	0	540	6/28/2015 0:45	0.10	0.39
0.2	0	0	555	6/28/2015 1:00	0.10	0.39
0.4	0	0.25	570	6/28/2015 1:15	0.23	0.93
0.2	0	0	585	6/28/2015 1:30	0.10	0.39
0	0	0.25	600	6/28/2015 1:45	0.04	0.16
0	0	0	615	6/28/2015 2:00	0.00	0.00
0	0	0	630	6/28/2015 2:15	0.00	0.00
0	0.2	0	645	6/28/2015 2:30	0.07	0.29
0.2	0.8	0.5	660	6/28/2015 2:45	0.46	1.85
0	0.2	0.25	675	6/28/2015 3:00	0.11	0.44
0.2	0	0.5	690	6/28/2015 3:15	0.18	0.70
0.2	0	0.25	705	6/28/2015 3:30	0.14	0.55
0.2	0.6	0.25	720	6/28/2015 3:45	0.35	1.40
0.2	0.2	0.75	735	6/28/2015 4:00	0.29	1.15
0.2	0.6	0.25	750	6/28/2015 4:15	0.35	1.40
0	0.2	0.5	765	6/28/2015 4:30	0.15	0.60
0.2	0.4	0.5	780	6/28/2015 4:45	0.32	1.28
0	0.2	0.5	795	6/28/2015 5:00	0.15	0.60
0.6	0.2	0.5	810	6/28/2015 5:15	0.44	1.77
0.2	0	0.5	825	6/28/2015 5:30	0.18	0.70
0	0.4	0.25	840	6/28/2015 5:45	0.18	0.73
0.2	0.2	0	855	6/28/2015 6:00	0.17	0.67
0	0.6	0.25	870	6/28/2015 6:15	0.25	1.01
0	0.2	0.5	885	6/28/2015 6:30	0.15	0.60
0.2	0.2	1	900	6/28/2015 6:45	0.33	1.31
0	0.4	0.25	915	6/28/2015 7:00	0.18	0.73
0	0	0.5	930	6/28/2015 7:15	0.08	0.32
0.2	0.2	2	945	6/28/2015 7:30	0.49	1.94
0.2	0	1.25	960	6/28/2015 7:45	0.30	1.18
1.4	0.2	2	975	6/28/2015 8:00	1.07	4.27
1.4	0.4	2	990	6/28/2015 8:15	1.14	4.55

Rain Gauge Distance to Watershed Centroid

Minesing	7460 m
Oro Medonte	8700 m
COB RG 3	13050 m

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Table B-4: Event 5 Rainfall Data

Validation, Large Event

Minesing (mm)	Oro-Medonte (mm)	COB RG 3 (mm)	Rainfall Period (mins)	Date & Time (mm/dd/yyyy hh:mm)	Ungauged Watershed Centroid (mm)	Rainfall Intensity (mm/hr)
1.8	0	1.25	1005	6/28/2015 8:30	1.07	4.28
2	1	0.75	1020	6/28/2015 8:45	1.45	5.78
1.8	1.6	1.25	1035	6/28/2015 9:00	1.64	6.57
0.8	1.8	1.5	1050	6/28/2015 9:15	1.27	5.07
1.2	1.6	1.5	1065	6/28/2015 9:30	1.39	5.56
2	1.2	0.75	1080	6/28/2015 9:45	1.52	6.07
1.4	0.8	0.25	1095	6/28/2015 10:00	1.00	4.02
1.2	1	0.25	1110	6/28/2015 10:15	0.98	3.91
0.8	1	0.25	1125	6/28/2015 10:30	0.78	3.14
0.6	1.4	0	1140	6/28/2015 10:45	0.79	3.16
1	0.8	0	1155	6/28/2015 11:00	0.77	3.08
0.6	0.2	0	1170	6/28/2015 11:15	0.36	1.45
0	1.2	0	1185	6/28/2015 11:30	0.43	1.71
0	0.4	0.25	1200	6/28/2015 11:45	0.18	0.73
0	0.4	0	1215	6/28/2015 12:00	0.14	0.57
0	0.2	0	1230	6/28/2015 12:15	0.07	0.29
0	0.2	0	1245	6/28/2015 12:30	0.07	0.29
0	1.2	0	1260	6/28/2015 12:45	0.43	1.71
0	0.2	0	1275	6/28/2015 13:00	0.07	0.29
0	0.6	0.25	1290	6/28/2015 13:15	0.25	1.01
0	0	0	1305	6/28/2015 13:30	0.00	0.00
0	0.8	0	1320	6/28/2015 13:45	0.29	1.14
0	1	0	1335	6/28/2015 14:00	0.36	1.43
0.2	1	0	1350	6/28/2015 14:15	0.45	1.81
1	0.6	0	1365	6/28/2015 14:30	0.70	2.80
0	1.8	0	1380	6/28/2015 14:45	0.64	2.57
0.2	0.4	0.25	1395	6/28/2015 15:00	0.28	1.12
0	0	0	1410	6/28/2015 15:15	0.00	0.00
0	0.2	0	1425	6/28/2015 15:30	0.07	0.29
0	0	0	1440	6/28/2015 15:45	0.00	0.00
0	0	0	1455	6/28/2015 16:00	0.00	0.00
0	0.2	0.25	1470	6/28/2015 16:15	0.11	0.44
0	0	0	1485	6/28/2015 16:30	0.00	0.00
0	0.6	0	1500	6/28/2015 16:45	0.21	0.86
0	0	0	1515	6/28/2015 17:00	0.00	0.00
0.6	0	0.25	1530	6/28/2015 17:15	0.33	1.32
0.2	0	0	1545	6/28/2015 17:30	0.10	0.39
0	0	0	1560	6/28/2015 17:45	0.00	0.00
0	0	0	1575	6/28/2015 18:00	0.00	0.00
0	0	0	1590	6/28/2015 18:15	0.00	0.00
0.2	0.2	0	1605	6/28/2015 18:30	0.17	0.67
0	0	0	1620	6/28/2015 18:45	0.00	0.00
0	0	0	1635	6/28/2015 19:00	0.00	0.00
0	0	0	1650	6/28/2015 19:15	0.00	0.00
0	0	0	1665	6/28/2015 19:30	0.00	0.00
0	0	0	1680	6/28/2015 19:45	0.00	0.00
0	0	0	1695	6/28/2015 20:00	0.00	0.00
0	0	0	1710	6/28/2015 20:15	0.00	0.00
0	0	0	1725	6/28/2015 20:30	0.00	0.00
0	0	0	1740	6/28/2015 20:45	0.00	0.00
0	0	0	1755	6/28/2015 21:00	0.00	0.00
0	0	0	1770	6/28/2015 21:15	0.00	0.00
0	0	0	1785	6/28/2015 21:30	0.00	0.00
0	0	0	1800	6/28/2015 21:45	0.00	0.00
0.2	0	0	1815	6/28/2015 22:00	0.10	0.39
0	0	0	1830	6/28/2015 22:15	0.00	0.00
0	0	0	1845	6/28/2015 22:30	0.00	0.00
0.2	0	0	1860	6/28/2015 22:45	0.10	0.39
0.2	0	0.25	1875	6/28/2015 23:00	0.14	0.55
0	0	0	1890	6/28/2015 23:15	0.00	0.00
Sum (mm)	38.0	46.4	42.8		41.7	

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Table B-5: Event 8 Rainfall Data

Validation, Small Event

Minesing (mm)	Oro-Medonte (mm)	COB RG 3 (mm)	Rainfall Period (mins)	Date & Time (mm/dd/yyyy hh:mm)	Ungauged Watershed Centroid (mm)	Rainfall Intensity (mm/hr)
0	0	0	0	9/9/2015 0:00	0.00	0.00
1.2	0	0.5	15	9/9/2015 0:15	0.66	2.64
2.4	0	0.75	30	9/9/2015 0:30	1.28	5.13
2	2	0.25	45	9/9/2015 0:45	1.72	6.89
1.4	0.8	0.25	60	9/9/2015 1:00	1.00	4.02
2.4	1.8	0.75	75	9/9/2015 1:15	1.92	7.70
2.4	2.8	4.75	90	9/9/2015 1:30	2.92	11.66
0.4	2	3.25	105	9/9/2015 1:45	1.42	5.69
0	2.4	1.5	120	9/9/2015 2:00	1.09	4.37
0	1.6	0	135	9/9/2015 2:15	0.57	2.28
0	3.4	0.25	150	9/9/2015 2:30	1.25	5.01
0.2	3	0	165	9/9/2015 2:45	1.17	4.67
0.2	0.2	0.25	180	9/9/2015 3:00	0.21	0.83
0.6	0.2	0	195	9/9/2015 3:15	0.36	1.45
1.2	0	0	210	9/9/2015 3:30	0.58	2.33
1.2	0	0.5	225	9/9/2015 3:45	0.66	2.64
2	0	0.75	240	9/9/2015 4:00	1.09	4.36
1.4	0.4	1.75	255	9/9/2015 4:15	1.10	4.40
0.8	0.8	1.5	270	9/9/2015 4:30	0.91	3.64
0.4	1.4	1	285	9/9/2015 4:45	0.85	3.41
1.2	4	1.5	300	9/9/2015 5:00	2.25	8.98
0.6	1.2	1.5	315	9/9/2015 5:15	0.96	3.83
0.6	1.2	0.75	330	9/9/2015 5:30	0.84	3.35
0.6	1	0.5	345	9/9/2015 5:45	0.73	2.91
0	0.2	0.25	360	9/9/2015 6:00	0.11	0.44
0	0.4	0.25	375	9/9/2015 6:15	0.18	0.73
0.2	0.4	0	390	9/9/2015 6:30	0.24	0.96
0.2	0.6	0.25	405	9/9/2015 6:45	0.35	1.40
0	0	0	420	9/9/2015 7:00	0.00	0.00
0	0	0	435	9/9/2015 7:15	0.00	0.00
0	0.2	0	450	9/9/2015 7:30	0.07	0.29
0	0.2	0	465	9/9/2015 7:45	0.07	0.29
0	0.2	0	480	9/9/2015 8:00	0.07	0.29
0	0	0	495	9/9/2015 8:15	0.00	0.00
Sum (mm)	23.6	32.4	23		26.6	

Rain Gauge Distance to Watershed Centroid

Minesing	7460 m
Oro Medonte	8700 m
COB RG 3	13050 m

Table B-6 : Event 3 (C, L) Storm File


```
2
Event 3 Storm Event
15
76
0.39
0.00
0.00
0.00
0.39
0.00
0.00
0.29
0.00
0.00
0.00
0.29
0.00
0.00
0.00
0.00
0.39
0.29
0.00
0.00
0.57
0.29
0.00
0.00
1.09
0.55
0.00
0.00
0.78
2.77
2.42
3.10
2.08
2.27
0.67
0.83
1.30
1.92
1.48
2.50
1.61
1.09
2.08
2.11
2.23
2.88
4.10
3.27
7.78
6.11
6.13
6.54
7.25
10.66
10.28
5.79
10.37
5.13
3.66
```

3.40
3.14
1.14
1.14
0.29
0.44
0.00
0.00
0.00
0.00
0.00
0.57
0.00
0.00
0.00
0.00
0.39
-1.00

Table B-7: Event 4 (C, S) Storm File

Event4

```
2
Event 4 Storm Event
15
23
0.16
0.00
0.00
1.01
0.39
0.00
0.00
0.83
0.96
2.15
6.52
35.36
35.76
0.39
0.73
2.00
3.81
13.98
3.22
1.85
0.00
0.00
0.39
-1.00
```

Table B-8: Event 5 (V, L) Storm File

Event5

```
2
Event 5 Storm Event
15
127
0.00
0.70
3.75
2.34
2.64
1.25
2.89
1.82
1.97
1.79
1.38
2.39
1.53
1.50
1.54
1.95
1.12
1.50
0.99
2.55
2.32
2.31
1.50
1.22
1.56
1.43
5.92
3.22
0.96
1.12
0.57
0.96
0.29
0.29
0.00
0.57
0.39
0.39
0.93
0.39
0.16
0.00
0.00
0.29
1.85
0.44
0.70
0.55
1.40
1.15
1.40
0.60
1.28
0.60
1.77
0.70
0.73
0.67
1.01
```

0.60
1.31
0.73
0.32
1.94
1.18
4.27
4.55
4.28
5.78
6.57
5.07
5.56
6.07
4.02
3.91
3.14
3.16
3.08
1.45
1.71
0.73
0.57
0.29
0.29
1.71
0.29
1.01
0.00
1.14
1.43
1.81
2.80
2.57
1.12
0.00
0.29
0.00
0.00
0.44
0.00
0.86
0.00
1.32
0.39
0.00
0.00
0.00
0.67
0.00
0.00
0.00
0.00
0.00
0.00
0.00
0.00
0.00
0.00
0.00
0.00
0.00
0.00
0.39

0.00
0.00
0.39
0.55
0.00
-1.00

Table B-9: Event 8 (V,S) Storm File

Event8

```
2
Event 8 Storm Event
15
34
0.00
2.64
5.13
6.89
4.02
7.70
11.66
5.69
4.37
2.28
5.01
4.67
0.83
1.45
2.33
2.64
4.36
4.40
3.64
3.41
8.98
3.83
3.35
2.91
0.44
0.73
0.96
1.40
0.00
0.00
0.29
0.29
0.29
0.00
-1.00
```

APPENDIX C

Watershed Characteristics

CROZIER & ASSOCIATES
Consulting Engineers

Project Name: Midhurst MDP
Project Number: 845-3675
Date: January 13, 2016
By: C. Wilson
Revised: February 23, 2016
Revised By: K. Wilmhurst

Table C-1: Base Model Hydrologic Parameters (CALIB NASHYD Command)
Pre Development Drainage Area: Catchments

Pre-Dev Catchment Area ID	Total Area	Composite Runoff Coefficient	Composite Curve No.	Composite Initial Abstraction	Time to Peak	N Value
No.	(ha)			(mm)	(hr)	
1	358.19	0.14	52.1	9.9	3.3	3.00
2	434.25	0.15	46.7	9.1	1.7	3.00
3	236.33	0.17	52.5	8.4	1.3	3.00
4	489.54	0.18	56.9	8.2	1.7	3.00
5	248.07	0.13	48.4	9.4	1.3	3.00
6	87.76	0.09	33.2	10.0	0.5	3.00
7	137.93	0.07	35.5	10.2	1.0	3.00
8	997.97	0.16	44.9	9.0	1.2	3.00
9	513.54	0.09	46.6	9.7	1.2	3.00
10	422.91	0.19	55.0	9.2	2.1	3.00
11	371.18	0.12	47.4	9.5	1.3	3.00
12	611.65	0.15	37.3	9.1	1.6	3.00
13	792.04	0.17	40.7	8.7	1.9	3.00
14	395.48	0.14	51.6	8.9	2.4	3.00
15	679.26	0.14	50.8	8.8	1.8	3.00
16	646.13	0.17	52.7	8.8	2.2	3.00
17	724.50	0.15	45.6	8.9	1.9	3.00
18	1089.96	0.14	42.3	9.5	3.2	3.00

Note: Due to the sandy soils in the watershed, wetland areas exhibiting A and AB type soils were modeled based on the "woods" CN values presented in the NVCA Technical SWM Guidelines, rather than the uniform value of CN=50 for wetland areas.

CROZIER &ASSOCIATES
Consulting Engineers

Project Name: Midhurst MDP
Project Number: 845-3675
Date: January 13, 2016
By: C. Wilson
Revised: February 23, 2016
Revised By: K. Wilmhurst

Table C-2: Base Model Time To Peak (Tp) (CALIB NASHYD Command)
Pre Development Drainage Area: Catchments

Catchment Area	Reach 1					Reach 2					Reach 3					Combined		
No.	length (m)	fall (m)	slope (m/m)	slope (%)	Travel Time (sec)	length (m)	fall (m)	slope (m/m)	slope (%)	Travel Time (sec)	length (m)	fall (m)	slope (m/m)	slope (%)	Travel Time (sec)	Total Travel Time (sec)	Total Travel Time (hr)	Tp (hr)
1	100	0.75	0.0075	0.75%	1924.501	703.400	29.25	0.0416	4.16%	749.864475	3622.29	10	0.0028	0.28%	14987.079	17661.444	4.906	3.287
2	100	3.33	0.0333	3.33%	913.328	1163.230	42.66	0.0367	3.67%	1320.47485	2454.62	14	0.0057	0.57%	7065.690	9299.492	2.583	1.731
3	100	2	0.0200	2.00%	261.891	4617.100	100	0.0217	2.17%	6820.18397	None	None	None	None	None	7082.075	1.967	1.318
4	100	1.25	0.0125	1.25%	1490.712	4997.440	98	0.0196	1.96%	7758.01319	None	None	None	None	None	9248.725	2.569	1.721
5	100	1.5	0.0150	1.50%	1360.828	3858.670	79	0.0205	2.05%	5862.53003	None	None	None	None	None	7223.358	2.006	1.344
6	100	3	0.0300	3.00%	962.250	1146.660	23	0.0201	2.01%	1760.07123	None	None	None	None	None	2722.322	0.756	0.507
7	100	2.5	0.0250	2.50%	1054.093	2517.840	37	0.0147	1.47%	4515.26765	None	None	None	None	None	5569.360	1.547	1.037
8	100	3	0.0300	3.00%	962.250	1706.190	66	0.0387	3.87%	1885.86799	2270.49	38	0.0167	1.67%	3815.309	6663.428	1.851	1.240
9	100	0.66	0.0066	0.66%	2051.525	2513.100	36.25	0.0144	1.44%	4548.86259	None	None	None	None	None	6600.387	1.833	1.228
10	100	2	0.0200	2.00%	1178.511	1507.060	46	0.0305	3.05%	1875.24954	2187.96	7	0.0032	0.32%	8409.152	11462.913	3.184	2.133
11	100	0.5	0.0050	0.50%	2357.023	2588.760	42.6	0.0165	1.65%	4387.07494	None	None	None	None	None	6744.098	1.873	1.255
12	100	2	0.0200	2.00%	428.550	5253.190	105	0.0200	2.00%	8077.597	None	None	None	None	None	8506.147	2.363	1.583
13	100	3	0.0300	3.00%	962.250	6080.800	121	0.0199	1.99%	9371.09979	None	None	None	None	None	10333.350	2.870	1.923
14	100	0.85	0.0085	0.85%	1807.754	893.750	17.2	0.0192	1.92%	1400.56099	3646.88	24.8	0.0068	0.68%	9613.876	12822.191	3.562	2.386
15	100	0.5	0.0050	0.50%	523.783	2088.600	38	0.0182	1.82%	3366.14857	2961.64	40	0.0135	1.35%	5540.010	9429.942	2.619	1.755
16	100	1.8	0.0180	1.80%	276.058	1447.730	32.25	0.0223	2.23%	2108.67024	3792.69	30.25	0.0080	0.80%	9232.100	11616.828	3.227	2.162
17	100	1	0.0100	1.00%	1666.667	3816.140	101	0.0265	2.65%	5099.3865	1589.58	16	0.0101	1.01%	3444.338	10210.391	2.836	1.900
18	100	4	0.0400	4.00%	833.333	5464.790	130	0.0238	2.38%	7702.48229	2358.87	8	0.0034	0.34%	8805.483	17341.299	4.817	3.227

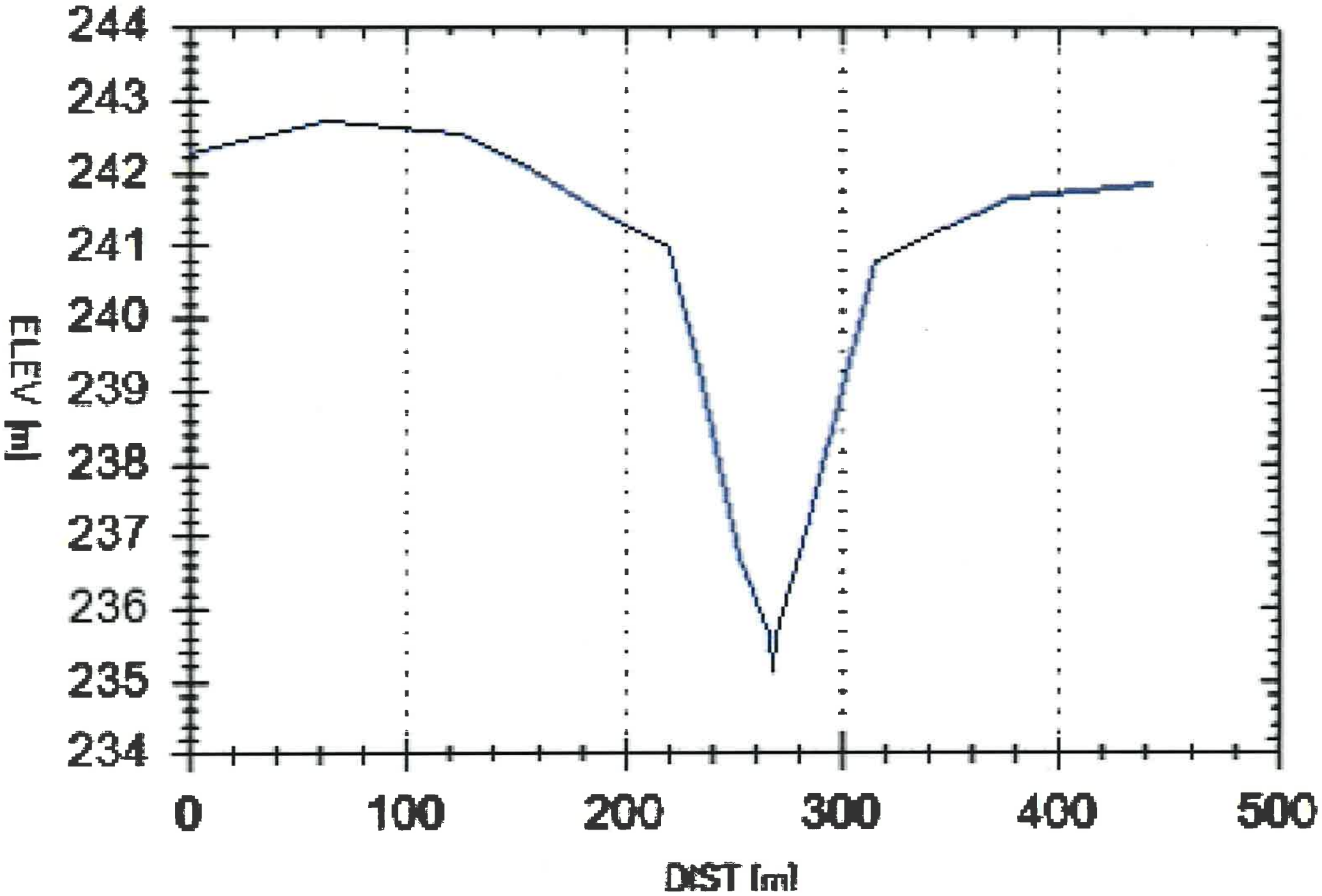
CROZIER & ASSOCIATES
Consulting Engineers

Project Name: Midhurst MDP
Project Number: 845-3675
Date: January 13, 2016
By C. Wilson
Revised: February 23, 2016
Revised By: K. Wilmhurst

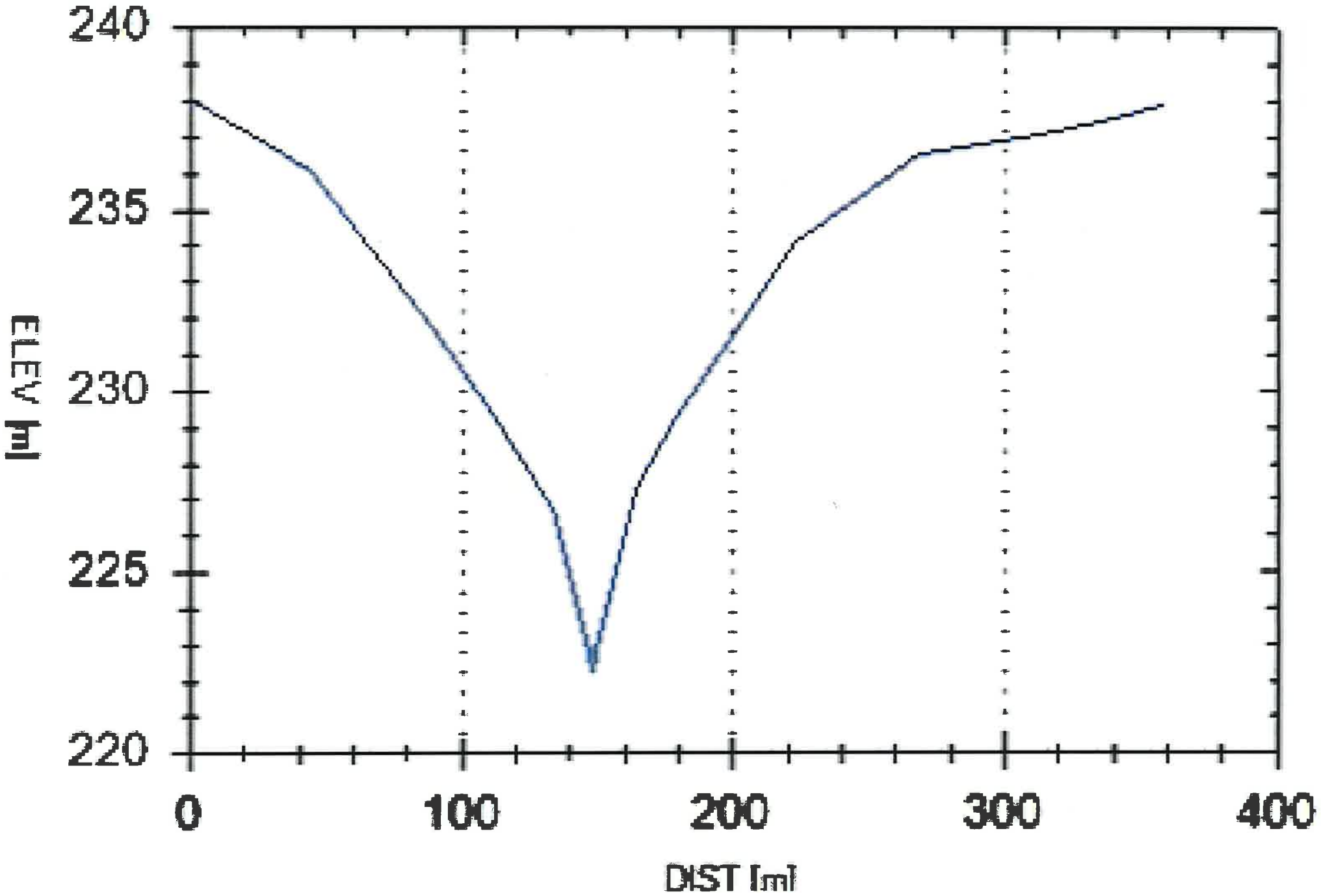
Table C-3: Base Model Time To Peak (Tp) Check (CALIB NASHYD Command)
Pre Development Drainage Area: Catchments

Catchment Area No.	CALIFORNIA CULVERT PRACTICE METHOD								KERBY - KERPICH METHOD									
	TOTAL LENGTH	TOTAL FALL	AVG SLOPE (%)	LENGTH (MILES)	FALL (FEET)	T_C (Min)	T_C (HR)	Tp (HR)	RETARDANCE FACTOR	OVERLAND FLOW LENGTH (m)	OVERLAND FLOW SLOPE	T_{OV} (MIN)	CHANNEL FLOW LENGTH (m)	CHANNEL FLOW SLOPE	T_{CH} (MIN)	T_C (MIN)	T_C (HR)	Tp (HR)
1	4425.69	40.00	0.01	2.75	131.23	76.60	1.28	0.86	0.50	100.00	0.01	28.26	4325.69	0.02	53.29	81.55	1.36	0.91
2	3717.85	59.99	0.02	2.31	196.82	53.58	0.89	0.60	0.50	100.00	0.03	19.91	3617.85	0.02	47.26	67.17	1.12	0.75
3	4717.10	102.00	0.02	2.93	334.65	57.50	0.96	0.64	0.50	100.00	0.02	22.44	4617.10	0.02	56.54	78.98	1.32	0.88
4	5097.44	99.25	0.02	3.17	325.62	63.56	1.06	0.71	0.50	100.00	0.01	25.06	4997.44	0.02	62.44	87.50	1.46	0.98
5	3958.67	80.50	0.02	2.46	264.11	51.44	0.86	0.57	0.50	100.00	0.02	24.01	3858.67	0.02	50.32	74.34	1.24	0.83
6	1246.66	26.00	0.02	0.77	85.30	20.93	0.35	0.23	0.50	100.00	0.03	20.40	1146.66	0.02	19.93	40.33	0.67	0.45
7	2617.84	39.50	0.02	1.63	129.59	41.97	0.70	0.47	0.50	100.00	0.03	21.29	2517.84	0.01	41.16	62.45	1.04	0.70
8	4076.68	107.00	0.03	2.53	351.05	47.70	0.79	0.53	0.50	100.00	0.03	20.40	3976.68	0.03	45.84	66.24	1.10	0.74
9	2613.10	36.91	0.01	1.62	121.10	42.99	0.72	0.48	0.50	100.00	0.01	29.12	2513.10	0.01	41.39	70.51	1.18	0.79
10	3795.02	55.00	0.01	2.36	180.45	56.74	0.95	0.63	0.50	100.00	0.02	22.44	3695.02	0.02	52.45	74.89	1.25	0.84
11	2688.76	43.10	0.02	1.67	141.40	41.86	0.70	0.47	0.50	100.00	0.01	31.08	2588.76	0.02	40.26	71.34	1.19	0.80
12	5353.19	107.00	0.02	3.33	351.05	65.33	1.09	0.73	0.50	100.00	0.02	22.44	5253.19	0.02	64.41	86.85	1.45	0.97
13	6180.80	124.00	0.02	3.84	406.82	72.88	1.21	0.81	0.50	100.00	0.03	20.40	6080.80	0.02	72.22	92.62	1.54	1.03
14	4640.63	42.85	0.01	2.88	140.58	78.79	1.31	0.88	0.50	100.00	0.01	27.44	4540.63	0.01	67.90	95.34	1.59	1.06
15	5150.24	78.50	0.02	3.20	257.55	70.39	1.17	0.79	0.50	100.00	0.01	31.08	5050.24	0.02	68.32	99.41	1.66	1.11
16	5340.42	64.30	0.01	3.32	210.96	79.27	1.32	0.89	0.50	100.00	0.02	23.00	5240.42	0.02	71.57	94.58	1.58	1.06
17	5505.72	118.00	0.02	3.42	387.14	64.99	1.08	0.73	0.50	100.00	0.01	26.41	5405.72	0.02	68.17	94.58	1.58	1.06
18	7923.66	142.00	0.02	4.92	465.88	92.16	1.54	1.03	0.50	100.00	0.04	19.07	7823.66	0.01	101.55	120.62	2.01	1.35

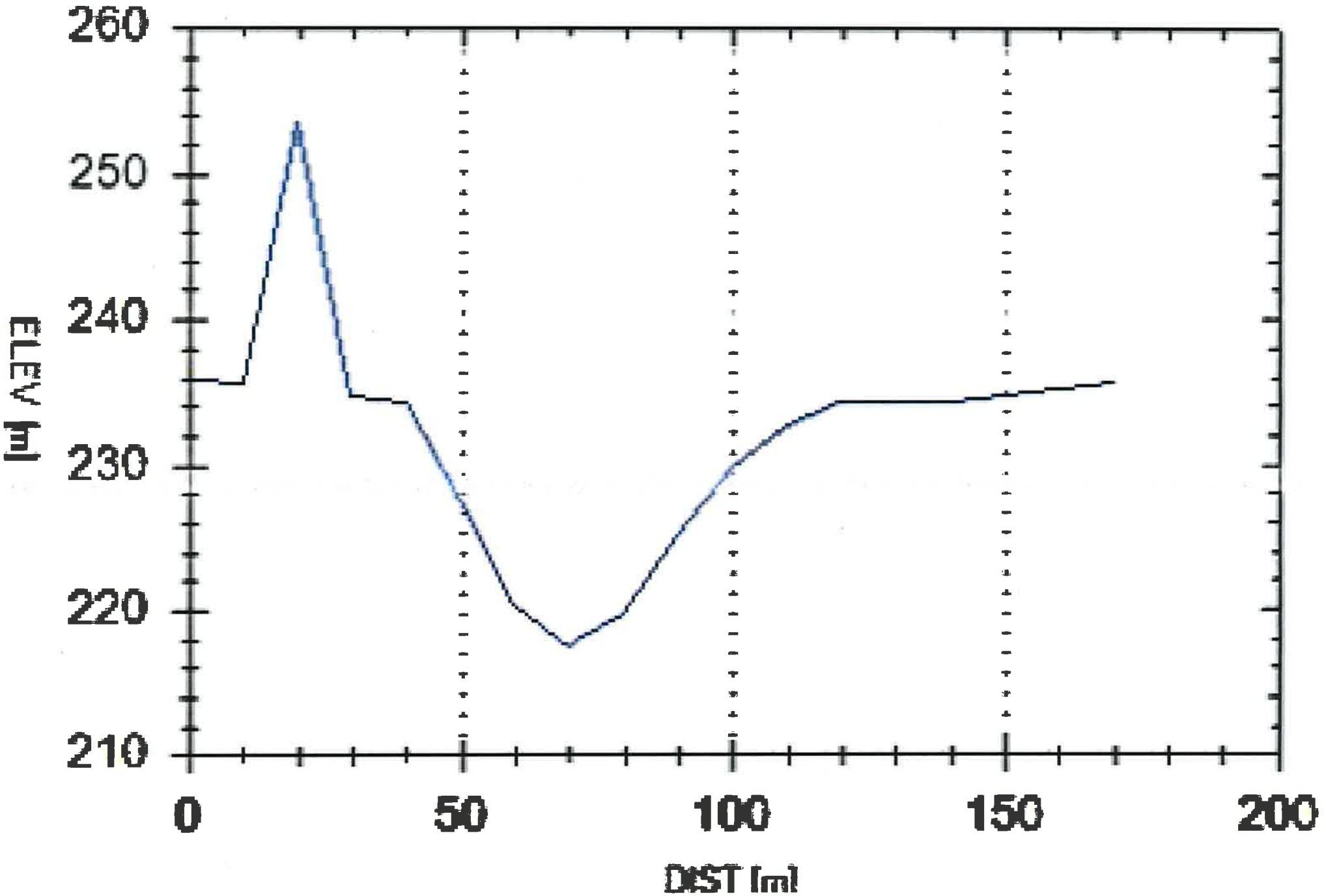
C-4 : **Route Channel** 1



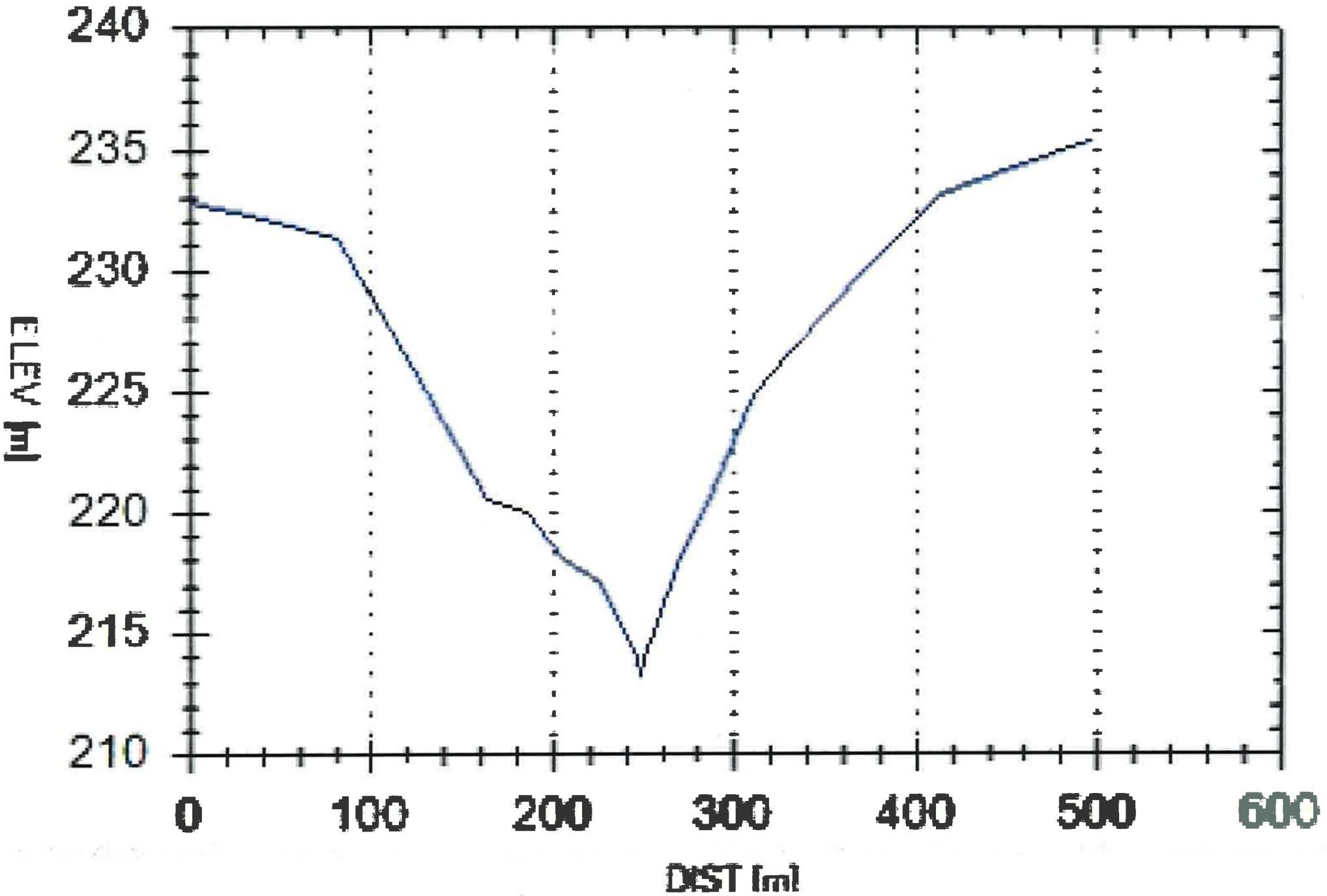
C-5: **Route Channel 2**



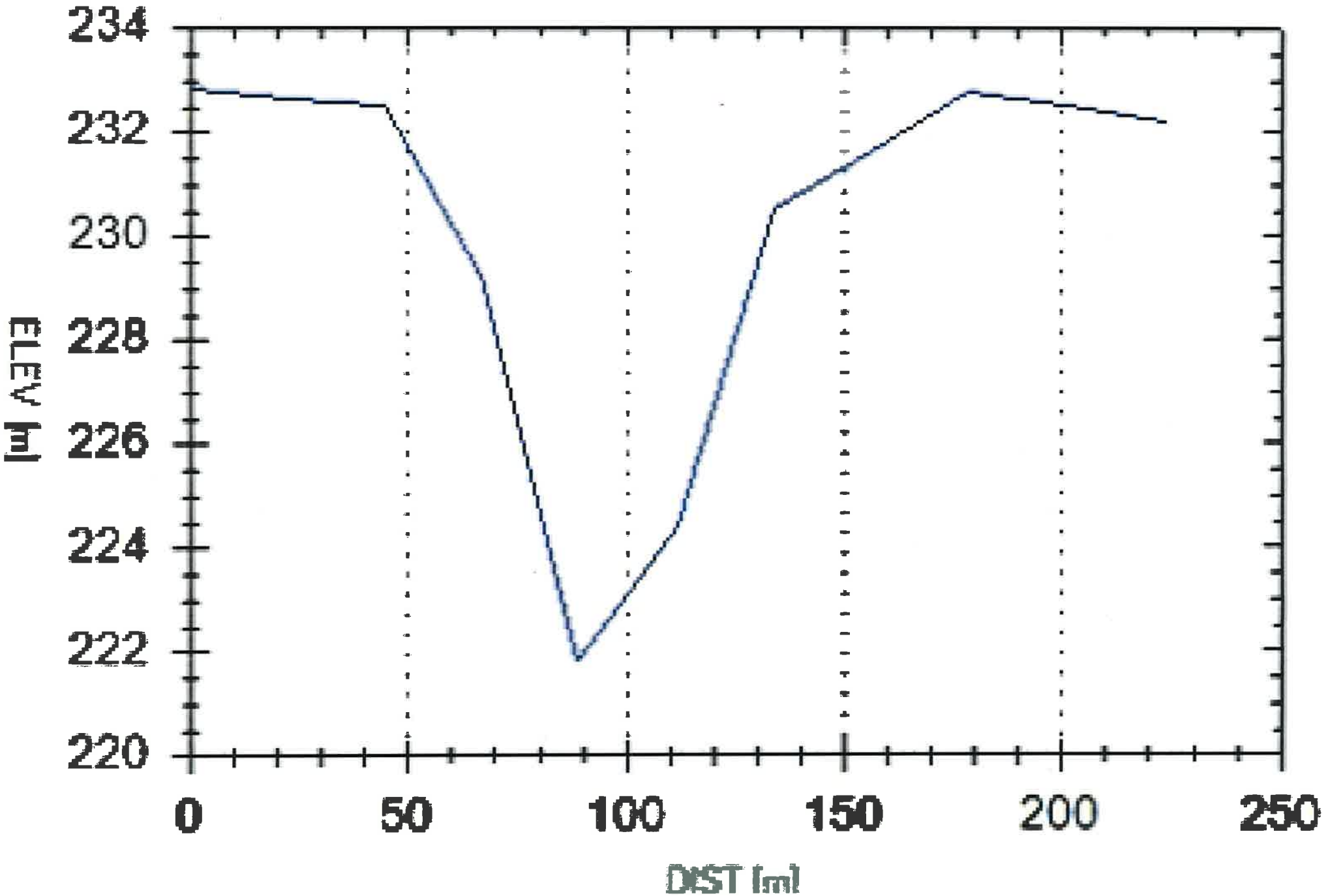
C-6: **Route Channel** 3



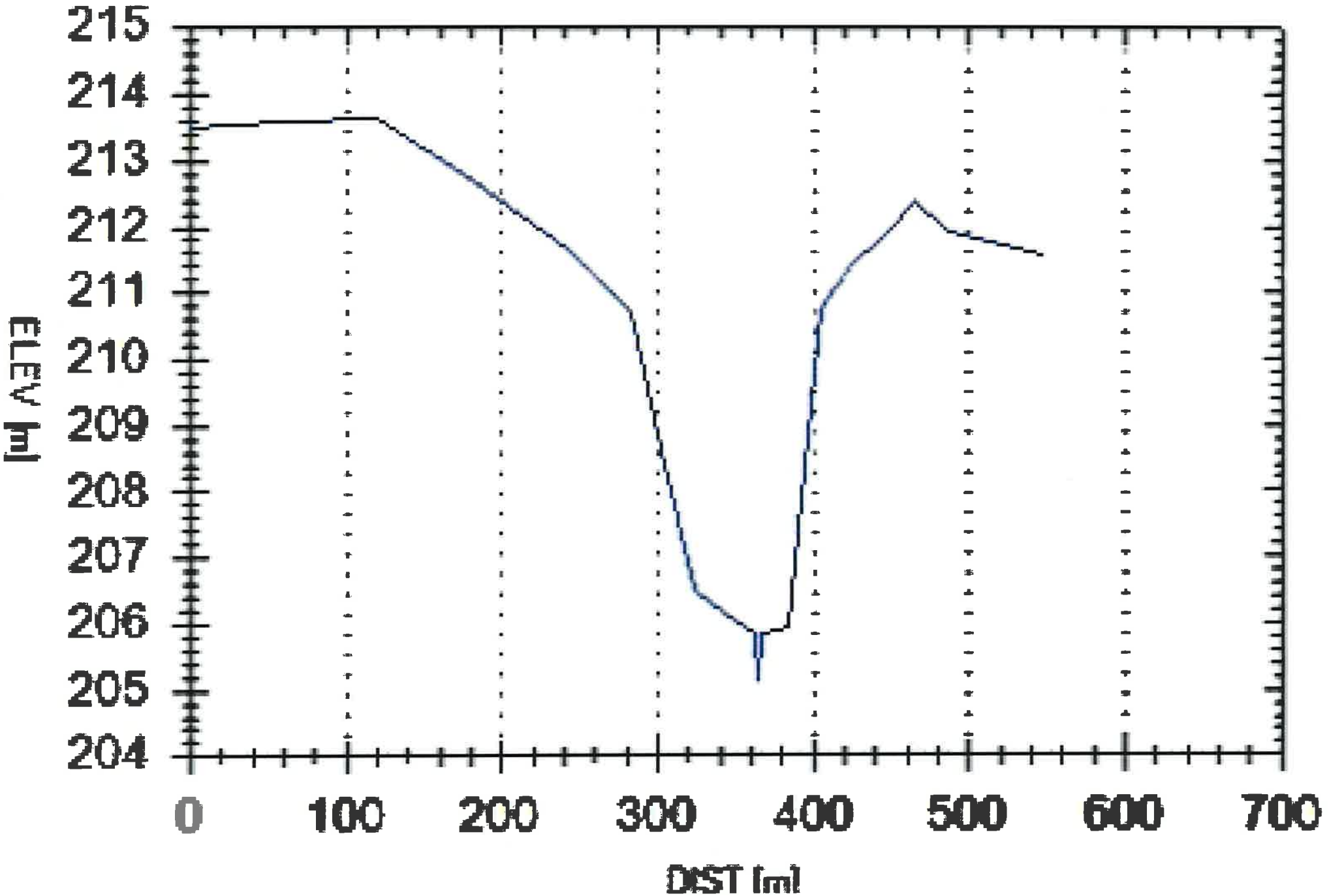
C-7: **Route Channel** 4



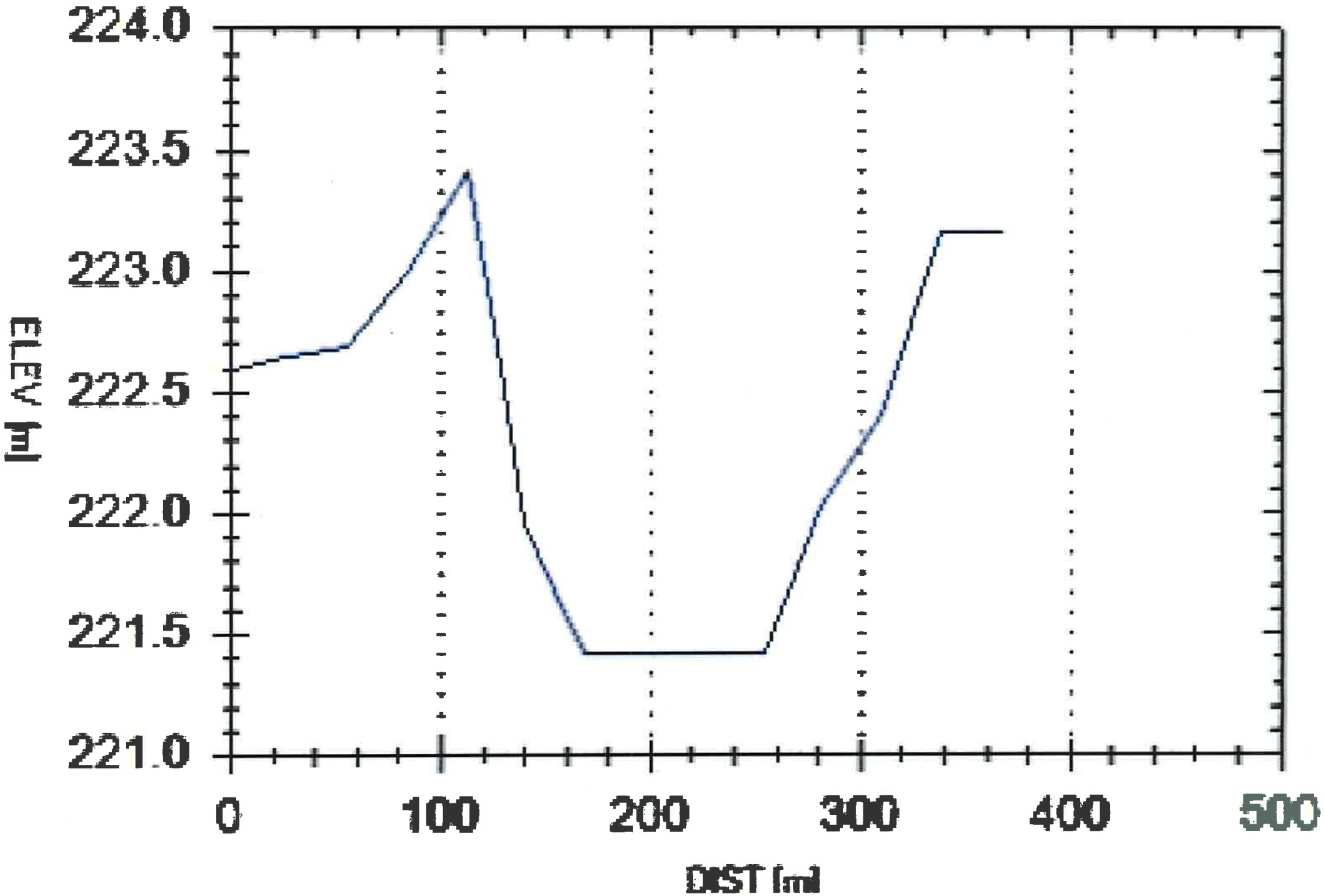
C-8: **Route Channel** 5



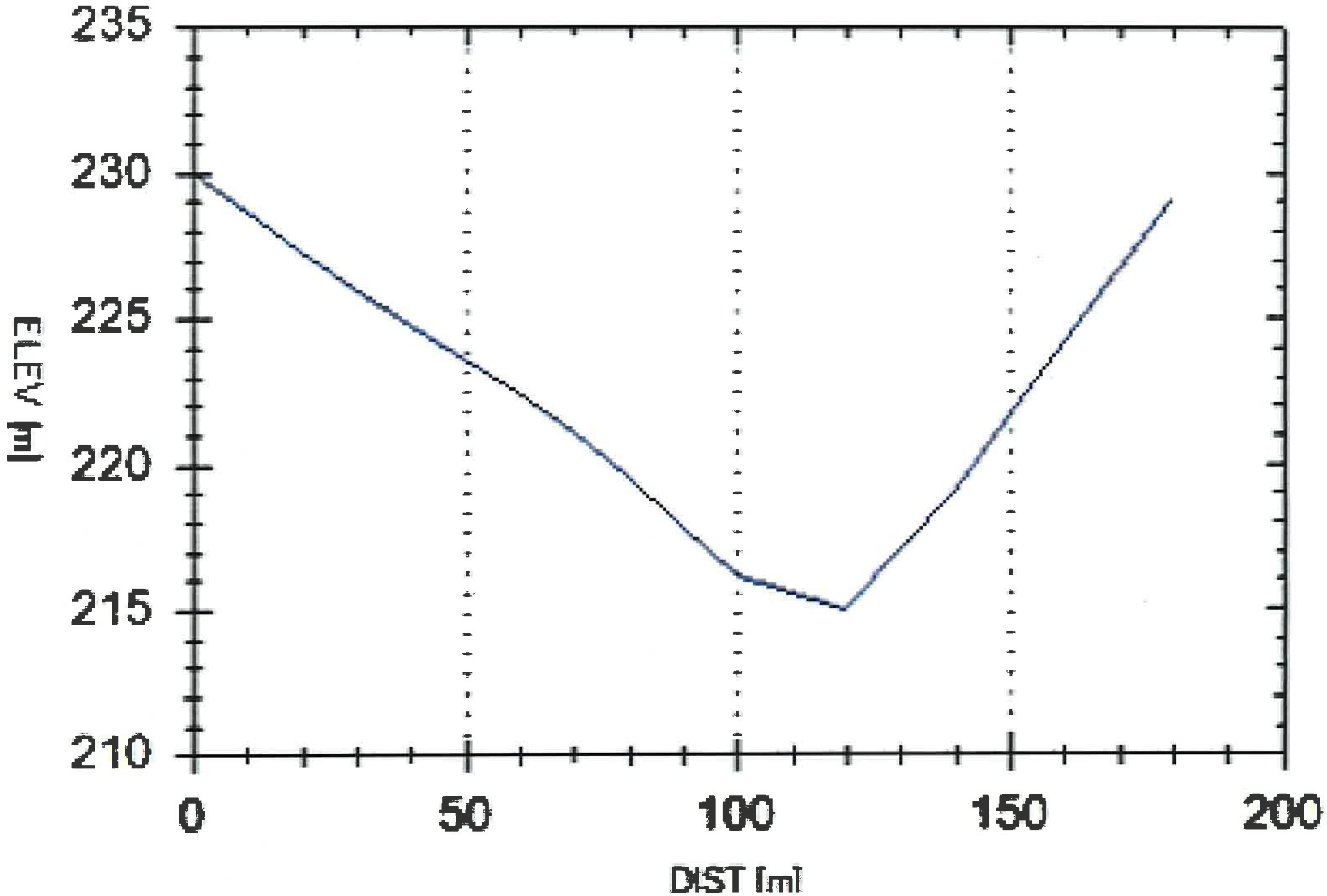
C-9: **Route Channel** 6



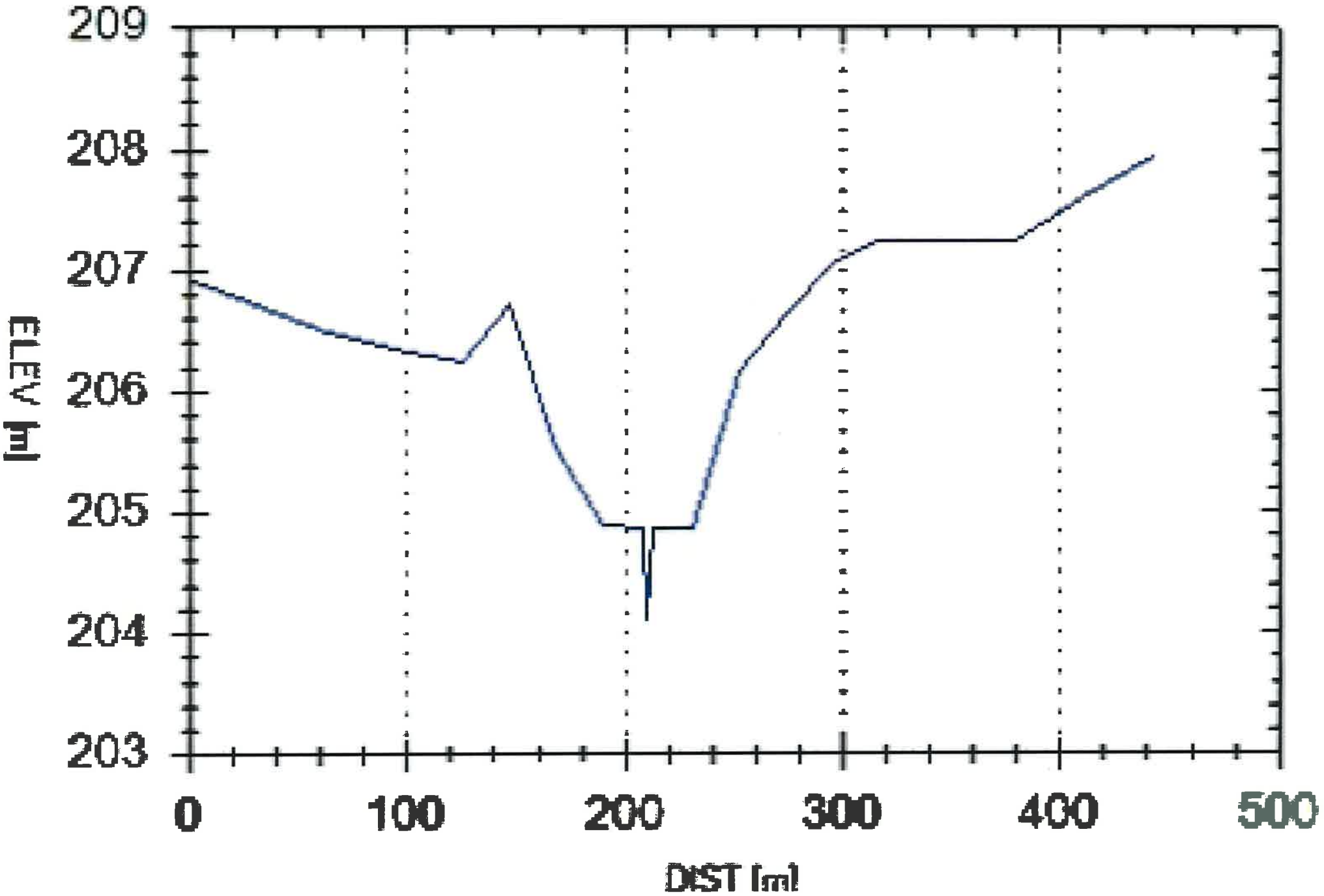
C-10 : **Route Channel 7**



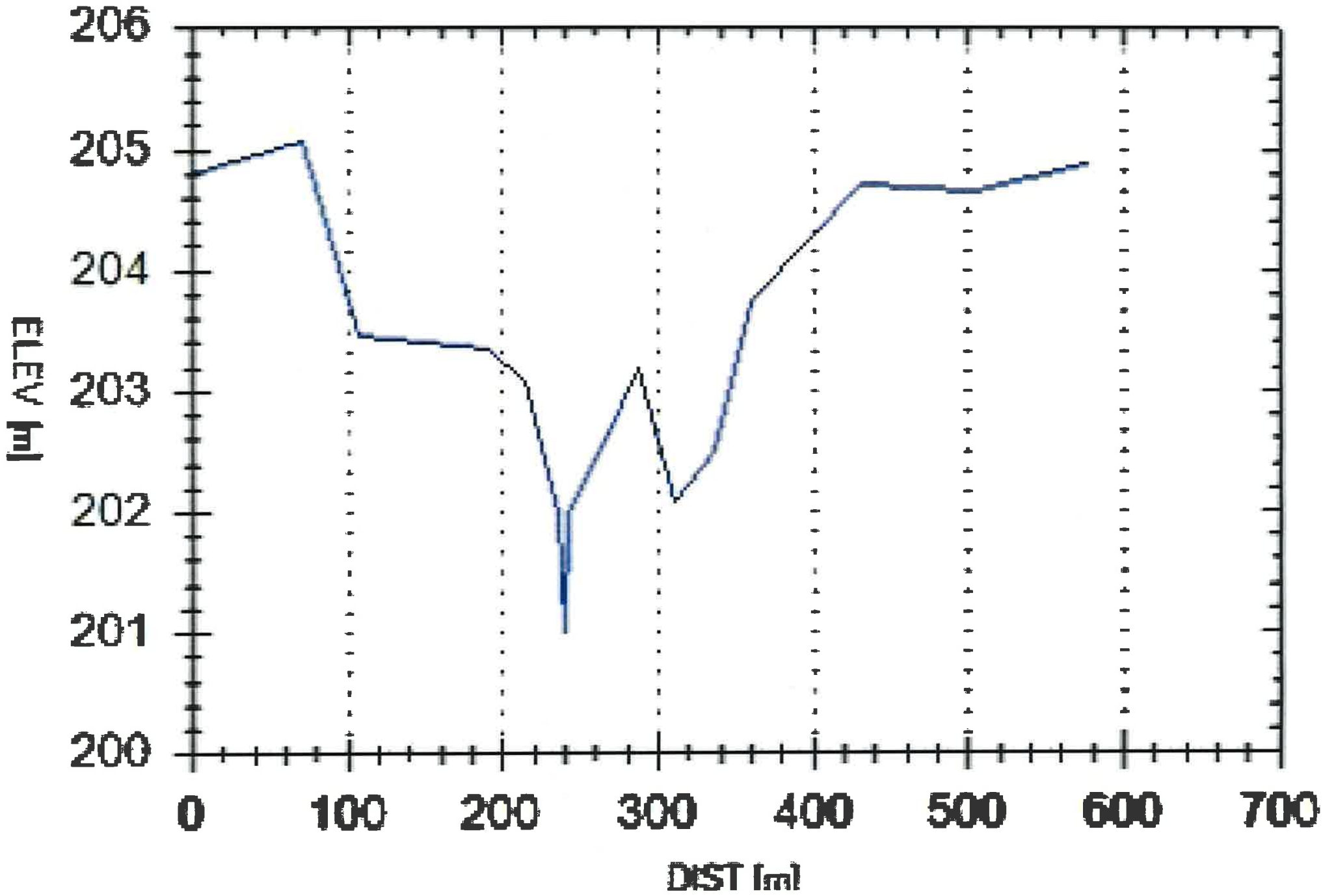
C-11 : **Route Channel** 8



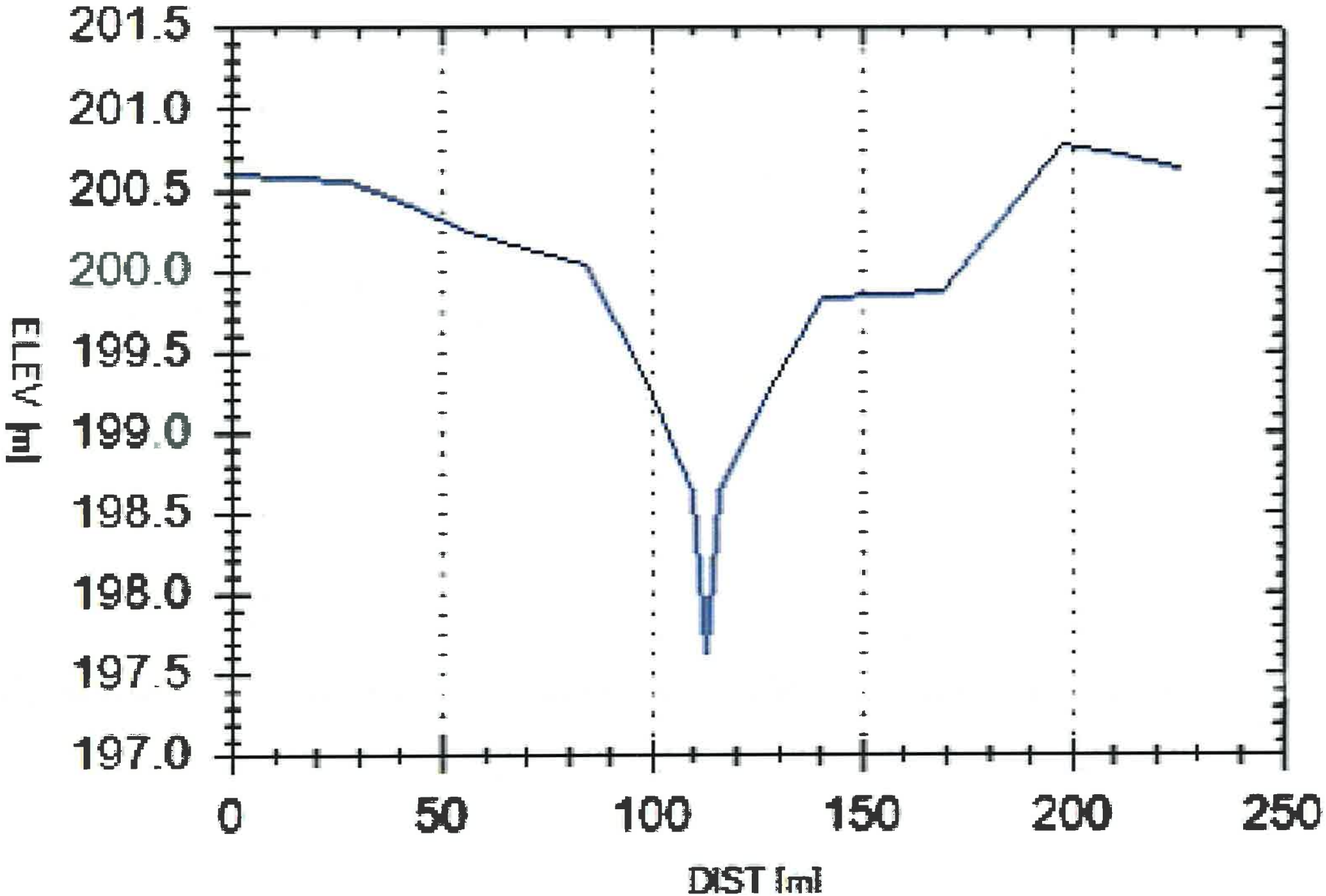
C-12: **Route Channel** 9



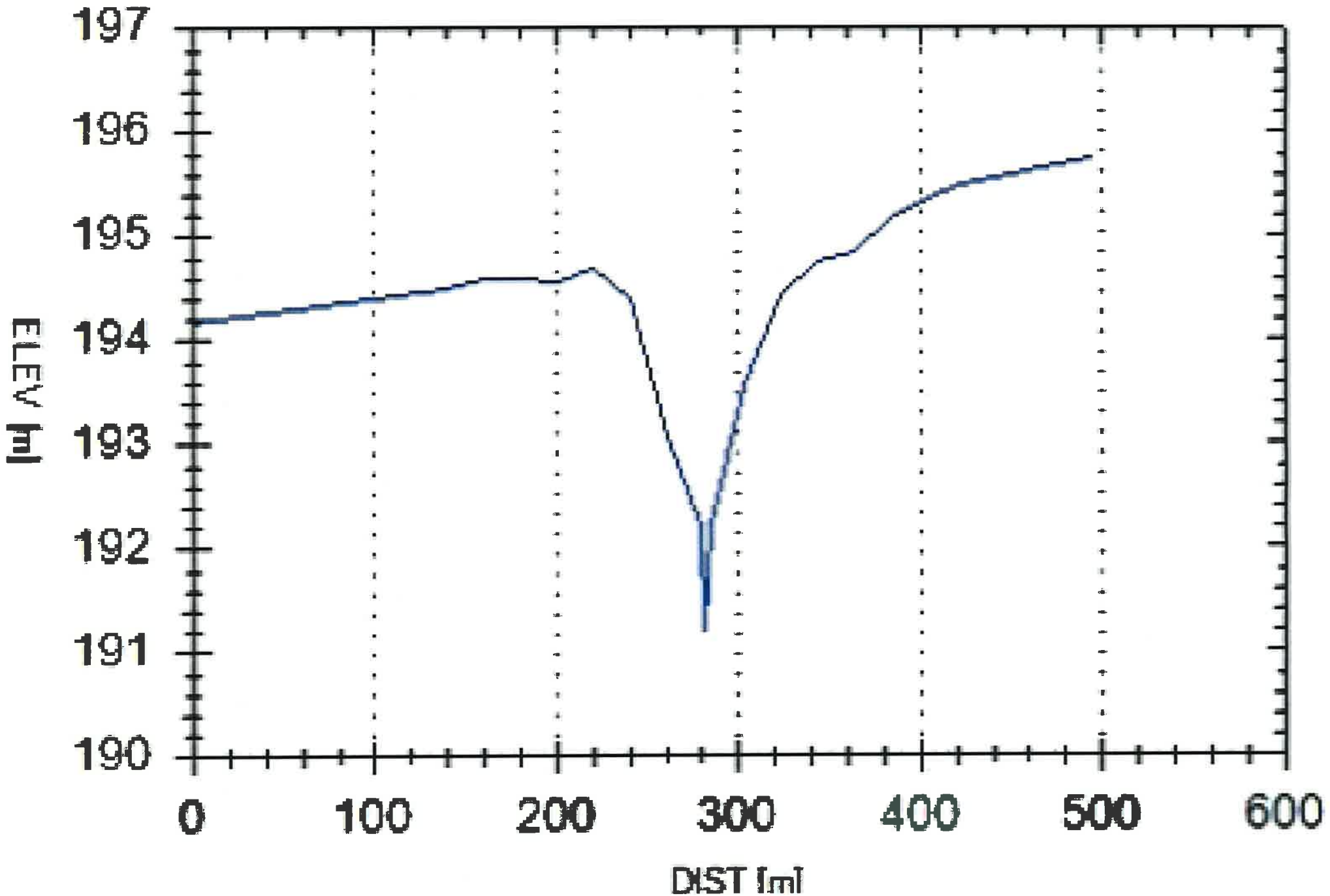
C-13 : **Route Channel** 10

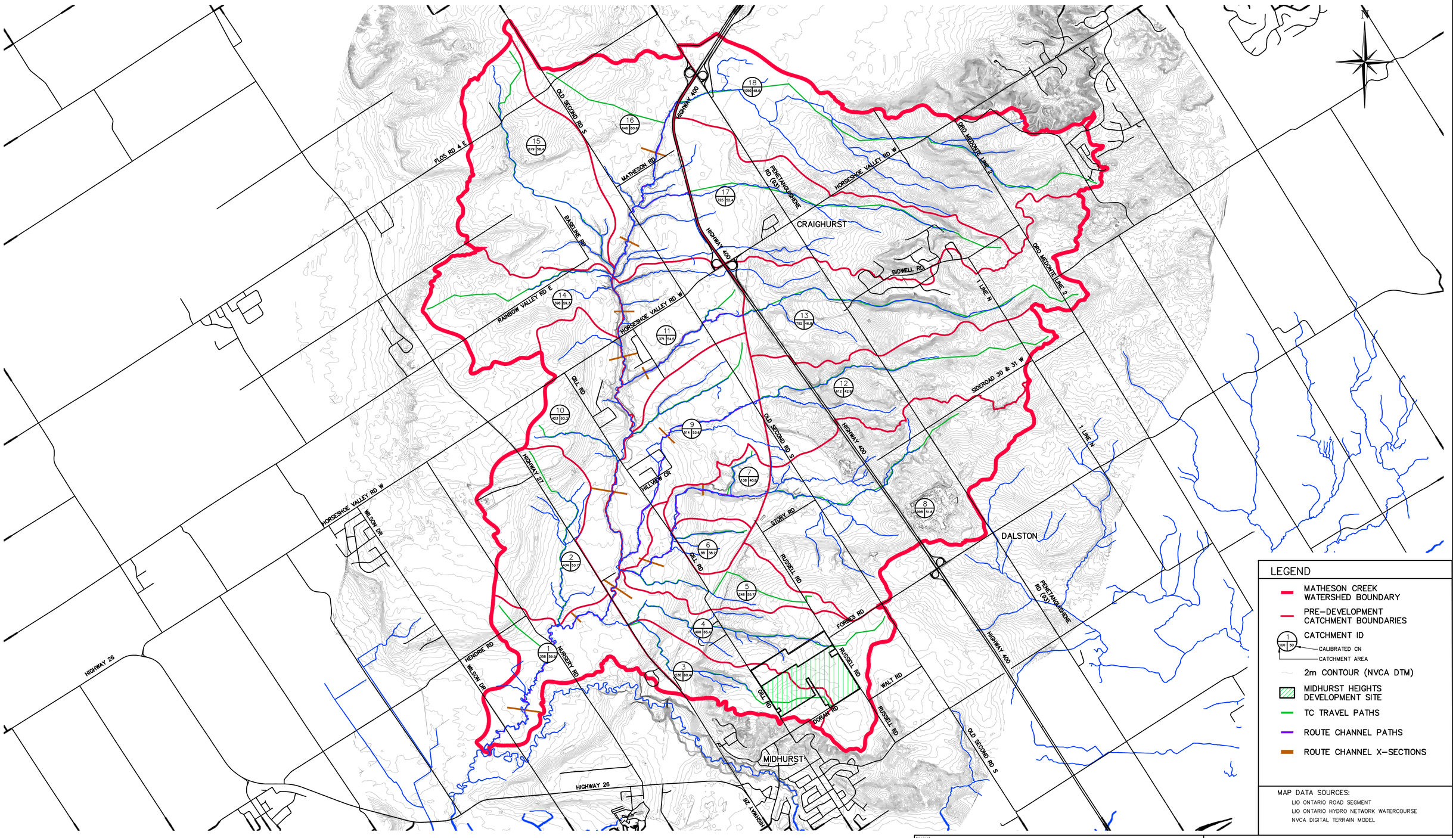


C-14 : **Route Channel II**



C-158 **Route Channel** 12





LEGEND

- MATHESON CREEK WATERSHED BOUNDARY
- PRE-DEVELOPMENT CATCHMENT BOUNDARIES
- CATCHMENT ID
  - CALIBRATED CN
  - CATCHMENT AREA
- 2m CONTOUR (NVCA DTM)
- MIDHURST HEIGHTS DEVELOPMENT SITE
- TC TRAVEL PATHS
- ROUTE CHANNEL PATHS
- ROUTE CHANNEL X-SECTIONS

MAP DATA SOURCES:
LIO ONTARIO ROAD SEGMENT
LIO ONTARIO HYDRO NETWORK WATERCOURSE
NVCA DIGITAL TERRAIN MODEL

Project: MIDHURST MDP

Drawing: HYDROLOGIC MODELING DETAILS

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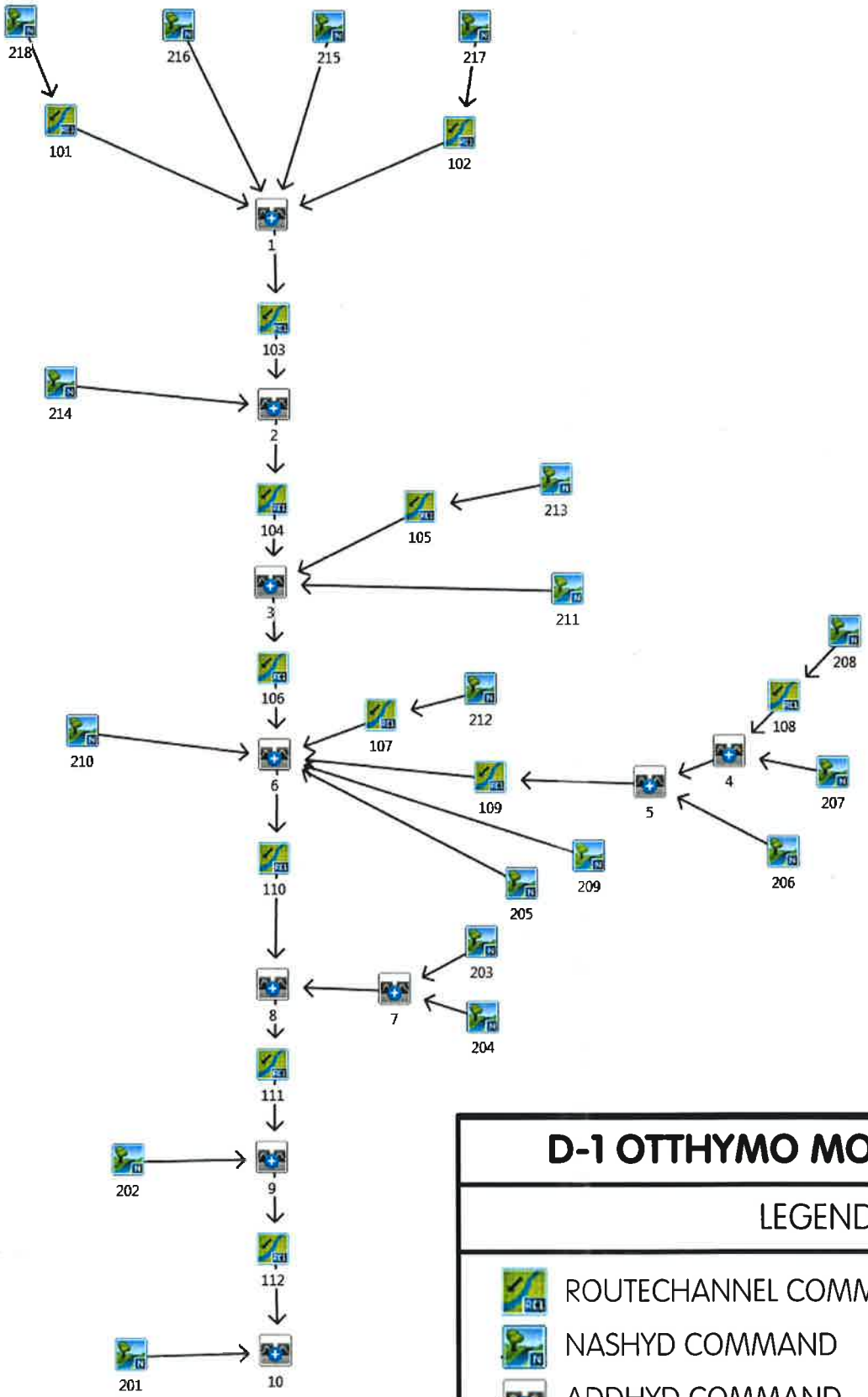
Drawn By	Design By	Project
L.W./C.W.	K.W.	845-3675
Scale	Date	Check By	Drawing
1: 30000	3/1/2016	K.W.	C-16

J:\800\845 - Midhurst Rose Alliance Inc\3675 - Midhurst Heights Development\CAD\CIVIL\MAP3D\3675-BASE.dwg, C-16, 4/14/2016 2:04:19 PM, cwilson

APPENDIX D

Modeling Results: Calibration & Validation



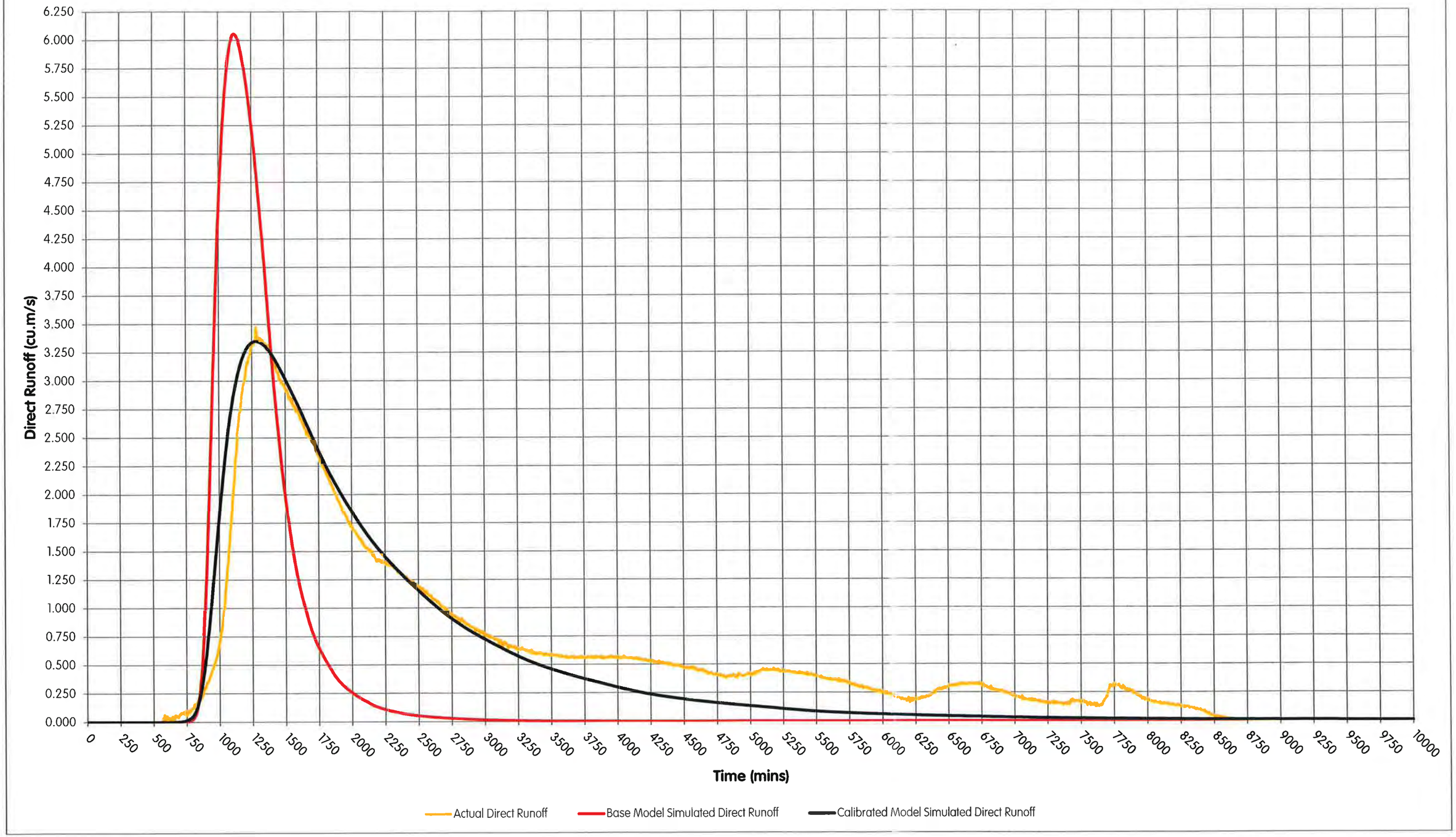
D-1 OTTHYMO MODEL LAYOUT

LEGEND

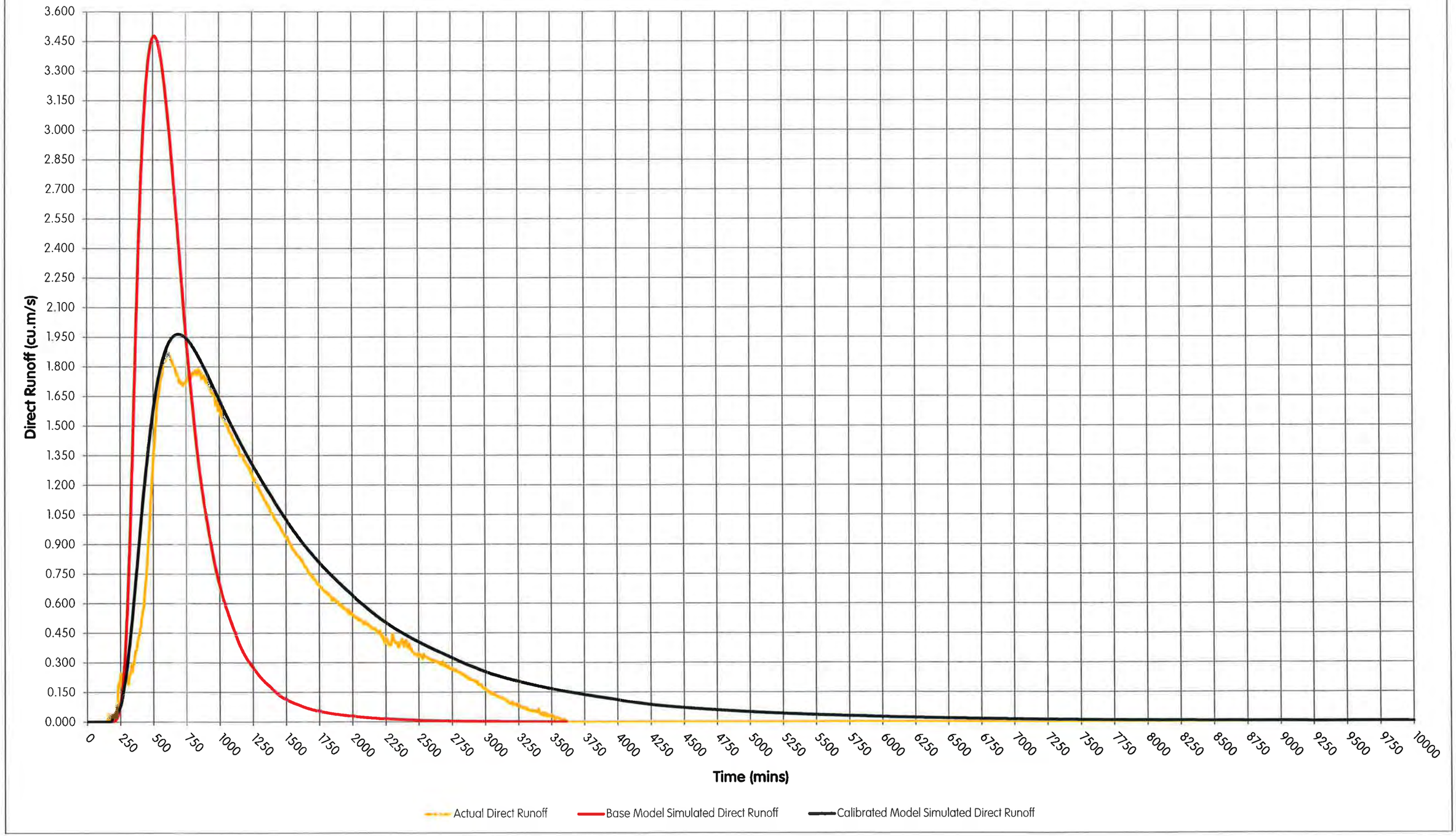
- ROUTECHANNEL COMMAND
- NASHYD COMMAND
- ADDHYD COMMAND
- LINK

DATE: 2016/04/06	MODEL BY: A.S.	PROJECT: 845-3675

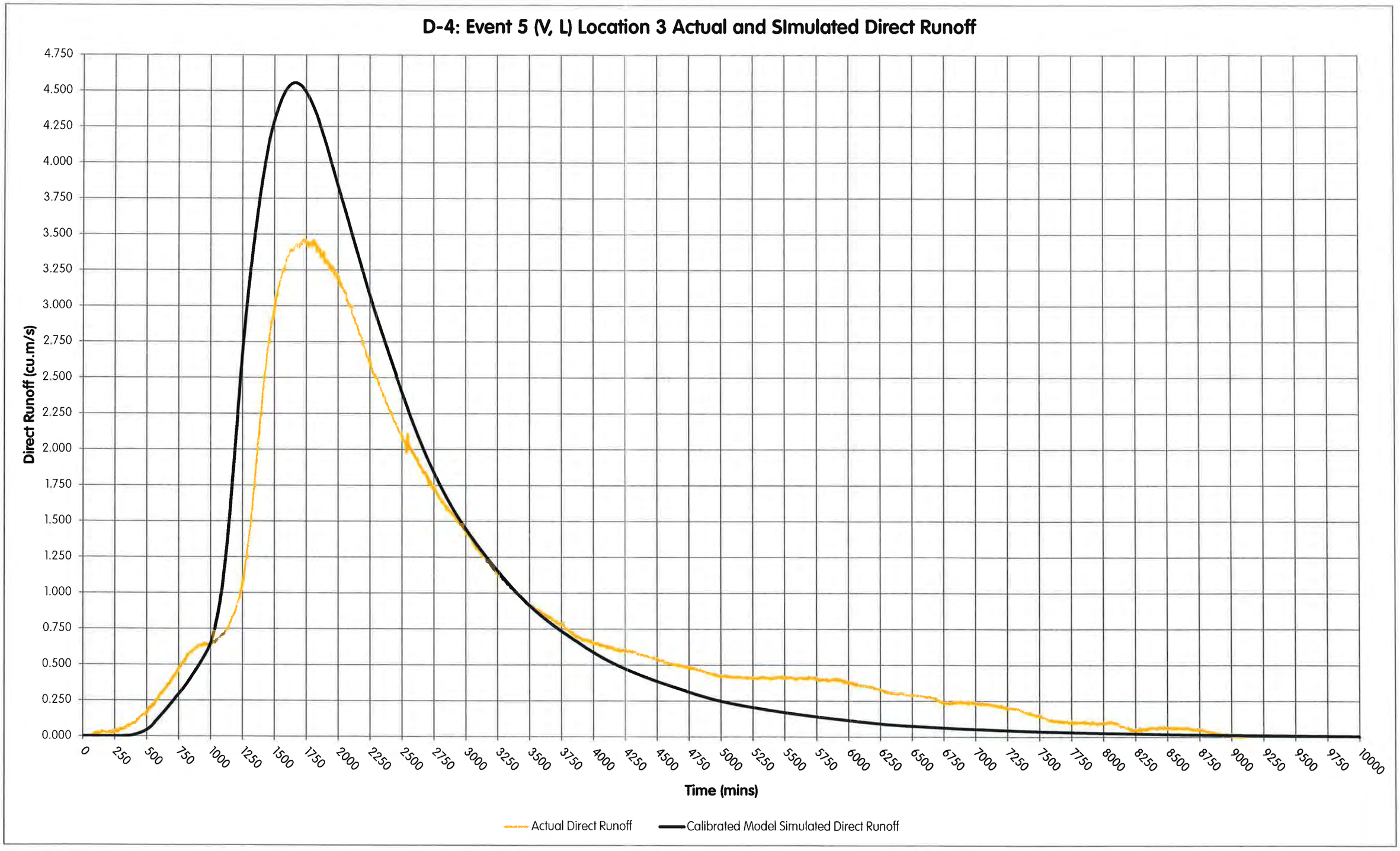
D-2: Event 3 (C, L) Location 3 Actual and Simulated Direct Runoff



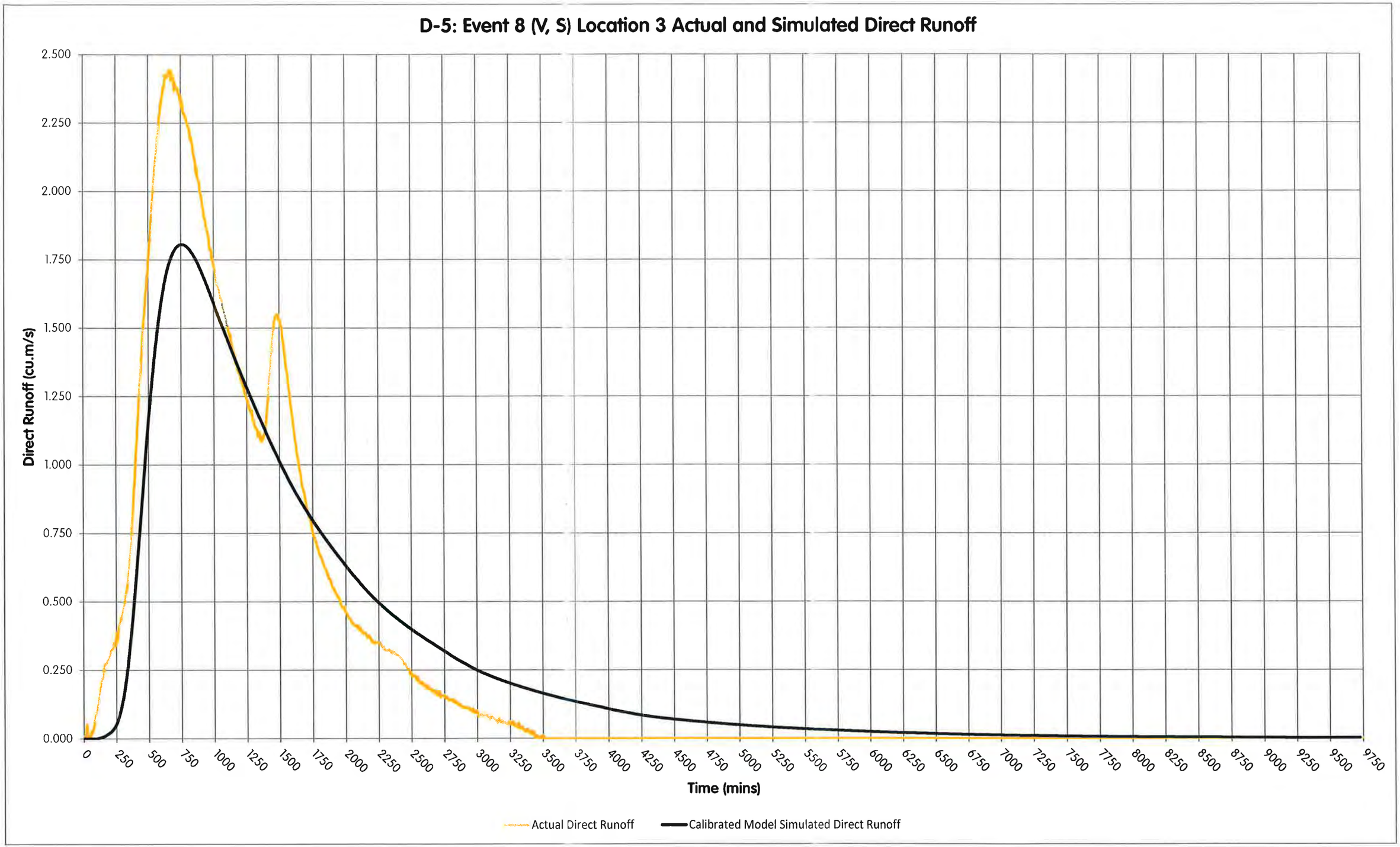
D-3: Event 4 (C, S) Location 3 Actual and Simulated Direct Runoff



D-4: Event 5 (V, L) Location 3 Actual and SImulated Direct Runoff



D-5: Event 8 (V, S) Location 3 Actual and Simulated Direct Runoff



D-6 : Event 3 (C, L) Base Model Summary Output

BaseModel

```
==============================================================================
======================


       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
       O   O    T      T    H   H   Y Y   MM MM  O   O
       O   O    T      T    H   H    Y    M   M  O   O
        OOO     T      T    H   H    Y    M   M   OOO
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                  *****  S U M M A R Y   O U T P U T  *****


  Input   filename: C:\Program Files (x86)\VH Suite 3.0\VO2\voin.dat

  Output  filename:
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  Summary filename:
C:\Users\aspencer\AppData\Local\CEG\VO3\61fe3ac0-5a97-4fee-8ce5-102abfc61ce9\b2c5ad7
7-6528-447b-b7d0-5302a2b7a5f5\scenar


DATE: 04/14/2016                          TIME: 11:40:14

USER:


COMMENTS: ____________________________________________________________


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

  W/E COMMAND             HYD ID   DT    AREA  ' Qpeak Tpeak   R.V. R.C.   Qbase
                                  min     ha   '  cms   hrs     mm          cms

      START @  0.00 hrs
      --------------------
    READ STORM                  15.0
    [ Ptot= 34.06 mm ]
    fname :
C:\Users\aspencer\AppData\Local\Temp\bd980d81-7470-4e43-b4f5-3a943e0c3262\9c673534-5
737-4539-9bfc-ed
    remark: Event 3 Storm Event

*
 ** CALIB NASHYD         0218  1  5.0 1089.96    0.76 17.33   1.63 0.05   0.000
    [CN=42.3          ]
    [ N = 3.0:Tp 3.20]
*
    CHANNEL[ 2:  0218]   0101  1  5.0 1089.96    0.68 18.58   1.63  n/a   0.000
*
```

```
*
 ** CALIB NASHYD          0206  1  5.0   87.76    0.11 14.58   1.08 0.03   0.000
    [CN=33.2          ]
    [ N = 3.0:Tp 0.50]
*
    ADD [  0206+  0004]  0005  3  5.0 1223.66    1.35 16.08   1.73  n/a   0.000
*
    CHANNEL[ 2:  0005]   0109  1  5.0 1223.66    1.28 16.75   1.73  n/a   0.000
*
 ** CALIB NASHYD          0205  1  5.0  248.07    0.42 15.50   2.06 0.06   0.000
    [CN=48.4          ]
    [ N = 3.0:Tp 1.30]
*
 ** CALIB NASHYD          0209  1  5.0  513.54    0.83 15.42   1.88 0.06   0.000
    [CN=46.6          ]
    [ N = 3.0:Tp 1.20]
*
 ** CALIB NASHYD          0210  1  5.0  422.91    0.68 16.25   2.66 0.08   0.000
    [CN=55.0          ]
    [ N = 3.0:Tp 2.10]
*
    ADD [  0106+  0107]  0006  3  5.0 5310.20    3.70 19.00   1.92  n/a   0.000
*
    ADD [  0006+  0109]  0006  1  5.0 6533.86    4.46 18.17   1.89  n/a   0.000
*
    ADD [  0006+  0205]  0006  3  5.0 6781.93    4.56 17.83   1.89  n/a   0.000
*
    ADD [  0006+  0209]  0006  1  5.0 7295.47    4.79 17.42   1.89  n/a   0.000
*
    ADD [  0006+  0210]  0006  3  5.0 7718.38    5.37 17.25   1.93  n/a   0.000
*
    CHANNEL[ 2:  0006]   0110  1  5.0 7718.38    5.30 17.67   1.93  n/a   0.000
*
 ** CALIB NASHYD          0203  1  5.0  236.33    0.49 15.42   2.58 0.08   0.000
    [CN=52.5          ]
    [ N = 3.0:Tp 1.30]
*
 ** CALIB NASHYD          0204  1  5.0  489.54    1.04 15.83   3.06 0.09   0.000
    [CN=56.9          ]
    [ N = 3.0:Tp 1.70]
*
    ADD [  0203+  0204]  0007  3  5.0  725.87    1.51 15.67   2.91  n/a   0.000
*
    ADD [  0110+  0007]  0008  3  5.0 8444.25    6.21 17.00   2.02  n/a   0.000
*
    CHANNEL[ 2:  0008]   0111  1  5.0 8444.25    6.06 17.50   2.02  n/a   0.000
*
 ** CALIB NASHYD          0202  1  5.0  434.25    0.60 15.92   1.98 0.06   0.000
    [CN=46.7          ]
    [ N = 3.0:Tp 1.70]
*
    ADD [  0111+  0202]  0009  3  5.0 8878.50    6.45 17.33   2.01  n/a   0.000
*
    CHANNEL[ 2:  0009]   0112  1  5.0 8878.50    5.77 18.83   2.01  n/a   0.000
*
 ** CALIB NASHYD          0201  1  5.0  358.19    0.34 17.42   2.27 0.07   0.000
    [CN=52.1          ]
    [ N = 3.0:Tp 3.30]
*
    ADD [  0112+  0201]  0010  3  5.0 9236.69    6.07 18.75   2.02  n/a   0.000
*
```

D-7: Event 4 (C,S) Base Model Summary Output


```
================================================================================
=======================

       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
       O   O    T      T    H   H   Y Y   MM MM  O   O
       O   O    T      T    H   H    Y    M   M  O   O
        OOO     T      T    H   H    Y    M   M   OOO
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                  *****  S U M M A R Y   O U T P U T  *****


  Input   filename: C:\Program Files (x86)\VH Suite 3.0\VO2\voin.dat

  Output  filename:
C:\Users\aspencer\AppData\Local\CEG\VO3\61fe3ac0-5a97-4fee-8ce5-102abfc61ce9\93f8e46
2-fc4e-4304-ad96-d6b8169eff58\scenar
  Summary filename:
C:\Users\aspencer\AppData\Local\CEG\VO3\61fe3ac0-5a97-4fee-8ce5-102abfc61ce9\93f8e46
2-fc4e-4304-ad96-d6b8169eff58\scenar


DATE: 04/14/2016                              TIME: 11:40:15

USER:


COMMENTS: ____________________________________________________________


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

  W/E COMMAND              HYD ID   DT    AREA  ' Qpeak Tpeak   R.V. R.C.   Qbase
                                   min     ha   '  cms   hrs     mm          cms

      START @  0.00 hrs
      ---------------------
    READ STORM                  15.0
    [ Ptot= 27.38 mm ]
    fname :
C:\Users\aspencer\AppData\Local\Temp\bd980d81-7470-4e43-b4f5-3a943e0c3262\1fe4287e-f
34b-46dc-b8d6-82
    remark: Event 4 Storm Event

*
 ** CALIB NASHYD          0218  1  5.0 1089.96    0.43  7.17   0.88 0.03   0.000
    [CN=42.3         ]
    [ N = 3.0:Tp 3.20]
*
    CHANNEL[ 2:  0218]   0101  1  5.0 1089.96    0.39  8.25   0.88  n/a   0.000
*
```

```
*
 ** CALIB NASHYD          0206  1  5.0   87.76    0.08  4.83   0.57 0.02   0.000
    [CN=33.2         ]
    [ N = 3.0:Tp 0.50]
*
    ADD [  0206+  0004] 0005  3  5.0 1223.66    0.79  6.00   0.94  n/a   0.000
*
    CHANNEL[ 2:  0005]  0109  1  5.0 1223.66    0.75  6.50   0.94  n/a   0.000
*
 ** CALIB NASHYD          0205  1  5.0  248.07    0.26  5.42   1.12 0.04   0.000
    [CN=48.4         ]
    [ N = 3.0:Tp 1.30]
*
 ** CALIB NASHYD          0209  1  5.0  513.54    0.51  5.33   1.01 0.04   0.000
    [CN=46.6         ]
    [ N = 3.0:Tp 1.20]
*
 ** CALIB NASHYD          0210  1  5.0  422.91    0.40  6.08   1.46 0.05   0.000
    [CN=55.0         ]
    [ N = 3.0:Tp 2.10]
*
    ADD [  0106+  0107] 0006  3  5.0 5310.20    2.17  8.67   1.06  n/a   0.000
*
    ADD [  0006+  0109] 0006  1  5.0 6533.86    2.62  8.00   1.03  n/a   0.000
*
    ADD [  0006+  0205] 0006  3  5.0 6781.93    2.67  7.83   1.04  n/a   0.000
*
    ADD [  0006+  0209] 0006  1  5.0 7295.47    2.78  7.33   1.04  n/a   0.000
*
    ADD [  0006+  0210] 0006  3  5.0 7718.38    3.12  7.00   1.06  n/a   0.000
*
    CHANNEL[ 2:  0006]  0110  1  5.0 7718.38    3.09  7.42   1.06  n/a   0.000
*
 ** CALIB NASHYD          0203  1  5.0  236.33    0.31  5.42   1.45 0.05   0.000
    [CN=52.5         ]
    [ N = 3.0:Tp 1.30]
*
 ** CALIB NASHYD          0204  1  5.0  489.54    0.65  5.75   1.74 0.06   0.000
    [CN=56.9         ]
    [ N = 3.0:Tp 1.70]
*
    ADD [  0203+  0204] 0007  3  5.0  725.87    0.96  5.58   1.64  n/a   0.000
*
    ADD [  0110+  0007] 0008  3  5.0 8444.25    3.69  6.67   1.11  n/a   0.000
*
    CHANNEL[ 2:  0008]  0111  1  5.0 8444.25    3.59  7.25   1.11  n/a   0.000
*
 ** CALIB NASHYD          0202  1  5.0  434.25    0.36  5.75   1.08 0.04   0.000
    [CN=46.7         ]
    [ N = 3.0:Tp 1.70]
*
    ADD [  0111+  0202] 0009  3  5.0 8878.50    3.83  7.00   1.11  n/a   0.000
*
    CHANNEL[ 2:  0009]  0112  1  5.0 8878.50    3.32  8.58   1.11  n/a   0.000
*
 ** CALIB NASHYD          0201  1  5.0  358.19    0.19  7.25   1.22 0.04   0.000
    [CN=52.1         ]
    [ N = 3.0:Tp 3.30]
*
    ADD [  0112+  0201] 0010  3  5.0 9236.69    3.49  8.50   1.11  n/a   0.000
*
 FINISH
```

D-8: Event 3 (C, L) Calibrated Model Summary Output


```
==========================================================================================
=======================

       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
       O   O    T      T    H   H   Y Y   MM MM  O   O
       O   O    T      T    H   H    Y    M   M  O   O
        OOO     T      T    H   H    Y    M   M   OOO
```

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***** S U M M A R Y O U T P U T *****

Input filename: C:\Program Files (x86)\VH Suite 3.0\VO2\voin.dat

Output filename:
C:\Users\aspencer\AppData\Local\CEG\VO3\61fe3ac0-5a97-4fee-8ce5-102abfc61ce9\b2c5ad77-6528-447b-b7d0-5302a2b7a5f5\scenar
Summary filename:
C:\Users\aspencer\AppData\Local\CEG\VO3\61fe3ac0-5a97-4fee-8ce5-102abfc61ce9\b2c5ad77-6528-447b-b7d0-5302a2b7a5f5\scenar

DATE: 04/14/2016 TIME: 11:45:00

USER:

COMMENTS: _____

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

W/E	COMMAND	HYD ID	DT min	AREA ha	Qpeak cms	Tpeak hrs	R.V. mm	R.C.	Qbase cms
	START @ 0.00 hrs								
	READ STORM		15.0						
	[Ptot= 34.06 mm]								
	fname : C:\Users\aspencer\AppData\Local\Temp\effca76f-40f4-4bc9-9b01-640fdfb9b0bd\9c673534-5737-4539-9bfc-ed								
	remark: Event 3 Storm Event								
*									
**	CALIB NASHYD	0218	1	5.0 1089.96	0.22	16.25	2.32	0.07	0.000
	[CN=48.6]								
	[N = 1.1:Tp 1.90]								
*									
	CHANNEL[2: 0218]	0101	1	5.0 1089.96	0.21	19.83	2.53	n/a	0.000
*									

```
*
 ** CALIB NASHYD          0206  1  5.0   87.76    0.06 15.25   1.66 0.05   0.000
    [CN=38.2          ]
    [ N = 1.1:Tp 0.30]
*
    ADD [  0206+  0004]  0005  3  5.0 1223.66    0.62 17.17   2.68  n/a   0.000
*
    CHANNEL[ 2:  0005]   0109  1  5.0 1223.66    0.61 17.83   2.68  n/a   0.000
*
 ** CALIB NASHYD          0205  1  5.0  248.07    0.15 15.75   3.27 0.10   0.000
    [CN=55.7          ]
    [ N = 1.1:Tp 0.80]
*
 ** CALIB NASHYD          0209  1  5.0  513.54    0.31 15.75   3.00 0.09   0.000
    [CN=53.6          ]
    [ N = 1.1:Tp 0.70]
*
 ** CALIB NASHYD          0210  1  5.0  422.91    0.21 16.25   4.25 0.12   0.000
    [CN=63.3          ]
    [ N = 1.1:Tp 1.30]
*
    ADD [  0106+  0107]  0006  3  5.0 5310.20    1.68 21.00   3.01  n/a   0.000
*
    ADD [  0006+  0109]  0006  1  5.0 6533.86    2.22 20.00   2.95  n/a   0.000
*
    ADD [  0006+  0205]  0006  3  5.0 6781.93    2.33 19.92   2.96  n/a   0.000
*
    ADD [  0006+  0209]  0006  1  5.0 7295.47    2.57 19.58   2.96  n/a   0.000
*
    ADD [  0006+  0210]  0006  3  5.0 7718.38    2.77 19.42   3.04  n/a   0.000
*
    CHANNEL[ 2:  0006]   0110  1  5.0 7718.38    2.76 19.67   3.04  n/a   0.000
*
 ** CALIB NASHYD          0203  1  5.0  236.33    0.17 15.75   4.05 0.12   0.000
    [CN=60.4          ]
    [ N = 1.1:Tp 0.80]
*
 ** CALIB NASHYD          0204  1  5.0  489.54    0.35 15.75   4.86 0.14   0.000
    [CN=65.4          ]
    [ N = 1.1:Tp 1.00]
*
    ADD [  0203+  0204]  0007  3  5.0  725.87    0.53 15.75   4.63  n/a   0.000
*
    ADD [  0110+  0007]  0008  3  5.0 8444.25    3.21 19.25   3.18  n/a   0.000
*
    CHANNEL[ 2:  0008]   0111  1  5.0 8444.25    3.20 19.83   3.18  n/a   0.000
*
 ** CALIB NASHYD          0202  1  5.0  434.25    0.20 15.75   3.07 0.09   0.000
    [CN=53.7          ]
    [ N = 1.1:Tp 1.00]
*
    ADD [  0111+  0202]  0009  3  5.0 8878.50    3.36 19.75   3.17  n/a   0.000
*
    CHANNEL[ 2:  0009]   0112  1  5.0 8878.50    3.26 21.42   3.17  n/a   0.000
*
 ** CALIB NASHYD          0201  1  5.0  358.19    0.10 16.33   3.37 0.10   0.000
    [CN=59.9          ]
    [ N = 1.1:Tp 2.00]
*
    ADD [  0112+  0201]  0010  3  5.0 9236.69    3.35 21.33   3.19  n/a   0.000
*
```

D-98 Event 4 (C,S) Calibrated Model Summary Output


```
================================================================================
======================


      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
       O   O    T      T    H   H   Y Y   MM MM  O   O
       O   O    T      T    H   H    Y    M   M  O   O
        OOO     T      T    H   H    Y    M   M   OOO
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                  *****  S U M M A R Y   O U T P U T  *****


  Input   filename: C:\Program Files (x86)\VH Suite 3.0\VO2\voin.dat

  Output  filename:
C:\Users\aspencer\AppData\Local\CEG\VO3\61fe3ac0-5a97-4fee-8ce5-102abfc61ce9\93f8e46
2-fc4e-4304-ad96-d6b8169eff58\scenar
  Summary filename:
C:\Users\aspencer\AppData\Local\CEG\VO3\61fe3ac0-5a97-4fee-8ce5-102abfc61ce9\93f8e46
2-fc4e-4304-ad96-d6b8169eff58\scenar


DATE: 04/14/2016                              TIME: 11:45:00

USER:


COMMENTS: ____________________________________________________________


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

  W/E COMMAND              HYD ID   DT    AREA  ' Qpeak Tpeak   R.V. R.C.   Qbase
                                   min     ha   '  cms   hrs     mm          cms

     START @  0.00 hrs
     ---------------------
    READ STORM                  15.0
    [ Ptot= 27.38 mm ]
    fname :
C:\Users\aspencer\AppData\Local\Temp\effca76f-40f4-4bc9-9b01-640fdfb9b0bd\1fe4287e-f
34b-46dc-b8d6-82
    remark: Event 4 Storm Event

*
 ** CALIB NASHYD         0218  1  5.0 1089.96    0.13  5.92   1.40 0.05   0.000
    [CN=48.6        ]
    [ N = 1.1:Tp 1.90]
*
    CHANNEL[ 2:  0218]   0101  1  5.0 1089.96    0.12 10.08   1.49  n/a   0.000
*
```

```
*
 ** CALIB NASHYD          0206  1  5.0   87.76    0.04  5.00   0.96 0.03   0.000
    [CN=38.2         ]
    [ N = 1.1:Tp 0.30]
*
    ADD [  0206+  0004]  0005  3  5.0 1223.66    0.37  7.00   1.58  n/a   0.000
*
    CHANNEL[ 2:  0005]   0109  1  5.0 1223.66    0.37  7.67   1.58  n/a   0.000
*
 ** CALIB NASHYD          0205  1  5.0  248.07    0.09  5.00   1.93 0.07   0.000
    [CN=55.7         ]
    [ N = 1.1:Tp 0.80]
*
 ** CALIB NASHYD          0209  1  5.0  513.54    0.19  5.00   1.76 0.06   0.000
    [CN=53.6         ]
    [ N = 1.1:Tp 0.70]
*
 ** CALIB NASHYD          0210  1  5.0  422.91    0.13  5.75   2.57 0.09   0.000
    [CN=63.3         ]
    [ N = 1.1:Tp 1.30]
*
    ADD [  0106+  0107]  0006  3  5.0 5310.20    0.99 10.58   1.79  n/a   0.000
*
    ADD [  0006+  0109]  0006  1  5.0 6533.86    1.32 10.00   1.75  n/a   0.000
*
    ADD [  0006+  0205]  0006  3  5.0 6781.93    1.39  9.58   1.75  n/a   0.000
*
    ADD [  0006+  0209]  0006  1  5.0 7295.47    1.53  9.33   1.75  n/a   0.000
*
    ADD [  0006+  0210]  0006  3  5.0 7718.38    1.65  9.33   1.80  n/a   0.000
*
    CHANNEL[ 2:  0006]   0110  1  5.0 7718.38    1.64  9.67   1.80  n/a   0.000
*
 ** CALIB NASHYD          0203  1  5.0  236.33    0.11  5.00   2.44 0.09   0.000
    [CN=60.4         ]
    [ N = 1.1:Tp 0.80]
*
 ** CALIB NASHYD          0204  1  5.0  489.54    0.22  5.08   2.97 0.11   0.000
    [CN=65.4         ]
    [ N = 1.1:Tp 1.00]
*
    ADD [  0203+  0204]  0007  3  5.0  725.87    0.33  5.08   2.81  n/a   0.000
*
    ADD [  0110+  0007]  0008  3  5.0 8444.25    1.91  9.33   1.89  n/a   0.000
*
    CHANNEL[ 2:  0008]   0111  1  5.0 8444.25    1.90  9.83   1.89  n/a   0.000
*
 ** CALIB NASHYD          0202  1  5.0  434.25    0.12  5.08   1.82 0.07   0.000
    [CN=53.7         ]
    [ N = 1.1:Tp 1.00]
*
    ADD [  0111+  0202]  0009  3  5.0 8878.50    2.00  9.75   1.88  n/a   0.000
*
    CHANNEL[ 2:  0009]   0112  1  5.0 8878.50    1.91 11.58   1.88  n/a   0.000
*
 ** CALIB NASHYD          0201  1  5.0  358.19    0.06  6.00   2.04 0.07   0.000
    [CN=59.9         ]
    [ N = 1.1:Tp 2.00]
*
    ADD [  0112+  0201]  0010  3  5.0 9236.69    1.97 11.50   1.90  n/a   0.000
*
 FINISH
```

D-10% Event 5 (V, L) Calibrated Model Summary Output


```
=============================================================================================
======================

      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
      O   O    T      T    H   H   Y Y   MM MM  O   O
      O   O    T      T    H   H    Y    M   M  O   O
       OOO     T      T    H   H    Y    M   M   OOO
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                  *****  S U M M A R Y   O U T P U T  *****

  Input   filename: C:\Program Files (x86)\VH Suite 3.0\VO2\voin.dat

  Output  filename:
C:\Users\aspencer\AppData\Local\CEG\VO3\61fe3ac0-5a97-4fee-8ce5-102abfc61ce9\c548a42
4-3a35-45de-a62d-3f76823f331f\scenar
  Summary filename:
C:\Users\aspencer\AppData\Local\CEG\VO3\61fe3ac0-5a97-4fee-8ce5-102abfc61ce9\c548a42
4-3a35-45de-a62d-3f76823f331f\scenar

DATE: 04/14/2016                              TIME: 11:51:23

USER:

COMMENTS: ____________________________________________________________

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

  W/E COMMAND              HYD ID   DT     AREA   Qpeak Tpeak   R.V. R.C.    Qbase
                                   min     ha     cms   hrs     mm           cms

      START @  0.00 hrs
      --------------------
    READ STORM                  15.0
    [ Ptot= 41.75 mm ]
    fname :
C:\Users\aspencer\AppData\Local\Temp\0cd4e4a3-d7af-4796-97c4-f9a203698774\97dfd14f-9
22e-484c-b388-f4
    remark: Event 5 Storm Event

*
 ** CALIB NASHYD          0218   1   5.0 1089.96    0.31 23.50   3.64 0.09    0.000
    [CN=48.6          ]
    [ N = 1.1:Tp 1.90]
*
    CHANNEL[ 2:  0218]    0101   1   5.0 1089.96    0.31 26.17   4.04  n/a    0.000
*
```

```
*
 ** CALIB NASHYD          0206  1  5.0   87.76    0.06 19.50   2.69 0.06   0.000
    [CN=38.2          ]
    [ N = 1.1:Tp 0.30]
*
    ADD [  0206+  0004]  0005  3  5.0 1223.66    0.74 24.00   4.26  n/a   0.000
*
    CHANNEL[ 2:  0005]   0109  1  5.0 1223.66    0.74 24.33   4.26  n/a   0.000
*
 ** CALIB NASHYD          0205  1  5.0  248.07    0.17 23.50   5.17 0.12   0.000
    [CN=55.7          ]
    [ N = 1.1:Tp 0.80]
*
 ** CALIB NASHYD          0209  1  5.0  513.54    0.36 23.50   4.77 0.11   0.000
    [CN=53.6          ]
    [ N = 1.1:Tp 0.70]
*
 ** CALIB NASHYD          0210  1  5.0  422.91    0.28 23.50   6.59 0.16   0.000
    [CN=63.3          ]
    [ N = 1.1:Tp 1.30]
*
    ADD [  0106+  0107]  0006  3  5.0 5310.20    2.31 27.67   4.76  n/a   0.000
*
    ADD [  0006+  0109]  0006  1  5.0 6533.86    2.99 26.75   4.66  n/a   0.000
*
    ADD [  0006+  0205]  0006  3  5.0 6781.93    3.14 26.50   4.68  n/a   0.000
*
    ADD [  0006+  0209]  0006  1  5.0 7295.47    3.45 26.17   4.69  n/a   0.000
*
    ADD [  0006+  0210]  0006  3  5.0 7718.38    3.71 26.00   4.81  n/a   0.000
*
    CHANNEL[ 2:  0006]   0110  1  5.0 7718.38    3.71 26.42   4.81  n/a   0.000
*
 ** CALIB NASHYD          0203  1  5.0  236.33    0.20 23.50   6.31 0.15   0.000
    [CN=60.4          ]
    [ N = 1.1:Tp 0.80]
*
 ** CALIB NASHYD          0204  1  5.0  489.54    0.43 23.50   7.48 0.18   0.000
    [CN=65.4          ]
    [ N = 1.1:Tp 1.00]
*
    ADD [  0203+  0204]  0007  3  5.0  725.87    0.63 23.50   7.17  n/a   0.000
*
    ADD [  0110+  0007]  0008  3  5.0 8444.25    4.28 26.08   5.01  n/a   0.000
*
    CHANNEL[ 2:  0008]   0111  1  5.0 8444.25    4.26 26.25   5.01  n/a   0.000
*
 ** CALIB NASHYD          0202  1  5.0  434.25    0.25 23.50   4.84 0.12   0.000
    [CN=53.7          ]
    [ N = 1.1:Tp 1.00]
*
    ADD [  0111+  0202]  0009  3  5.0 8878.50    4.49 26.25   5.00  n/a   0.000
*
    CHANNEL[ 2:  0009]   0112  1  5.0 8878.50    4.42 27.83   5.00  n/a   0.000
*
 ** CALIB NASHYD          0201  1  5.0  358.19    0.14 26.00   5.23 0.13   0.000
    [CN=59.9          ]
    [ N = 1.1:Tp 2.00]
*
    ADD [  0112+  0201]  0010  3  5.0 9236.69    4.56 27.75   5.04  n/a   0.000
*
```

D-11: Event 8 (V,S) Calibrated Model Summary Output

CalibratedModel

```
================================================================================
======================


       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
       O   O    T      T    H   H   Y Y   MM MM  O   O
       O   O    T      T    H   H    Y    M   M  O   O
        OOO     T      T    H   H    Y    M   M   OOO
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                  *****  S U M M A R Y   O U T P U T  *****


  Input   filename: C:\Program Files (x86)\VH Suite 3.0\VO2\voin.dat

  Output  filename:
C:\Users\aspencer\AppData\Local\CEG\VO3\61fe3ac0-5a97-4fee-8ce5-102abfc61ce9\89ab698
9-6743-425d-9528-de4185505a6c\scenar
  Summary filename:
C:\Users\aspencer\AppData\Local\CEG\VO3\61fe3ac0-5a97-4fee-8ce5-102abfc61ce9\89ab698
9-6743-425d-9528-de4185505a6c\scenar


DATE: 04/14/2016                          TIME: 11:51:24

USER:


COMMENTS: ____________________________________________________________


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

  W/E COMMAND              HYD ID   DT    AREA  ' Qpeak Tpeak   R.V. R.C.   Qbase
                                   min     ha   '  cms   hrs     mm          cms

      START @  0.00 hrs
      --------------------
    READ STORM                  15.0
    [ Ptot= 26.65 mm ]
    fname :
C:\Users\aspencer\AppData\Local\Temp\0cd4e4a3-d7af-4796-97c4-f9a203698774\06c6044e-d
14b-4345-bb5a-32
    remark: Event 8 Storm Event

*
 ** CALIB NASHYD         0218  1  5.0 1089.96    0.12  8.25   1.30 0.05   0.000
    [CN=48.6        ]
    [ N = 1.1:Tp 1.90]
*
    CHANNEL[ 2:  0218]   0101  1  5.0 1089.96    0.11 11.25   1.39  n/a   0.000
*
```

```
*
 ** CALIB NASHYD          0206  1  5.0   87.76    0.03  6.00   0.89 0.03   0.000
    [CN=38.2          ]
    [ N = 1.1:Tp 0.30]
*
    ADD [  0206+  0004]  0005  3  5.0 1223.66    0.34  8.33   1.48  n/a   0.000
*
    CHANNEL[ 2:  0005]   0109  1  5.0 1223.66    0.33  9.00   1.48  n/a   0.000
*
 ** CALIB NASHYD          0205  1  5.0  248.07    0.08  7.00   1.80 0.07   0.000
    [CN=55.7          ]
    [ N = 1.1:Tp 0.80]
*
 ** CALIB NASHYD          0209  1  5.0  513.54    0.17  7.00   1.64 0.06   0.000
    [CN=53.6          ]
    [ N = 1.1:Tp 0.70]
*
 ** CALIB NASHYD          0210  1  5.0  422.91    0.12  7.00   2.40 0.09   0.000
    [CN=63.3          ]
    [ N = 1.1:Tp 1.30]
*
    ADD [  0106+  0107]  0006  3  5.0 5310.20    0.91 11.83   1.67  n/a   0.000
*
    ADD [  0006+  0109]  0006  1  5.0 6533.86    1.21 11.17   1.63  n/a   0.000
*
    ADD [  0006+  0205]  0006  3  5.0 6781.93    1.27 10.75   1.64  n/a   0.000
*
    ADD [  0006+  0209]  0006  1  5.0 7295.47    1.40 10.50   1.64  n/a   0.000
*
    ADD [  0006+  0210]  0006  3  5.0 7718.38    1.51 10.50   1.68  n/a   0.000
*
    CHANNEL[ 2:  0006]   0110  1  5.0 7718.38    1.50 10.75   1.68  n/a   0.000
*
 ** CALIB NASHYD          0203  1  5.0  236.33    0.10  7.00   2.29 0.09   0.000
    [CN=60.4          ]
    [ N = 1.1:Tp 0.80]
*
 ** CALIB NASHYD          0204  1  5.0  489.54    0.20  7.00   2.78 0.10   0.000
    [CN=65.4          ]
    [ N = 1.1:Tp 1.00]
*
    ADD [  0203+  0204]  0007  3  5.0  725.87    0.29  7.00   2.63  n/a   0.000
*
    ADD [  0110+  0007]  0008  3  5.0 8444.25    1.75 10.50   1.76  n/a   0.000
*
    CHANNEL[ 2:  0008]   0111  1  5.0 8444.25    1.74 10.92   1.76  n/a   0.000
*
 ** CALIB NASHYD          0202  1  5.0  434.25    0.11  7.00   1.70 0.06   0.000
    [CN=53.7          ]
    [ N = 1.1:Tp 1.00]
*
    ADD [  0111+  0202]  0009  3  5.0 8878.50    1.83 10.83   1.76  n/a   0.000
*
    CHANNEL[ 2:  0009]   0112  1  5.0 8878.50    1.76 12.58   1.76  n/a   0.000
*
 ** CALIB NASHYD          0201  1  5.0  358.19    0.06  8.25   1.90 0.07   0.000
    [CN=59.9          ]
    [ N = 1.1:Tp 2.00]
*
    ADD [  0112+  0201]  0010  3  5.0 9236.69    1.81 12.58   1.77  n/a   0.000
*
 FINISH
```

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Project MDP Midhurst
Project No. 845-3675
Date January 14, 2016
By A. Spencer/C. Wilson
Revised April 14, 2016
Revised By A.Spencer

Table D-12: Base and Calibrated Model Hydrologic Parameters: CALIB NASHYD Command

Pre Development Drainage Area: Catchments

Catchment Area No.	Hydrologic Parameters				
	Parameters			Base Values	Calibrated Values
1	Total Area	A	ha	358.2	358.2
	Composite Runoff Coefficient	C	-	0.1	0.1
	Curve No.	CN	-	52.1	59.9
	Composite Initial Abstraction	IA	mm	9.9	6.9
	Time to Peak	TP	hr	3.3	2.0
	N Value	N	-	3.0	1.07
2	Total Area	A	ha	434.3	434.3
	Composite Runoff Coefficient	C	-	0.2	0.2
	Curve No.	CN	-	46.7	53.7
	Composite Initial Abstraction	IA	mm	9.1	6.4
	Time to Peak	TP	hr	1.7	1.0
	N Value	N	-	3.0	1.07
3	Total Area	A	ha	236.3	236.3
	Composite Runoff Coefficient	C	-	0.2	0.2
	Curve No.	CN	-	52.5	60.4
	Composite Initial Abstraction	IA	mm	8.4	5.9
	Time to Peak	TP	hr	1.3	0.8
	N Value	N	-	3.0	1.07
4	Total Area	A	ha	489.5	489.5
	Composite Runoff Coefficient	C	-	0.2	0.2
	Curve No.	CN	-	56.9	65.4
	Composite Initial Abstraction	IA	mm	8.2	5.8
	Time to Peak	TP	hr	1.7	1.0
	N Value	N	-	3.0	1.07
5	Total Area	A	ha	248.1	248.1
	Composite Runoff Coefficient	C	-	0.1	0.1
	Curve No.	CN	-	48.4	55.7
	Composite Initial Abstraction	IA	mm	9.4	6.6
	Time to Peak	TP	hr	1.3	0.8
	N Value	N	-	3.0	1.07
6	Total Area	A	ha	87.8	87.8
	Composite Runoff Coefficient	C	-	0.1	0.1
	Curve No.	CN	-	33.2	38.2
	Composite Initial Abstraction	IA	mm	10.0	7.0
	Time to Peak	TP	hr	0.5	0.3
	N Value	N	-	3.0	1.07

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Consulting Engineers

Project MDP Midhurst
Project No. 845-3675
Date January 14, 2016
By A. Spencer/C. Wilson
Revised April 14, 2016
Revised By A.Spencer

Table D-12: Base and Calibrated Model Hydrologic Parameters: CALIB NASHYD Command

Pre Development Drainage Area: Catchments

Catchment Area No.	Hydrologic Parameters				
	Parameters			Base Values	Calibrated Values
7	Total Area	A	ha	137.9	137.9
	Composite Runoff Coefficient	C	-	0.1	0.1
	Curve No.	CN	-	35.5	40.8
	Composite Initial Abstraction	IA	mm	10.2	7.1
	Time to Peak	TP	hr	1.0	0.6
	N Value	N	-	3.0	1.07
8	Total Area	A	ha	998.0	998.0
	Composite Runoff Coefficient	C	-	0.2	0.2
	Curve No.	CN	-	44.9	51.6
	Composite Initial Abstraction	IA	mm	9.0	6.3
	Time to Peak	TP	hr	1.2	0.7
	N Value	N	-	3.0	1.07
9	Total Area	A	ha	513.5	513.5
	Composite Runoff Coefficient	C	-	0.1	0.1
	Curve No.	CN	-	46.6	53.6
	Composite Initial Abstraction	IA	mm	9.7	6.8
	Time to Peak	TP	hr	1.2	0.7
	N Value	N	-	3.0	1.07
10	Total Area	A	ha	422.9	422.9
	Composite Runoff Coefficient	C	-	0.2	0.2
	Curve No.	CN	-	55.0	63.3
	Composite Initial Abstraction	IA	mm	9.2	6.4
	Time to Peak	TP	hr	2.1	1.3
	N Value	N	-	3.0	1.07
11	Total Area	A	ha	371.2	371.2
	Composite Runoff Coefficient	C	-	0.1	0.1
	Curve No.	CN	-	47.4	54.5
	Composite Initial Abstraction	IA	mm	9.5	6.7
	Time to Peak	TP	hr	1.3	0.8
	N Value	N	-	3.0	1.07
12	Total Area	A	ha	611.7	611.7
	Composite Runoff Coefficient	C	-	0.2	0.2
	Curve No.	CN	-	37.3	42.9
	Composite Initial Abstraction	IA	mm	9.1	6.4
	Time to Peak	TP	hr	1.6	0.9
	N Value	N	-	3.0	1.07

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Project MDP Midhurst
Project No. 845-3675
Date January 14, 2016
By A. Spencer/C. Wilson
Revised April 14, 2016
Revised By A.Spencer

Table D-12: Base and Calibrated Model Hydrologic Parameters: CALIB NASHYD Command

Pre Development Drainage Area: Catchments

Catchment Area No.	Hydrologic Parameters				
	Parameters			Base Values	Calibrated Values
13	Total Area	A	ha	792.0	792.0
	Composite Runoff Coefficient	C	-	0.2	0.2
	Curve No.	CN	-	40.7	46.8
	Composite Initial Abstraction	IA	mm	8.7	6.1
	Time to Peak	TP	hr	1.9	1.2
	N Value	N	-	3.0	1.07
14	Total Area	A	ha	395.5	395.5
	Composite Runoff Coefficient	C	-	0.1	0.1
	Curve No.	CN	-	51.6	59.3
	Composite Initial Abstraction	IA	mm	8.9	6.2
	Time to Peak	TP	hr	2.4	1.4
	N Value	N	-	3.0	1.07
15	Total Area	A	ha	679.3	679.3
	Composite Runoff Coefficient	C	-	0.1	0.1
	Curve No.	CN	-	50.8	58.4
	Composite Initial Abstraction	IA	mm	8.8	6.1
	Time to Peak	TP	hr	1.8	1.1
	N Value	N	-	3.0	1.07
16	Total Area	A	ha	646.1	646.1
	Composite Runoff Coefficient	C	-	0.2	0.2
	Curve No.	CN	-	52.7	60.6
	Composite Initial Abstraction	IA	mm	8.8	6.1
	Time to Peak	TP	hr	2.2	1.3
	N Value	N	-	3.0	1.07
17	Total Area	A	ha	724.5	724.5
	Composite Runoff Coefficient	C	-	0.2	0.2
	Curve No.	CN	-	45.6	52.4
	Composite Initial Abstraction	IA	mm	8.9	6.2
	Time to Peak	TP	hr	1.9	1.1
	N Value	N	-	3.0	1.07
18	Total Area	A	ha	1090.0	1090.0
	Composite Runoff Coefficient	C	-	0.1	0.1
	Curve No.	CN	-	42.3	48.6
	Composite Initial Abstraction	IA	mm	9.5	6.6
	Time to Peak	TP	hr	3.2	1.9
	N Value	N	-	3.0	1.07

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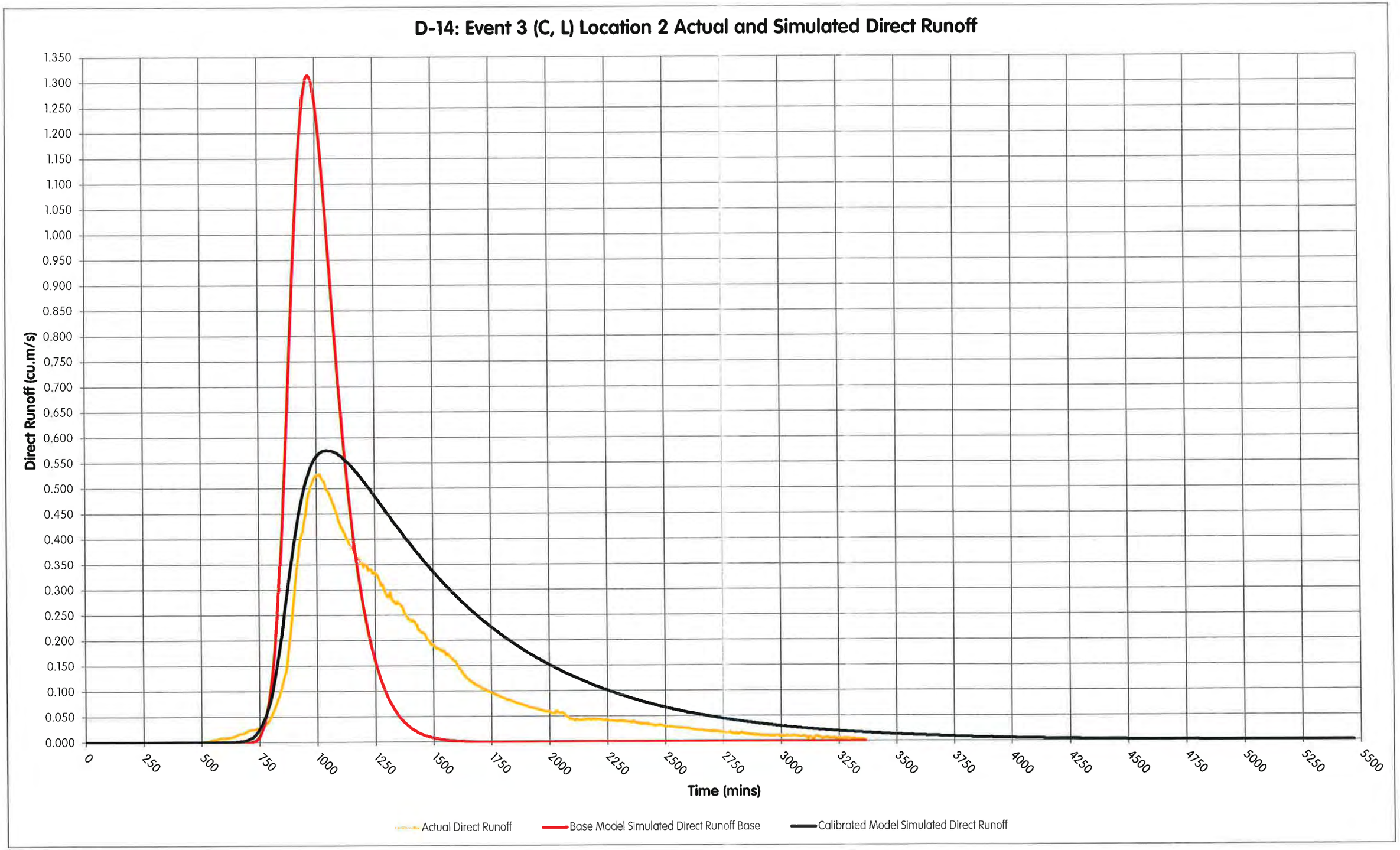
Project Midhurst MDP
Project No. 845-3675
Date February 24, 2016
Name A. Spencer
Date Revised March 23, 2016

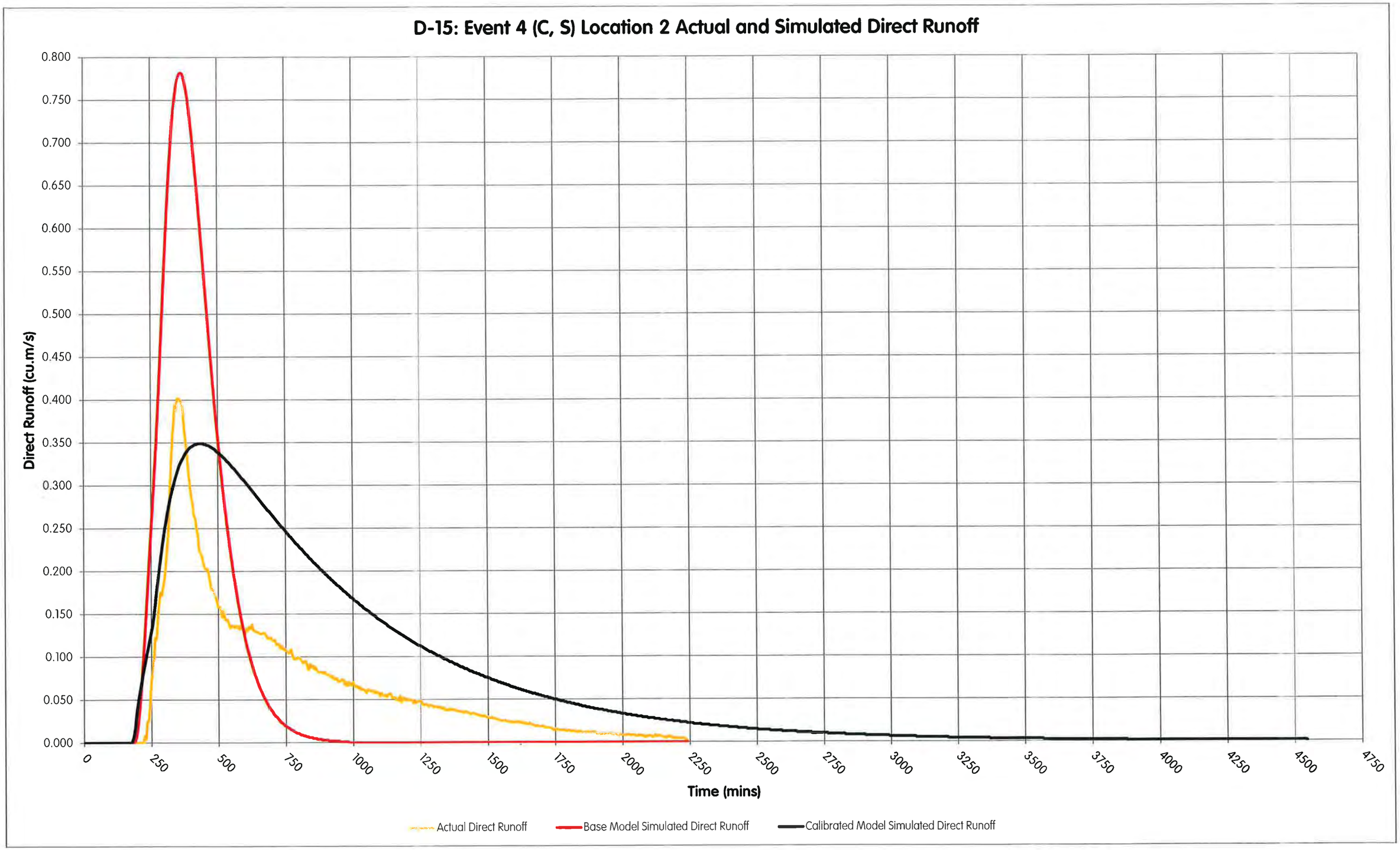
Table D-13: Statistical Comparison of Actual and Simulated Data (Location 3)
Calibration and Validation

Parameters		Base Model			Calibrated Model					
		Event 3 (Calibration, Large)	Event 4 (Calibration, Small)	Average	Event 3 (Calibration, Large)	Event 4 (Calibration, Small)	Average	Event 5 (Validation, Large)	Event 8 (Validation, Small)	Average
Curve No.	CN	-	-		15%	15%		15%	15%	
Composite Initial Abstraction	IA	-	-		-30%	-30%		-30%	-30%	
Time to Peak	TP	-	-		-40%	-40%		-40%	-40%	
N Value	N	3	3		1.07	1.07		1.07	1.07	
	Nash-Sutcliffe Efficiency	-0.40	-0.65	-0.52	0.91	0.96	0.94	0.80	0.91	0.86
	Mean Square Error	0.85	1.08	0.96	0.05	0.01	0.03	0.16	0.03	0.10
	Difference in Time to Peak (mins)	160.00	110.00	135.00	10.00	70.00	40.00	75.00	80.00	77.50
	Qpeak Modelled/Qpeak Actual	1.74	1.86	1.80	0.96	1.05	1.01	1.32	0.74	1.03
	Runoff Volume Modelled (m^3)	3112.04	1709.40	2410.72	4907.45	2914.31	3910.88	7743.34	2724.71	5234.03
	Runoff Volume Actual (m^3)	5772.90	2368.76	4070.83	5772.88	2368.76	4070.82	7225.80	2732.58	4979.19
	Runoff Volume Modelled/Runoff Volume Actual	0.54	0.72	0.63	0.85	1.23	1.04	1.07	1.00	1.03

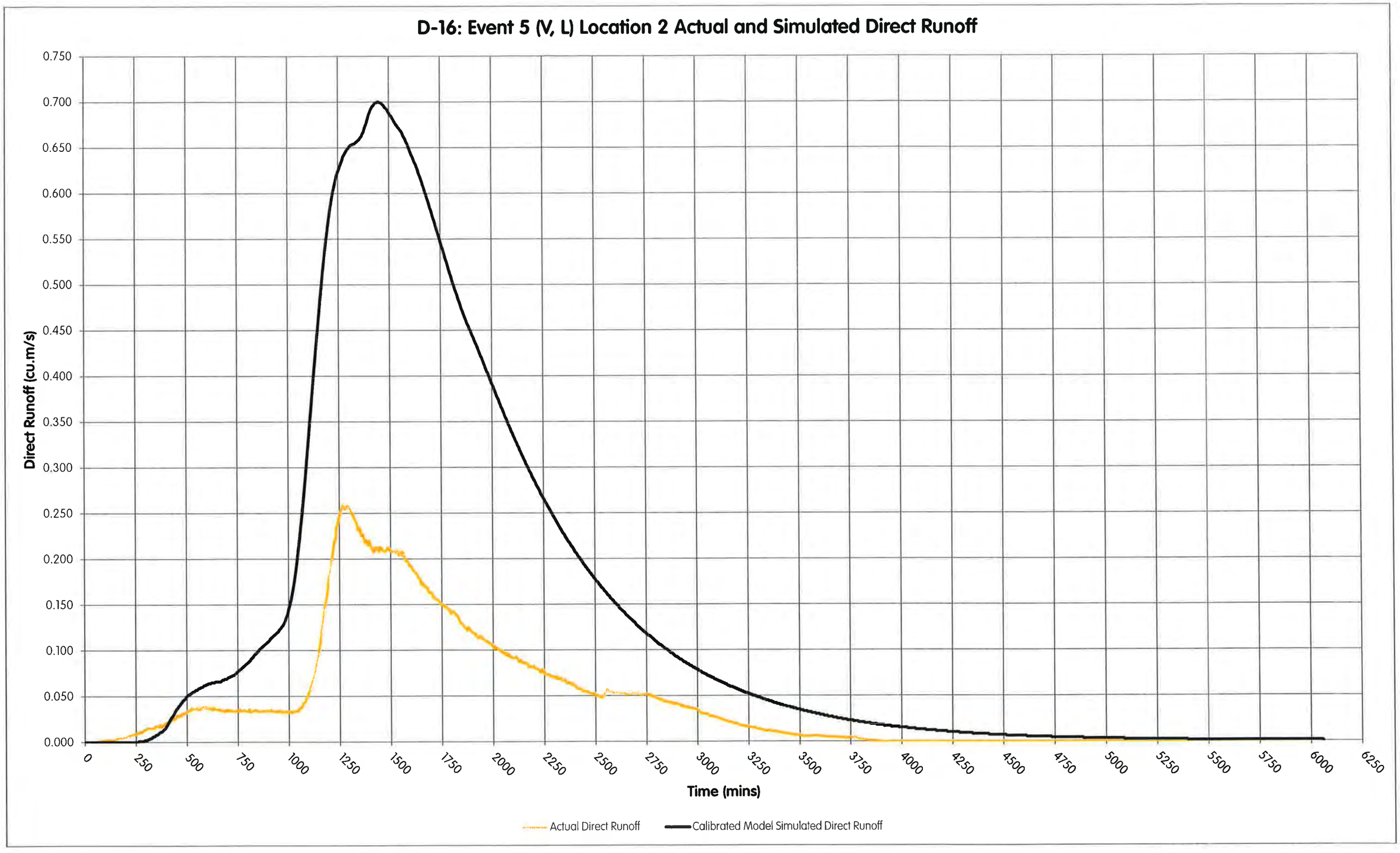
D-14: Event 3 (C, L) Location 2 Actual and Simulated Direct Runoff



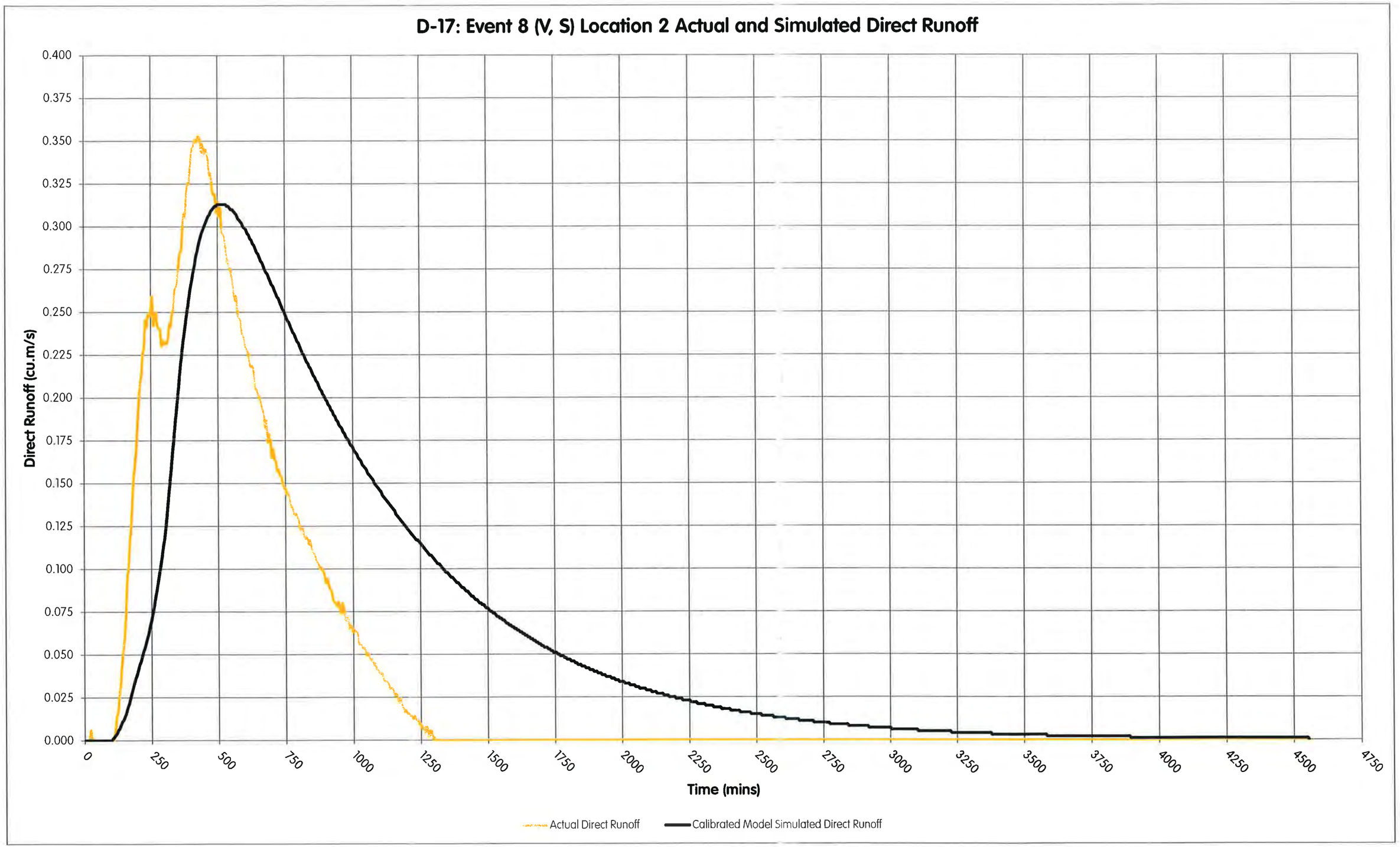
D-15: Event 4 (C, S) Location 2 Actual and Simulated Direct Runoff



D-16: Event 5 (V, L) Location 2 Actual and Simulated Direct Runoff



D-17: Event 8 (V, S) Location 2 Actual and Simulated Direct Runoff



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Project Midhurst MDP
Project No. 845-3675
Date January 14, 2016
Name A. Spencer
Date Revised April 7, 2016

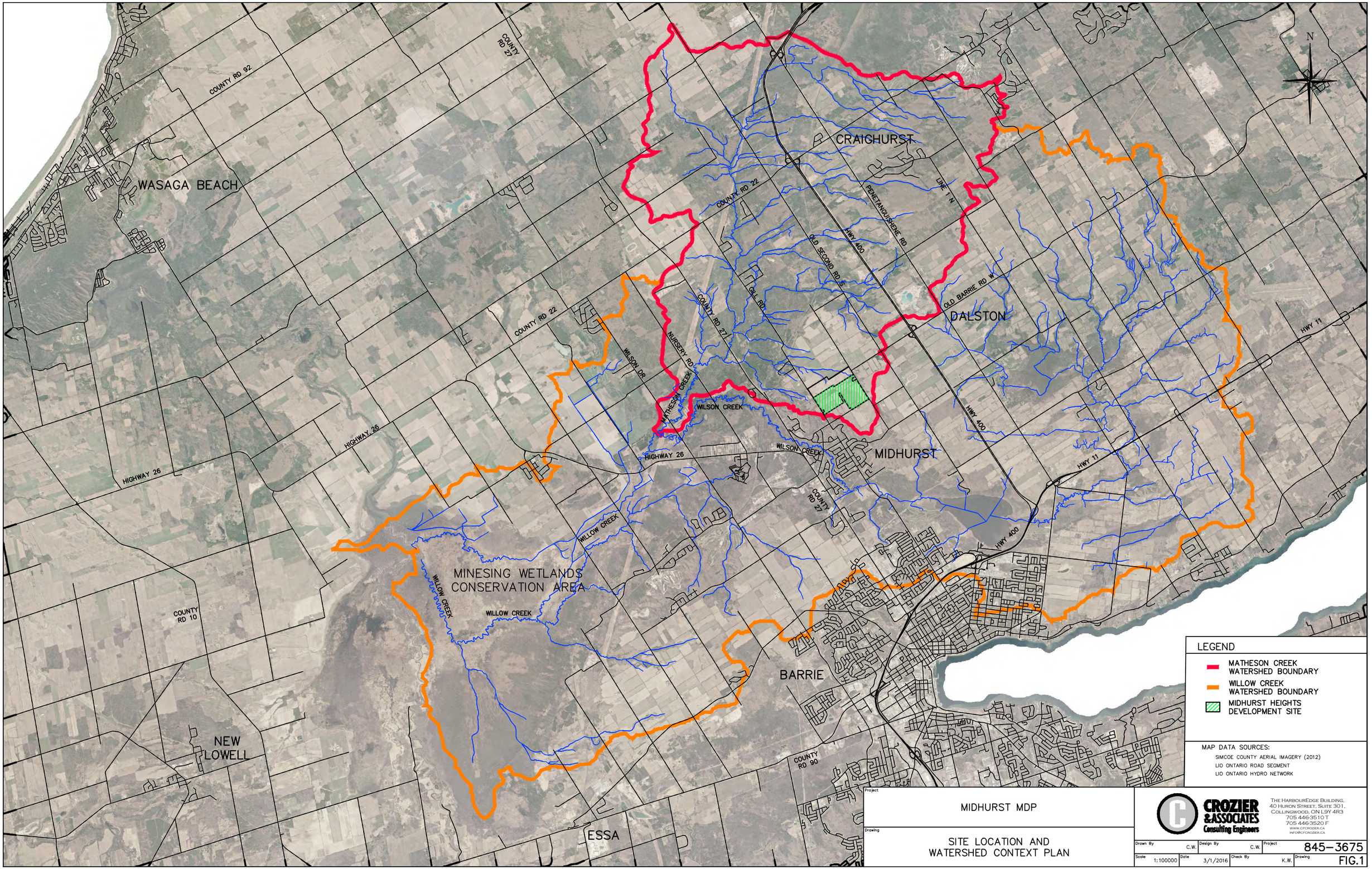
Table D-18: Statistical Comparison of Actual and Simulated (Location 2)
Calibration and Validation

Parameters		Base Model			Calibrated Model				
		Event 3 (Calibration, Large)	Event 4 (Calibration, Small)	Average	Event 3 (Calibration, Large)	Event 4 (Calibration, Small)	*Event 5 (Validation, Large)	Event 8 (Validation, Small)	Average
Curve No.	CN	-	-		15%	15%	15%	15%	
Composite Initial Abstraction	IA	-	-	Average	-30%	-30%	-30%	-30%	Average
Time to Peak	TP	-	-		-40%	-40%	-40%	-40%	
N Value	N	3	3		1.07	1.07	1.07	1.07	
	Nash-Sutcliffe Efficiency	-0.99	-1.39	-1.19	0.70	0.17	-6.42	0.56	-1.25
	Mean Square Error	0.04	0.04	0.04	0.00	0.01	0.06	0.01	0.02
	Difference in Time to Peak (mins)	45.00	15.00	30.00	30.00	75.00	175.00	70.00	87.50
	Qpeak Simulated/Qpeak Actual	2.49	1.95	2.22	1.09	0.87	2.70	0.89	1.39
	Runoff Volume Simulated (m^3)	337	184	260.68	522	308	830	288	487.06
	Runoff Volume Actual (m^3)	318	150	233.65	318	150	255	181	225.98
	Runoff Volume Simulated/Runoff Volume Actual	1.06	1.23	1.15	1.64	2.06	3.25	1.59	2.14

*** Note:** Results of Event 5 appear to be incongruent with findings of all other events. It is assumed that some localized source of error was present during Event 5 at Location 2.

Figures

J:\800\845 - Midhurst Rose Alliance Inc\3675 - Midhurst Heights Development\CAD\CIVIL\MAP3D\3675-BASE.dwg, FIG.1, 4/14/2016 9:38:20 AM, cwilson



Project: MIDHURST MDP

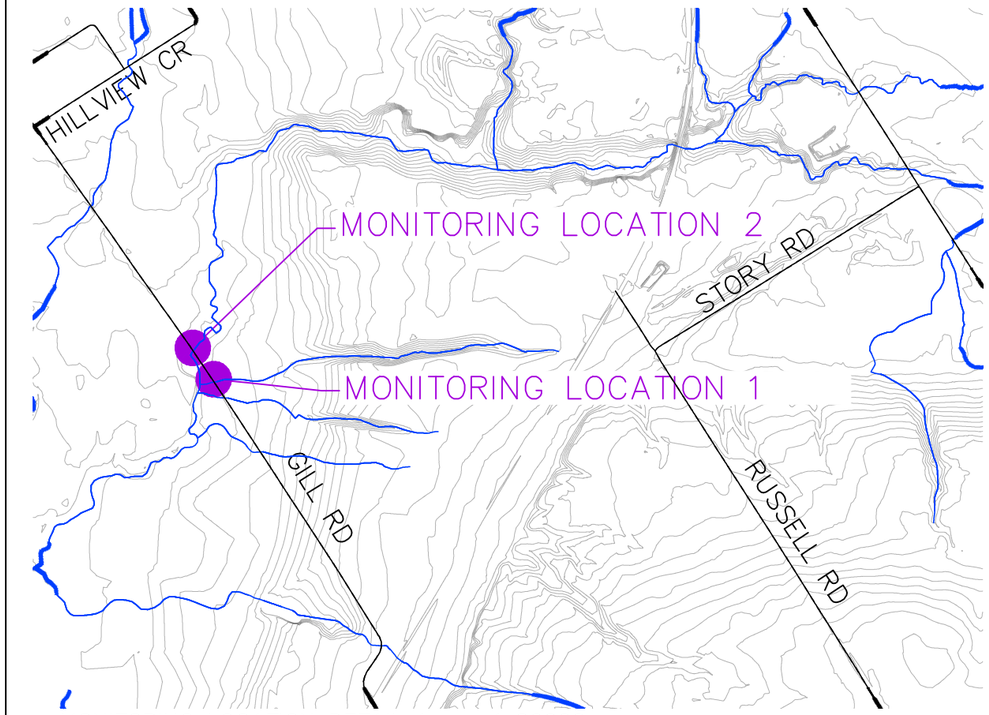
Drawing: SITE LOCATION AND WATERSHED CONTEXT PLAN

CROZIER & ASSOCIATES Consulting Engineers
The HarbourEdge Building, 40 Huron Street, Suite 301, Collingwood, ON L9Y 4R3
705 446 3510 T
705 446 3520 F
www.cfcrozier.ca
info@cfcrozier.ca

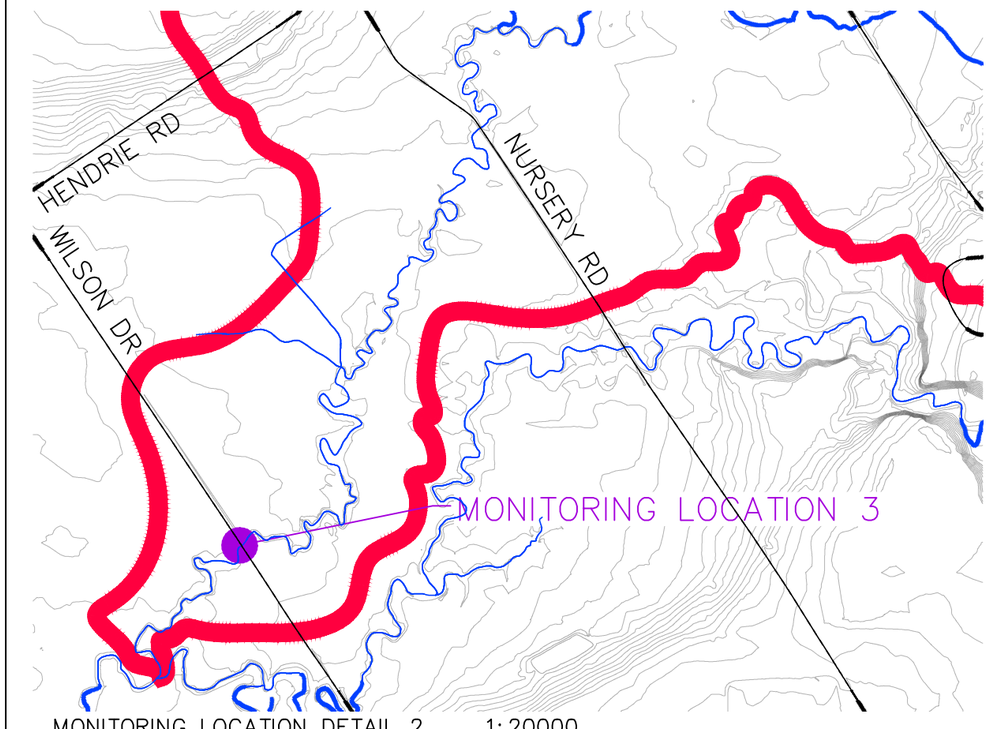
Drawn By	Design By	Project
C.W.	C.W.	845–3675

Scale	Date	Check By	Drawing
1:100000	3/1/2016	K.W.	FIG.1

J:\800\845 - Midhurst Rose Alliance Inc\3675 - Midhurst Heights Development\CAD\CIVIL\1MAP3D\3675-BASE.dwg, FIG.2, 4/14/2016 9:41:29 AM, cwilson



MONITORING LOCATION DETAIL 1 1:20000



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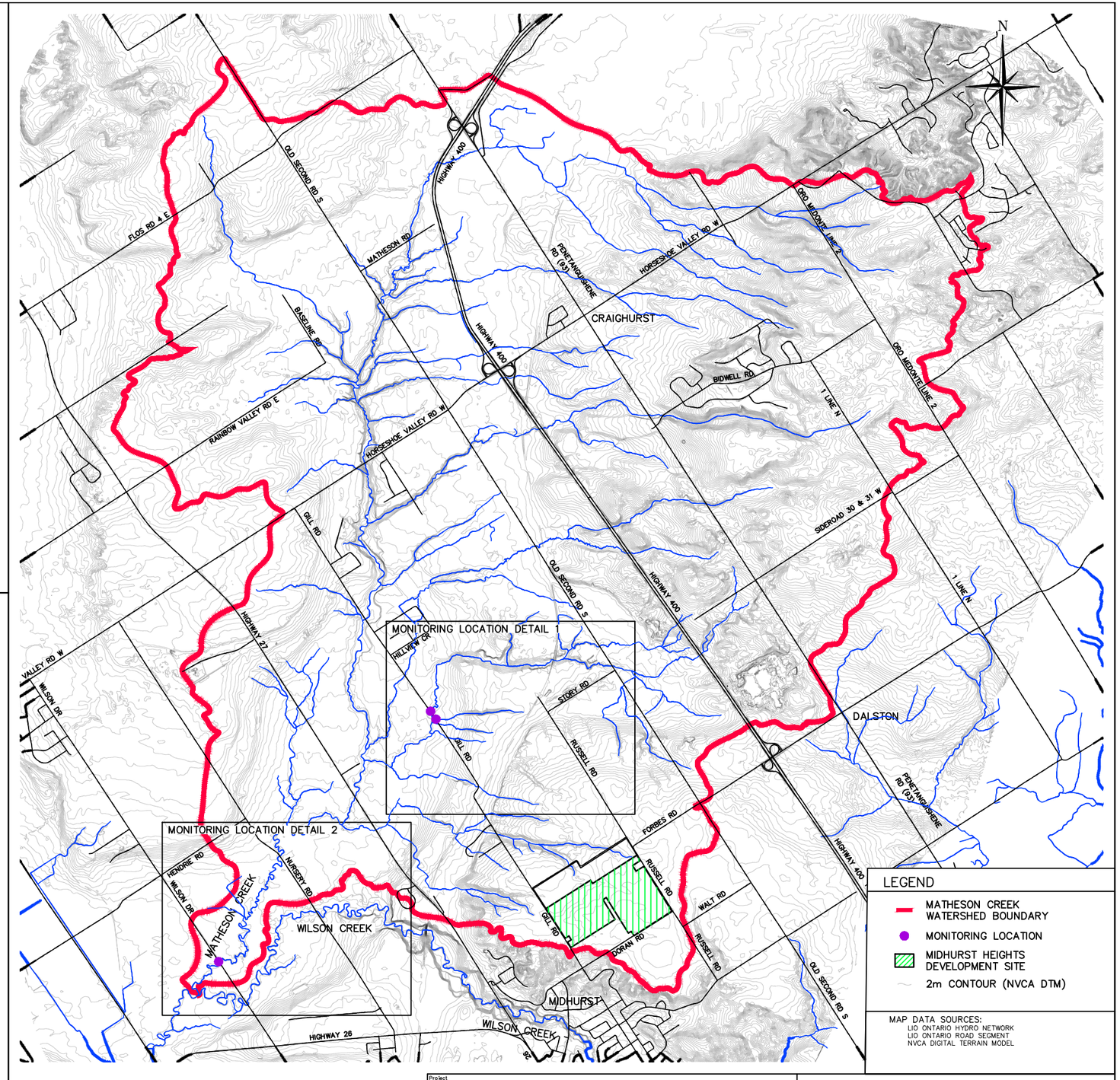

Project: MIDHURST MDP

Drawing: MATHESON CREEK WATERSHED AND MONITORING LOCATIONS PLAN

CROZIER & ASSOCIATES Consulting Engineers
The HarbourEdge Building, 40 Huron Street, Suite 301, Collingwood, ON L9Y 4R3
705 446 3510 T
705 446 3520 F
www.CFCROZIER.CA
INFO@CFCROZIER.CA

Drawn By	Design By	Project
L.W./C.W.	K.W.	845–3675
Scale	Date	Check By	Drawing
1:60000	3/1/2016	K.W.	FIG.2

J:\800\845 - Midhurst Rose Alliance Inc\3675 - Midhurst Heights Development\CAD\CIVIL\1MAP3D\3675-BASE.dwg, FIG.3, 4/14/2016 9:43:32 AM, cwilson

ORO-MEDONTE RAIN GAUGE
(8700m FROM CENTROID)

CITY OF BARRIE RAIN GAUGE 3
(13050m FROM CENTROID)

MINESING RAIN GAUGE
(7460m FROM CENTROID)

CENTROID

ELMVALE
HILLSDALE
CRAIGHURST
DALSTON
MIDHURST
BARRIE
ORILLIA
WASAGA BEACH
STAYNER

COUNTY RD 19
COUNTY RD 27
COUNTY RD 22
COUNTY RD 42
COUNTY RD 10
COUNTY RD 90
HIGHWAY 26
HWY 400
HWY 11

N

LEGEND

- MATHESON CREEK WATERSHED BOUNDARY
- WATERSHED CENTROID
- RAIN GAUGE LOCATION
- TRAPEZOID FOR CALCULATION OF WATERSHED CENTROID
- MIDHURST HEIGHTS DEVELOPMENT SITE

MAP DATA SOURCES:
LIO ONTARIO ROAD SEGMENT
SIMCOE COUNTY AERIAL IMAGERY (2012)

Project: MIDHURST MDP

Drawing: WATERSHED CENTROID AND RAIN GAUGE LOCATIONS

CROZIER & ASSOCIATES Consulting Engineers
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Drawn By	Design By	Project
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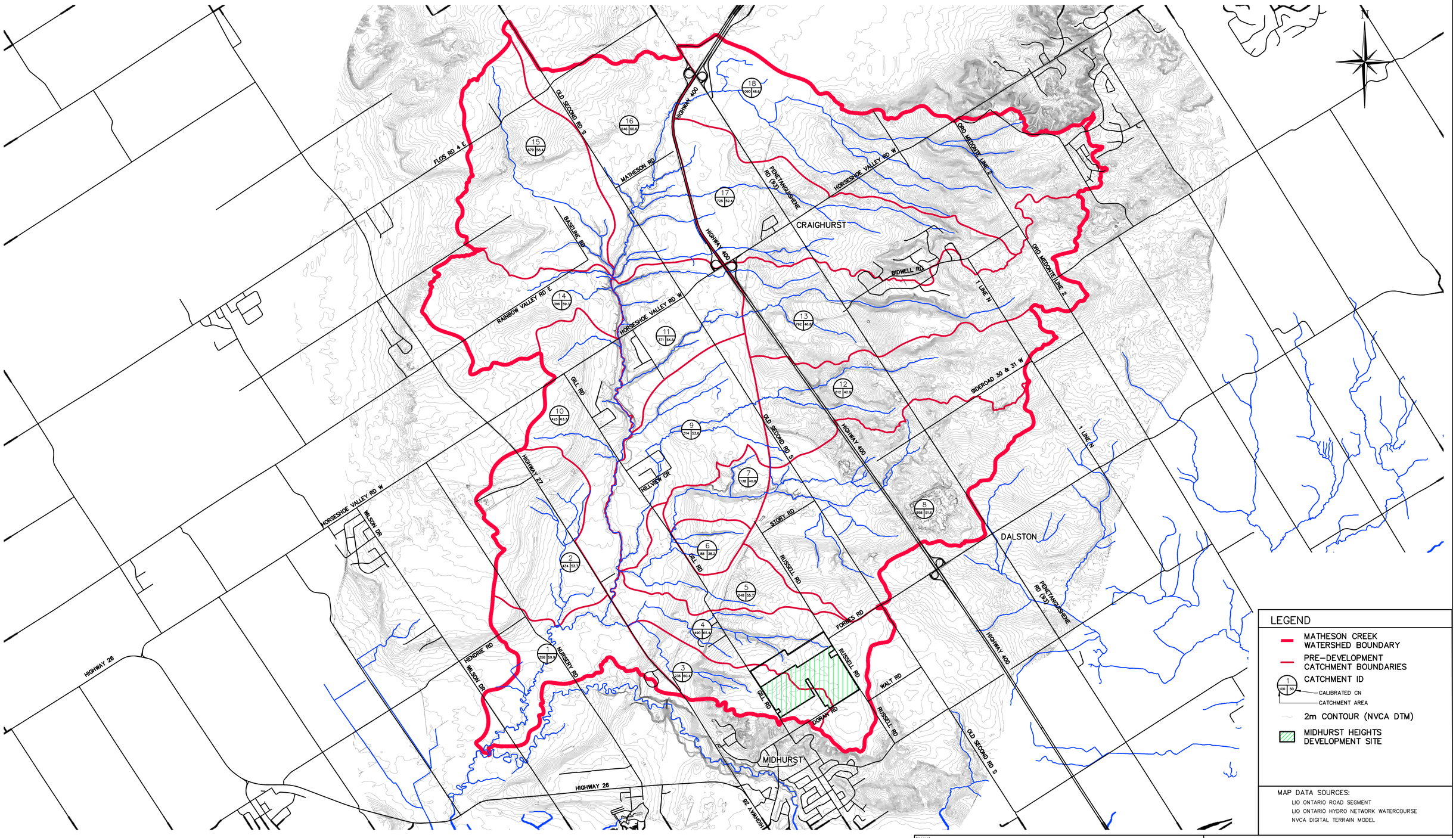
Scale	Date	Check By	Drawing
1:150000	3/1/2016	K.W.	FIG.3



Project

MIDHURST MDP

Drawing

PRE-DEVELOPMENT
WATERSHED CHARACTERISTICS PLAN

CROZIER & ASSOCIATES
Consulting Engineers
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Collingwood, ON L9Y 4R3
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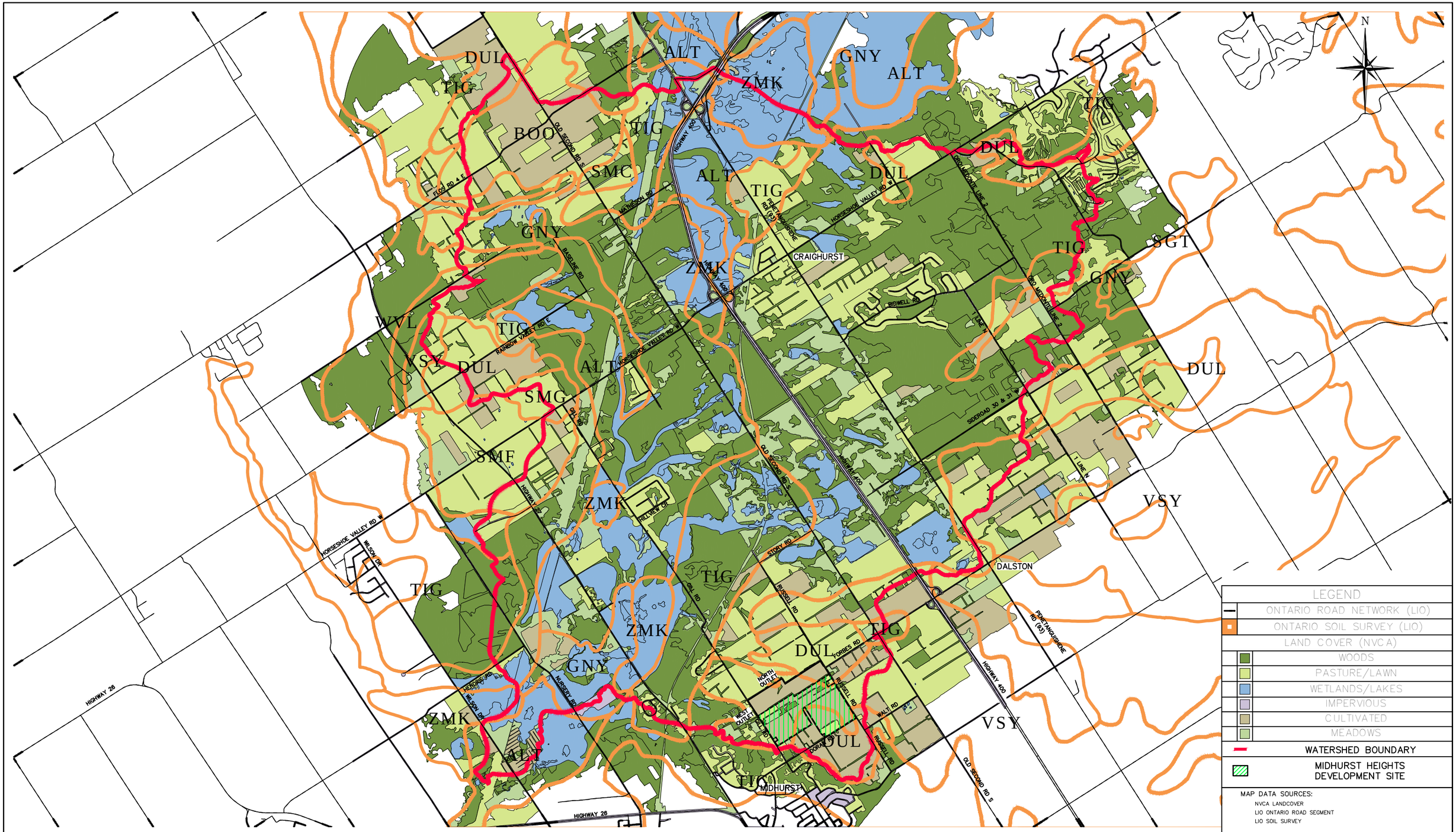
Scale	Date	Check By	Drawing
1: 30000	3/1/2016	K.W.	FIG.4

J:\800\845 - Midhurst Rose Alliance Inc\3675 - Midhurst Heights Development\CAD\CIVIL\MAP\3675-BASE.dwg, FIG.4, 4/14/2016 2:02:36 PM, cwilson

J:\800\845 - Midhurst Rose Alliance Inc\3675 - Midhurst Heights Development\CAD\CIVIL\1MAP3D\3675-BASE.dwg, FIG.5, 4/14/2016 9:44:51 AM, cwilson



LEGEND

- ONTARIO ROAD NETWORK (LIO)
- ONTARIO SOIL SURVEY (LIO)
- LAND COVER (NVCA)
  - WOODS
  - PASTURE/LAWN
  - WETLANDS/LAKES
  - IMPERVIOUS
  - CULTIVATED
  - MEADOWS
- WATERSHED BOUNDARY
- MIDHURST HEIGHTS DEVELOPMENT SITE

MAP DATA SOURCES:
NVCA LANDCOVER
LIO ONTARIO ROAD SEGMENT
LIO SOIL SURVEY

Project: MIDHURST MDP

Drawing: SOIL AND LAND USE

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Scale	Date	Check By	Drawing
1:60000	3/1/2016	K.W.	FIG.5

Appendix I

Water Quality

SCS consulting group ltd

File #: 1168/1194
Date: June 16, 2014

Mr. Glenn Switzer, P. Eng.
Director of Engineering and Technical Services
Nottawasaga Conservation Authority
8195 8th Line
Utopia, Ontario, L0M 1T0

Dear Mr. Switzer:

Re: **Midhurst Master Drainage Plan – Phase 1**
Item #9 – Erosion Hazard Assessment
Midhurst, Ontario

Further to our submissions of May 2, 2014 and May 27, 2014, please accept the following supplemental information in support of confirming appropriate setbacks from steep slopes adjacent to a watercourse (Item #9) of the Phase 1 work program for the Master Drainage Plan for your review and approval.

As per NVCA's correspondence of May 29, 2014, the target statement for provision of erosion hazard assessment on steep slopes is:

> *Hazards were also discussed and further work was requested to demonstrate that all development lands were set back from the erosion hazards on steep slopes even if no water course was present. Before addressing, provide a drawing of the slopes that will be evaluated for agency approval..*

Erosion Hazard assessment locations were provided to NVCA on June 2, 2014. Confirmation of the assessment locations was provided by NVCA on June 16, 2014.

An Erosion Hazard assessment was completed in accordance with the MNR guidelines for each of the cross sections (**Figure 6.1**). The associated cross sections are appended to this letter.

A Geormorphic Development Setback Analysis was completed for Black Creek by Aqualogic. The report was included in the 2008 FSR and has been appended to this letter. The resulting 100 year erosion rate for the creek (11.2 m for main branch, 5 m for 1st order tributaries) was utilized in the Erosion Hazard assessment.

The resultant Erosion Hazard line was added to the appended Limit of Development Figure (**Figure 6.1**) for the Carson community. In all cases, the Erosion Hazard limit does not set the overall limit of development and therefore has no impact on the draft plans.

The Hazard assessment for the Doran community identified all slopes as being stable. Therefore, the limit of development boundary on the Doran community draft plan is not impacted by this assessment. A figure

illustrating the slopes adjacent to the limit of the Phase 1 lands (adjacent to SWM Pond Block) has been included for your reference.

Please call the undersigned if you have any questions or require any additional information.

Sincerely,

SCS Consulting Group Ltd.

Steve Schaefer, P. Eng.
Principal
sschaefer@scsconsultinggroup.com

Attachments: Geomorphic Development Setback Analysis, Aqualogic, 2008
Figure 6.1 – Limit of Development – Carson Community
Erosion Hazard Cross Sections

c. Mr. Wayne Wilson, NVCA
Mr. Chris Hibbard, NVCA
Mr. Brad Sokach, Township of Springwater
Mr. Brent Spagnol, Township of Springwater
Mr. Joe Mullan, Ainley
Mr. Greg Marek, Simcoe County
Ms. Shauna Dudding, Geranium Corporation
Mr. Bill De Geus, Aqualogic
Mr. Matthew Cory, Malone Given Parsons

P:\1168 Midhurst - Doran Road\Correspondence\Letters\NVCA-sms-Item 9 - Phase 1 Master Drainage Information-11June14.docx

ATTACHMENT A

GEOMORPHIC DEVELOPMENT SETBACK ANALYSIS, AQUALOGIC, 2008

Geomorphic Development Setback Analysis
Willow Creek Tributary
Carson Rd. Geranium Properties
Township of Springwater

Submitted to:

SCS Consulting Group Ltd.
30 Centurian Drive, Suite 100
Markham, ON, L3R 8B8

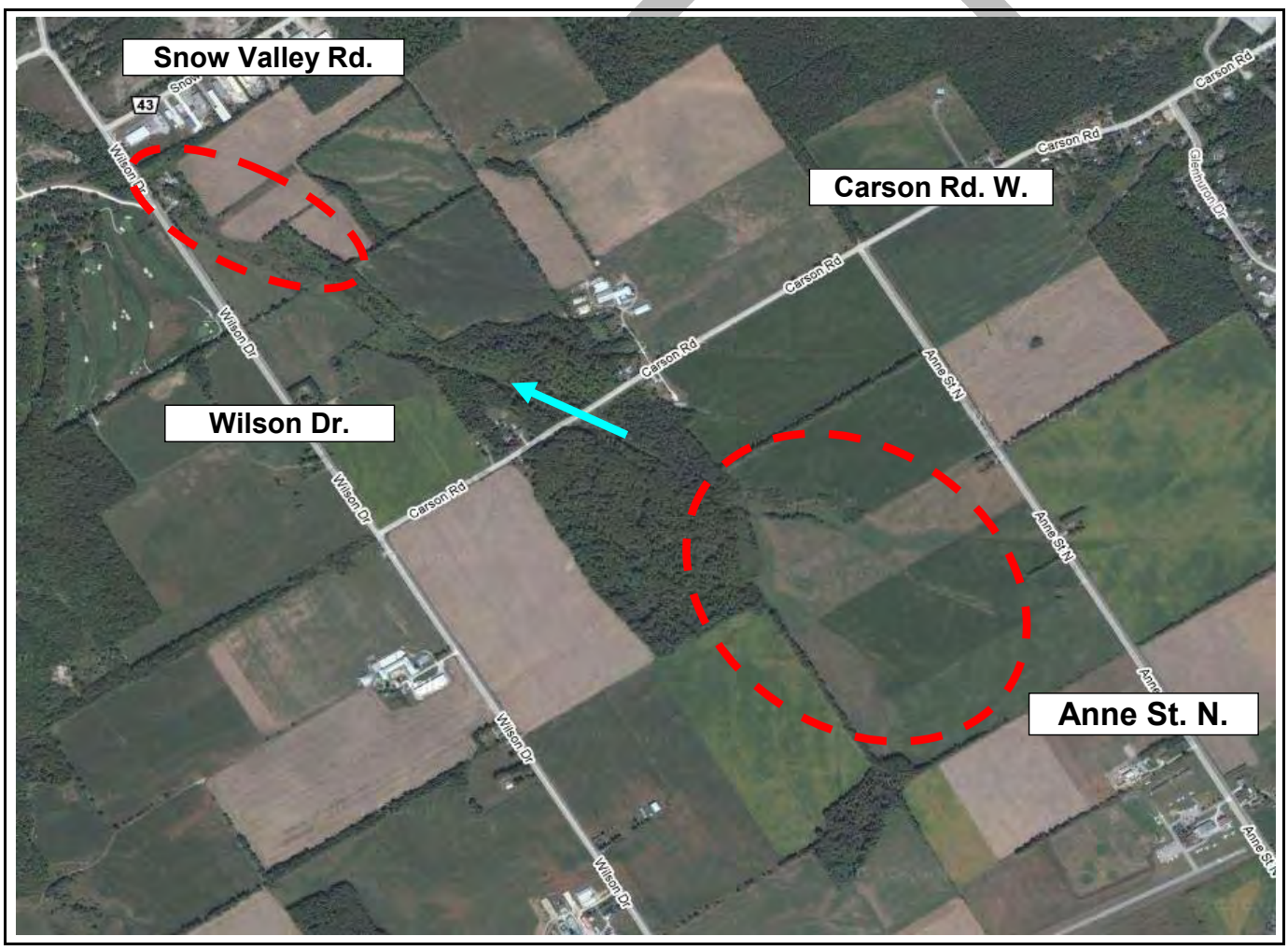
October 15, 2008

AquaLogic Consulting
1-9 Ellen St., Mississauga, Ont., L5M 1R8
Tel: (905) 819-9076 Fax: (416) 850-3749
bill.degeus@sympatico.ca

Geomorphic Development Setback Analysis
Willow Creek Tributary
Carson Rd. Geranium Properties
Township of Springwater

Development setback analysis has been done based on geomorphic screening of meander belt criteria and determination of the 100yr erosion limits in two study areas for three reaches of a Willow Creek Tributary that traverses north westerly from Anne St. N. to Carson Rd. W. to Wilson Dr. in the Township of Springwater. The study area locations are shown in Figure 1.

Figure 1: Study Area (N▲, not to scale)



Willow Creek Tributary Characterization

The Willow Creek Tributary is transitional from a 1st order to 2nd order watercourse with upstream drainage area increments of 1.40km^2 to Anne St. N. for the easterly 1st order feature, 1.80km^2 for the westerly 1st order feature, 5.47km^2 to Carson Rd. W. for the 2nd order branch, and 6.83km^2 to Wilson Dr. at the downstream study limit of the 2nd order branch. Two additional short local drainage features are confluent in the lower study area. The small westerly feature represents drainage from a small wet meadow area (possibly a former beaver pond/meadow) and the easterly feature is characterized by local farm field drainage contribution. The 1st and 2nd order features are officially identified on 1:10,000 Provincial OBM mapping and 1:50,000 Federal NTS mapping. The local drainage features as described above are not seen on mapping and would therefore be deemed not to represent primary drainage functions. The main branch 2nd order tributary is confluent downstream of the study area with the main branch of Willow Creek, which is confluent with the Nottawasaga River. Figures 2 and 3, appended, show the detailed drainage network.

The study area is mainly within the Simcoe Uplands physiographic region, with the downstream area near Wilson Dr. falling to the Simcoe Lowlands physiographic region. Topography is characterized as a deeply rolling till plain with the tributary falling from a shallow U-shaped valley at Anne St. N. to a relatively deep glacial moraine valley at Carson Rd. and a valley transition to the elevation of Willow Creek near Wilson Dr. At its deepest point near Carson Rd. the valley is 15-20m deep. The valley slopes are variable from well defined to convex, with gentle to steep gradients and width varying from 50m to over 300m.

The valley floor flood plain varies from agricultural row crop and pasture at Anne St. N. to well vegetated lowland forest and transitional upland forest conditions. Forest cover upstream of Carson Rd. includes a mix of swamp wetland, scrub forest, and coniferous-deciduous forest. Vegetative cover above Wilson Dr. has

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scrub forest definition with openings in the canopy resulting in thicker herbaceous groundcover. Each study section would be considered to be contiguous channel reaches based on relatively consistent local vegetative conditions.

The tributary branches are ephemeral to intermittent in the south study area while the main ranch appears to gain permanent base flow in the forest upstream of Carson Rd. Channel width varies from about 3-5m in the two 1st order features to 8m in the northerly 2nd order study reach. Low flow definition varies from ill-defined ephemeral/intermittent at the upstream limits of the 1st order southerly features, up to about 3m wide, at the downstream limits of the northerly study reach. The tributary flows over deposits of the parent geology with variable low flow bed forms from ill-defined swale, in the south, to occasional pools and riffles and eventually steps of coarser gravel to cobble material, in the northerly reach. There are areas of wetland diffusion, and influence from apparent beaver activity in the intervening forest area between the two study areas. Channel sinuosity is relatively low while the reach average slope is approximately 1%. Channel stability varies from moderate to relatively high due to changes in biotechnical reinforcement and channel bed materials. Some erosion scars are evident on outside banks, in the mid to lower reach. As expected, the channel tributaries are very stable near the upstream end were flows are ephemeral to intermittent and groundcover vegetation density is high. Stability is moderate to high in the shaded forest area between the two study sections. Near the downstream study limits the tributary emerges from forest cover into denser groundcover and shrub thicket cover and stability is very high.

Historical Channel Comparison

Digital overlay of scanned 1976 grayscale contact print air photo coverage was done with 2002 digital colour image coverage for each of the study areas. This process has a certain margin of error attributable to any original photo distortion and enlargement distortion. In this case, fixed road crossing reference points

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were used as match points and reasonable accuracy was achieved with regard to photo orientation and scale. A digital centre line trace was made of each channel pattern followed by enlargement to be approximately equal to the low flow channel width. Figures 2 and 3, as appended, show the results of this process, for the respective study areas.

The southerly study area shows virtually identical channel plan form comparisons. There is no identifiable development of a compound meander pattern in either time step and there is no distinctly different land use that would affect the channel. Relatively straight sections of each 1st order drainage feature suggest that possible past alteration has occurred.

The comparative channel plots for the northern study area are generally coincident over much of the reach. There are a few points of notable meander evolution seen in the 2002 plot. These locations appear to be natural responses in the tributary as opposed to influences from beaver activity, or adverse changes in upstream flow regime. The comparative plots show what might be man-made straightening in the section just above Wilson Dr. as the tributary wraps around existing farm buildings. There is a significant increase in riparian shrub and tree growth over the documented time span. The 1976 photo suggests that the flood plain was likely in continuous pasture with land to the west, while the 2002 photo shows a distinct field break outside the riparian zone. The riparian zone appears to have been allowed to naturalize in more recent years.

Meander Belt Analysis

The meander belt limits of the watercourse are defined by the largest meander footprint of the compound meander pattern based on historical comparison to current conditions. In a confined valley the meander belt is often the same as the coincident toe of valley slope and lateral limit of the valley floor. In this study case the meander belt limits are easily demarcated from historical air photos. Based

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on the historical channel comparison seen in the northerly study area the maximum meander belt limits are identified as 34m. As noted previously, there is no identifiable consistent compound meander pattern seen in the features in the southern study area. A short section of the westerly 1st order feature appears to display some measure of amplitude. In addition, the distinct demarcation between actively farmed fields and the natural buffer left on the easterly 1st order feature is suggestive of a possible amplitude/belt width. The belt limits of these sections would be estimated as 15m and would be deemed to apply to both features based on broadly similar land use, drainage area, and vegetative conditions. Immediately below the confluence of the 1st order features the meander belt would be defined as approximately 25m in the southerly end of forested valley conditions.

The study location reaches are characterized by distinct but low gradient slopes on each side of the tributary. The tributary would be technically classified as confined based on the tableland top of slope being confirmed to be greater than 2m above the tributary elevation. Application of Provincial Technical Guidelines identifies that a watercourse confined within a valley does not require that meander belt limits be used to define development setbacks as a constraint limit transferred to tableland (OMNR 2003). In the case of a confined valley, the geomorphic development limits are based on the 100yr erosion limits determined by historical analysis or by application of criteria noted in the guidelines. Stable slope limits determined by geotechnical analysis are then added to the erosion limits.

100yr Erosion Limits Analysis

Erosion limits analysis is undertaken based on either measurement of lateral meander migration over the air photo record, with translation to the 100yr planning horizon, or through application of Provincial technical guidelines when reliable historical measurements cannot be made. Significant channel plan form

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movement can be caused by factors such as major changes in hydrology and sediment load, or other upstream alterations. Rapid or catastrophic changes can cause channel avulsion and related slope failure in relatively short periods of time. Past and current conditions in the upstream watershed appear relatively similar and there is no direct evidence to conclude that one or more major changes have resulted in highly adverse channel migration in either study area.

The southerly study area has been noted to display distinctly similar channel plan form alignments in each of the historical air photos. Based on the historical channel comparison it appears unrealistic to attempt measurement of consistent recession rates over the entire study area and translate these to the 100 year planning horizon. In lieu of direct historical measurement, Provincial Technical Guidelines for 100 year erosion limits can be used as a reasonable criterion.

Table 1 presents the applicable guidelines used for identification of the erosion setback allowance.

Based on soil conditions and characterization of defined stable features it is recommended that the 100 year erosion limits be based on 'no evidence of active erosion'. The study site would be conservatively characterized as having cohesionless soils, reflected as the fourth guideline category. Active channel widths have been noted to be up to 5m wide therefore the second column criteria would result in a setback equivalent of 5m. It is recommended to apply the setback as a curvilinear line from the respective channel limits on each side of the 1st order tributary features and for the short section of the 2nd order main tributary contained within the southerly study area.

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Table 1: 100yr Erosion Setbacks (OMNR 2003)

Native Soil Structure	Range of Suggested Toe Erosion Allowances			
	Evidence of Active Erosion or Bankfull Flow Velocity > Competent Flow Velocity	No Evidence of Active Erosion or Bankfull Flow Velocity < Competent Flow Velocity		
		Bankfull Width		
		<5m	5-30m	>30m
Hard Rock (granite)	0-2m	0m	0m	1m
Soft Rock (shale, limestone), Cobbles, Boulders	2-5m	0m	1m	2m
Stiff/Hard Cohesive Soil (clays, clay silt), Coarse Granular (gravels), Till	5-8m	1m	2m	4m
Soft/Firm Cohesive Soil, Loose Granular (sand, silt), Fill	8-15m	1-2m	5m	7m

i) Where a combination of different native soil structures occurs, the greater or largest range of applicable to erosion allowances for the materials found at the site should be applied

ii) Active Erosion is defined as: bank material is exposed directly to stream flow under normal or flood flow conditions where undercutting, over-steepening, slumping of a bank or down stream sediment loading is occurring. An area may have erosion but there may not be evidence of 'active erosion' either as a result of well rooted vegetation or as a result of a condition of net sediment deposition. The area may still suffer erosion at some point in the future as a result of shifting of the channel

iii) Competent Flow Velocity is the flow velocity that the bed material in the stream can support without resulting in erosion or scour

Direct measurement of historical erosion limits was possible for the northerly study reach based on layered plan form alignments. Meander recession was measured in ten locations using demarcation to the nearest metre, reflecting the obtainable accuracy of the enlarged scale air photos. The 100 year erosion limits were determined by the equation:

$$(\sum n1{:}n10) / n / (2002\text{-}1976) \times 100$$

The resultant 100 year recession rate is 0.112 m yr^{-1} and the 100 year erosion limits therefore equal 11.2m. It is recommended to apply the setback as a curvilinear line from the outside apex of all meanders that encroach towards the valley slope toe.

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The geotechnical stable slope line should be projected from locations where the erosion limits are greater than the valley toe to determine if the greater of the combined technical hazard or the staked top of valley slope is used as a development limit constraint.

In support of the recommended erosion allowance setbacks, it is by default also recommended that no removal of vegetation should occur along valley walls and channel margins and that no concentrated stormwater, roof leader, or foundation collector flows should be directed to the tributary over the valley slope, without mitigation.

Summary

Development setback analysis has been done based on geomorphic screening of meander belt criteria and determination of the 100yr erosion limits for two study areas of a Willow Creek Tributary in the Township of Springwater. Meander belt criteria do not explicitly apply in the identified confined valley type and the resultant geomorphic based setback was determined based on the 100 year erosion limits. The 100 year erosion limits were determined to be equal to 5m for each of the southerly 1st order tributaries and equal to 11.2m for the northerly 2nd order main branch tributary.

DRAFT

Prepared by,

Bill de Geus, B.Sc., CET, CPESC, CCEP
AquaLogic Consulting

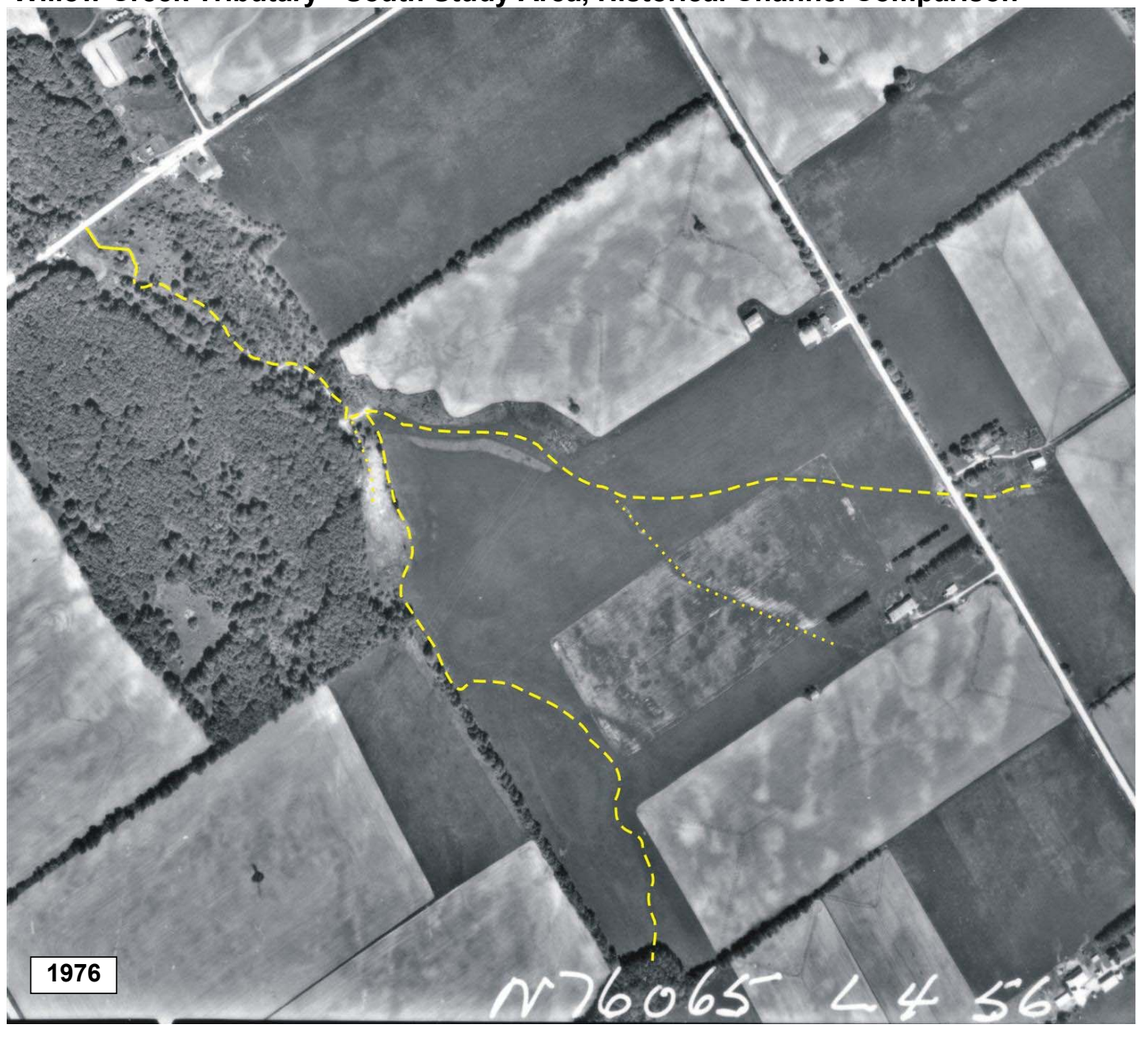
References

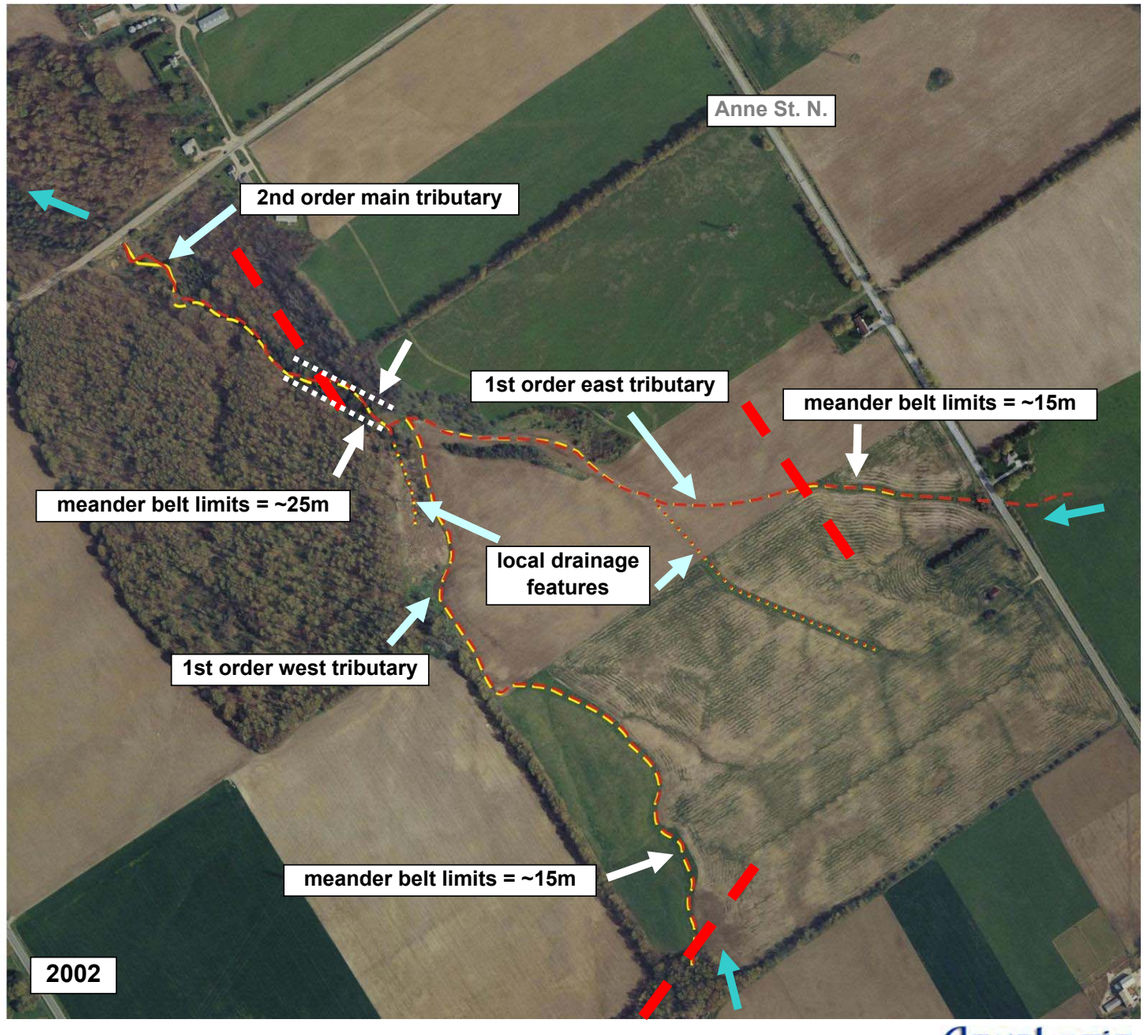
Chapman. L.J., and D.F. Putnam. 1984. The Physiography of Southern Ontario: Ontario Geological Survey, Special Volume 2.

Ontario Ministry of Natural Resources. 2003. Natural Hazards Technical Guides; River and Stream Systems Erosion Hazard Limit Technical Guide.

DRAFT

Willow Creek Tributary - South Study Area, Historical Channel Comparison





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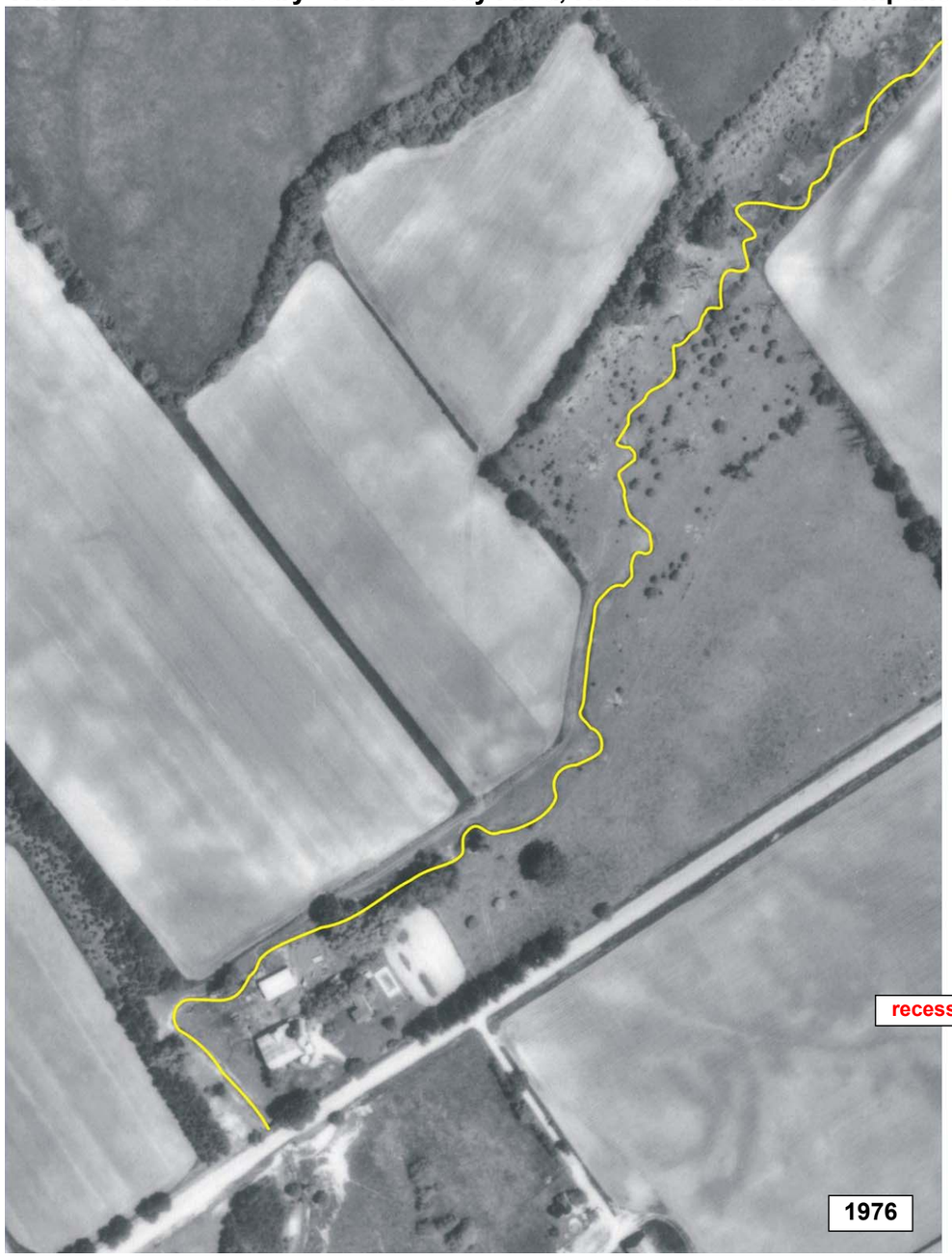
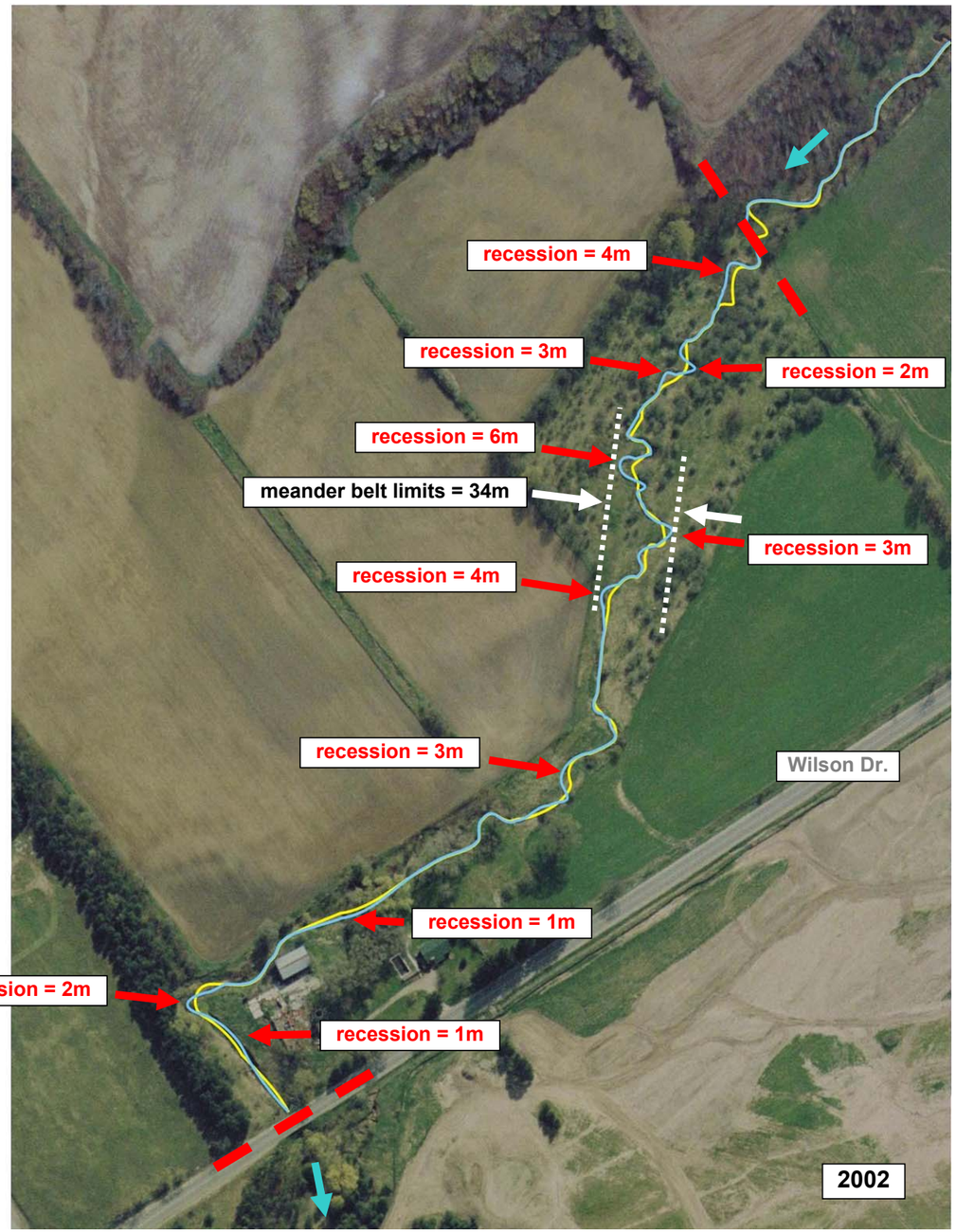
AquaLogic

Willow Creek Tributary - North Study Area, Historical Channel Comparison





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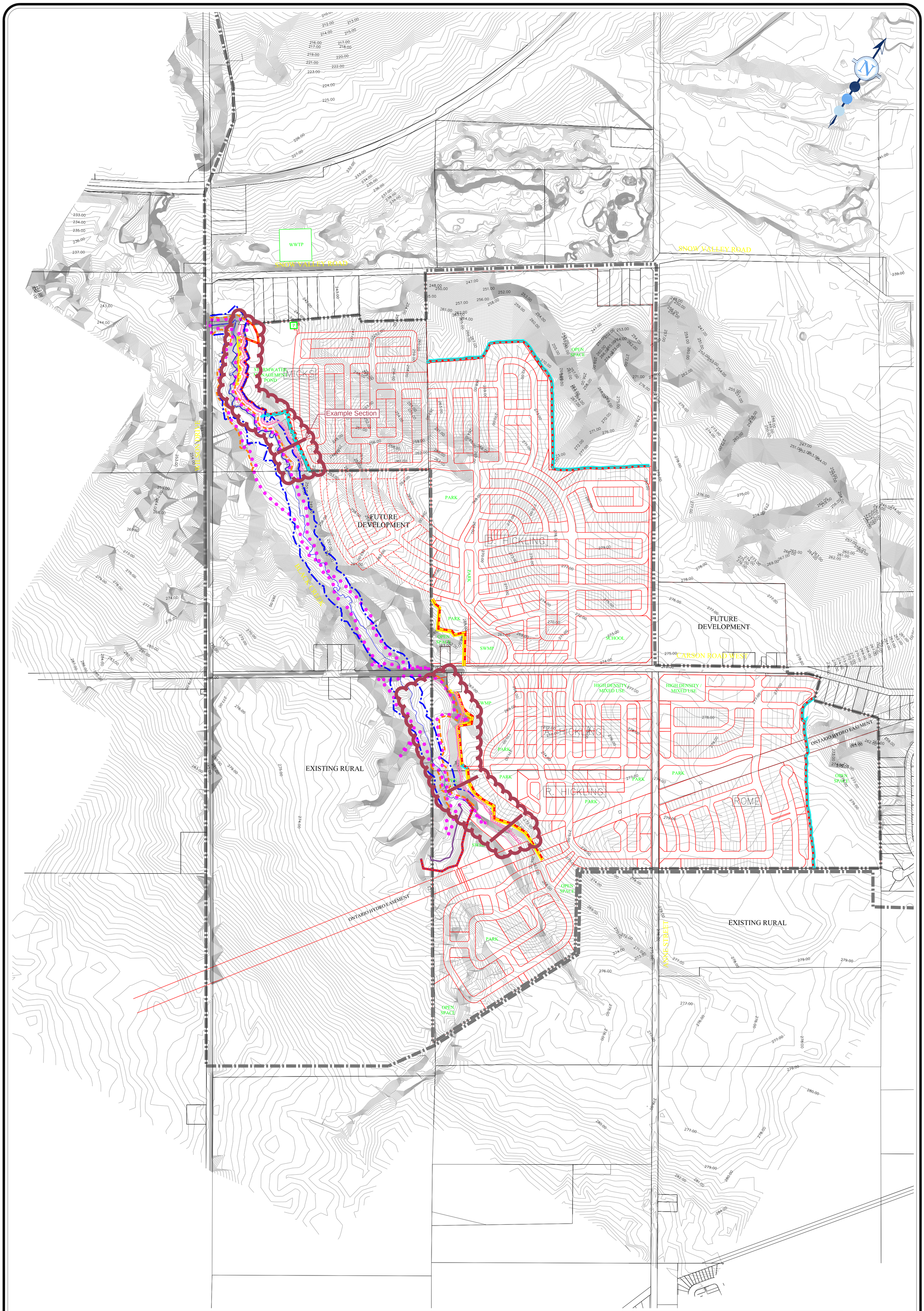
AquaLogic

ATTACHMENT B

FIGURE 6.1 – LIMIT OF DEVELOPMENT – CARSON COMMUNITY WITH SECTION LOCATIONS



CARSON ROAD DEVELOPMENT INC.

3190 STEELES AVE. EAST, SUITE 3000
MARKHAM, ONTARIO L3R 1G9
TEL: (905) 477-1177
FAX: (905) 477-1279

SCS consulting group ltd

30 CENTURIAN DRIVE, SUITE 100
MARKHAM, ONTARIO L3R 8B8
TEL: (905) 475-1900
FAX: (905) 475-8335

LEGEND:

- PROPERTY LIMIT
- 276.00 EXISTING CONTOURS
- STAKED DRIPLINE
- STAKED DRIPLINE BUFFER (5m)
- STAKED TOP OF BANK
- STAKED TOP OF BANK SETBACK (6m)
- EDGE OF WATERCOURSE
- EDGE OF WATERCOURSE BUFFER (30m)
- PROPOSED FLOODLINE
- REGIONAL FLOODLINE SET BACK (6m)
- LIMIT OF WETLAND
- LIMIT OF WETLAND BUFFER (30m)
- LIMIT OF ENVIRONMENTAL FEATURES
- LIMIT OF TOE OF SLOPE OR TOE EROSION ALLOWANCE
- EROSION HAZARD LIMIT
- EROSION HAZARD LIMIT ACCESS ALLOWANCE

CARSON ROAD DEVELOPMENT INC. (CRDI)

LIMIT OF DEVELOPMENT

DATE:	MAY 2014	PROJECT No:	1194	FIGURE No:	6.1
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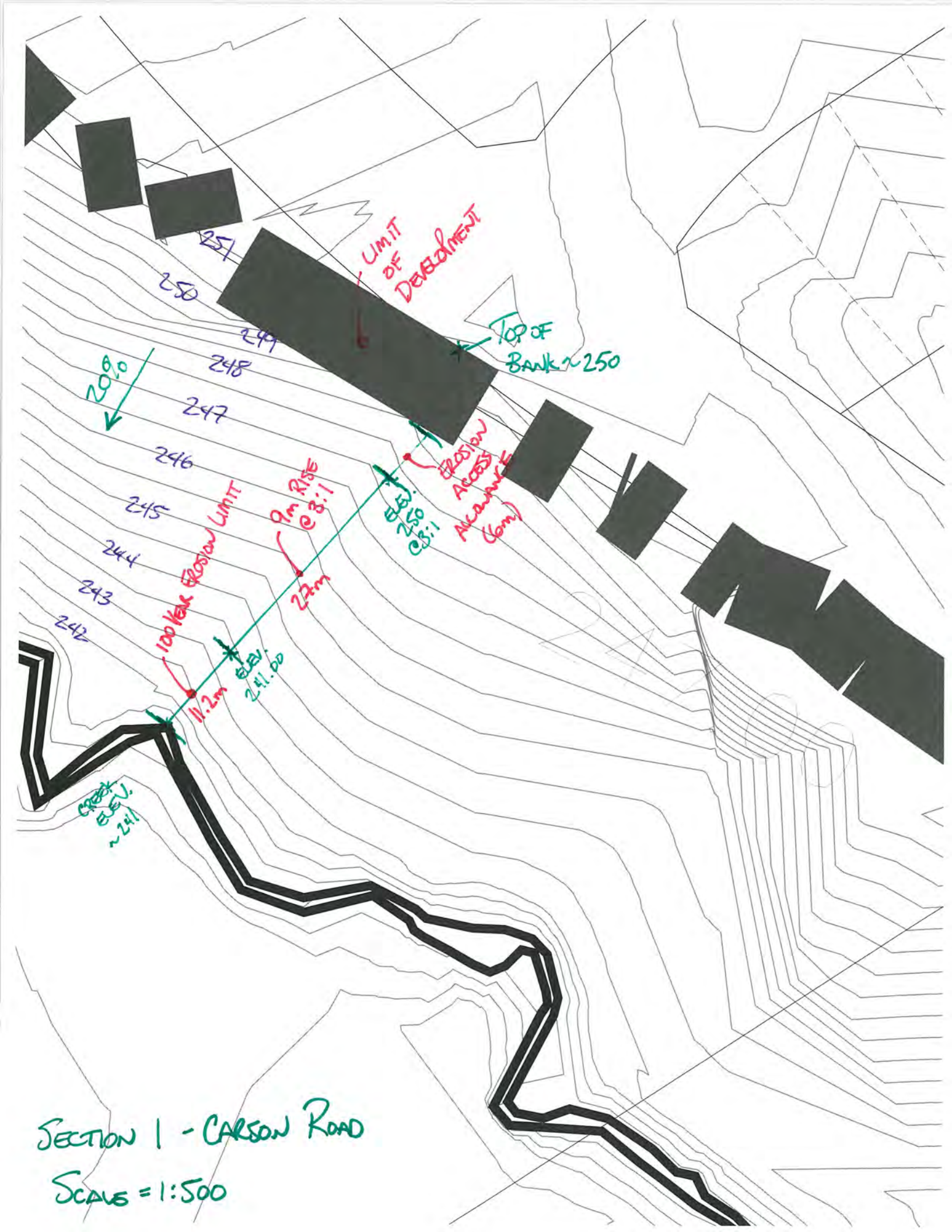
ATTACHMENT C

EROSION HAZARD ASSESSMENT CROSS SECTIONS

SCS consulting group ltd



SECTION 1 - CARSON ROAD

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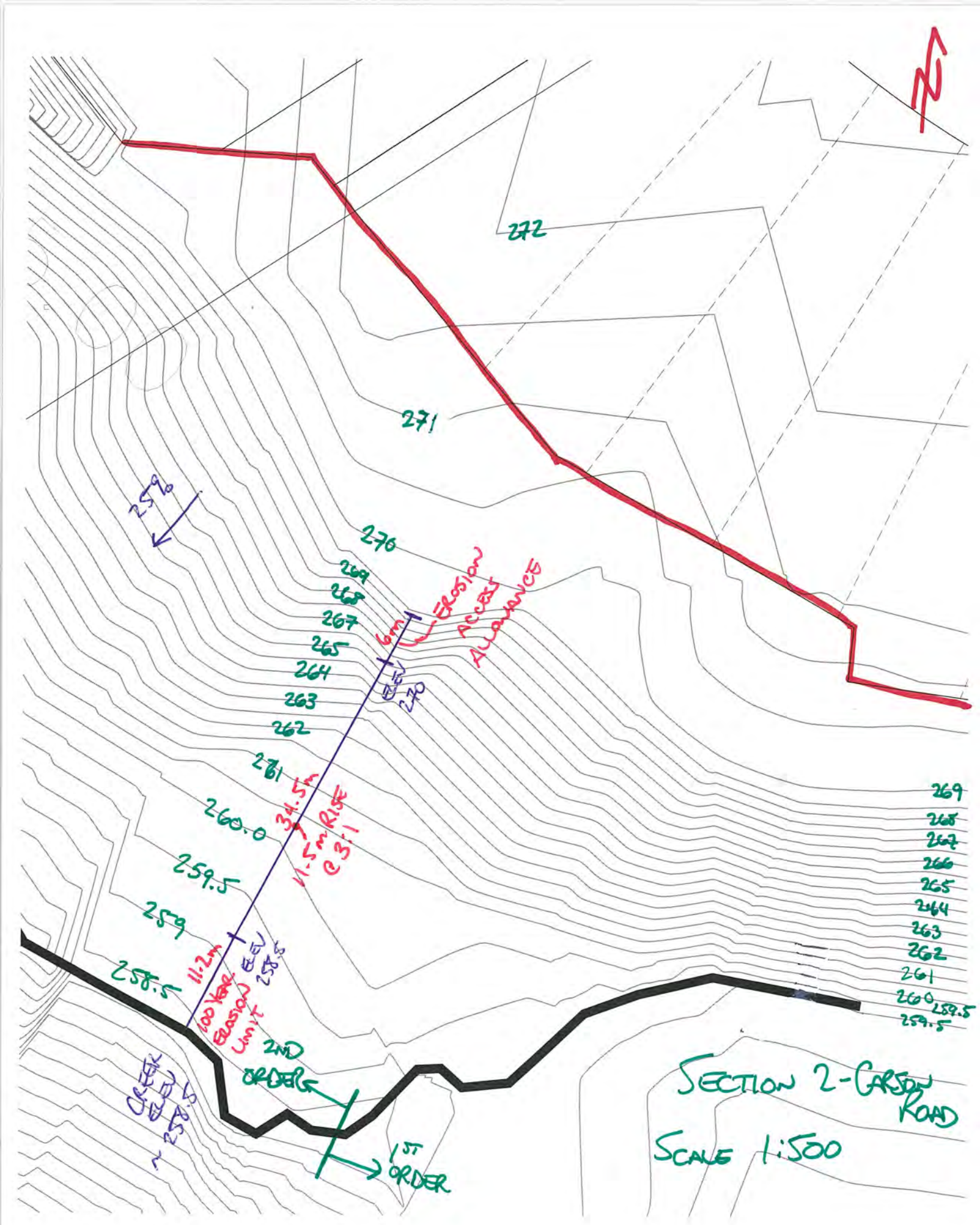
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EEV
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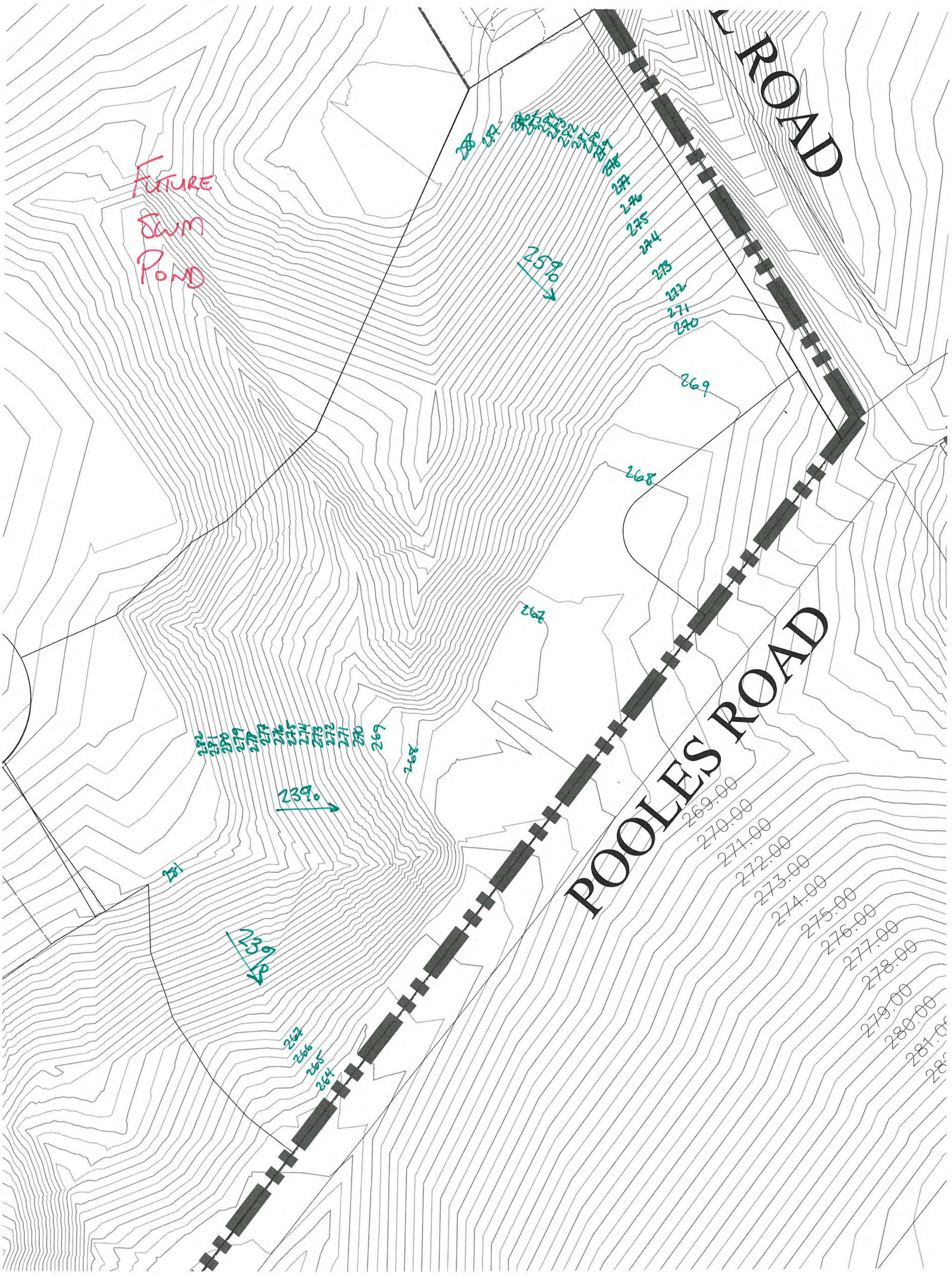
SCALE 1:500

SECTION #3 - CARSON ROAD

SCALE 1:500

June 2014

Doran Road Slope Analysis



Scale 1:1000

Appendix J

Water Balance

SCS consulting group ltd

File #: 1168/1194
Date: August 8, 2014

Mr. Glenn Switzer, P. Eng.
Director of Engineering and Technical Services
Nottawasaga Conservation Authority
8195 8th Line
Utopia, Ontario, L0M 1T0

Dear Mr. Switzer:

Re: **Midhurst Master Drainage Plan – Phase 1**
Item #5 – Maximize Infiltration – 25mm Rainfall Target
Midhurst, Ontario

Further to our submissions of May 2, 2014 and May 27, 2014, please accept the following supplemental information in support of the Maximum Infiltration analysis (Item #4) of the Phase 1 work program for the Master Drainage Plan for your review and approval.

As per NVCA's correspondence of May 29, 2014, the target statement for Maximum Infiltration is:

> *Infiltrate as much water back into the ground as possible aiming for the first 25mm of rainfall runoff. This will assist in the volume control and the water quality control.*

As requested by the NVCA, an analysis was completed to determine a preliminary maximum achievable infiltration volume, with a goal of retaining the entire 25mm rainfall event on-site through infiltration, and more specifically, low impact development strategies.

The existing hydraulic conductivity of the site soils have been characterized by Golder in the attached memo. As shown, the average hydraulic conductivity in the Doran and Carson lands is 10^{-5} cm/s. The associated infiltration rate is 30 mm/hour per the table provided by NVCA, taken from the LID SWM Planning and Design Guide, CVC & TRCA.

As discussed with NVCA, the infiltration potential of the site was modeled using the Initial Abstraction (IA) parameter, which was developed based on the following parameters:

- Infiltration rates are not to be included in the analysis at this stage, the entire volume of runoff to be infiltrated from the 25mm storm event needs to be available on site,
- Proposed infiltration measures are required to drawdown over the CVC/TRCA maximum drawdown time for below grade infiltration measures of 72 hours,
- A factor of safety of 2.5 needs to be applied per the CVC/TRCA Design Guide,

- Develop overall infiltration volume capacity for each SWM Pond drainageshed and average over drainage area to provide weighted IA to be used in hydrologic modelling, and
- Update hydrologic model with revised IA parameters to determine the impact on the proposed infrastructure and downstream receivers.

To determine which LID's were applicable, they were broken into two types: private lot level LID's and LID's within the public realm. The following LID's are what has been utilized in the analysis:

Private Lot Level LID's

- *Soakaway pits*
  - Located in both the front and rear yards, the soakaway pits will be connected directly to the roof leaders and infiltrate all roof runoff from the 25mm storm event,
  - The soakaway pits have been located in areas that would not be disturbed by a typical homeowner and can be put on title to ensure that they are to be maintained, and
  - As roof runoff is considered clean runoff, no pre-treatment is necessary.
- *RLCB exfiltration trenches*
  - In any instance where an RLCB is necessary, RLCB exfiltration trenches will provide adequate infiltration volume to infiltrate all roof and rear lot drainage from the 25 mm storm event,
  - The exfiltration trenches can be located in areas that would not be disturbed by a typical homeowner and can be put on title to ensure that they are to be maintained, and
  - As roof and rear lot runoff is considered clean runoff, no pre-treatment is necessary.
- *Increased Topsoil Depth*
  - Landscaped areas on a lot level basis (lawns) will have a minimum topsoil depth of 300 mm to encourage additional IA potential.

LID's within Public Realm

- *Infiltration Galleries*
  - In each park area, it has been assume that there is the potential for an infiltration galley that can utilize up to 50% of the park surface area,
  - It was assumed that the infiltration galleries would consist of a 1.0 m deep stone trench, and

- As the drainage directed to the park areas will be directly connected to the municipal storm sewer, pre-treatment will be required prior to flows entering the proposed facilities.

→ *Permanent Pool Drawdown*

- A $2m^3$/linear meter trench is proposed around the majority of the perimeter of each SWM Pond,
- The first 0.5-1.0 m of permanent pool will be directed to the drawdown trench and infiltrated,
- This practice infiltrates water that is warmest in the pond, while increasing pond capacity between storm events.

→ *Municipal Rain Gardens/Bio-swales on Single Loaded ROW's*

- Where appropriate (only anticipated on Doran) single loaded roads that are loaded by a green space on the non-loaded side provide an ideal location to direct surface runoff to at grade infiltration measures such as rain gardens or bioswales, and
- The entire 25 mm runoff from the municipal ROW adjacent to the bio-swale can be infiltrated.

→ *Increased Topsoil Depth*

- Landscaped areas within the municipal lands (boulevards and park areas) will have a minimum topsoil depth of 300 mm to encourage additional IA potential.

Low Impact Development techniques for the conveyance system have been chosen in the park and pond areas as opposed to exfiltration systems within the right of way for the following reasons:

→ Pre-treatment should be provided

- Several conveyance exfiltration systems have been installed without pre-treatment, however in discussions with MOE, their current preference is to provide pre-treatment for road runoff to remove oil and grit particles prior to the flow entering the groundwater system. This would require an oil grit separator at each manhole which would result in a considerable long term capital cost for the municipality for both maintenance and replacement
- If pre-treatment is not provided, the exfiltration systems will be both subject to more frequent cleaning or replacement and there is a greater potential for contamination of groundwater supplies from direct deposition of hydrocarbons, heavy metals and other deleterious materials.

→ Potential for long term settlement

- Construction of conveyance exfiltration systems along the right of way includes a stone trench wrapped with filter cloth as well as anti-seepage collars spaced at approximately 80 to 100m to avoid the exfiltration trench acting as an underground conduit.
  - There is a risk of long term road settlement if there is any breach or construction issue with the filter cloth around the stone trench, which could result in the native ground migrating into the stone voids, which is most concerning under a road
  - Should there be any breaches in the anti-seepage collars, there is a risk of increased velocities through the stone trenches, which also increase the risk of long term road settlement

→ Long term municipal capital maintenance cost

- Placing the exfiltration trenches under the road surface (asphalt) would result in the highest potential long term maintenance cost and disturbance to the residents, and has therefore been avoided to the extent possible.
- Placing the exfiltration trenches in the boulevards would result in an over-depth requirement to avoid conflict with the sanitary, storm and water service connections, and would also result in direct resident disturbance during any long term maintenance or replacement

Based on the inclusion of applicable LID's for each SWM Pond drainage shed, Table 3 outlines the potential volumes of infiltration that are available.

SWM Pond	Weighted IA with No LID's	Weighted IA with Lot Level LID's	Weighted IA with Lot Level and Municipal LID's	Resultant Rainfall Event with no Runoff*
North Pond	2.8 mm	9.9 mm	20 mm	23.3
Carson Road North Pond	2.8 mm	12 mm	18.7 mm	22.5
Carson Road South Pond	2.7 mm	9.2 mm	20.3 mm	23.4
South Pond	2.9 mm	10.6 mm	21.5 mm	23.0
Russell Road Pond	2.7 mm	8.9 mm	23.5 mm	24.6

* 25 mm subtract runoff volume from 25 mm event modelling from each outlet, included in Item #2 – Peak Flows

As shown above, an average of 20 mm of rainfall runoff can be retained on-site and infiltrated. This volume accounts for approximately 90% of average annual rainfall. All supporting calculations are appended.

Please call the undersigned if you have any questions or require any additional information.

Sincerely,

SCS Consulting Group Ltd.

Steve Schaefer, P. Eng.
Principal
sschaefer@scsconsultinggroup.com

Attachments: Attachment A - Infiltration Calculations
Attachment B - Golder Memo Re: Hydraulic Conductivity Rates

c. Mr. Wayne Wilson, NVCA
Mr. Chris Hibbard, NVCA
Mr. Brad Sokach, Township of Springwater
Mr. Brent Spagnol, Township of Springwater
Mr. Joe Mullan, Ainley
Mr. Greg Marek, Simcoe County
Ms. Shauna Dudding, Geranium Corporation
Mr. Matthew Cory, Malone Given Parsons

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ATTACHMENT A

INFILTRATION CALCULATIONS

SCS consulting group ltd

Step 1 - Determine In-Situ Infiltration Rates (i)

Per Tables 1 & 2 in the Hydraulic Conductivity Estimates Memo (Golder, June 3, 2014) the average Hydraulic Conductivity for both the Carson Road and Doran Road sites is approximately 10-5.

Using Table C1 from the CVC/TRCA LID SWM Manual, an approximate Infiltration Rate for a Hydraulic Conductivity of 10-5 is 30 mm/hr.

Step 2 - Determine Drawdown Time (t_s)

Per the CVC/TRCA LID SWM Manual (pg. 4-61) the maximum acceptable length of drawdown time is 72 hours

Step 3 - Factor of Safety (Fs)

Per the CVC/TRCA LID SWM Manual a safety factor of 2.5 has been applied.

Step 4 - Max Depth of Stone Trenches (all LIDs proposed have below grade stone based storage)

$d_{r\ max} = i * t_s / V_{r\ /\ Fs}$

Fs=	2.5	
i=	30	mm/hr
t_s=	48	hr
V_r=	0.4	(Void ration, assuming 50 mm clearstone)

$d_{r\ max}$ = 1.44 m

Therefore the maximum depth of 1.44 m is acheivable. To be conservative, we have assumed a depth of 1.0 m for all infiltration measures.

Average IA for Single Detached Lots without RLCB's

Assumptions:
- all runoff from roof to soakaway pits for 25mm event
- excess topsoil in landscape areas, IA for lawns increased from 5 to 7, accounting for 20-40% reduction in runoff per STEP document titled, evaluation of residential lot level stormwater management practices (http://dev.sustainabletechnologies.ca/wp/wp-content/uploads/2013/09/Residential-Lot-Level-SWM-practices_FINAL-2013.pdf)

Land Use	Average Area (%)	Infiltration Capacity (mm)
Roof	46%	25
Driveway	8%	0
Landscape	46%	7
Total	100%	14.8

Average IA for Single Detached Lots with RLCB's

Assumptions:
- all runoff from roof to soakaway pits for 25mm event
- excess topsoil in landscape areas, IA for lawns increased from 5 to 7, accounting for 20-40% reduction in runoff per STEP document titled, evaluation of residential lot level stormwater management practices (http://dev.sustainabletechnologies.ca/wp/wp-content/uploads/2013/09/Residential-Lot-Level-SWM-practices_FINAL-2013.pdf)
- all runoff from area directed to RLCB to be infiltrated from 25mm event (*assume 50% landscape area)

Land Use	Average Area (%)	Infiltration Capacity (mm)
Roof	46%	25
Driveway	8%	0
Landscape	46%	16
Total	100%	18.9

* = (7*0.5 + 25*0.5)

Mixed Use/School Blocks

Public Property LID's

Average IA for Township ROW (proposed previously by SCS)

Land Use	Width (m)	Average Area (%)	Infiltration Capacity (mm)
Asphalt & Curb	9	45%	0
Sidewalk	3	15%	0
Landscape	8	40%	5
Total	20	100%	2.0

Average IA for Single Loaded Township ROW with Bioretention

Assumptions:
- all runoff from non-loaded side of road to be infiltrated for 25mm event

Land Use	Width (m)	Average Area (%)	Infiltration Capacity (mm)
Asphalt & Curb	9	45%	12.5
Sidewalk	3	15%	12.5
Landscape	8	40%	15
Total	20	100%	13.5

Average IA for Infiltration Galleries in Park Areas

- Maximum volume available = 50% park surface area * 1m * 0.4 stone voids
- Determine volume directed to park infiltration gallery in 25mm event
- Use lesser of two numbers

Averate IA for Permanent Pool Drawdown

- Maximum volume available = 3.5m * 1.4m * 0.4 * NWL Perimeter
*Some ponds were assumed to have additional areas for infiltration based on layout.

North Pond IA

Total Weighted IA to North Pond without Public Property LIDs

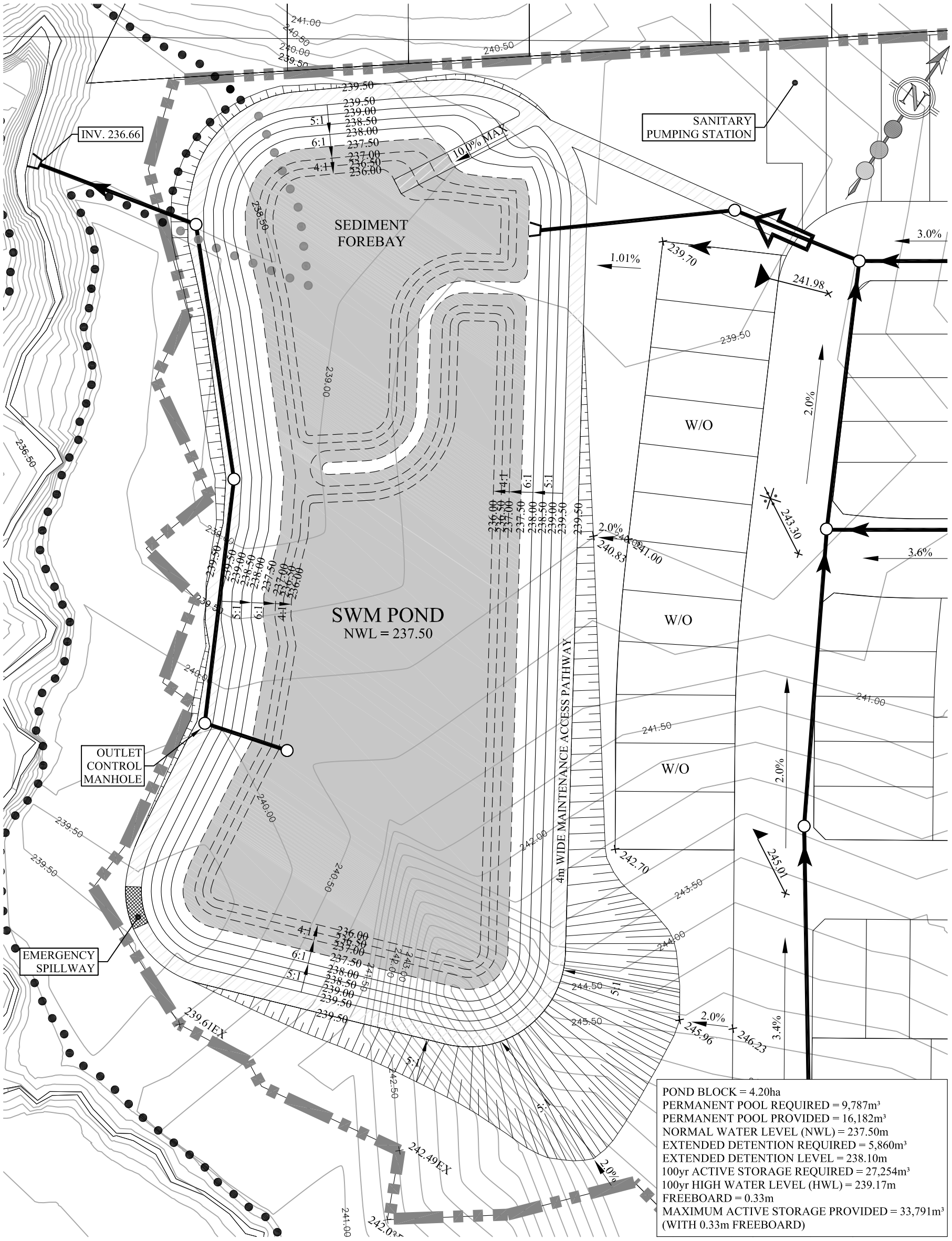
Land Use	Total Area (ha)	Average Infiltration Depth (mm)	Infiltration Volume (m^3)
Single Detached	36.88	14.8	5455
Single Detached w RLCB	1.02	18.9	193
Townhomes	0	2.0	0
Mixed Use/School	0	15.0	0
Standard ROWs	19.16	2.0	383
Parks/Open Space*	6.33	8.0	506
SWM Ponds	3.65	4.0	146
TOTAL (w/o Public LIDs)	**67.04**	**10.0**	**6684**

*IA assumed based on extra topsoil depth and volume of plantings

Total Weighted IA to North Pond Including Public Property LIDs

Land Use	Upstream Drainage Area	Available Runoff	Available Storage	Proposed Infiltration Volume
Block 819	28.1	4224	6200	4224
Block 341	10.2	1533	1140	1140
Pond Infiltration Gallery	67.04	4713	1340	1340

Land Use	Total Area (ha)	Average Infiltration Depth (mm)	Infiltration Volume (m^3)
TOTAL (w all LIDs)	**67.04**	**20.0**	**13387**



LEGEND:

- LIMIT OF DEVELOPMENT APPLICATION
- EXISTING FLOODLINE
- PROPOSED FLOODLINE
- MAX. 3:1 SLOPE
- 243.00 — EXISTING CONTOUR
- × 246.50 — PROPOSED GRADE
- ×237.59EX — EXISTNG GRADE
- OVERLAND FLOW
- 238.50 — POND CONTOUR
- PROPOSED MAINTENACE ACCESS ROAD
- PROPOSED EMERGENCY SPILLWAY
- PROPOSED OVERLAND FLOW ROUTE
- PROPOSED STORM SEWER

CARSON ROAD DEVELOPMENT INC. (CRDI)

PRELIMINARY SWM POND GRADING - NORTH POND

CARSON ROAD DEVELOPMENT INC.
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SCS consulting group ltd
30 CENTURIAN DRIVE, SUITE 100
MARKHAM, ONTARIO L3R 8B8
TEL: (905) 475-1900
FAX: (905) 475-8335

DATE:	AUGUST 2014	CHECKED BY:	J.M.P
SCALE:	1:1000	DRAWN BY:	Y.K.
PROJECT No:	1194	FIGURE No:	4.4.1

File: P:\1194 Midhurst Carson Road\Drawings\FSP\Figs\Report Figures\1194D-PREL-POND-NRTH-4.4.1.dwg – Revised by <MBRITTON> : Fri, Aug 08 2014 – 9:32am

Carson Road North Pond IA

Total Weighted IA to North Pond without Public Property LIDs

Land Use	Total Area (ha)	Average Infiltration Depth (mm)	Infiltration Volume (m^3)
Single Detached	21.08	14.8	3118
Single Detached w RLCB	0	18.9	0
Townhomes	0	2.0	0
Mixed Use/School	4.48	20.0	896
Standard ROWs	5.59	2.0	112
Parks/Open Space*	1.5	8.0	120
SWM Ponds	1.17	4.0	47
TOTAL (w/o Public LIDs)	**33.82**	**12.7**	**4293**

*IA assumed based on extra topsoil depth and volume of plantings

Total Weighted IA to North Pond Including Public Property LIDs

Land Use	Upstream Drainage Area	Available Runoff	Available Storage	Proposed Infiltration Volume
Block 819	19.5	2400	540	540
Pond Infiltration Gallery	33.82	3622	1500	1500

Land Use	Total Area (ha)	Average Infiltration Depth (mm)	Infiltration Volume (m^3)
TOTAL (w all LIDs)	**33.82**	**18.7**	**6333**

POND BLOCK = 1.30ha
PERMANENT POOL REQUIRED = 5,273m³
PERMANENT POOL PROVIDED = 7,953m³
NORMAL WATER LEVEL (NWL) = 264.00m
EXTENDED DETENTION REQUIRED =3,414m³
EXTENDED DETENTION LEVEL = 264.51m
100yr ACTIVE STORAGE REQUIRED = 15,885m³
100yr HIGH WATER LEVEL (HWL) = 265.97m
FREEBOARD = 0.33m
MAXIMUM ACTIVE STORAGE PROVIDED = 18,755m³
(WITH 0.33m FREEBOARD)

PARK

OPEN SPACE

CARSON ROAD WEST

SWM POND
NWL = 264.00

SEDIMENT FOREBAY

LIMIT OF DEVELOPMENT

1 m BUFFER

2 m FLAT BERM

EMERGENCY SPILLWAY

OVERLAND FLOW ROUTE

MAINTENANCE ACCESS ROAD

MAINTENANCE ACCESS ROAD

TO BLACK CREEK VIA EXISTING CARSON ROAD CULVERT

CARSON ROAD SOUTH POND OUTLET

NOTE: SCHEMATIC LAYOUT ONLY, DETAILS TO BE PROVIDED AT DETAILED DESIGN STAGE.

CARSON ROAD DEVELOPMENT INC.
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TEL: (905) 475-1900
FAX: (905) 475-8335

LEGEND:
- MAX. 3:1 SLOPE
- LIMIT OF DEVELOPMENT APPLICATION
- PROPOSED FLOODLINE
- 290.00 EXISTING CONTOUR
- × 166.50 PROPOSED GRADE
- 291.70 POND CONTOUR
- OVERLAND FLOW
- PROPOSED MAINTENACE ACCESS ROAD
- PROPOSED EMERGENCY SPILLWAY
- PROPOSED OVERLAND FLOW ROUTE
- PROPOSED STORM SEWER

CARSON ROAD DEVELOPMENT INC. (CRDI)

PRELIMINARY SWM POND GRADING - CARSON ROAD NORTH POND

DRAWN BY: S.F.	CHECKED BY: J.M.P.
SCALE: 1:1000	DATE: JUNE 2014
PROJECT No: 1194	FIGURE No: 4.4.2

File: P:\1194 Midhurst Carson Road\Drawings\FSP\Figs\Report Figures\1194D-PREL-POND-CARS-NRTH-4.4.2.dwg – Revised by <KPESENGCO> : Fri, Aug 08 2014 – 1:52pm

Total Weighted IA to Carson Road South Pond without Public Property LIDs

Land Use	Total Area (ha)	Average Infiltration Depth (mm)	Infiltration Volume (m^3)
Single Detached	19.87	14.8	2939
Single Detached w RLCB	5.03	18.9	950
Townhomes	5.09	2.0	102
Mixed Use/School	3.17	20.0	634
Standard ROWs	16.95	2.0	339
Parks/Open Space*	9.68	8.0	774
SWM Ponds	2.11	4.0	84
TOTAL (w/o Public LIDs)	**61.9**	**9.4**	**5823**

*IA assumed based on extra topsoil depth and natural cover

Total Weighted IA to Carson Road South Pond Including Public Property LIDs

Land Use	Upstream Drainage Area	Available Runoff	Available Storage	Proposed Infiltration Volume
Block 331	6.2	967	960	960
Block 536	10.2	1590	1920	1590
Block 535	59.3	9246	2920	2920
Pond Infiltration Gallery	61.9	4181	1250	1250

Land Use	Total Area (ha)	Average Infiltration Depth (mm)	Infiltration Volume (m^3)
TOTAL (w all LIDs)	**61.9**	**20.3**	**12544**

CARSON ROAD WEST

1m FLAT SHELF

MAINTENANCE ACCESS ROAD

OVERLAND FLOW ROUTE

SWM POND
NWL = 263.00

SEDIMENT FOREBAY

CARSON ROAD NORTH POND OUTLET

CB'S TO CAPTURE 100-YEAR OVERLAND FLOW

TO BLACK CREEK VIA EXISTING CARSON ROAD CULVERT

MAINTENANCE ACCESS ROAD

DICB

OUTLET CONTROL STRUCTURE

EMERGENCY SPILLWAY

LIMIT OF DEVELOPMENT

POND BLOCK = 3.26ha
PERMANENT POOL REQUIRED = 10,340m³
PERMANENT POOL PROVIDED = 11,944m³
NORMAL WATER LEVEL (NWL) = 263.00m
EXTENDED DETENTION REQUIRED = 6,190m³
EXTENDED DETENTION LEVEL = 263.58m
100yr ACTIVE STORAGE REQUIRED = 30,688m³
100yr HIGH WATER LEVEL (HWL) = 265.42m
FREEBOARD = 0.08m
MAXIMUM ACTIVE STORAGE PROVIDED = 31,895m³
(WITH 0.08m FREEBOARD)

NOTE: SCHEMATIC LAYOUT ONLY, DETAILS TO BE PROVIDED AT DETAILED DESIGN STAGE.

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FAX: (905) 475-8335

LEGEND:

- MAX. 3:1 SLOPE
- PROPOSED FLOODLINE
- 290.00 EXISTING CONTOUR
- × 166.50 PROPOSED GRADE
- 291.70 POND CONTOUR
- OVERLAND FLOW
- PROPOSED MAINTENACE ACCESS ROAD
- PROPOSED OVERLAND FLOW ROUTE
- PROPOSED STORM SEWER

CARSON ROAD DEVELOPMENT INC. (CRDI)

PRELIMINARY SWM POND GRADING - CARSON ROAD SOUTH POND

DRAWN BY:	S.F.	CHECKED BY:	J.M.P.
SCALE:	1:1000	DATE:	JUNE 2014
PROJECT No:	1194	FIGURE No:	4.4.3

File: P:\1194 Midhurst Carson Road\Drawings\FSP\Figs\Report Figures\1194D-PREL-POND-CARS-SOTH-4.4.3.dwg - Revised by <MBRITTON> : Fri, Aug 08 2014 - 3:10pm

South Pond IA

Total Weighted IA to South Pond without Public Property LIDs

Land Use	Total Area (ha)	Average Infiltration Depth (mm)	Infiltration Volume (m^3)
Single Detached	7.43	14.8	1099
Single Detached w RLCB	2.85	18.9	539
Townhomes	0	2.0	0
Mixed Use/School	0	20.0	0
Standard ROWs	4.73	2.0	95
Parks/Open Space*	1.46	8.0	117
SWM Ponds	1.18	4.0	47
TOTAL (w/o Public LIDs)	**17.65**	**10.7**	**1896**

*IA assumed based on extra topsoil depth and volume of plantings

Total Weighted IA to South Pond Including Public Property LIDs

Land Use	Upstream Drainage Area	Available Runoff	Available Storage	Proposed Infiltration Volume
Block 819	9.75	1390	2000	1390
Pond Infiltration Gallery	17.65	1126	500	500

Land Use	Total Area (ha)	Average Infiltration Depth (mm)	Infiltration Volume (m^3)
TOTAL (w all LIDs)	**17.65**	**21.5**	**3786**

POND BLOCK = 0.95 ha
PERMANENT POOL REQUIRED = 2,520 m³
PERMANENT POOL PROVIDED = 3,445 m³
NORMAL WATER LEVEL (NWL) = 264.25 m
EXTENDED DETENTION REQUIRED = 5,130 m³
EXTENDED DETENTION LEVEL = 265.34 m
100yr ACTIVE STORAGE REQUIRED = 6,990 m³
100yr HIGH WATER LEVEL (HWL) = 265.67 m
FREEBOARD = 0.38m
MAXIMUM ACTIVE STORAGE PROVIDED = 9,323 m³
(WITH 0.38m FREEBOARD)

NOTE: SCHEMATIC LAYOUT ONLY, DETAILS TO BE PROVIDED AT DETAILED DESIGN STAGE.

CARSON ROAD DEVELOPMENT INC.
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TEL: (905) 475-1900
FAX: (905) 475-8335

LEGEND:

- LIMIT OF DEVELOPMENT APPLICATION
- PROPOSED FLOODLINE
- 290.00 EXISTING CONTOUR
- × 268.83 EX EXISTING GRADE
- 266.05 POND CONTOUR
- PROPOSED MAINTENACE ACCESS ROAD
- PROPOSED EMERGENCY SPILLWAY
- PROPOSED OVERLAND FLOW ROUTE
- PROPOSED STORM SEWER

CARSON ROAD DEVELOPMENT INC. (CRDI)

PRELIMINARY SWM POND GRADING - SOUTH POND

DRAWN BY:	S.F.	CHECKED BY:	J.M.P.
SCALE:	1:1000	DATE:	JUNE 2014
PROJECT No:	1194	FIGURE No:	4.4.4

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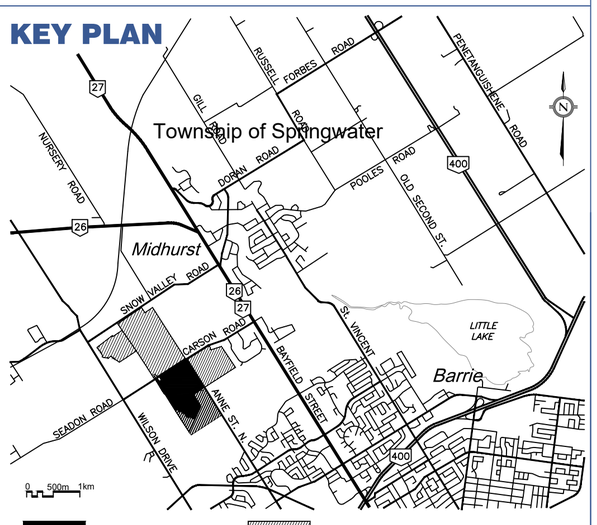
DRAFT PLAN OF SUBDIVISION

A. Hickling & R. Hickling

SP-T-1006

Part of Lots 16 & 17
Concession 6
Township of Springwater
County of Simcoe

KEY PLAN



Subject Lands Other Lands Owned by Applicant

SCHEDULE OF LAND USE

LOT/BLOCK	LAND USE	LAND USE	UNITS	AREA (ha)
Lots 1-511	Low Density Residential			
	Single Detached - 12.2m (B units)		225	18.78
	Single Detached - 9.75m (C units)		229	
	Single-Detached - 10.5m Flankage(D units)		57	
Blocks 512-533	4.5m Laneway Townhouses (LWTH)		169	3.02
Block 534	Mixed Use			1.95
Block 535-537	Parks			3.42
Blocks 538	Environmental Protection Area			7.71
Blocks 539-544	Open Space			3.39
Blocks 545-546	Stormwater Management Pond			3.29
Blocks 547-548	Servicing Blocks			0.10
Blocks 549-555	Future Development			0.15
Blocks 556-558	Future Road			0.18
Blocks 559-561	Road Widenings			0.75
Streets A-C	23.0m ROW	996m		11.87
Streets B-O	20.0m ROW	4,380m		
Lanes 1-4	10.0m Lane	362m		
TOTAL		5,738m	680	54.61

Net Density - 680 units / 44.95 ha = 15.1 upha
(Excludes Environtmental Protection Area and High Density / Mixed Use Block)

OWNER'S AUTHORIZATION

I hereby authorize Malone Given Parsons Ltd. to prepare and submit this Draft Plan of Subdivision to the County of Simcoe.

SEE ORIGINAL
1757690 Ontario Inc. Date

SEE ORIGINAL
1757689 Ontario Inc. Date

SURVEYOR'S CERTIFICATE

I hereby certify that the boundaries of the lands to be subdivided as shown on this Plan and their relationship to the adjacent lands are accurately and correctly shown.

SEE ORIGINAL
Paul Edward Date
Ontario Land Surveyor
RPE Surveying Ltd.

ADDITIONAL INFORMATION

AS REQUIRED UNDER SECTION 51(17) OF THE PLANNING ACT, CHAPTER P.13(R.S.O. 1990).
(a),(e),(f),(g),(j),(l) - As shown on the Draft Plan.
(b),(c) - As shown on the Draft and Key Plan.
(d) - Land to be used in accordance with the Schedule of Land Use.
(i) - Sandy loam.
(h),(k) - Full services and water supply to be provided.

Prepared by:

G:\Templates\06-MGP Logos\Two Line MGP Logo\Two Line MGP Logo-MGP Logo - Grafx.jpg

140 Renfrew Drive, Suite 201
Markham, Ontario, L3R 6B3
Tel: (905) 513-0170
www.mgp.ca

G:\2012\12-2139 Geranium Midhurst\Graphics\JPEGs\MBTW_WAI_COLOUR.png

Scale: 1:2000

Date: December 23, 2009
Project No.: 12-2139

Date	Revision	Rev.#
April 8, 2014	Revised as per Township and agency comments	1
May 14, 2014	Revised as per Township and agency comments	2

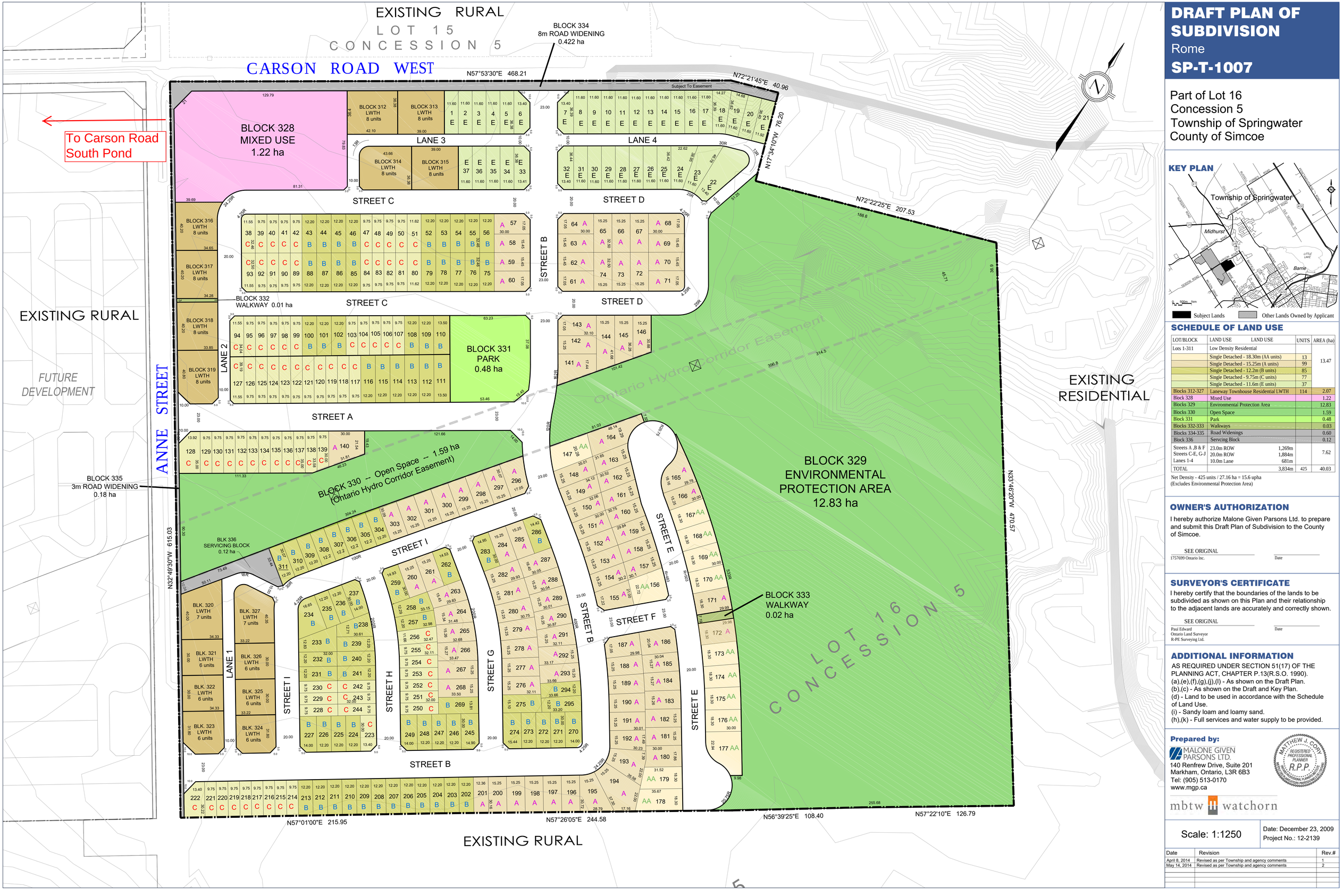
0 10 25 50 75m

DRAFT PLAN OF SUBDIVISION

Rome

SP-T-1007

Part of Lot 16
Concession 5
Township of Springwater
County of Simcoe



KEY PLAN

Subject Lands | Other Lands Owned by Applicant

SCHEDULE OF LAND USE

LOT/BLOCK	LAND USE	LAND USE	UNITS	AREA (ha)
Lots 1-311	Low Density Residential			
	Single Detached - 18.30m (AA units)		13	13.47
	Single Detached - 15.25m (A units)		99	
	Single Detached - 12.2m (B units)		85	
	Single Detached - 9.75m (C units)		77	
	Single Detached - 11.6m (E units)		37	
Blocks 312-327	Laneway Townhouse Residential LWTH		114	2.07
Block 328	Mixed Use			1.22
Blocks 329	Environmental Protection Area			12.83
Blocks 330	Open Space			1.59
Block 331	Park			0.48
Blocks 332-333	Walkways			0.03
Blocks 334-335	Road Widenings			0.60
Block 336	Servcing Block			0.12
Streets A ,B & F	23.0m ROW	1,269m		7.62
Streets C-E, G-J	20.0m ROW	1,884m		
Lanes 1-4	10.0m Lane	681m		
TOTAL		3,834m	425	40.03

Net Density - 425 units / 27.16 ha = 15.6 upha
(Excludes Environmental Protection Area)

OWNER'S AUTHORIZATION

I hereby authorize Malone Given Parsons Ltd. to prepare and submit this Draft Plan of Subdivision to the County of Simcoe.

SEE ORIGINAL
1757699 Ontario Inc. Date

SURVEYOR'S CERTIFICATE

I hereby certify that the boundaries of the lands to be subdivided as shown on this Plan and their relationship to the adjacent lands are accurately and correctly shown.

SEE ORIGINAL
Paul Edward Date
Ontario Land Surveyor
R-PE Surveying Ltd.

ADDITIONAL INFORMATION

AS REQUIRED UNDER SECTION 51(17) OF THE PLANNING ACT, CHAPTER P.13(R.S.O. 1990).
(a),(e),(f),(g),(j),(l) - As shown on the Draft Plan.
(b),(c) - As shown on the Draft and Key Plan.
(d) - Land to be used in accordance with the Schedule of Land Use.
(i) - Sandy loam and loamy sand.
(h),(k) - Full services and water supply to be provided.

Prepared by:
MALONE GIVEN PARSONS LTD.
140 Renfrew Drive, Suite 201
Markham, Ontario, L3R 6B3
Tel: (905) 513-0170
www.mgp.ca

MATTHEW J. CORY REGISTERED PROFESSIONAL PLANNER R.P.P.

mbtw watchorn

Scale: 1:1250

Date: December 23, 2009
Project No.: 12-2139

Date	Revision	Rev.#
April 8, 2014	Revised as per Township and agency comments	1
May 14, 2014	Revised as per Township and agency comments	2

Russell Road Pond IA

Total Weighted IA to North Pond without Public Property LIDs

Land Use	Total Area (ha)	Average Infiltration Depth (mm)	Infiltration Volume (m^3)
Single Detached	31.07	14.8	4596
Single Detached w RLCB	5.81	18.9	1098
Townhomes	9.52	2.0	190
Mixed Use/School	3.44	20.0	688
Standard ROWs	23.62	2.0	472
Parks/Open Space*	7.4	8.0	592
SWM Ponds	4.39	4.0	176
TOTAL (w/o Public LIDs)	**85.25**	**9.2**	**7812**

*IA assumed based on extra topsoil depth and volume of plantings

Total Weighted IA to North Pond Including Public Property LIDs

Land Use	Total Area (ha)	Average Infiltration Depth (mm)	Infiltration Volume (m^3)
Single Loaded ROW w Bioretention	2.5	13.5	338

Land Use	Upstream Drainage Area	Available Runoff	Available Storage	Proposed Infiltration Volume
Main Park Infiltraiton Gallery	53.5	8472	3200	3200
Block 558	0.6	95	150	95
Future 1	1.9	301	360	301
Future 2	1.2	190	66	66
Future 3	4.6	728	1008	728
Future 4	0.8	127	232	127
Block 553	7.25	1053	1900	1053
Block 553A	4.25	673	1016	673
Block 553B	4.75	451	1100	451
Block 553C	6.5	963	1100	963
Block 555/556/557	66	2921	2980	2921
Pond Infiltration Gallery	85.25	2584	1300	1300

Land Use	Total Area (ha)	Average Infiltration Depth (mm)	Infiltration Volume (m^3)
TOTAL (w all LIDs)	**85.25**	**23.5**	**20028**

POND BLOCK = 4.39ha
PERMANENT POOL REQUIRED = 13,213m³
PERMANENT POOL PROVIDED = 16,619m³
NORMAL WATER LEVEL (NWL) = 280.00m
EXTENDED DETENTION REQUIRED = 7,098m³
EXTENDED DETENTION LEVEL = 280.38m
100yr ACTIVE STORAGE REQUIRED = 46,133m³
100yr HIGH WATER LEVEL (HWL) = 282.14m
FREEBOARD = 0.46m
MAXIMUM ACTIVE STORAGE PROVIDED = 57,440m³
(WITH 0.46m FREEBOARD)

RUSSELL ROAD

POOLES ROAD

OVERLAND FLOW ROUTE

PARK

INLET STRUCTURE

SEDIMENT FOREBAY

SEDIMENT FOREBAY

SWM POND
NWL = 280.00

LIMIT OF DEVELOPMENT

4.0m WIDE FLAT BERM

MAX 3:1 TO MATCH EXISTING

EMERGENCY SPILLWAY

4.0m WIDE MAINTENANCE ACCESS ROAD

DICB

OUTLET CONTROL STRUCTURE

4.0m WIDE MAINTENANCE ACCESS ROAD

TO EXISTING MUNICIPAL OUTLET

OVERLAND FLOW ROUTE

NOTE: SCHEMATIC LAYOUT ONLY, DETAILS TO BE PROVIDED AT DETAILED DESIGN STAGE.

MIDHURST DEVELOPMENT DORAN ROAD INC.
3190 STEELES AVE EAST, SUITE 300
MARKHAM, ONTARIO L3R 1G9
TEL: (905) 477-1177
FAX: (905) 477-1279

SCS consulting group ltd
30 CENTURIAN DRIVE, SUITE 100
MARKHAM, ONTARIO L3R 8B8
TEL: (905) 475-1900
FAX: (905) 475-8335

LEGEND:

- LIMIT OF DEVELOPMENT APPLICATION
- MAX. 3:1 SLOPE
- 290.00 EXISTING CONTOUR
- × 166.50 PROPOSED GRADE
- × 287.59 EX EXISTNG GRADE
- 291.70 POND CONTOUR
- OVERLAND FLOW
- PROPOSED MAINTENACE ACCESS ROAD
- PROPOSED EMERGENCY SPILLWAY
- PROPOSED OVERLAND FLOW ROUTE
- PROPOSED STORM SEWER

MIDHURST DEVELOPMENT DORAN ROAD INC. (MDDRI)

PRELIMINARY SWM POND GRADING - RUSSELL ROAD POND

DRAWN BY: S.F.	CHECKED BY: J.M.P.
SCALE: 1:1500	DATE: JUNE 2014
PROJECT No: 1168	FIGURE No: 4.4.1

File: P:\1168 Midhurst – Doran Road\Drawings\FSP\Fig\Report Figures\1168–PREL–POND–RUSL–4.4.1.dwg – Revised by <MBRITTON> : Tue, Aug 05 2014 – 4:45pm

EXISTING RURAL

Doran Road

BLOCK 625
SERVICING BLOCK
0.06 ha.

BLOCK 626
8.0m ROAD WIDENING
0.79 ha.

BLOCK 623
WALKWAY
0.01 ha.

BLOCK 619
OPEN SPACE
0.17 ha.

BLOCK 627
8.0m ROAD WIDENING
0.77 ha.

Russell Road

BLOCK 622
ENVIRONMENTAL PROTECTION
10m BUFFER
0.16 ha.

BLOCK 621
ENVIRONMENTAL PROTECTION AREA
0.07 ha.

BLOCK 618
OPEN SPACE
0.05 ha.

BLOCK 566 LWTH 8 Units
BLOCK 567 LWTH 8 Units
BLOCK 568 LWTH 8 Units
BLOCK 569 LWTH 8 Units
BLOCK 570 LWTH 8 Units
BLOCK 571 LWTH 7 Units
BLOCK 572 LWTH 8 Units
BLOCK 573 LWTH 8 Units
BLOCK 574 LWTH 8 Units
BLOCK 575 LWTH 8 Units
BLOCK 576 LWTH 8 Units
BLOCK 577 LWTH 6 Units
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BLOCK 603 LWTH 8 Units
BLOCK 604 LWTH 6 Units
BLOCK 605 LWTH 7 Units
BLOCK 606 LWTH 8 Units
BLOCK 607 LWTH 6 Units
BLOCK 608 LWTH 8 Units
BLOCK 609 LWTH 8 Units
BLOCK 610 LWTH 8 Units

BLOCK 611
MIXED USE
0.96 ha.

BLOCK 612
PUBLIC ELEMENTARY SCHOOL
2.45 ha.
6.1 ac.

BLOCK 613
PARK
0.95 ha.

BLOCK 614
PARK
1.62 ha.

BLOCK 615
PARK
0.51 ha.

BLOCK 616
PARK
0.61 ha.

BLOCK 617
PARKETTE
0.37 ha.

BLOCK 620
OPEN SPACE
0.14 ha.

BLOCK 624
WALKWAY
0.03 ha.

LANE 1
LANE 2
LANE 3
LANE 4
LANE 5
LANE 6
LANE 7
LANE 8
LANE 9
LANE 10

STREET 'A'
STREET 'B'
STREET 'C'
STREET 'D'
STREET 'E'
STREET 'F'
STREET 'G'
STREET 'H'
STREET 'I'
STREET 'J'
STREET 'K'
STREET 'L'
STREET 'M'
STREET 'N'
STREET 'O'
STREET 'P'
STREET 'R'
STREET 'S'
STREET 'Z'

Future 1
Future 2
Future 3
Future 4

OTHER LANDS OWNED BY APPLICANT

Russell Road Pond Block

Pooles Road

RESIDENTIAL

EXISTING RURAL

REG PLAN 51M-181
BLOCK F
BLOCK I
BLOCK 124
BLK 125 (WALKWAY)
BLK 127 (RES)
COLE'S COURT
ROSEWOOD AVENUE
FRID BOULEVARD
SILVERWOOD CRESCENT
EWOOD DRIVE
D AVENUE

FUTURE DEVELOPMENT

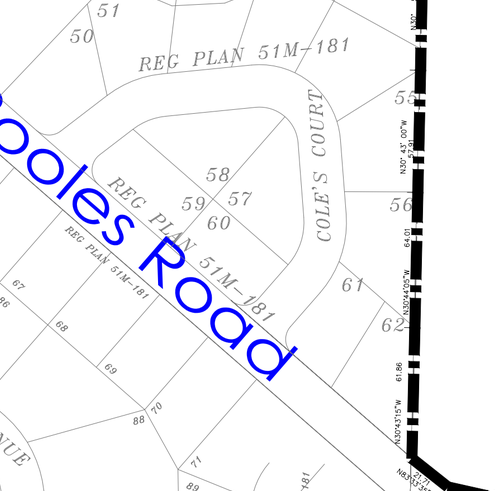
DRAFT PLAN OF SUBDIVISION

Bell-Coutts-Rusdor

SP-T-1001

Part of Lots 13 & 14
Concession 3
Township of Springwater
County of Simcoe

KEY PLAN



SCHEDULE OF LAND USE

LOT/BLOCK	LAND USE		UNITS	AREA (ha)
Lots 1-565				
	Single Detached - 12.2m (B units)		244	20.68
	Single Detached - 9.75m (C units)		214	
	Single Detached - 10.5m (D units)		52	
	Single Detached -11.6m (E units)		55	
Blocks 566-610	Townhouse Residential LWTH 4.50m		339	5.65
Block 611	Mixed Use			0.96
Block 612	Public Elementary School			2.45
Blocks 613-616	Parks			3.69
Block 617	Parkette			0.37
Blocks 618-620	Open Space			0.36
Block 621	Environmental Protection Area			0.07
Block 622	Environmental Protection 10 Buffer			0.16
Blocks 623-624	Walkways			0.04
Block 625	Servicing Block			0.06
Blocks 626-627	Road Widenings			1.56
Roads	23.0m ROW	1,440m		14.47
	20.0m ROW	4,637m		
	10.0m ROW	1,660m		
TOTAL	Totals	7,737m	904	50.52

Net Density* - 904 units / 50.45 ha = 17.9 upha
* Excludes Environmental Protection Area

OWNER'S AUTHORIZATION

I hereby authorize Malone Given Parsons Ltd. to prepare and submit this Draft Plan of Subdivision to the County of Simcoe.

SEE ORIGINAL SUBMISSION
1754866 Ontario Inc. — Date

SEE ORIGINAL SUBMISSION
1754865 Ontario Inc. — Date

SEE ORIGINAL SUBMISSION
1755571 Ontario Inc. — Date

SURVEYOR'S CERTIFICATE

I hereby certify that the boundaries of the lands to be subdivided as shown on this Plan and their relationship to the adjacent lands are accurately and correctly shown.

SEE ORIGINAL SUBMISSION
Paul Edward
Ontario Land Surveyor
RPE Surveying Ltd. — Date

ADDITIONAL INFORMATION

AS REQUIRED UNDER SECTION 51(17) OF THE PLANNING ACT, CHAPTER P.13(R.S.O. 1990).
(a),(e),(f),(g),(j),(l) - As shown of the Draft Plan.
(b),(c) - As shown on the Draft and Key Plan.
(d) - Land to be used in accordance with the Schedule of Land Use.
(i) - Sandy loam.
(h),(k) - Full services & Water Supply to be provided.

Prepared by:

MALONE GIVEN PARSONS LTD.
140 Renfrew Drive, Suite 201
Markham, Ontario, L3R 6B3
Tel: (905) 513-0170
www.mgp.ca

C:\Graham Users\Matt\Matthew Cory RPP Stamp.JPG

mbtw watchorn

Scale: 1:2000

Date: Dec 23, 2009
Project No.: 12-2139

Date	Revision	#
April 26/13	Revised Plan Limits	1
April 8/14	Revisions as per Township & Agency Comments	2
April 17/14	Add Public Elementary School Block	3
April 22/14	Revise Park and Public Elementary School Block	4
May 14/14	Revisions as per Township & Agency Comments	5

ATTACHMENT B

HYDRAULIC CONDUCTIVITY ESTIMATES, GOLDER, 2014

SCS consulting group ltd

TECHNICAL MEMORANDUM

DATE June 3, 2014 **PROJECT No.** 13-1170-0040

TO John Priamo, P.Eng.
SCS Consulting Group Ltd.

CC

FROM Jim Regier, CET; John Easton, M.Sc., P.Geo. **EMAIL** John_Easton@golder.com

HYDRAULIC CONDUCTIVITY ESTIMATES

Dear Sir,

We have been able to estimate the hydraulic conductivity of soils throughout the Carson Road Development Inc. (CRDI) and the Midhurst Developments Doran Road Inc. (MDDRI) lands using grain size analyses obtained from samples taken from test pits. The Ministry of the Environment (MOE) design manual for septic disposal beds (MOE, 1984) contains type curves for various soils. An approximate relationship among grain size curves, hydraulic conductivity, and T-time is presented in the manual. Laboratory testing conducted as part of the field work for this project (Figures 3A to 4B), the type grain size curves (MOE, 1984), and correlation table (MOE, 1984) forms the basis of the analysis contained herein.

The test pit locations with grain size analyses for the Carson Road Neighbourhood are shown on Figure 1. The grain size analyses for the Carson Road Neighbourhood are shown on Figures 3A to 3E. The MOE Type Curve that the soils most closely match the above noted analysis locations and the corresponding hydraulic conductivity are shown on Table 1.

The test pit locations with grain size analyses for the Doran Road area are shown on Figure 2. The grain size analyses for the Doran Road area are shown on Figures 4A and 4B. The MOE Type Curve that the soils most closely match the above noted analysis locations and the corresponding hydraulic conductivity are shown on Table 2.

Golder Associates Ltd.

JPR/JAE/plc

Reference:
Ministry of the Environment, 1984. Manual of Policy. Procedure, and Guidelines for Private Sewage Disposal Systems. Ontario Ministry of the Environment, Toronto.

CANADA'S BEST MANAGED COMPANIES Platinum member

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Attachments: Table 1 – Carson Road Development Inc. Test Pits
Table 2 – Midhurst Development Doran Road Inc. Test Pits

Figure 1 – Carson Road Area Test Pits and Quaternary Soils
Figure 2 – Doran Road Area Test Pits and Quaternary Soils
Figure 3A – Midhurst Carson Road Development Inc. Sieve Analysis (D Hickling Site)
Figure 3B - Carson Road Development Inc. Sieve Analysis (A Hickling Site)
Figure 3C - Carson Road Development Inc. Sieve Analysis (R Hickling Site)
Figure 3D - Carson Road Development Inc. Sieve Analysis (Rome Site)
Figure 3E - Carson Road Development Inc. Sieve Analysis (Micks Site)
Figure 4A – Midhurst Development Doran Road Inc. Sieve Analysis Wright Test Pits
Figure 4B - Midhurst Development Doran Road Inc. Sieve Analysis (Pooles Site)

SOIL INFILTRATION ASSESSMENT
TABLE 1: CARSON ROAD NEIGHBOURHOOD TEST PITS

Geological Material	TP #	Depth	Classification	Hydraulic Conductivity
See Figure 1 for Legend		Mbgs	(CH, SC, ML, etc)	(cm/s)
5b	1	4.6 - 5.0		
5b	3	3.1 - 3.5	SC	$1x10^{-4}$ to $1x10^{-6}$
5b	4	2.3 - 2.8	SC	10^{-4} to 10^{-6}
5b	8	3.1 - 3.5	SM	10^{-3} to 10^{-5}
5b	12	1.2 - 1.8	ML	10^{-5} to 10^{-6}
5b	14	0.6 - 1.2	SC	10^{-4} to 10^{-6}
5b	18	0.6 - 1.2	CH	10^{-7}
8a	19	4.6 - 4.9	SC	10^{-4} to 10^{-6}
5b	21	4.5 - 4.8	SM	10^{-3} to 10^{-5}
8a	22	1.2 - 1.8	SC	10^{-4} to 10^{-6}
8a	25	0.2 -0.6	SC	10^{-4} to 10^{-6}
*5b	28	0.6 - 1.2	SC	10^{-4} to 10^{-6}

SE = 1x10-4 to 1x10-6 cm/sec

SP = 10-1 to 10-3 cm/sec

ML = 10-5 to 10-6 cm/sec

SM = 10-3 to 10-5 cm/sec

CH = 10-7 or Lower

CL = 10-6 or Lower

Note - (*) Test Pit No Grain Size Analysis Performed

SOIL INFILTRATION ASSESSMENT
TABLE 2: DORAN ROAD NEIGHBOURHOOD TEST PITS

Geological Material	TP #	Depth	Classification	Hydraulic Conductivity
See Figure 1 for Legend		Mbgs	(CH, SC, ML, etc)	(cm/s)
9c	39	0.6 - 1.2	CL	$1x10^{-6}$ OR LOWER
5b	41	1.2 - 1.8	SM	$1x10^{-3}$ to $1x10^{-5}$
5b	42	1.2 - 1.8	SC	10^{-4} to 10^{-6}
5b	43	3.0 - 3.2	SC	10^{-4} to 10^{-6}
5b	45	0.6 - 1.2	ML	10^{-5} to 10^{-6}

SE = 1x10-4 to 1x10-6 cm/sec
SP = 10-1 to 10-3 cm/sec
ML = 10-5 to 10-6 cm/sec
SM = 10-3 to 10-5 cm/sec
CH = 10-7 or Lower
CL = 10-6 or Lower
Note - (*) Test Pit No Grain Size Analysis Performed

WWTP

SNOW VALLEY ROAD

WILSON ROAD

CARSON ROAD NEIGHBOURHOOD

CARSON ROAD

ANNE STREET

5b

12

6

8a

9b

101

102

100

LEGEND:

Development Property Limits

20	Organic Deposits	Peat, Muck, Marl
12	Fluvial or Deltaic Sediments	Sand, Minor Gravel, Silt & Clay
9b	Glaciolacustrine Coarse Grained Deposits	Gravel, Sand gravel, and Gravelly Sand
9c	Glaciolacustrine Coarse Grained Deposits	f Sands, Silt
8a	Glaciolacustrine Fine Grained Deposits	Silt and Clay
6	Glaciofluvial Ice-contact Stratified Deposits	Gravel, Sand gravel, and Gravelly Sand
5b	Till (Newmarket)	Stoney Silty Sand / Sand Till

Existing Grade Contours (5 masl interval)

Surface Water / Inferred Shallow Water Table Divide

Surface Water Basin ID

Test Pit Location

Test Pit Grain Size Analysis

REFERENCES:

1. Map Base courtesy SCS Consulting, digital CAD files
2. Map to be read in conjunction with the accompanying Report
3. Ontario Base Map contours, ESRI Geography Network

0 100 250 500 750

metres

Datum is UTM NAD 83 Zone 17

PROJECT

SOIL INFILTRATION ASSESSMENT

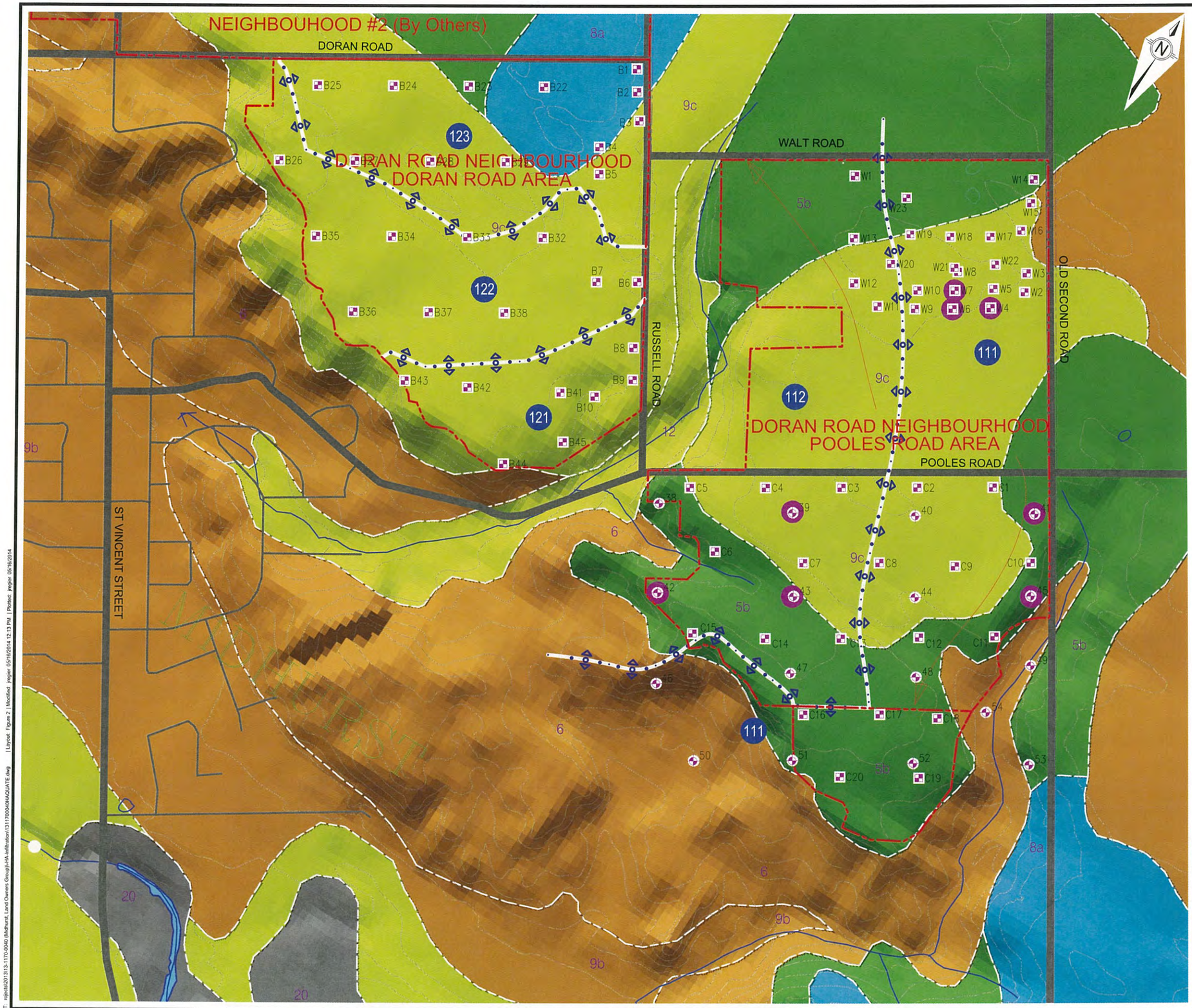
TITLE

CARSON ROAD NEIGHBOURHOOD
TEST PITS AND QUATERNARY SOILS

Golder Associates

PROJECT No.	13-1170-0040		FILE No.	1311700040HAQUATW	
DESIGN			SCALE	AS SHOWN	
CADD	JPR	2014-05-15	FIGURE	1	
CHECK	AP	30 Apr 14			
REVIEW	JAE	30 Apr 14			

T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\HA-Hillbrae\1311700040HAQUATW.dwg | Layout: Figure 1 | Modified: Stowerman 06/02/2014 11:34 AM | Plotted: Stowerman 06/02/2014



LEGEND:

- Development Property Limits
- 20 — Organic Deposits: Peat, Muck, Marl
- 12 — Fluvial or Deltaic Sediments: Sand, Minor Gravel, Silt & Clay
- 9b — Glaciolacustrine Coarse Grained Deposits: Gravel, Sand gravel, and Gravelly Sand
- 9c — Glaciolacustrine Coarse Grained Deposits: f Sands, Silt
- 8a — Glaciolacustrine Fine Grained Deposits: Silt and Clay
- 6 — Glaciofluvial Ice-contact Stratified Deposits: Gravel, Sand gravel, and Gravelly Sand
- 5b — Till (Newmarket): Stoney Silty Sand / Sand Till
- Existing Grade Contours (5 masl interval)
- Surface Water / Inferred Shallow Water Table Divide
- 100 — Surface Water Basin ID
- Test Pit Location
- Test Pit Grain Size Analysis

REFERENCES:

1. Map Base courtesy SCS Consulting, digital CAD files
2. Map to be read in conjunction with the accompanying Report
3. Ontario Base Map contours, ESRI Geography Network

0 100 250 500 750 metres

Datum is UTM NAD 83 Zone 17

PROJECT

SOILS INFILTRATION ASSESSMENT

TITLE

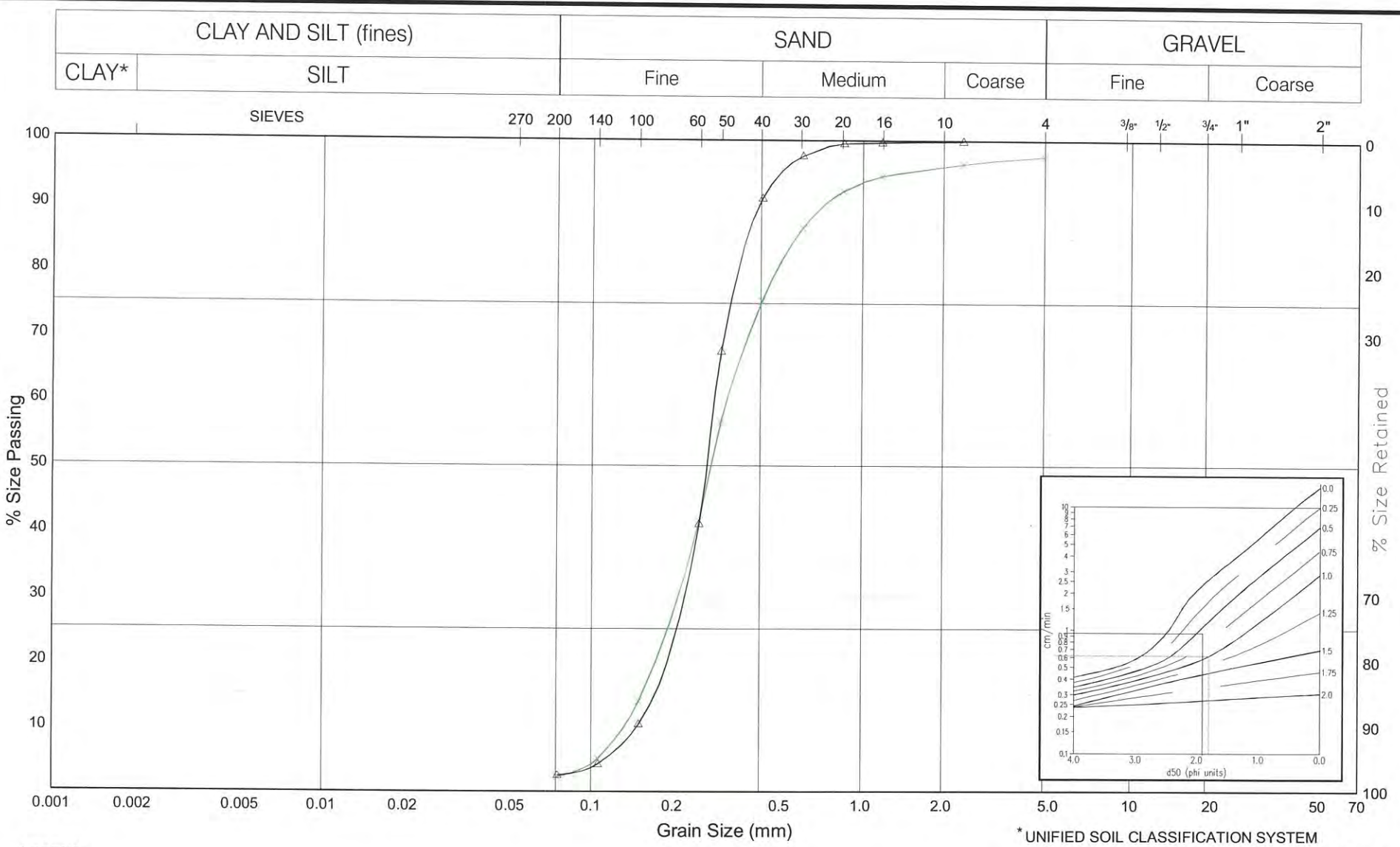
DORAN ROAD NEIGHBOURHOOD
TEST PITS AND QUATERNARY SOILS

Golder Associates

PROJECT No.	13-1170-0040		FILE No.	1311700040HAQUATE
DESIGN			SCALE	AS SHOWN
CADD	JPR	2014-05-15	FIGURE	2
CHECK	AP	30 Apr 14		
REVIEW	JAE	2014-05-15		

T:\projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\4A-Infiltration\1311700040HAQUATE.dwg [Layout: Figure 2 | Modified: jmgair 05/16/2014 12:13 PM | Plotted: jmgair 05/16/2014

PLOT DATE: June 3, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\-HA-Infiltration\1311700040HASVE-W1.dwg



LEGEND

× D17 - 10'
△ D26 - 12'

MOE TYPE SP (Poorly Graded Sands)

* UNIFIED SOIL CLASSIFICATION SYSTEM
CLAY DENOTED FROM MIT SOIL CLASSIFICATION

TITLE

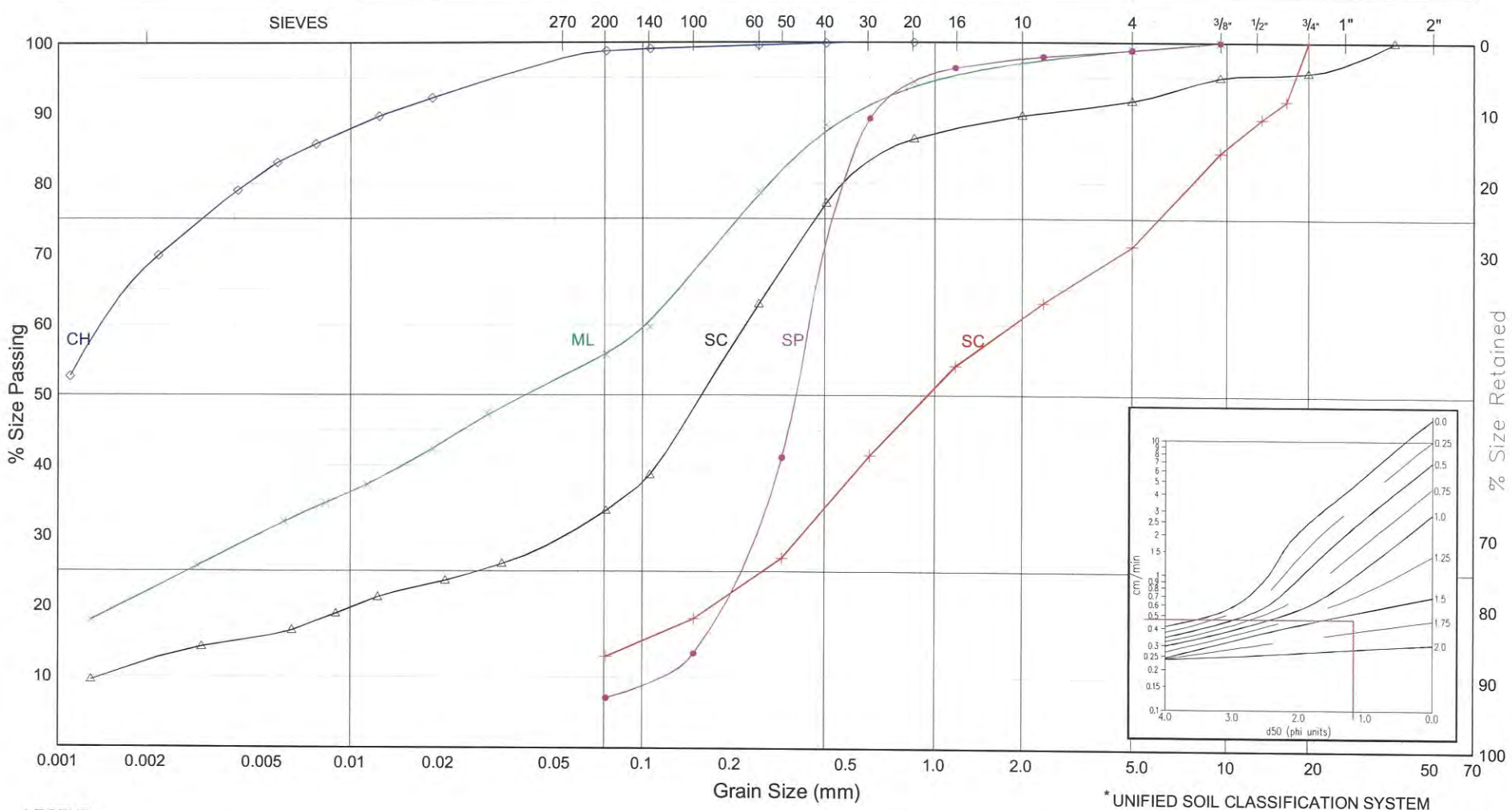
SIEVE ANALYSIS

Golder Associates
Barrie, Ontario, Canada

MIDHURST DEVELOPMENT
CARSON ROAD INC (D HICKLING SITE)

SCALE	AS SHOWN
DATE	2014-05-16
CAD	JPR
CHECK REVIEW	
FILE No.	1311700040HASVE-W1.dwg
PROJECT No.	13-1170-0040
REV.	
FIGURE	3A

PLOT DATE: June 3, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\-HA-Infiltration\1311700040HASVE-W2.dwg



LEGEND

- × BH12 1.2-1.8 m
- △ BH14 0.6-1.2 m
- ◇ BH18 0.6-1.2 m
- \+ BH19 4.6-4.9 m
- • BH19 6.1-6.3 m*

MOE TYPE CH (Inorganic Clays) to SC (Clay / Sand Mixtures)
* DEEPER SAND SAMPLE - MOE TYPE SP (Poorly Sorted Sand)

*UNIFIED SOIL CLASSIFICATION SYSTEM
CLAY DENOTED FROM MIT SOIL CLASSIFICATION

TITLE

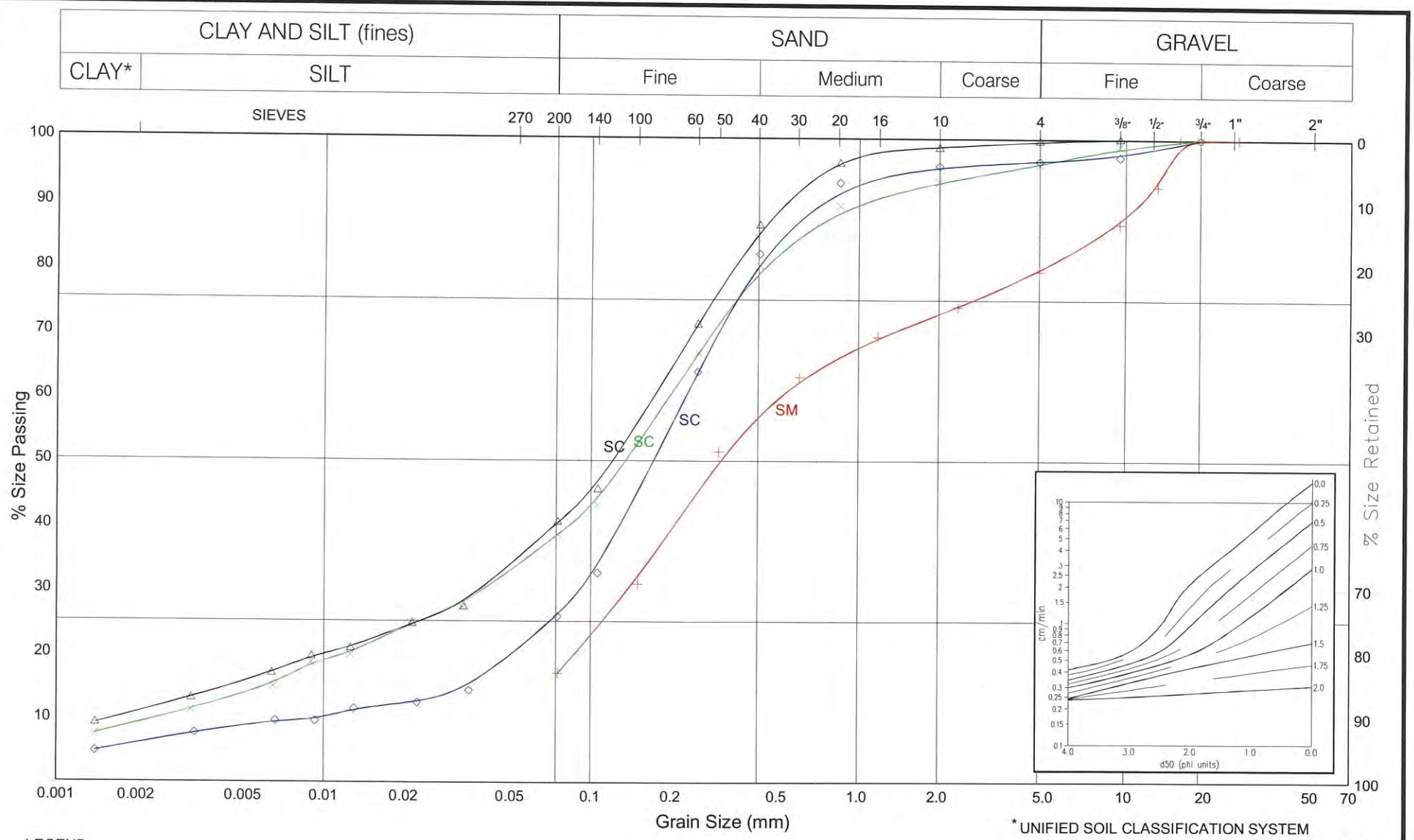
SIEVE ANALYSIS

MIDHURST DEVELOPMENT
CARSON ROAD INC (A HICKLING SITE)

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-05-16
CAD	JPR
CHECK REVIEW	
FILE No.	1311700040HASVE-W2.dwg
PROJECT No.	13-1170-0040
REV.	
FIGURE	3B

PLOT DATE: June 3, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\-HA-Infiltration\1311700040HASVE-W3.dwg



LEGEND

- BH22 1.2-1.8m
- BH25 0.2-0.6m
- BH28 0.6-1.2m
- BH21 4.5-4.8m

MOE TYPE SM (Silty Sands) to SC (Clay / Sand Mixtures)

*UNIFIED SOIL CLASSIFICATION SYSTEM
CLAY DENOTED FROM MIT SOIL CLASSIFICATION

TITLE

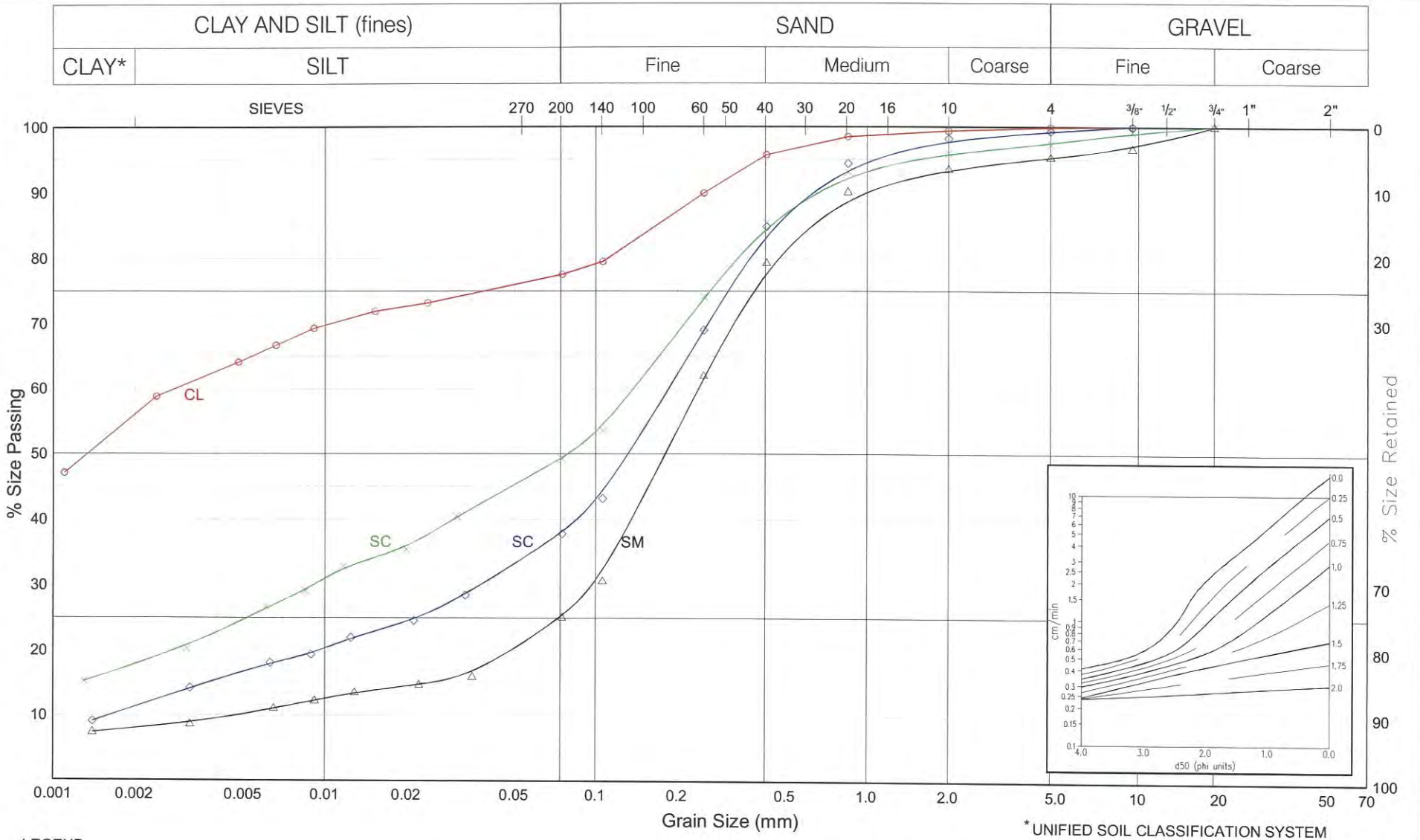
SIEVE ANALYSIS

MIDHURST DEVELOPMENT
CARSON ROAD INC (R HICKLING SITE)

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-05-16
CAD	JPR
CHECK REVIEW	
FILE No.	1311700040HASVE-W3.dwg
PROJECT No.	13-1170-0040
REV.	
FIGURE	3C

PLOT DATE: June 3, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\-HA-Infiltration\1311700040HASVE-W4.dwg



LEGEND

- BH30 0.6-1.2m
- BH32 0.6-1.2m
- BH34 1.2-1.8m
- BH37 1.2-1.8m

MOE TYPE SM (Silty Sands) to SC (Clay / Sand Mixtures)
TYPE CL (Inorganic Clays)

*UNIFIED SOIL CLASSIFICATION SYSTEM
CLAY DENOTED FROM MIT SOIL CLASSIFICATION

TITLE

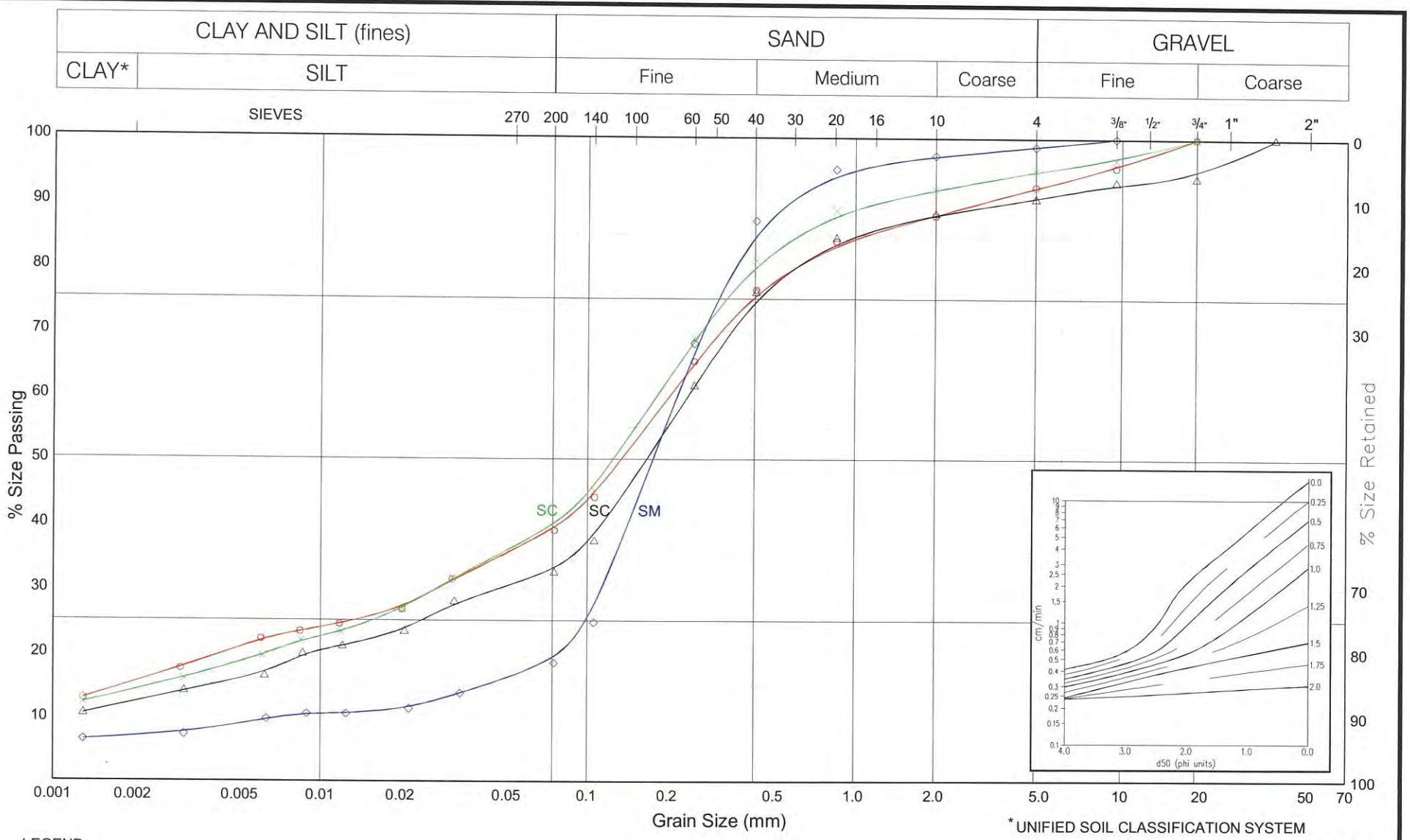
SIEVE ANALYSIS

MIDHURST DEVELOPMENT
CARSON ROAD INC (ROME SITE)

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-05-16
CAD	JPR
CHECK REVIEW	
FILE No.	1311700040HASVE-W4.dwg
PROJECT No.	13-1170-0040
REV.	
FIGURE	3D

PLOT DATE: June 3, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\-HA-Infiltration\1311700040HASVE-W5.dwg



LEGEND

- ○ BH1 4.6-5.0m
- × BH3 3.1-3.5m
- △ BH4 2.3-2.8m
- ◇ BH8 3.1-3.5m

MOE TYPE SM (Silty Sands) to SC (Clay / Sand Mixtures)

*UNIFIED SOIL CLASSIFICATION SYSTEM
CLAY DENOTED FROM MIT SOIL CLASSIFICATION

TITLE

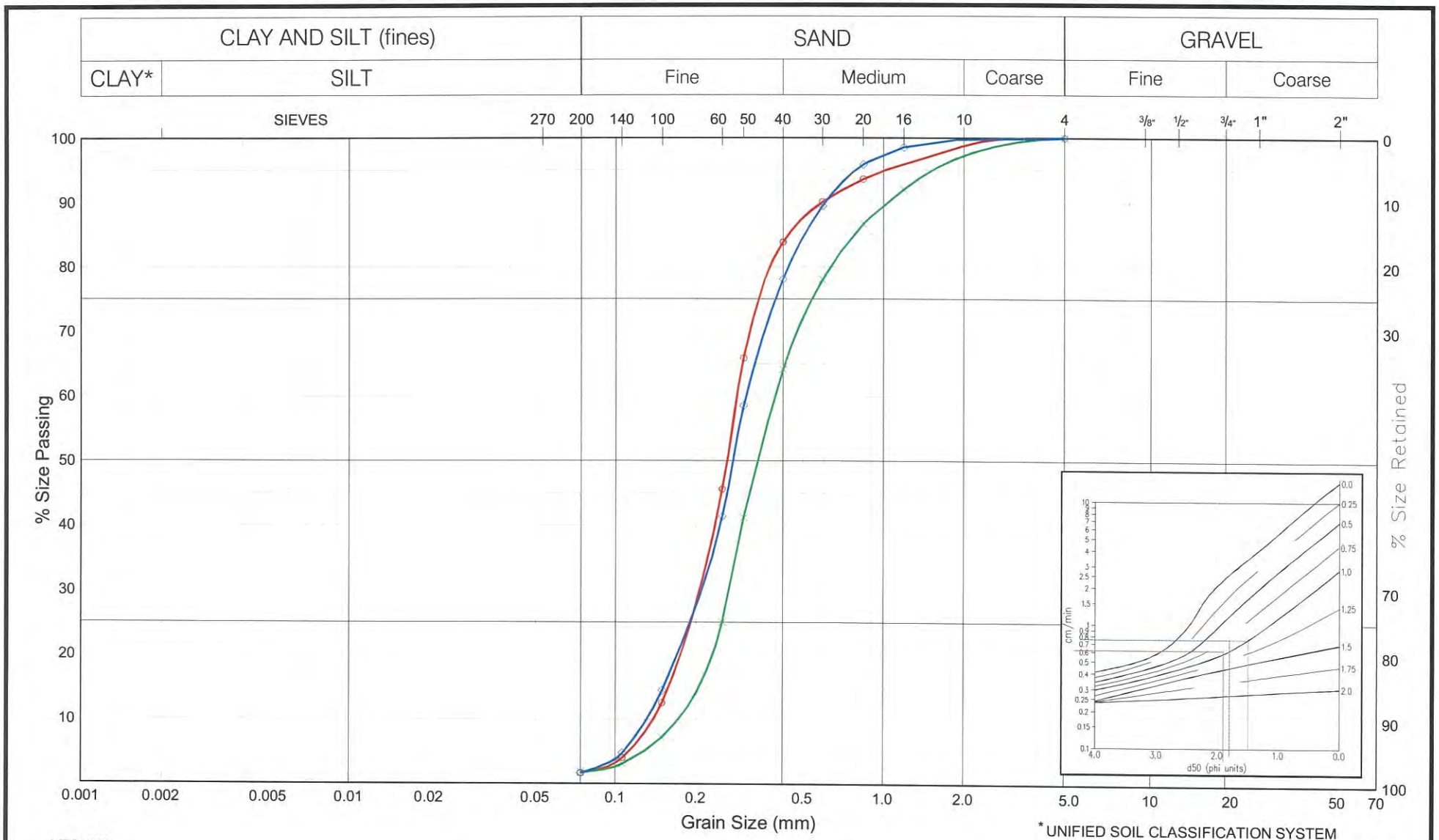
SIEVE ANALYSIS

MIDHURST DEVELOPMENT
CARSON ROAD INC (MICKS SITE)

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-05-16
CAD	JPR
CHECK REVIEW	
FILE No.	1311700040HASVE-W5.dwg
PROJECT No.	13-1170-0040
REV.	
FIGURE	3E

PLOT DATE: June 3, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\-HA-Infiltration\1311700040HASVE-E1.dwg



LEGEND

- TP6-6ft
- TP4-9ft
- TP7-8ft

MOE TYPE SP (Poorly Graded Sands)

*UNIFIED SOIL CLASSIFICATION SYSTEM
CLAY DENOTED FROM MIT SOIL CLASSIFICATION

TITLE

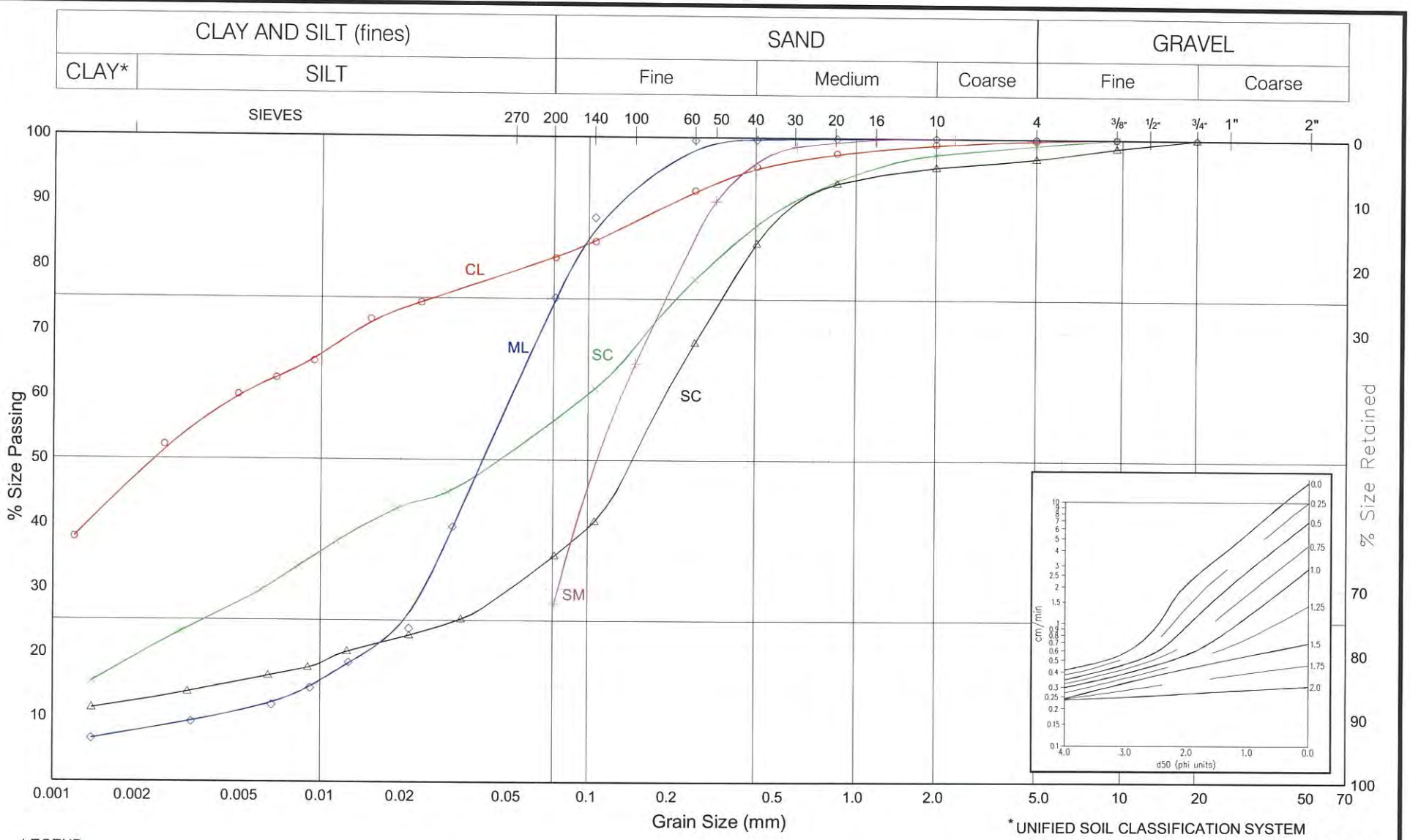
SIEVE ANALYSIS
WRIGHT TEST PITS

MIDHURST DEVELOPMENT
DORAN ROAD INC.

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-05-16
CAD	JPR
CHECK REVIEW	
FILE No.	1311700040HASVE-E1.dwg
PROJECT No.	13-1170-0040
REV.	
FIGURE	4A

PLOT DATE: June 3, 2014
FILENAME: T:\Projects\2013\13-1170-0040 (Midhurst, Land Owners Group)\-HA-Infiltration\1311700040HASVE-E2.dwg



LEGEND

- BH39 0.6-1.2m
- BH42 1.2-1.8m
- BH43 3.0-3.2m
- BH45 0.6-1.2m
- BH41 1.2-1.8m

MOE TYPE SM (Silty Sands) to SC, ML, CL

*UNIFIED SOIL CLASSIFICATION SYSTEM
CLAY DENOTED FROM MIT SOIL CLASSIFICATION

TITLE

SIEVE ANALYSIS

MIDHURST DEVELOPMENT
DORAN ROAD INC (POOLES SITE)

Golder Associates
Barrie, Ontario, Canada

SCALE	AS SHOWN
DATE	2014-05-16
CAD	JPR
CHECK REVIEW	
FILE No.	1311700040HASVE-E2.dwg
PROJECT No.	13-1170-0040
REV.	
FIGURE	4B

Appendix K

Fluvial Geomorphology

Geomorphological Monitoring of Matheson Creek in Support of Adaptive Management for the Midhurst Rose Alliance Development, Midhurst, Ontario

Final Report

Prepared for:
Midhurst Rose Alliance Inc.
6048 Highway #9 Unit 7
Schomberg, Ontario
Canada, L0G 1T0

December 22, 2017
PN14026a

GEO MORPHIX
Geomorphology
Earth Science
Observations

Report Prepared by:	GEO Morphix Ltd. 2800 High Point Drive, Unit 100a Milton, ON L9T 6P4
Report Title:	Geomorphological Monitoring of Matheson Creek in Support of Adaptive Management for the Midhurst Rose Alliance Development, Midhurst, Ontario
Project Number:	PN14026a
Status:	Final
Version:	1.0
First Submission Date:	December 22, 2017
Prepared by:	Ben Miller, Cara Hutton, Kat Woodrow
Approved by:	Paul Villard, Ph.D., P.Geo.
Approval Date:	December 22, 2017

Table of Contents

Appendices

1 Introduction

GEO Morphix Ltd. was retained by Midhurst Rose Alliance Inc. to complete baseline geomorphological monitoring for Matheson Creek and its tributaries in the Town of Midhurst, Ontario. Baseline geomorphological data collected through this program are in support of the adaptive management plan associated with the Midhurst Rose Alliance Development and will inform the Midhurst Master Drainage Plan.

Baseline monitoring data characterizes the range of natural geomorphic variability within selected channels. It will also assist in identifying any changes to the hydrologic and sediment regime that could be associated with the development activities. Monitoring data also provides an opportunity to mitigate any impacts, should they be identified through an adaptive management approach.

An adaptive management monitoring approach was developed in the context of the proposed alternative storm outlet that will direct larger flows to a tributary of Matheson Creek located along Gill Road. The adaptive management plan is based on the BACI approach (Before-After-Control-Impact). Before (pre-development) and After (post-development) sampling can be used to determine how and if development changes the site through time from its historical condition. Control (reference site) and Impact (site to potentially see changes) sampling allows the effects of development to be discerned from natural variability and trends. The potentially impacted site and reference sites are monitored with the same protocol (methods, frequency, and timing) to allow for paired comparison of changes among the sites. This approach provides a mechanism to adapt designs should future monitoring indicate the occurrence of unacceptable erosion impacts.

GEO Morphix Ltd. has developed a baseline monitoring program in order to characterize the existing geomorphology within Matheson Creek and its tributaries downstream of the respective development site. Sites were selected based on proximity to the proposed outlet and sensitive reaches identified through the desktop assessment. Sites were also selected to provide coverage across a range of geomorphologically distinct reaches, where in public or roadside access was available. Our desktop examination of slope and geology suggested that road side and public access could bring us within proximity of the most sensitive channels and provide a diverse collection of observations.

This second year monitoring report outlines all geomorphological monitoring that has occurred to date. This includes fluvial geomorphological monitoring, and more specifically, addresses potential adjustment in channel geometry, rates of change with regards to channel adjustment, and instream sediment characteristics. Erosion thresholds were determined as part of the first report submitted August 22, 2016, titled *Geomorpholgical Monitoring of Matheson Creek in support of Adaptive Management for the Midhurst Rose Alliance Development, Midhurst, Ontario*.

2 Background Review

The Midhurst Rose Alliance Development falls within the Nottawasaga River Watershed and the Midhurst Secondary Plan area. Flows from these lands naturally drain into two small tributaries of Matheson Creek.

Matheson Creek provides coldwater habitat for various fish species and substantial drainage to the Nottawasaga River system. The upstream section of these tributaries lies within an area of drumlin till plain and drains into a kame moraine and sand plain at the confluence of the main stem of Matheson Creek.

The Midhurst Rose Alliance Development falls within a subcatchment that drains to several tributaries of Matheson Creek. Proposed stormwater management plans show runoff from the development area piped approximately two kilometers upstream of the current receiving tributaries, to a new outlet at a larger tributary of Matheson Creek. The increase in flow volume and peaks downstream of the proposed outlet, if unmitigated, could impact stream function and exacerbate rates of erosion.

Reach delineation for Matheson Creek was completed through desktop analysis. Reach delineation is a prerequisite of a geomorphological assessment. Reaches divide watercourses into homogeneous channel segments having similar inputs, outputs and controls. Indicators for reach breaks include:

- Channel planform;
- Channel gradient;
- Physiography;
- Land cover (land use or vegetation);
- Flow, due to tributary inputs;
- Soil type and surficial geology; and
- Certain types of channel modifications by humans.

A reach map is provided in Appendix A. Only those reaches considered relevant to the proposed SWM plan were further assessed in the field.

3 Geomorphological Monitoring

The geomorphological monitoring program was created to characterize baseline conditions within the Matheson Creek subwatershed. The program follows an adaptive management approach within the context of the proposed stormwater outlets. As such, data collected will assist in identifying and mitigating any potential impacts to watercourses that may occur in relation to the proposed development.

Monitoring sites were established in Fall 2014. These monitoring sites were reassessed twice anually, in the Spring and Fall of 2015 and 2016. This report summarizes and compares all data spanning 2014 to 2016.

3.1 Monumented Cross Sections

Monumented cross sections were established and reassessed at each instream monitoring location. These locations include sites measured and characterized during prior detailed assessments and additional sites selected to provide a more robust and spatially varied characterization of the subwatersheds. A map of the monitoring locations is included in Appendix A.

Site selection was based on the background review completed in 2014. These locations were selected based on sensitivity of the watercourses, proximity to the proposed pond outlets and development areas, and to represent a range of environmental conditions that exist within the subcatchments. Property access was a contributing but not a limiting factor.

Monitoring sites were first established in the Fall of 2014. Site establishment included:

- Establishment and measurement of permanent monumented cross sections to assess changes in channel and bankfull geometry over time;

- Establishment of erosion pins at each cross sections (one in each bank) to assess erosion/deposition rates over time;
- Grain size analysis using the modified Wolman (1954) pebble count or a bed material sample at each monumented cross section to assess changes in substrate composition over time; and
- Monumented photographs at each cross section location.

Monumented cross sections involved the installation of permanent bank pins at two cross sections per monitoring location. Cross section location was chosen to monitor a variety of characteristic geomorphic environments, where they were present (i.e., riffles, pools, runs). During each monitoring event, cross sections were measured using a survey level from left to right bank pin while facing downstream.

All collected monitoring data are presented in the following appendices: a photographic record showing each cross section presented in Appendix B and a graphical representation of each monumented cross section geometry presented in Appendix D.

Reach MTS1 cross sections were unable to be surveyed in both spring and fall 2016 due to beaver dams causing flooding across the floodplain (photo 23 of Appendix B).

Reach MTS2-2 cross section upstream rebar had been removed due to the unchanging swale feature and this cross section did not re-establish.

Cross sections at reaches MTS2, MTS2-2, MTS3, and MTS3-d had little changes in bed and bank dimensions as observed in Appendix D. Fluctuations in bed dimensions were observed in cross sections at reaches MTN2, MTN3/4, and MTN3-C. More notably in cross section 3 of reach MTN3/4. The pool feature is infilling with sands.

3.1.1 Erosion Pins

Erosion pins were installed at each monitoring location in Fall of 2014. Two bank pins were installed at each monumented cross section: one on the right bank and one on the left bank.

Each erosion pin was installed by hammering a rebar into the lower section of the bank. Bank pin location was selected in areas of the bank that appeared sensitive to localized erosion or deposition. Once installed, a typical exposure length of 0.20 m was left as a baseline for future monitoring. Bank pins were measured again during each monitoring event.

Repeated measurements of erosion pins helps gauge baseline variability and note any changes in erosion or deposition over time. Progressive change in erosion or deposition may be indicative of localized geomorphic instability. In combination with other geomorphic measurements, this data may be used to infer larger scale geomorphic processes.

A tabular summary of changes in bank pin exposure are presented in Appendix E.

3.1.2 Substrate

Bed material sampling was completed at each monumented cross section using a modified Wolman (1954) pebble count technique, where applicable. For cross sections that contained fine substrate, such as sand or silts, a bed sample was collected and sent for laboratory analysis.

Median grain size grain size (D_{50}) as determined through pebble counts or sediment sample analysis represents the size of sediment that is transported during bankfull (channel forming) conditions. In terms of monitoring sediment data, a change in D_{50} over time may be indicative of

a change in localized flow conditions. In combination with other geomorphic parameters, this data may be used to infer changes in channel processes and stability over time.

A tabular summary of sediment data is presented in Appendix F.

3.2 Detailed Geomorphological Assessments

Detailed assessments were completed in 2014 at a selection of sites throughout the study area. Sites for the detailed assessments were selected in sensitive tributaries that were in proximity to the proposed outlet and to the development area. The detailed field assessments provide bankfull and bed slope, bank and bed sediment characteristics, cross sectional dimensions, and a visual assessment of channel roughness factors. Detailed assessments included the following observations:

- Longitudinal profile of the channel centre line;
- Eight (8) detailed cross sectional surveys across the watercourse;
- Two (2) monumented cross sections were installed and included erosion pins in both banks.
- Detailed instream measurements at each cross section location including bankfull channel geometry, riparian conditions, bank material, bank height/angle, and bank root density;
- Bed material sampling at each cross section following a modified Wolman's (1954) Pebble Count Technique or substrate sample; and
- Velocity, discharge and observations of active/inactive sediment transport at select representative cross sections.

Locations at which detailed assessments took place are provided in Appendix A. The two monumented cross sections installed at all detailed assessments were revisited and recorded with the monumented cross sections.

Detailed assessment summaries are provided in Appendix C.

4 Summary and Conclusions

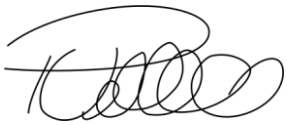
The Spring and Fall 2016 data show minor changes in channel conditions compared to those observed in the Spring and Fall of 2015 and in Fall 2014. A few cross-sections exhibited changes along the channel bed but minor changes within the banks. Erosion and deposition were generally recorded in the range of a few centimetres at several erosion pin locations.

Overall, the reaches have remained reasonably stable over the period of baseline monitoring. The slight variations documented are all within the natural variability of the system.

Further monitoring will be completed in Spring and Fall of 2017. Additional updates will be provided upon completion of 2017 monitoring activities.

We trust this report meets your requirements. Should you have any questions, please do not hesitate to contact the undersigned.

Respectfully submitted,



Paul Villard Ph.D., P.Geo., CAN-CISEC
Director, Principal Geomorphologist

Kat Woodrow, M.Sc.
Environmental Scientist

5 References

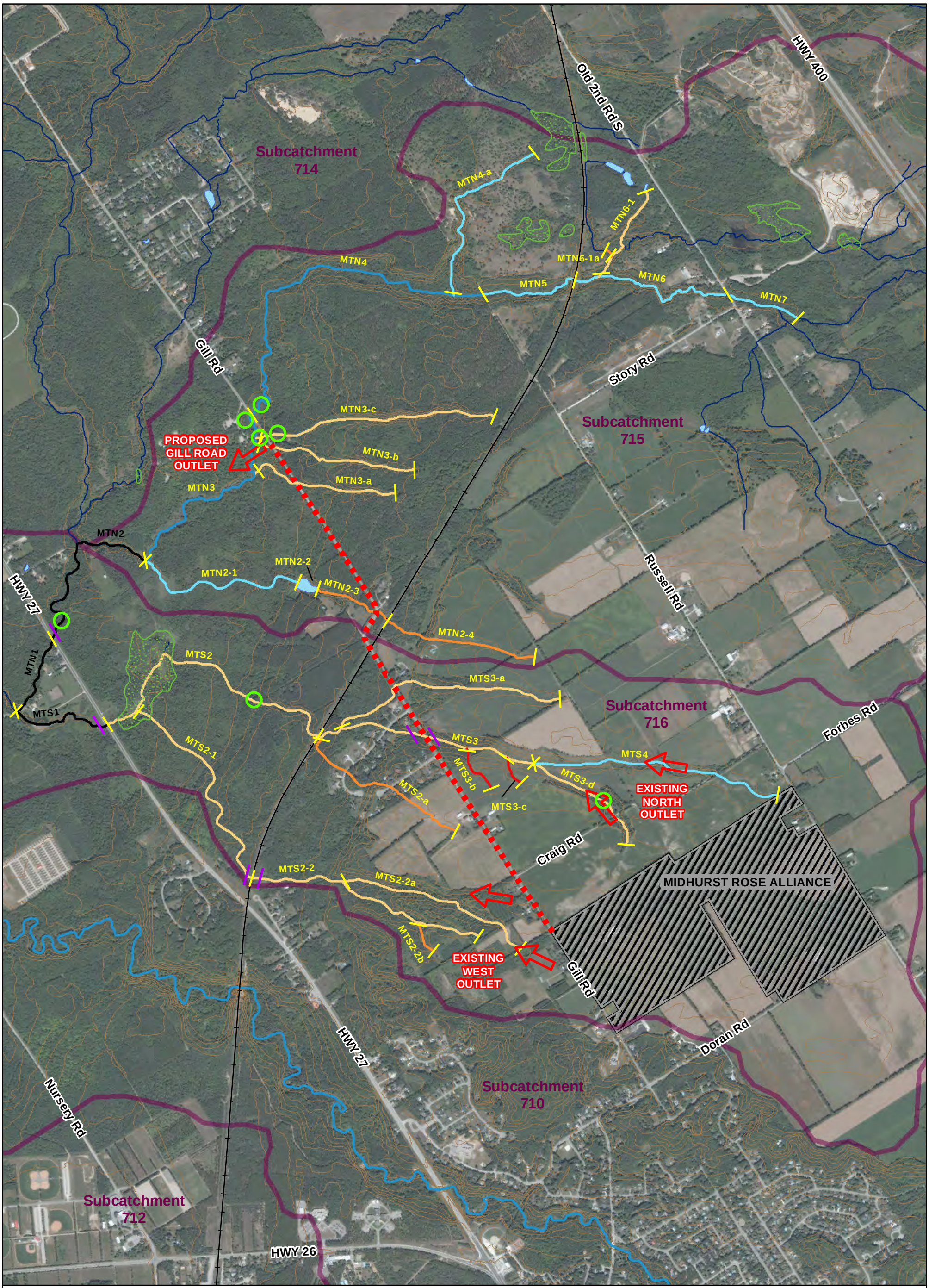
Chow, V.T. 1959. Open channel hydraulics. McGraw Hill, New York.

Julien, P.Y., and Klaassen, G.J. 1995. Sand-dune geometry of large rivers during floods. Journal of Hydrology, 53, 73-84.

Komar, P.D. 1987. Selective gravel entrainment and the empirical evaluation of flow competence. Sedimentology, 34: 1165-1176

Wolman, M.G. 1954. A method of sampling coarse river-bed material. Transactions of the American Geophysical Union, 35: 951-956.

Appendix A



LEGEND

- MTN2 — Reach break and label
- 5 m Contour
- Watercourse
- Waterbody
- Wetland
- Detailed site
- Cross-section site
- Proposed pipe and open ditch flow route

Reach Gradients (m/m)

- Insufficient contour detail
- 0.000000 - 0.005534
- 0.005535 - 0.019086
- 0.019087 - 0.032781
- 0.032782 - 0.058221
- 0.058222 - 0.113619

N

0 250 500

Metres

Baseline Monitoring Sites

Matheson Creek Tributaries

GEO MORPHIX

Geomorphology Earth Science Observations

Imagery: Google Earth Pro, 2006. Reach break and label, Monitoring sites, and Reach gradients: GEO Morphix Ltd., 2014. 5 m Contour: MNR, 2003. Proposed pipe and open ditch flow route, Proposed and existing outlets, and Midhurst Rose Alliance: C.F. Crozier & Associates Inc., 2014. Watercourse: County of Simcoe, 2014, and C.F. Crozier & Associates Inc., 2014. Waterbody and Wetland: County of Simcoe, 2014. Subcatchment boundary (approx.): Willow Creek Subwatershed Study, Willow Creek Sub-catchments, Map 6, NVCA, 2001.

Appendix B

Photo 1	
	Nov 12, 2014: Reach MTN2, cross-section 1 at a riffle. Photograph taken facing downstream.
Photo 2	
	Nov 5, 2015: Reach MTN2, cross-section 1 at a riffle. Photograph taken facing downstream.

Photo 3	
	Nov 16, 2016: Reach MTN2, cross-section 1 at a riffle. Photograph taken facing downstream.
Photo 4	
	Nov 13, 2014: Reach MTN2, cross-section 2 at a pool. Photograph taken facing upstream.

Photo 5	
	Nov 5, 2015: Reach MTN2, cross-section 2 at a pool. Photograph taken facing upstream.
Photo 6	
	Nov 16, 2016: Reach MTN2, cross-section 2 at a pool. Photograph taken facing upstream.

Photo 7	
	Nov 25, 2014: Reach MTN3, cross-section 2 at a run. Photograph taken facing the left bank.
Photo 8	
	Nov 5, 2015: Reach MTN3, cross-section 2 at a run. Photograph taken facing upstream.

Photo 9	
	Nov 16, 2016: Reach MTN3, cross-section 2 at a run. Photograph taken facing upstream.
Photo 10	
	Nov 5, 2015: Reach MTN3, cross-section 3 at a pool. Photograph taken facing upstream.

Photo 11	
	Nov 25, 2014: Reach MTN3, cross-section 3 at a pool. Photograph taken facing the left bank.
Photo 12	
	Nov 16, 2016: Reach MTN3, cross-section 3 at a pool. Photograph taken facing the left bank.

Photo 13	
	Nov 14, 2014: Reach MTN3-c, cross-section 6 at a riffle. Photograph taken facing downstream.
Photo 14	
	Nov 5, 2015: Reach MTN3-c, cross-section 6 at a riffle. Photograph taken facing downstream.

Photo 15	
	Nov 16, 2016: Reach MTN3-c, cross-section 6 at a riffle. Photograph taken facing downstream.
Photo 16	
	Nov 14, 2014: Reach MTN3-c, cross-section 5 at a pool. Photograph taken facing downstream.

Photo 17	
	Nov 5, 2015: Reach MTN3-c, cross-section 5 at a pool. Photograph taken facing downstream.
Photo 18	
	Nov 16, 2016: Reach MTN3-c, cross-section 5 at a pool. Photograph taken facing downstream.

Photo 19	
	Nov 13, 2014: Reach MTS1, upstream cross-section at a riffle. Photograph taken facing upstream.
Photo 20	
	Nov 6, 2015: Reach MTS1, upstream cross-section at a riffle. Photograph taken facing upstream. New beaver dam downstream caused backwatering.

Photo 21	
	Nov 13, 2014: Reach MTS1, downstream cross-section at a pool. Photograph taken facing downstream.
Photo 22	
	Nov 6, 2015: Reach MTS1, downstream cross-section at a pool. Photograph taken facing downstream. New beaver dam downstream caused backwatering.

Photo 23	
	Nov 16, 2016: Reach MTS1 Photograph showing extensive backwatering due to beaver dam downstream.
Photo 24	
	Nov 25, 2014: Reach MTS2, cross-section 4 at a riffle. Photograph taken facing upstream.

Photo 25	
	Nov 5, 2015: Reach MTS2, cross-section 4 at a riffle. Photograph taken facing upstream.
Photo 26	
	Nov 16, 2016: Reach MTS2, cross-section 4 at a riffle. Photograph taken facing upstream.

Photo 27	
	Nov 25, 2014: Reach MTS2, cross-section 5 at a pool. Photograph taken facing upstream.
Photo 28	
	Nov 5, 2015: Reach MTS2, cross-section 5 at a pool. Photograph taken facing upstream.

Photo 29	
	Nov 16, 2016: Reach MTS2, cross-section 5 at a pool. Photograph taken facing upstream.
Photo 30	
	Nov 20, 2014: Reach MTS2-2, cross-section downstream of rail crossing. Photograph taken facing upstream.

Photo 31	
	Nov 5, 2015: Reach MTS2-2, cross-section downstream of rail crossing. Photograph taken facing the right bank.
Photo 32	
	Nov 16, 2016: Reach MTS2-2, cross-section downstream of rail crossing. Photograph taken facing upstream.

Photo 33	
	Nov 20, 2014: Reach MTS2-2, cross-section upstream of rail crossing. Photograph taken facing downstream.
Photo 34	
	Nov 5, 2015: Reach MTS2-2, cross-section upstream of rail crossing. Photograph taken facing downstream.

Photo 35	
	Nov 20, 2014: Reach MTS3, cross-section upstream of road crossing. Photograph taken facing downstream.
Photo 36	
	Nov 5, 2015: Reach MTS3, cross-section upstream of road crossing. Photograph taken facing downstream.

Photo 37	
	Nov 16, 2016: Reach MTS3, cross-section upstream of road crossing. Photograph taken facing downstream.
Photo 38	
	Nov 20, 2014: Reach MTS3, cross-section downstream of road crossing. Photograph taken facing the left bank.

Photo 39	
	Nov 5, 2015: Reach MTS3, cross-section downstream of road crossing. Photograph taken facing the left bank.
Photo 40	
	Nov 16, 2016: Reach MTS3, cross-section downstream of road crossing. Photograph taken facing the left bank.

Photo 41	
	Nov 12, 2014: Reach MTS3-d, cross-section 2 at a pool. Photograph taken facing downstream.
Photo 42	
	Nov 6, 2015: Reach MTS3-d, cross-section 2 at a pool. Photograph taken facing downstream.

Photo 43	
	Nov 16, 2016: Reach MTS3-d, cross-section 2 at a pool. Photograph taken facing downstream.
Photo 44	
	Nov 13, 2014: Reach MTS3-d, cross-section 6 at a riffle. Photograph taken facing downstream.

Photo 45	
	Nov 6, 2015: Reach MTS3-d, cross-section 6 at a riffle. Photograph taken facing downstream.
Photo 46	
	Nov 16, 2016: Reach MTS3-d, cross-section 6 at a riffle. Photograph taken facing downstream.

Appendix C

Detailed Geomorphological Assessment Summary

Project Number:	PN14026a	**Date:**	November 11, 2014
Client:	Midhurst Rose Alliance Inc.	**Length Surveyed (m):**	105.8
Location:	MTN2, Matheson Crk, Midhurst, ON	**# of Cross-Sections:**	8

Reach Characteristics

Drainage Area:	N/A	**Dominant Riparian Vegetation Type:**	Trees and shrubs
Geology/Soils:	Glaciolacustrine deposits	**Extent of Riparian Cover:**	Continuous
Surrounding Land Use:	Agricultural	**Width of Riparian Cover (m):**	>10 channel widths
Valley Type:	Partially confined	**Age Class of Riparian Vegetation:**	Mature (>30 yrs)
Dominant Instream Vegetation Type:	None	**Extent of Encroachment into Channel:**	Minimal
Portion of Reach with Vegetation:	N/A	**Density of Woody Debris:**	Moderate

Hydrology

Measured Discharge (m^3/s):	1.13	**Calculated Bankfull Discharge (m^3/s):**	12.15
Modeled 2-year Discharge (m^3/s):	Not modelled	**Calculated Bankfull Velocity (m/s):**	1.27
Modeled 2-year Velocity (m/s):	Not modelled		

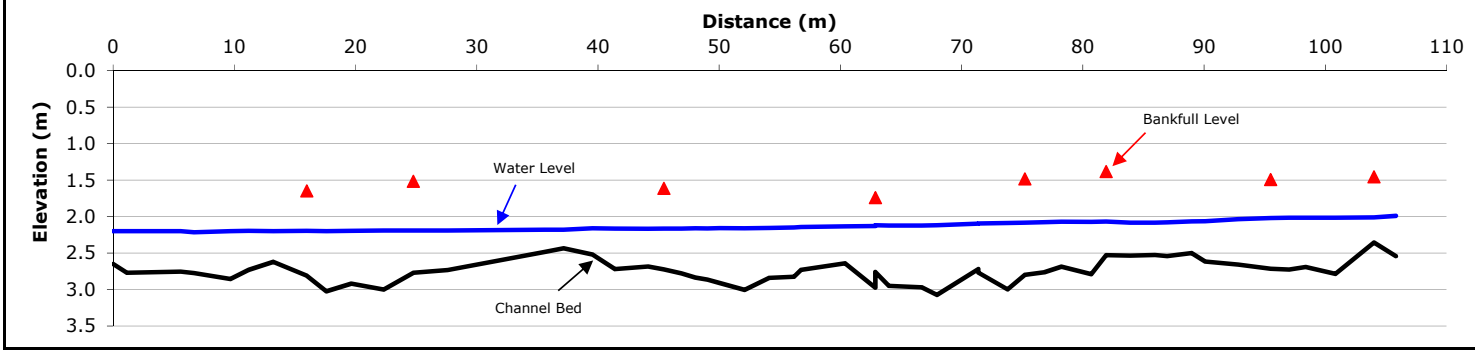
Profile Characteristics

Bankfull Gradient (%):	0.20
Channel Bed Gradient (%):	0.20
Riffle Gradient (%):	3.48
Riffle Length (m):	3.09
Riffle-Pool Spacing (m):	3.84

Planform Characteristics

Sinuosity:	1.21
Meander Belt Width (m):	Not measured
Radius of Curvature (m):	Not measured
Meander Amplitude (m):	Not measured
Meander wavelength (m):	Not measured

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	0.50	1.10	0.75
Bank Angle (deg):	45	90	78
Root Depth (m):	0.05	0.60	0.24
Root Density (%):	5	60	25
Bank Undercut (m):	0.05	0.50	0.26

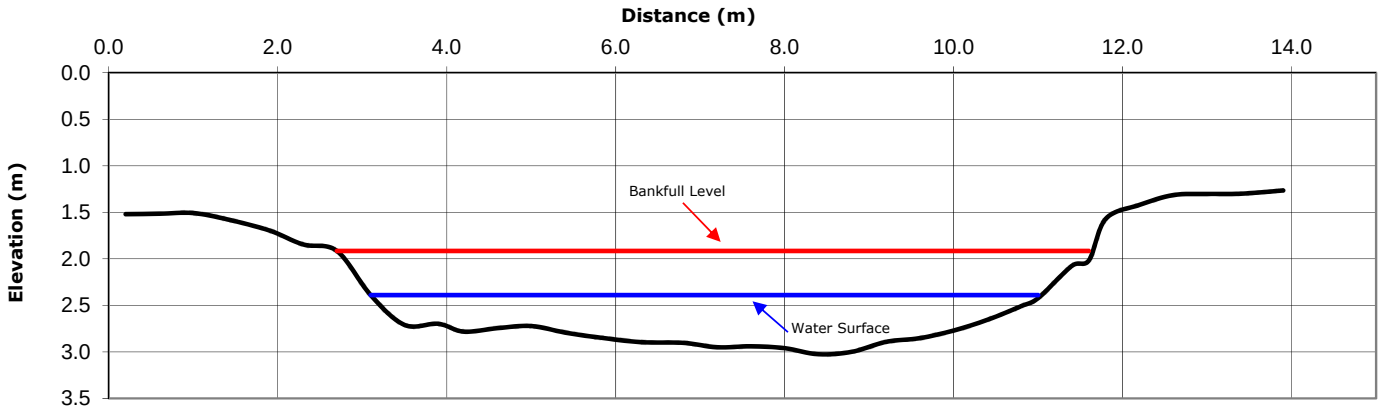
	Minimum	Maximum	Average
Torvane Value (kg/cm^2):		Not measured	
Penetrometer Value (kg/cm^3):		Not measured	
Bank Material (range):		Clay to coarse sand	

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	8.05	12.20	9.61
Average Bankfull Depth (m):	0.84	1.18	0.99
Bankfull Width/Depth (m/m):	8	12	10
Wetted Width (m):	6.90	11.35	8.70
Average Water Depth (m):	0.39	0.57	0.46
Wetted Width/Depth (m/m):	12	26	19
Entrenchment (m):		Not measured	
Entrenchment Ratio (m/m):		Not measured	
Maximum Water Depth (m):	0.51	0.89	0.73
Manning's n:		0.035	

Photograph of cross section 3 (looking upstream)

Representative Cross-Section 4

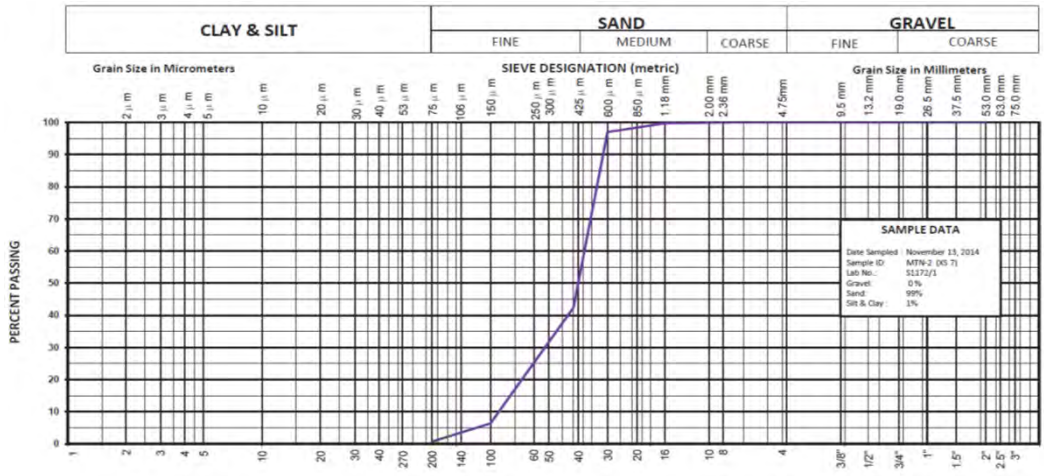


Substrate Characteristics

Particle Size (mm)

D_{10} :	0.170
D_{50} :	0.425
D_{84} :	0.580

Subpavement:	Coarse sand
Particle shape:	N/A: fines only
Embeddedness (%):	N/A: fines only
Particle range (run):	Coarse sand



Samples were taken and analyzed by SHAD and Associtates Inc.

Channel Thresholds

Flow Competency (m/s):		**Tractive Force at Bankfull (N/m^2):**	19.50
for D_{50}:	N/A	**Tractive Force at 2-year flow (N/m^2):**	Not modelled
for D_{84}:	N/A	**Critical Shear Stress (D_{50}) (N/m^2):**	0.31
Unit Stream Power at Bankfull (W/m^2):	24.81		

General Field Observations

Channel Description

This reach assessment was completed upstream of Highway 27. The creek was confined with a valley wall contact along the left bank throughout the reach. Riparian vegetation consisted of a mixture of grasses, shrubs, and mature trees. The reach bed and banks consisted mainly of sand throughout. There was no riffle-pool development. Instream vegetation was not present. Average channel bankfull width and depth were 9.61 m and 0.99 m, respectively. Channel banks displayed signs of instability (e.g., recent slumping or failure). The channel was characterized by multiple woody debris jams with approximately one debris jam every 15 m.

Cross Section 4 - Looking Upstream

Detailed Geomorphological Assessment Summary

Project Number:	PN14026a	**Date:**	November 26, 2014
Client:	Midhurst Rose Alliance Inc.	**Length Surveyed (m):**	92
Location:	MTN3&4, Matheson Crk, Midhurst	**# of Cross-Sections:**	8

Reach Characteristics

Drainage Area:	N/A	**Dominant Riparian Vegetation Type:**	Grasses and trees
Geology/Soils:	Glaciolacustrine deposits	**Extent of Riparian Cover:**	Continuous
Surrounding Land Use:	Forest	**Width of Riparian Cover (m):**	>10 channel widths
Valley Type:	Unconfined	**Age Class of Riparian Vegetation:**	Immature (<5 yrs)
Dominant Instream Vegetation Type:	Grasses	**Extent of Encroachment into Channel:**	Minimal
Portion of Reach with Vegetation:	<10%	**Density of Woody Debris:**	Low

Hydrology

Measured Discharge (m^3/s):	0.30	**Calculated Bankfull Discharge (m^3/s):**	2.47
Modeled 2-year Discharge (m^3/s):	Not modelled	**Calculated Bankfull Velocity (m/s):**	1.42
Modeled 2-year Velocity (m/s):	Not modelled		

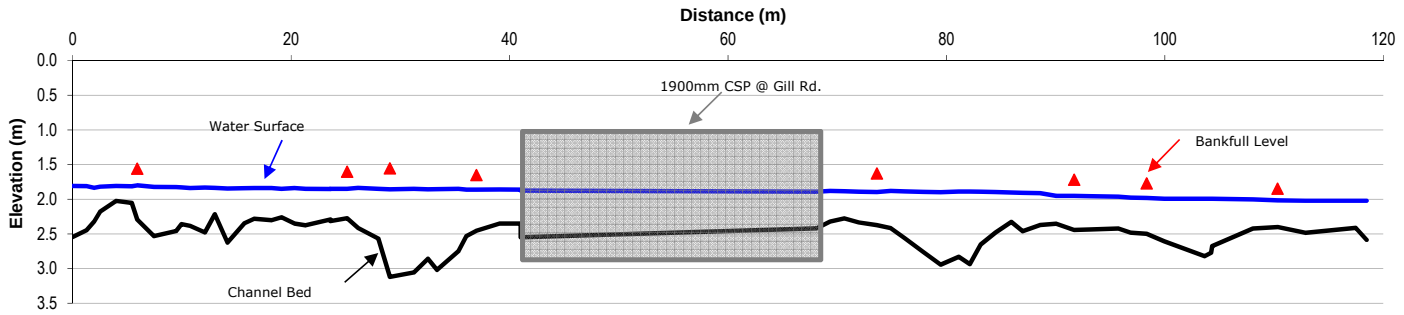
Profile Characteristics

Bankfull Gradient (%):	0.45
Channel Bed Gradient (%):	0.58
Riffle Gradient (%):	3.36
Riffle Length (m):	4.22
Riffle-Pool Spacing (m):	7.78

Planform Characteristics

Sinuosity:	1.44
Meander Belt Width (m):	Not measured
Radius of Curvature (m):	Not measured
Meander Amplitude (m):	Not measured
Meander wavelength (m):	Not measured

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	0.40	1.00	0.61
Bank Angle (deg):	90	90	90
Root Depth (m):	0.10	0.40	0.16
Root Density (%):	10	100	67
Bank Undercut (m):	0.05	0.20	0.04

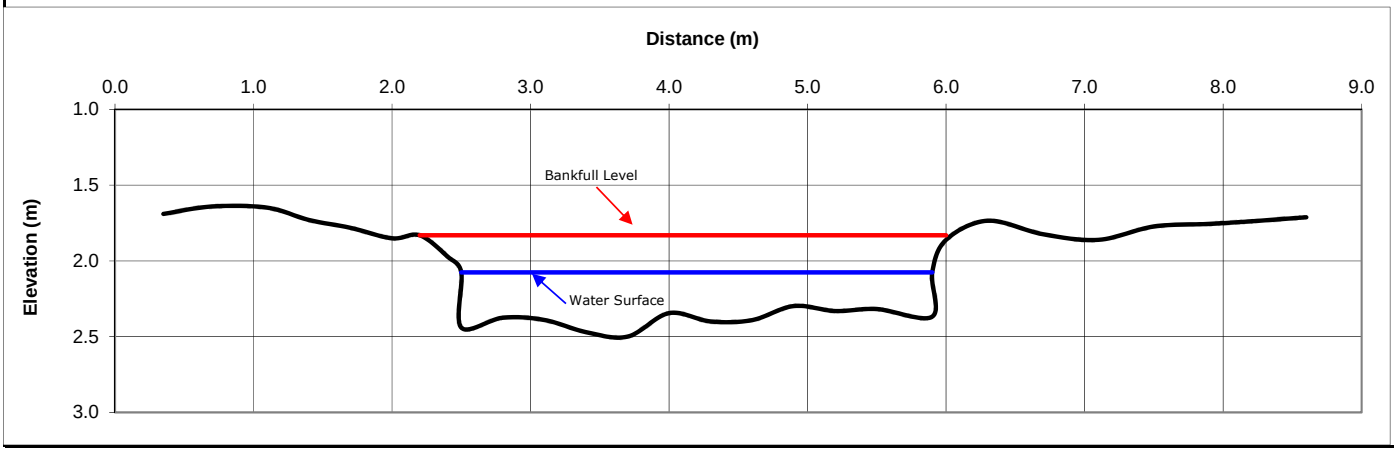
	Minimum	Maximum	Average
Torvane Value (kg/cm^2):		Not measured	
Penetrometer Value (kg/cm^3):		Not measured	
Bank Material (range):		Clay to coarse sand	

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	2.30	3.80	2.84
Average Bankfull Depth (m):	0.44	0.91	0.55
Bankfull Width/Depth (m/m):	2.54	8.27	5.61
Wetted Width (m):	2.05	3.10	2.51
Average Water Depth (m):	0.26	0.83	0.45
Wetted Width/Depth (m/m):	2.59	11.31	6.72
Entrenchment (m):		Not measured	
Entrenchment Ratio (m/m):		Not measured	
Maximum Water Depth (m):	0.43	1.29	0.60
Manning's n:		0.030	

Photograph of cross section 8 (looking downstream)

Representative Cross-Section 8

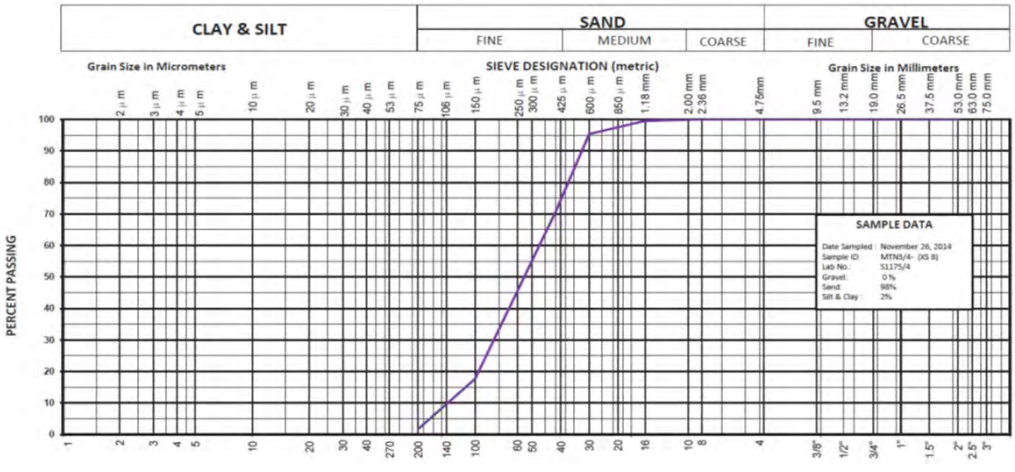


Substrate Characteristics

Particle Size (mm)

D_{10} :	0.106
D_{50} :	0.275
D_{84} :	0.550

Subpavement:	Sand
Particle shape:	N/A: only fines
Embeddedness (%):	N/A: only fines
Particle range (run):	Sand to coarse sand



Samples were taken and analyzed by SHAD and Associtates Inc.

Channel Thresholds

Flow Competency (m/s):		**Tractive Force at Bankfull (N/m^2):**	22.40
for D_{50}:	0.27	**Tractive Force at 2-year flow (N/m^2):**	Not modelled
for D_{84}:	0.27	**Critical Shear Stress (D_{50}) (N/m^2):**	1.46
Unit Stream Power at Bankfull (W/m^2):	31.88		

General Field Observations

Channel Description

This reach demonstrated a high-sinuosity and was a sand dominated system. The reach bed and banks consisted mainly of sand throughout. Some instream grasses were present. Riparian vegetation included grasses and immature trees. Average channel bankfull widths and depths were 2.84 m and 0.55 m, respectively. There was poor riffle-pool formation. Only one riffle was noted downstream of the CSP at Gill Road. Evidence of active sediment transport included fine-coarse sand saltation. The reach exhibited near bankfull conditions during the time of the site visit, as a result of snowmelt.

Cross Section 4 - Looking Downstream

Detailed Geomorphological Assessment Summary

Project Number:	PN14026a	**Date:**	November 11, 2014
Client:	Midhurst Rose Alliance Inc.	**Length Surveyed (m):**	65
Location:	MTS3-d, Matheson Crk, Midhurst, ON	**# of Cross-Sections:**	8

Reach Characteristics

Drainage Area:	N/A	**Dominant Riparian Vegetation Type:**	Trees and shrubs
Geology/Soils:	Older alluvial deposits & till	**Extent of Riparian Cover:**	Continuous
Surrounding Land Use:	Forest and agricultural	**Width of Riparian Cover (m):**	>10 channel widths
Valley Type:	Partially confined	**Age Class of Riparian Vegetation:**	Immature (>5 yrs)
Dominant Instream Vegetation Type:	Grasses	**Extent of Encroachment into Channel:**	Minimal
Portion of Reach with Vegetation:	10%	**Density of Woody Debris:**	Low

Hydrology

Measured Discharge (m^3/s):	N/A: no water	**Calculated Bankfull Discharge (m^3/s):**	0.15
Modeled 2-year Discharge (m^3/s):	Not modelled	**Calculated Bankfull Velocity (m/s):**	0.98
Modeled 2-year Velocity (m/s):	Not modelled		

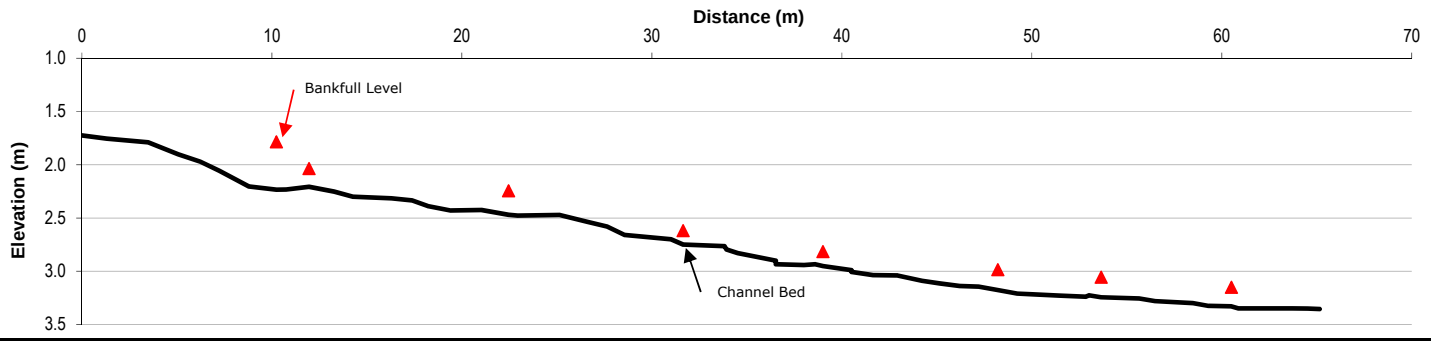
Profile Characteristics

Bankfull Gradient (%):	2.04
Channel Bed Gradient (%):	2.51
Riffle Gradient (%):	N/A: no riffles
Riffle Length (m):	N/A: no riffles
Riffle-Pool Spacing (m):	N/A: no riffle-pool spacing

Planform Characteristics

Sinuosity:	1.01
Meander Belt Width (m):	Not measured
Radius of Curvature (m):	Not measured
Meander Amplitude (m):	Not measured
Meander wavelength (m):	Not measured

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	0.20	0.30	0.23
Bank Angle (deg):	15	30	23
Root Depth (m):	0.00	0.05	0.03
Root Density (%):	0	10	3
Bank Undercut (m):		No undercuts	

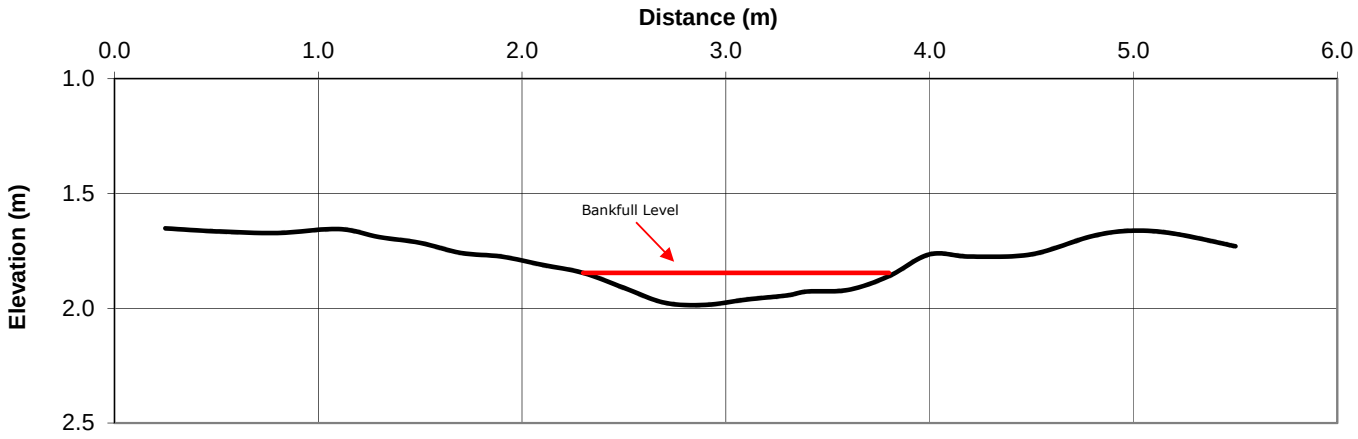
	Minimum	Maximum	Average
Torvane Value (kg/cm^2):		Not measured	
Penetrometer Value (kg/cm^3):		Not measured	
Bank Material (range):		Clay to gravel	

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	1.40	2.40	1.97
Average Bankfull Depth (m):	0.09	0.16	0.12
Bankfull Width/Depth (m/m):	12.80	22.10	16.80
Wetted Width (m):		No water	
Average Water Depth (m):		No water	
Wetted Width/Depth (m/m):		No water	
Entrenchment (m):		Not measured	
Entrenchment Ratio (m/m):		Not measured	
Maximum Water Depth (m):		No water	
Manning's n:		0.035	

Photograph of cross section 1 (looking downstream)

Representative Cross-Section 1



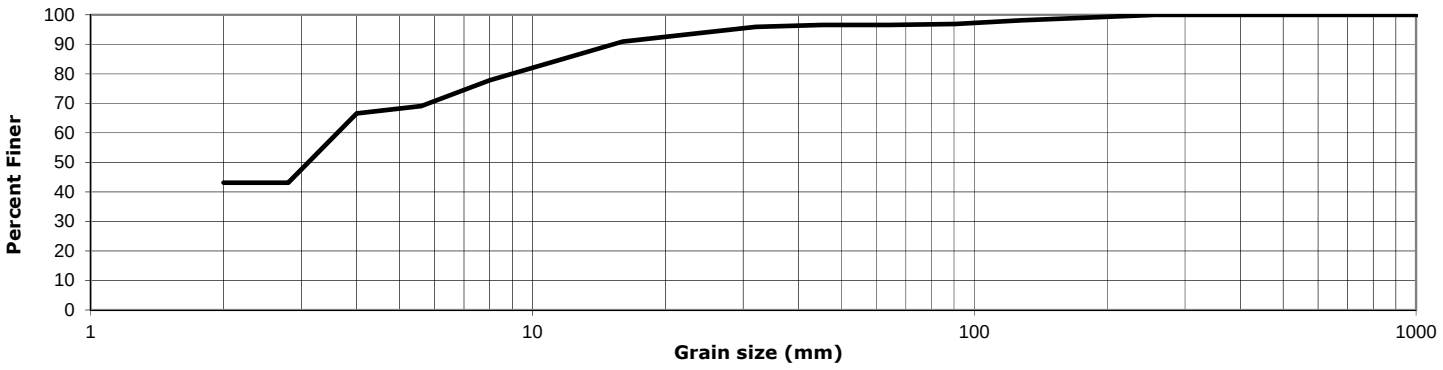
Substrate Characteristics

Particle Size (mm)

D_{10} :	<2.0
D_{50} :	3.1
D_{90} :	16.0

Subpavement:	Sand
Particle shape:	Sub-angular to sub-rounded
Embeddedness (%):	95
Particle range (run):	Sand to cobbles

Cumulative Particle Size Distribution



Channel Thresholds

Flow Competency (m/s):		**Tractive Force at Bankfull (N/m^2):**	24.62
for D_{50}:	0.33	**Tractive Force at 2-year flow (N/m^2):**	Not modelled
for D_{84}:	0.60	**Critical Shear Stress (D_{50}) (N/m^2):**	2.26
Unit Stream Power at Bankfull (W/m^2):	24.00		

General Field Observations

Channel Description

The reach was unconfined and fairly straight. There was no water in the channel at the time of assessment. No apparent riffle-pool features were noted. The channel was intermittently defined. Riparian vegetation was wide and included shrubs and immature trees. Average channel bankfull width and depth were 2.0 m and 0.1 m, respectively. Substrate consisted of sand to large cobbles. No erosion was observed. The portion of the reach upstream of Craig Road was poorly defined.

Cross Section 7 - Looking Downstream

Detailed Geomorphological Assessment Summary

Project Number:	PN14026a	**Date:**	November 24, 2014
Client:	Midhurst Rose Alliance Inc.	**Length Surveyed (m):**	93
Location:	MTN3-c, Matheson Crk, Midhurst, ON	**# of Cross-Sections:**	8

Reach Characteristics

Drainage Area:	N/A	**Dominant Riparian Vegetation Type:**	Grasses and trees
Geology/Soils:	Glaciolacustrine deposits	**Extent of Riparian Cover:**	Continuous
Surrounding Land Use:	Forest	**Width of Riparian Cover (m):**	>10 channel widths
Valley Type:	Partially confined	**Age Class of Riparian Vegetation:**	Established (5-30 yrs)
Dominant Instream Vegetation Type:	None	**Extent of Encroachment into Channel:**	Minimal
Portion of Reach with Vegetation:	N/A	**Density of Woody Debris:**	Low

Hydrology

Measured Discharge (m^3/s):	0.11	**Calculated Bankfull Discharge (m^3/s):**	0.85
Modeled 2-year Discharge (m^3/s):	Not modelled	**Calculated Bankfull Velocity (m/s):**	1.12
Modeled 2-year Velocity (m/s):	Not modelled		

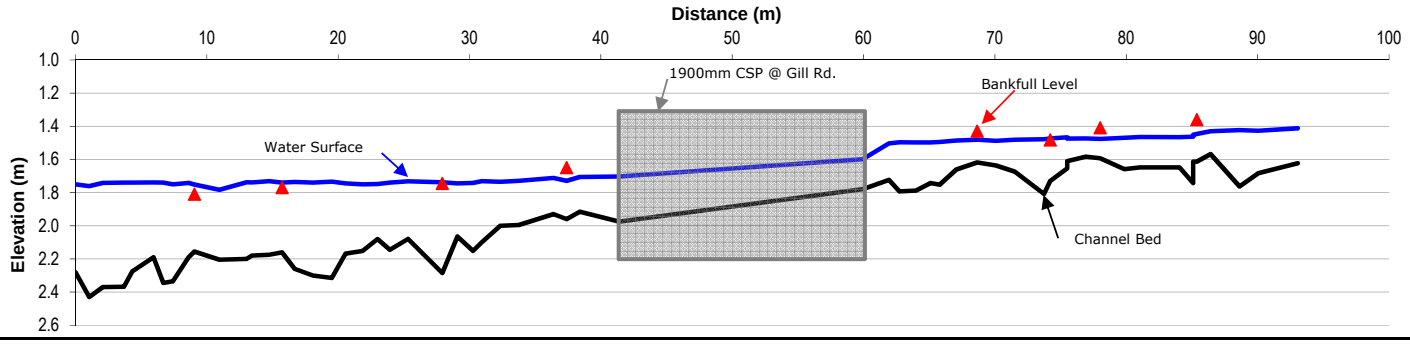
Profile Characteristics

Bankfull Gradient (%):	0.49
Channel Bed Gradient (%):	0.71
Riffle Gradient (%):	N/A: no riffles
Riffle Length (m):	N/A: no riffles
Riffle-Pool Spacing (m):	N/A: No riffle-pool spacing

Planform Characteristics

Sinuosity:	1.06
Meander Belt Width (m):	Not measured
Radius of Curvature (m):	Not measured
Meander Amplitude (m):	Not measured
Meander wavelength (m):	Not measured

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	0.10	0.70	0.28
Bank Angle (deg):	30	90	63
Root Depth (m):	0.00	0.15	0.08
Root Density (%):	0	100	30
Bank Undercut (m):		No undercuts	

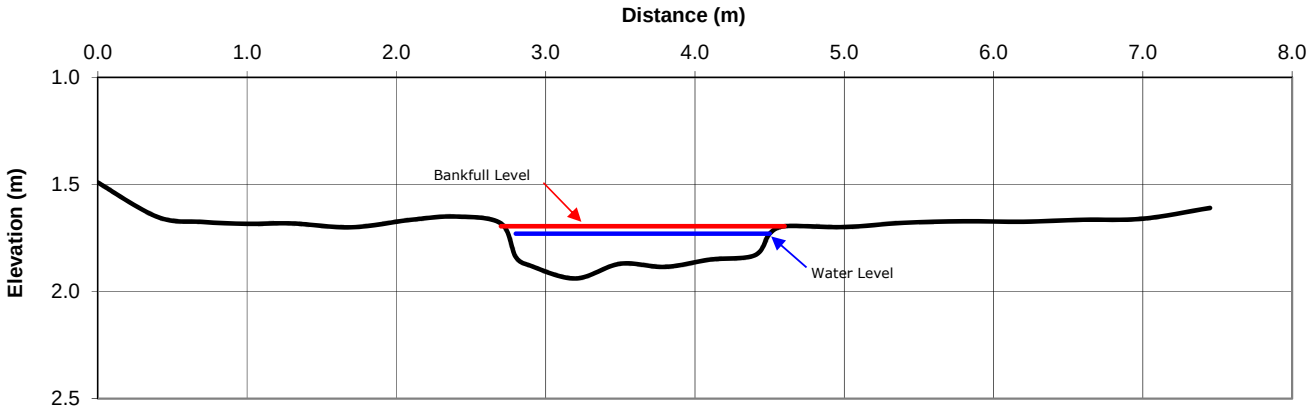
	Minimum	Maximum	Average
Torvane Value (kg/cm^2):		Not measured	
Penetrometer Value (kg/cm^3):		Not measured	
Bank Material (range):		Clay to sand	

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	1.50	3.90	2.37
Average Bankfull Depth (m):	0.13	0.34	0.25
Bankfull Width/Depth (m/m):	6	19	10
Wetted Width (m):	1.50	4.10	2.67
Average Water Depth (m):	0.09	0.34	0.20
Wetted Width/Depth (m/m):	8	22	14
Entrenchment (m):		Not measured	
Entrenchment Ratio (m/m):		Not measured	
Maximum Water Depth (m):	0.14	0.56	0.33
Manning's n:		0.030	

Photograph of cross section 5 (looking upstream)

Representatve Cross-Section 5

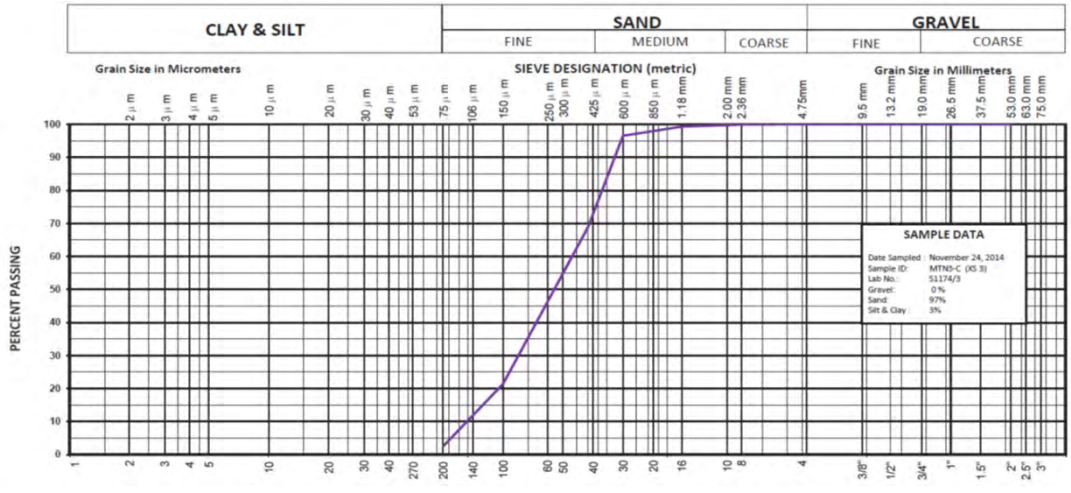


Substrate Characteristics

Particle Size (mm)

D_{10} :	0.100
D_{50} :	0.270
D_{84} :	0.550

Subpavement:	Coarse sand
Particle shape:	N/A: fines only
Embeddedness (%):	N/A: fines only
Particle range (run):	Sand to gravel



Samples were taken and analyzed by SHAD and Associtates Inc.

Channel Thresholds

Flow Competency (m/s):		**Tractive Force at Bankfull (N/m^2):**	15.91266252
for D_{50}:	N/A	**Tractive Force at 2-year flow (N/m^2):**	Not modelled
for D_{84}:	N/A	**Critical Shear Stress (D_{50}) (N/m^2):**	196.67
Unit Stream Power at Bankfull (W/m^2):	17.75		

General Field Observations

Channel Description

Water levels were at bankfull at the time of the survey and the floodplain was saturated as a result of recent snowmelt. This reach displayed a high-sinuosity and sand-dominated system. The riparian buffer zone was wide and the vegetation included grasses and trees. Average channel bankfull width and depth were 2.37 m and 0.25 m, respectively. Active sediment transport was noted in the form of sand saltation was observed at the time of assessment. Little to no bank erosion was observed.

Cross Section 7 - Looking Downstream

Detailed Geomorphological Assessment Summary

Project Number:	PN14026a	**Date:**	Novemeber 25, 2014
Client:	Midhurst Rose Alliance Inc.	**Length Surveyed (m):**	74
Location:	MTS2, Matheson Crk, Midhurst, ON	**# of Cross-Sections:**	8

Reach Characteristics

Drainage Area:	N/A	**Dominant Riparian Vegetation Type:**	Trees
Geology/Soils:	Glaciolacustrine deposits	**Extent of Riparian Cover:**	Continuous
Surrounding Land Use:	Forest	**Width of Riparian Cover (m):**	>10 channel widths
Valley Type:	Unconfined	**Age Class of Riparian Vegetation:**	Mature (>30 yrs)
Dominant Instream Vegetation Type:	None	**Extent of Encroachment into Channel:**	Minimal
Portion of Reach with Vegetation:	N/A	**Density of Woody Debris:**	Low

Hydrology

Measured Discharge (m^3/s):	0.01	**Calculated Bankfull Discharge (m^3/s):**	1.22
Modeled 2-year Discharge (m^3/s):	Not modelled	**Calculated Bankfull Velocity (m/s):**	1.56
Modeled 2-year Velocity (m/s):	Not modelled		

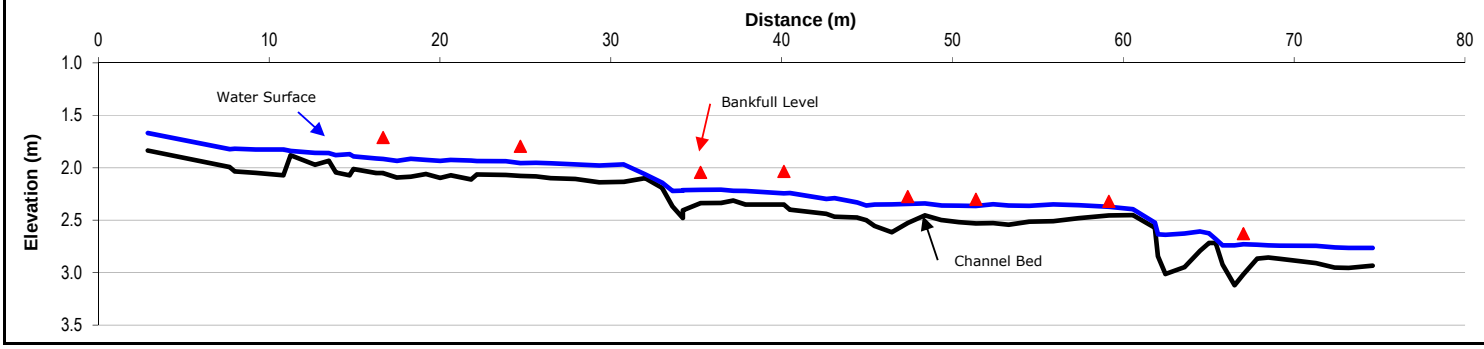
Profile Characteristics

Bankfull Gradient (%):	1.74
Channel Bed Gradient (%):	1.56
Riffle Gradient (%):	1.22
Riffle Length (m):	5.88
Riffle-Pool Spacing (m):	6.30

Planform Characteristics

Sinuosity:	1.14
Meander Belt Width (m):	Not measured
Radius of Curvature (m):	Not measured
Meander Amplitude (m):	Not measured
Meander wavelength (m):	Not measured

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	0.10	1.00	0.45
Bank Angle (deg):	15	60	41
Root Depth (m):	0.00	0.10	0.04
Root Density (%):	0	10	5
Bank Undercut (m):		0.05	

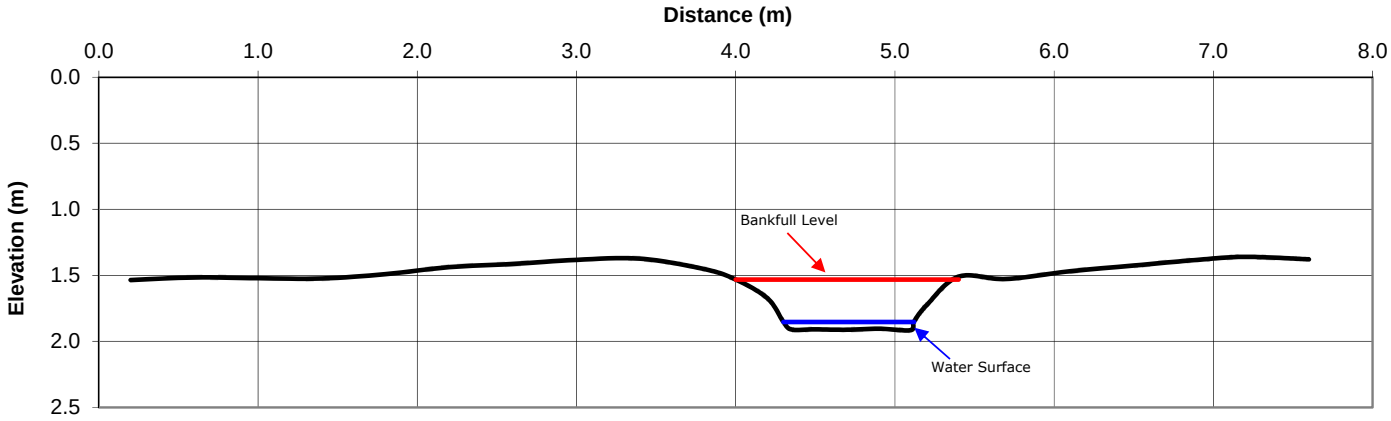
	Minimum	Maximum	Average
Torvane Value (kg/cm^2):		Not measured	
Penetrometer Value (kg/cm^3):		Not measured	
Bank Material (range):		Clay to coarse sand	

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	0.90	2.10	1.32
Average Bankfull Depth (m):	0.08	0.32	0.20
Bankfull Width/Depth (m/m):	4	11	7
Wetted Width (m):	0.60	1.82	0.94
Average Water Depth (m):	0.06	0.41	0.12
Wetted Width/Depth (m/m):	5	14	9
Entrenchment (m):		Not measured	
Entrenchment Ratio (m/m):		Not measured	
Maximum Water Depth (m):	0.06	0.20	0.14
Manning's n:		0.030	

Photograph of cross section 4 (looking upstream)

Representative Cross-Section 4



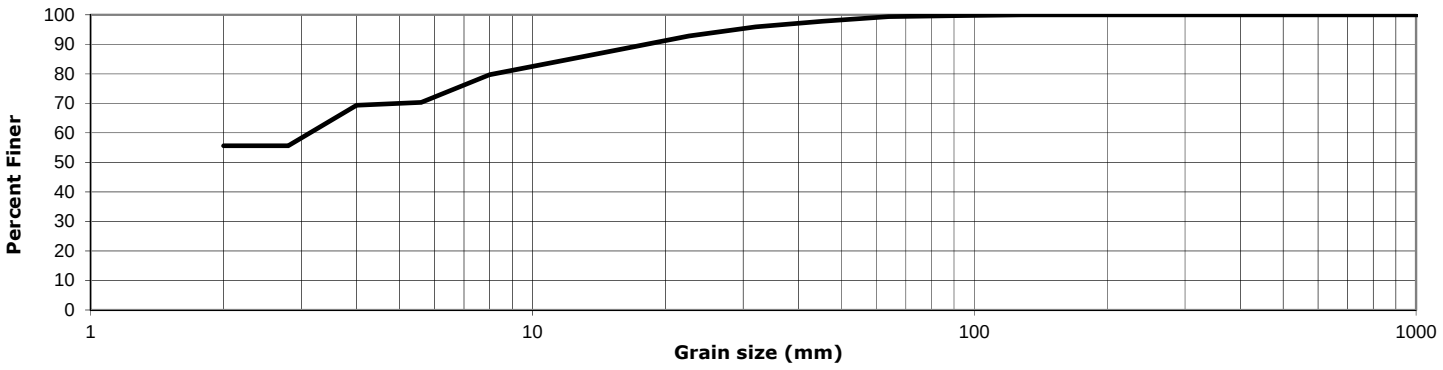
Substrate Characteristics

Particle Size (mm)

D_{10} :	<1.0
D_{50} :	1.0
D_{90} :	19.0

Subpavement:	Silt, sand, and till
Particle shape:	Angular to sub-rounded
Embeddedness (%):	40 to 80
Particle range (riffle):	Sand to cobbles
Particle Range (pool):	Silt and sand

Cumulative Particle Size Distribution



Channel Thresholds

Flow Competency (m/s):		**Tractive Force at Bankfull (N/m^2):**	35.20
for D_{50}:	0.20	**Tractive Force at 2-year flow (N/m^2):**	Not modelled
for D_{84}:	0.60	**Critical Shear Stress (D_{50}) (N/m^2):**	0.73
Unit Stream Power at Bankfull (W/m^2):	54.99		

General Field Observations

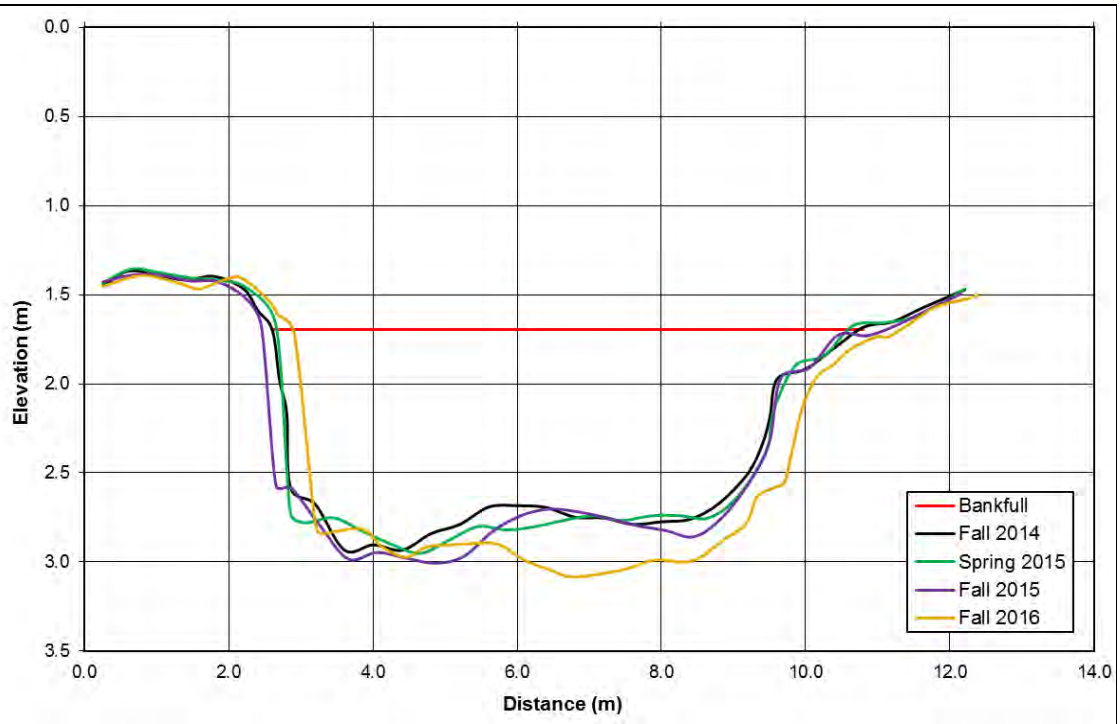
Channel Description

This reach displayed a low-sinuosity and sand dominated system. The channel was unconfined with a low sinuosity and moderate gradient. The riparian buffer zone was wide consisted of mature trees. Riffle-pool formation was present. Riffle substrate consisted of sand, gravel, and small cobbles. Pool substrate consisted of silt and sand. Instream vegetation was not present. Average channel bankfull width and depth were 1.32 m and 0.20 m, respectively. Roots were exposed in the banks. One undercut was measured at 0.05 m. Three knickpoints were noted in the surveyed section of channel with heights of 0.19 m, 0.20 m, and 0.27 m.

Cross Section 2 - Looking Downstream

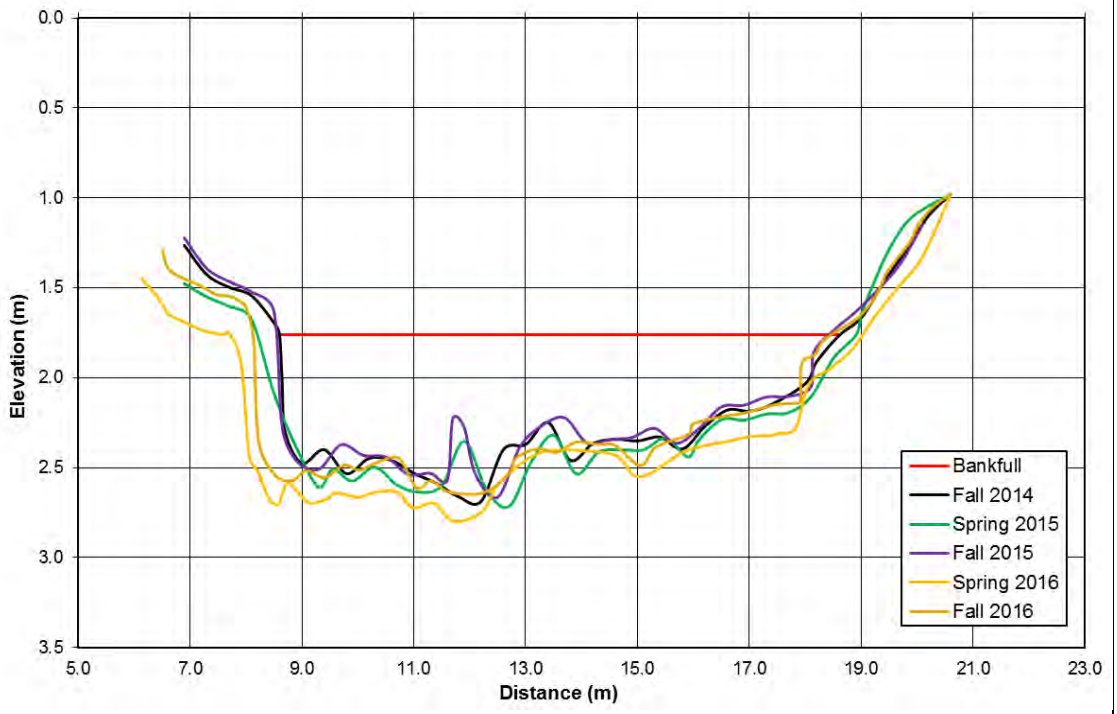
Appendix D

Figure 1



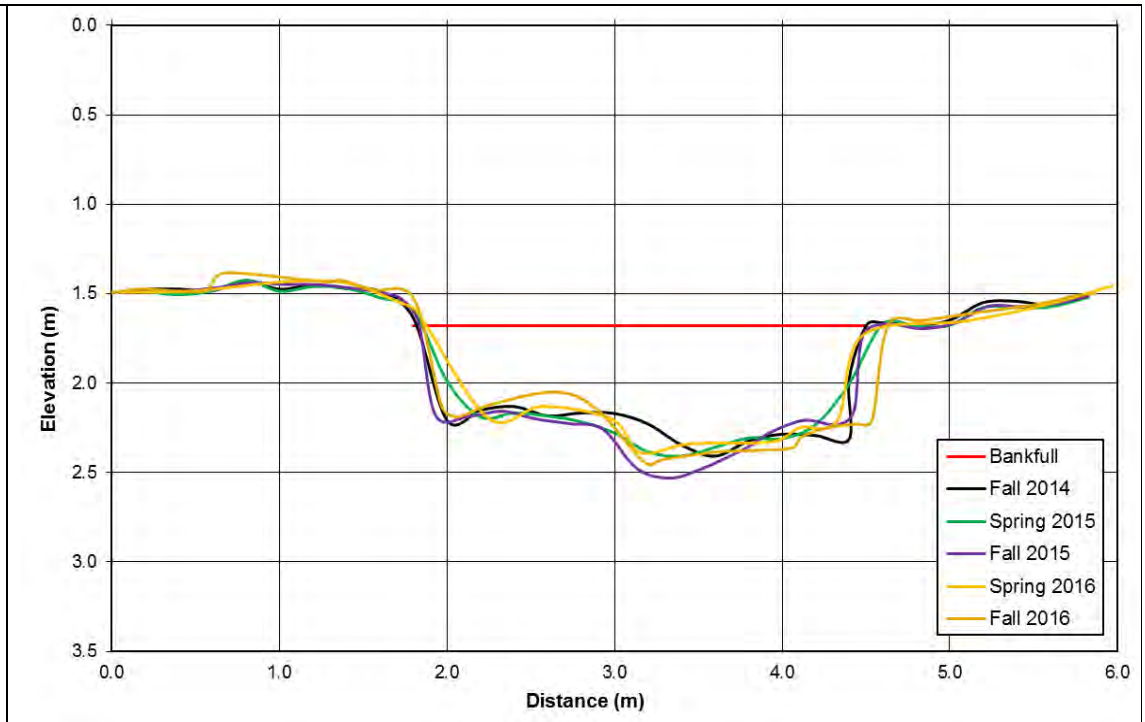
Reach MTN2: Cross section 1, riffle
Channel bed and bank extent at cross section 1 for 2014 to 2016 site visits.

Figure 2



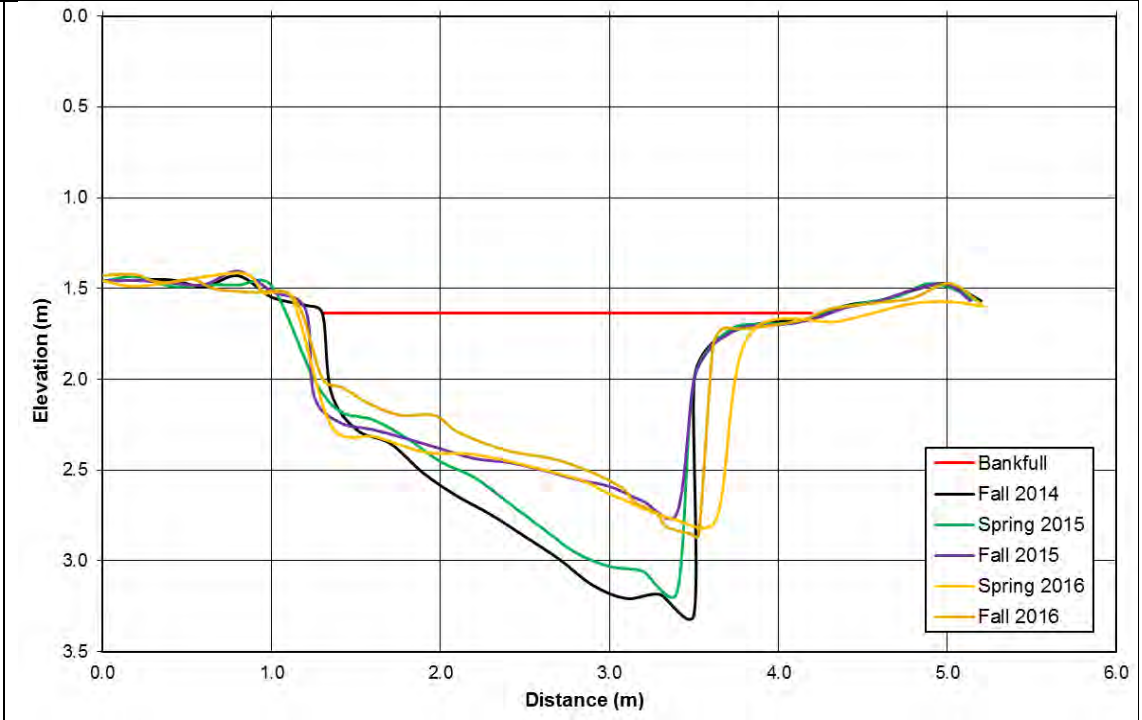
Reach MTN2: Cross section 2, pool
Channel bed and bank extent at cross section 2 for 2014 to 2016 site visits.

Figure 3



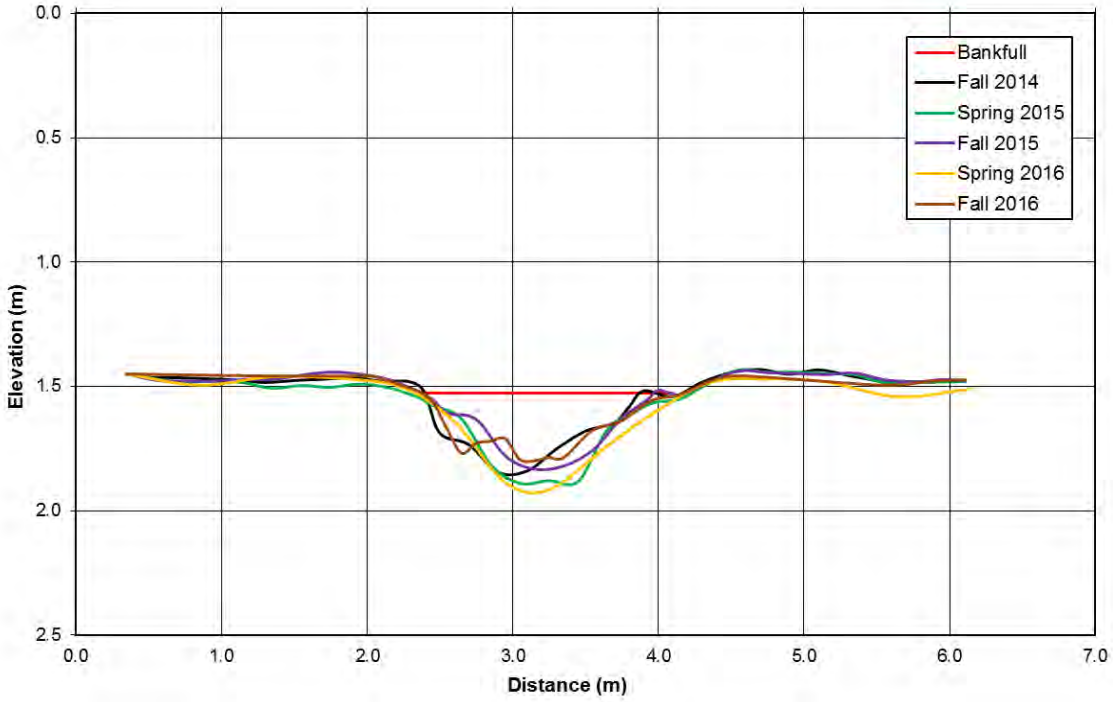
Reach MTN3/4: Cross section 2, run
Channel bed and bank extent at cross section 2 for 2014 to 2016 site visits.

Figure 4



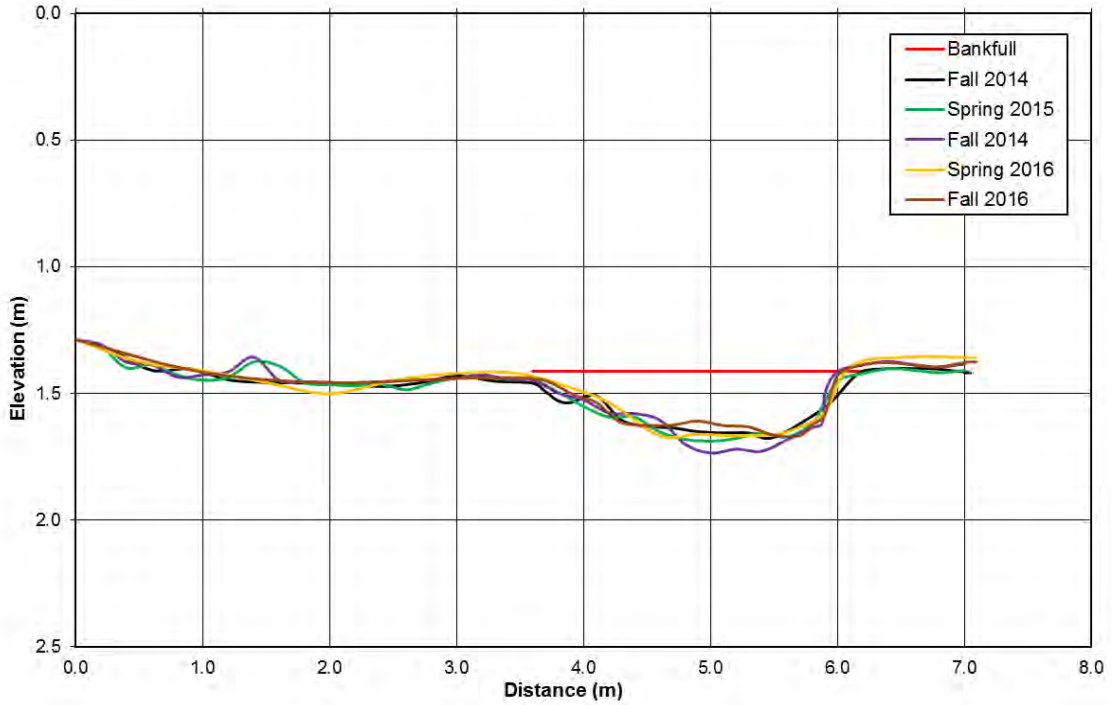
Reach MTN3/4: Cross section 3, pool
Channel bed and bank extent at cross section 3 for 2014 to 2016 site visits.

Figure 5



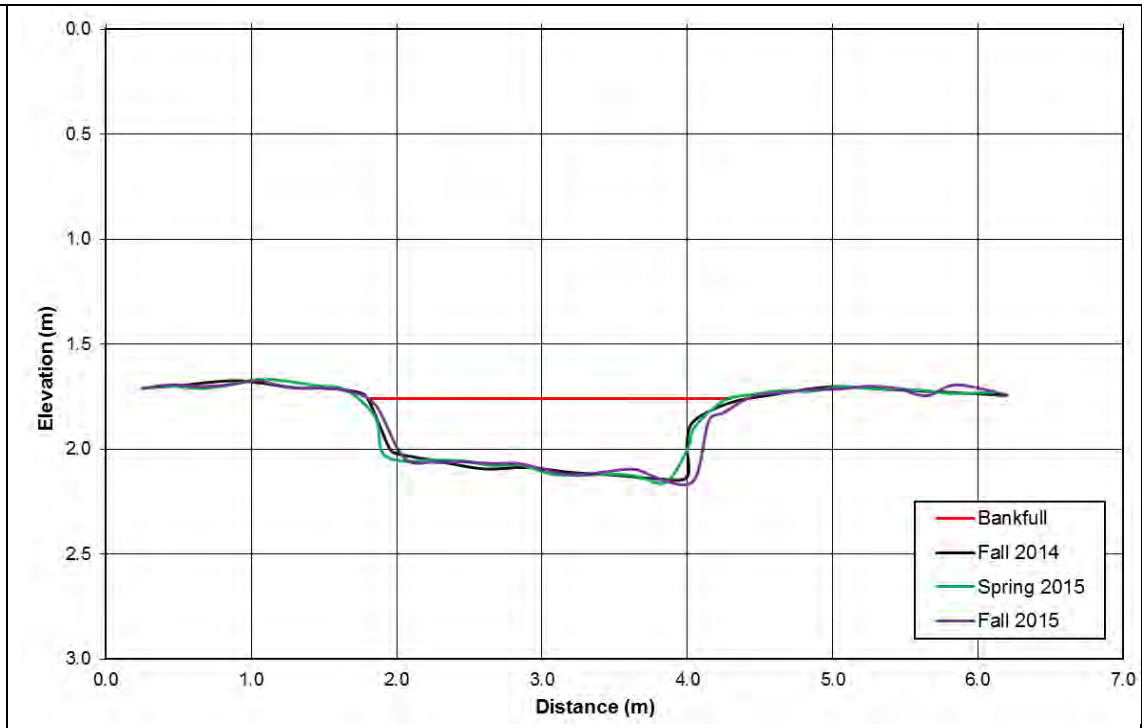
Reach MTN3-c: Cross section 5, pool
Channel bed and bank extent at cross section 5 for 2014 to 2016 site visits.

Figure 6



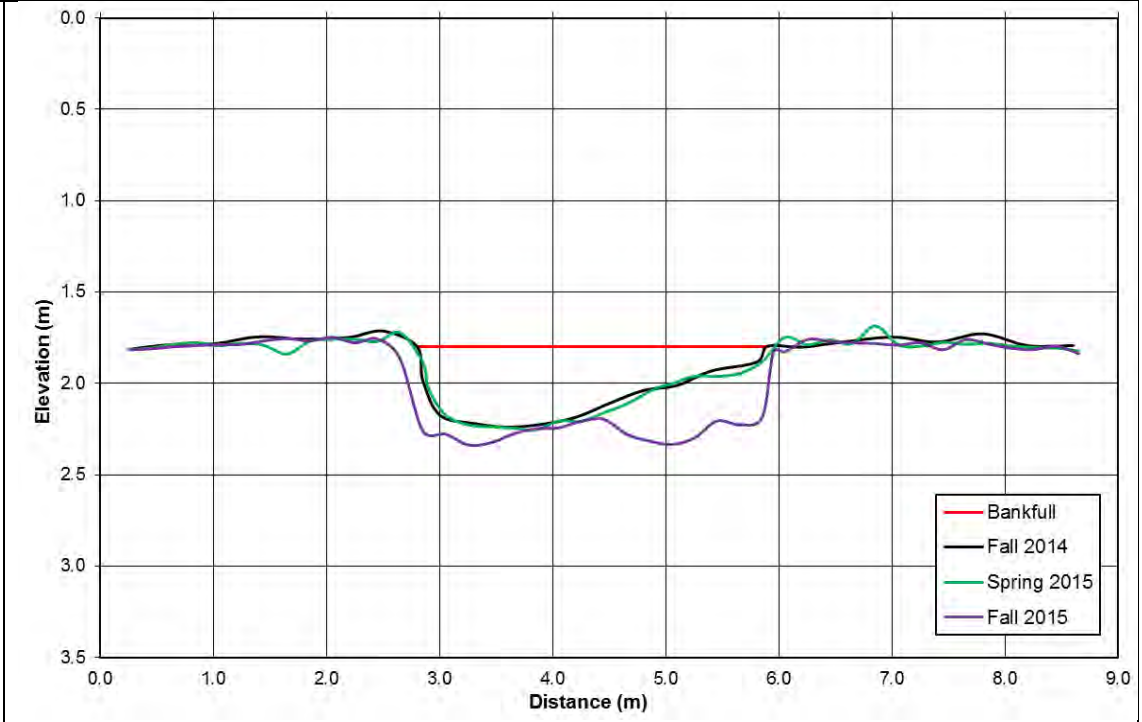
Reach MTN3-c: Cross section 6, run-riffle
Channel bed and bank extent at cross section 6 for 2014 to 2016 site visits.

Figure 7



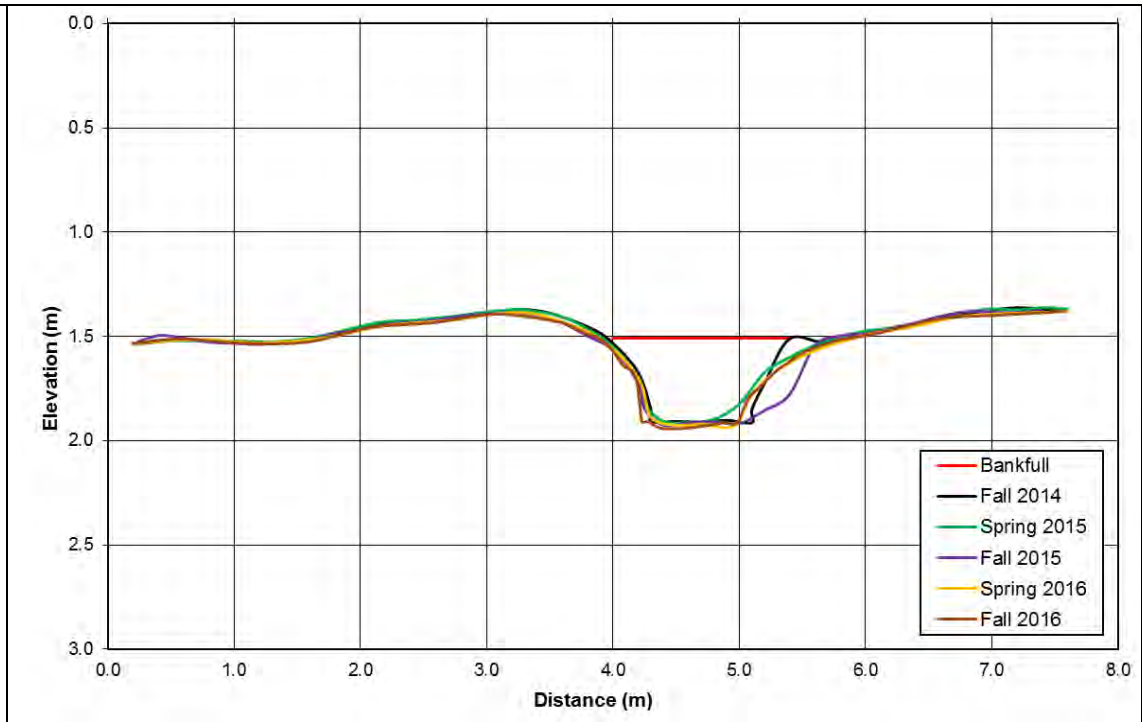
Reach MTS1: Upstream, riffle
Channel bed and bank extent at upstream cross section for 2014 to 2015 site visits.

Figure 8



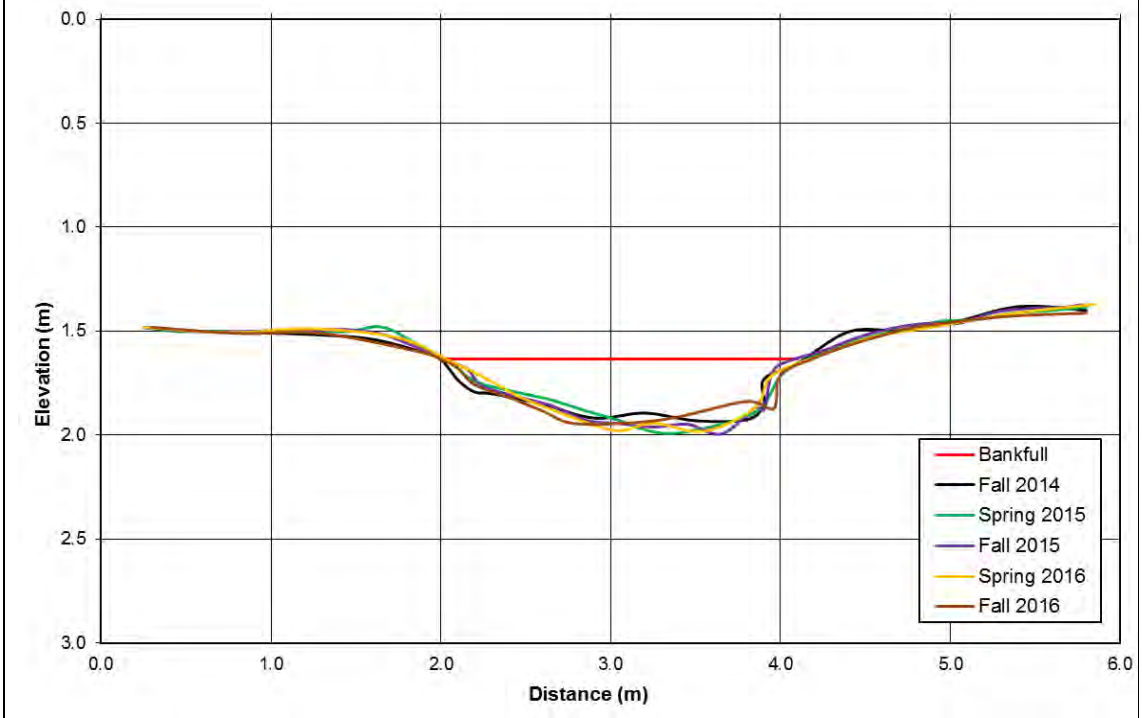
Reach MTS1: Downstream, pool
Channel bed and bank extent at downstream cross section for 2014 to 2015 site visits.

Figure 9



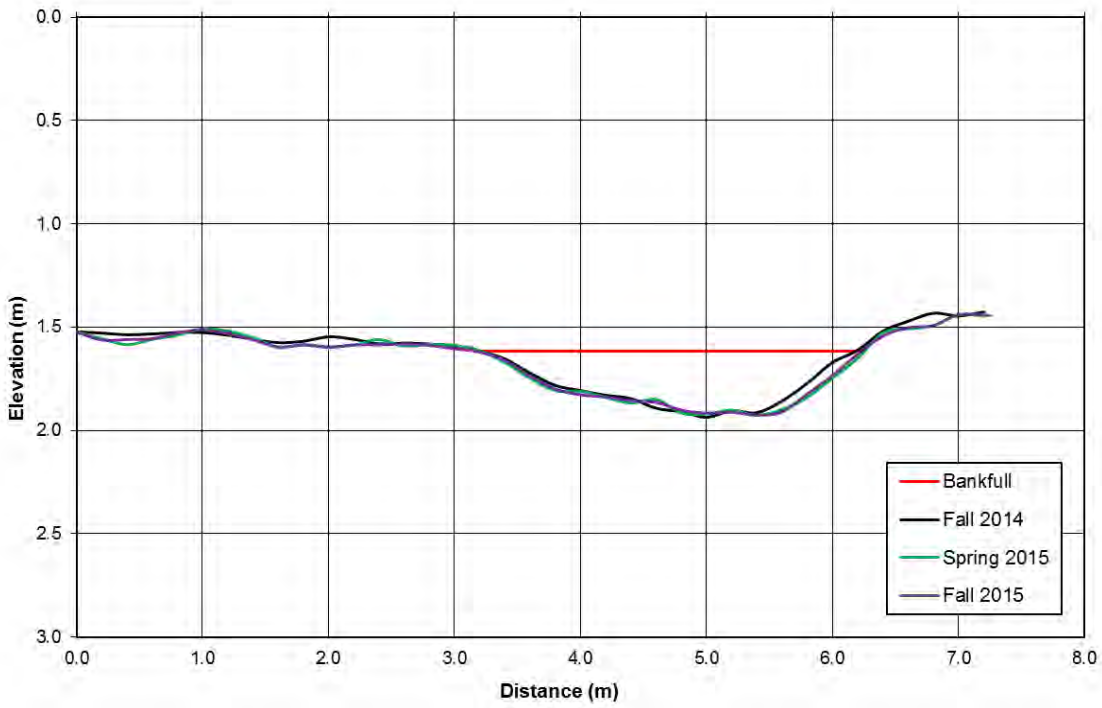
Reach MTS2: Cross section 4, riffle
Channel bed and bank extent at cross section 4 for 2014 to 2016 site visits.

Figure 10



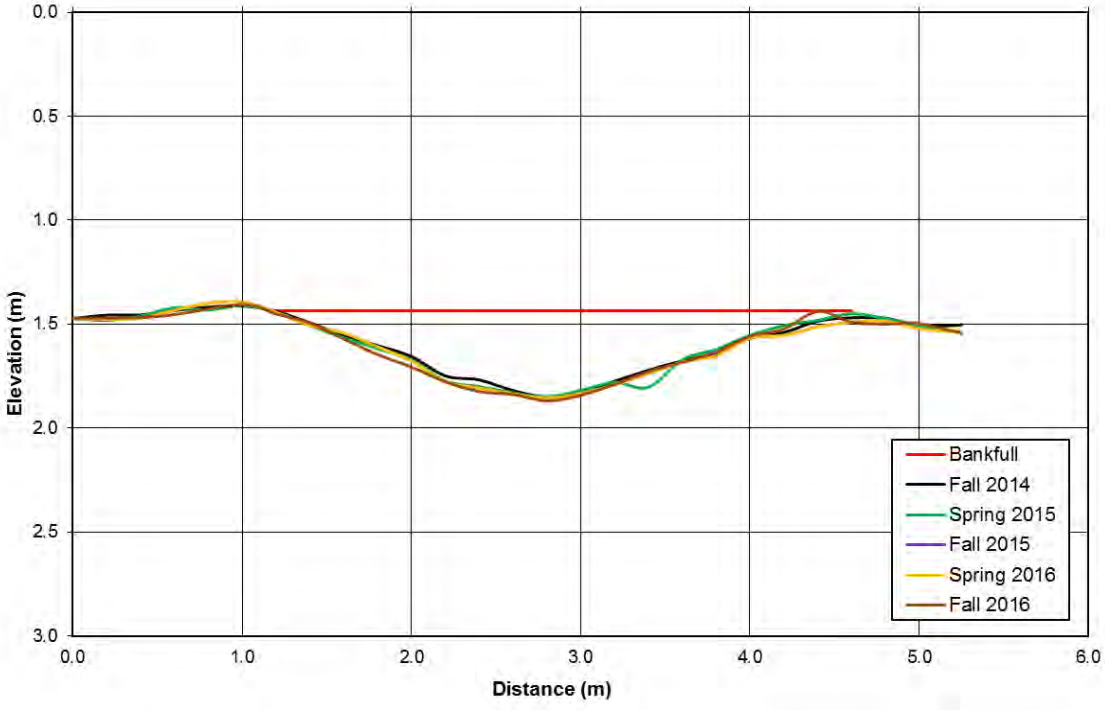
Reach MTS2: Cross section 5, pool
Channel bed and bank extent at cross section 5 for 2014 to 2016 site visits.

Figure 11



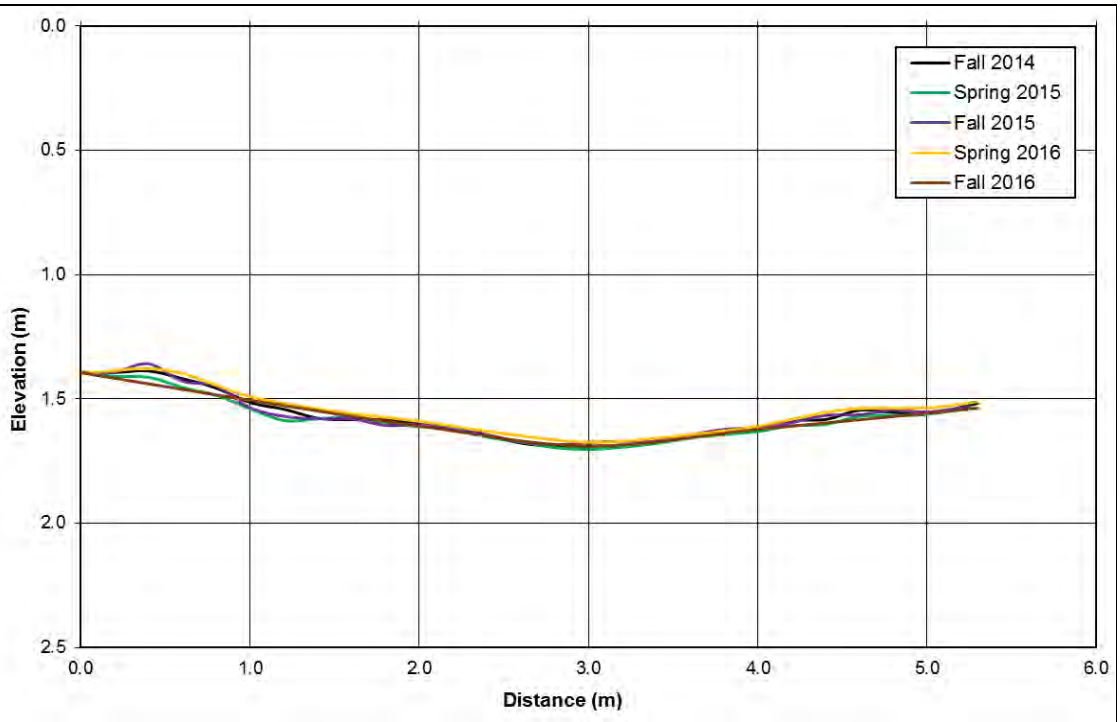
Reach MTS2-2: Upstream
Channel bed and bank extent at upstream cross section for 2014 to 2015 site visits.

Figure 12



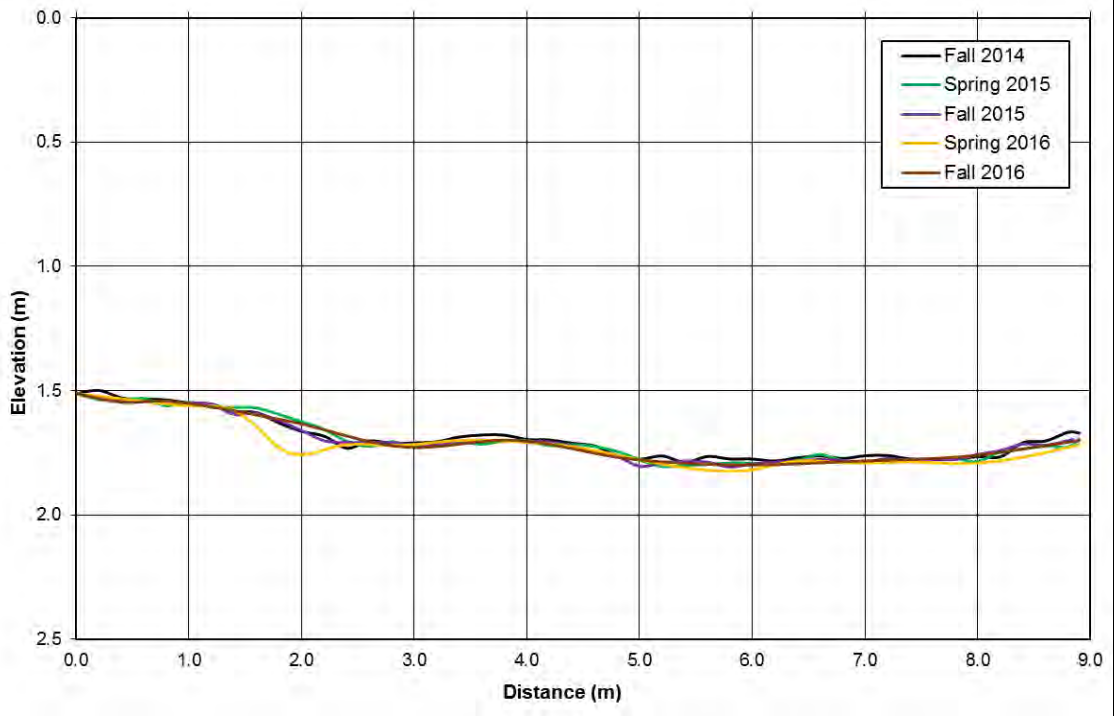
Reach MTS2-2: Downstream
Channel bed and bank extent at downstream cross section for 2014 to 2016 site visits.

Figure 13



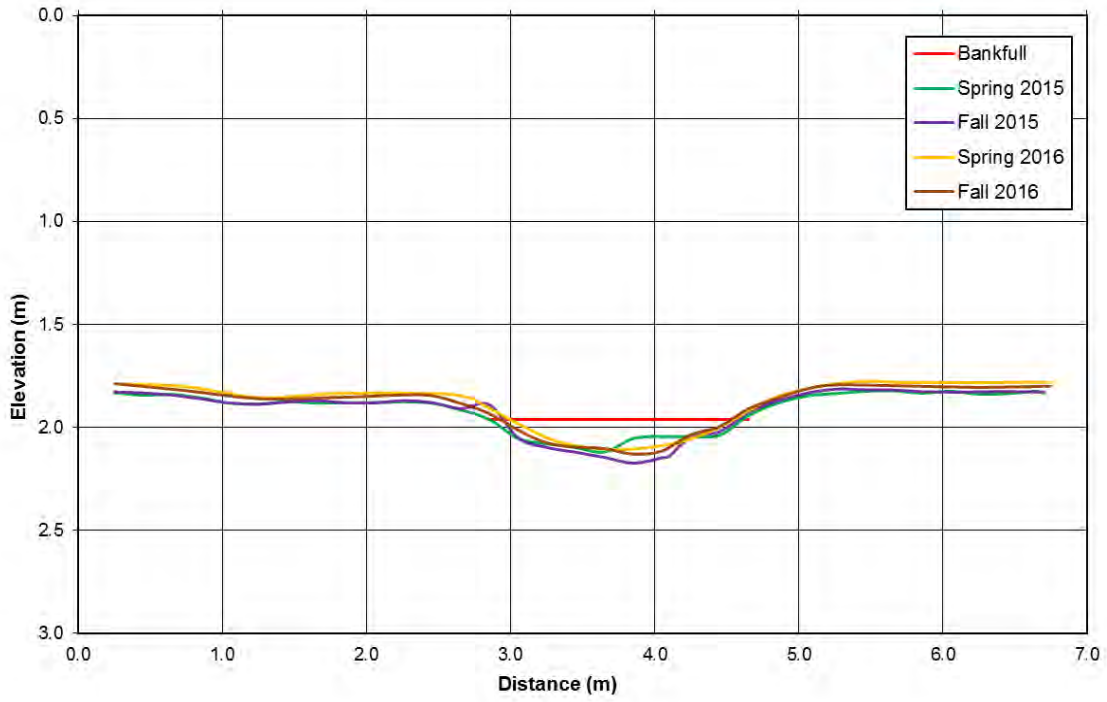
Reach MTS3: Upstream
Channel bed at upstream cross section for 2014 to 2016 site visits.

Figure 14



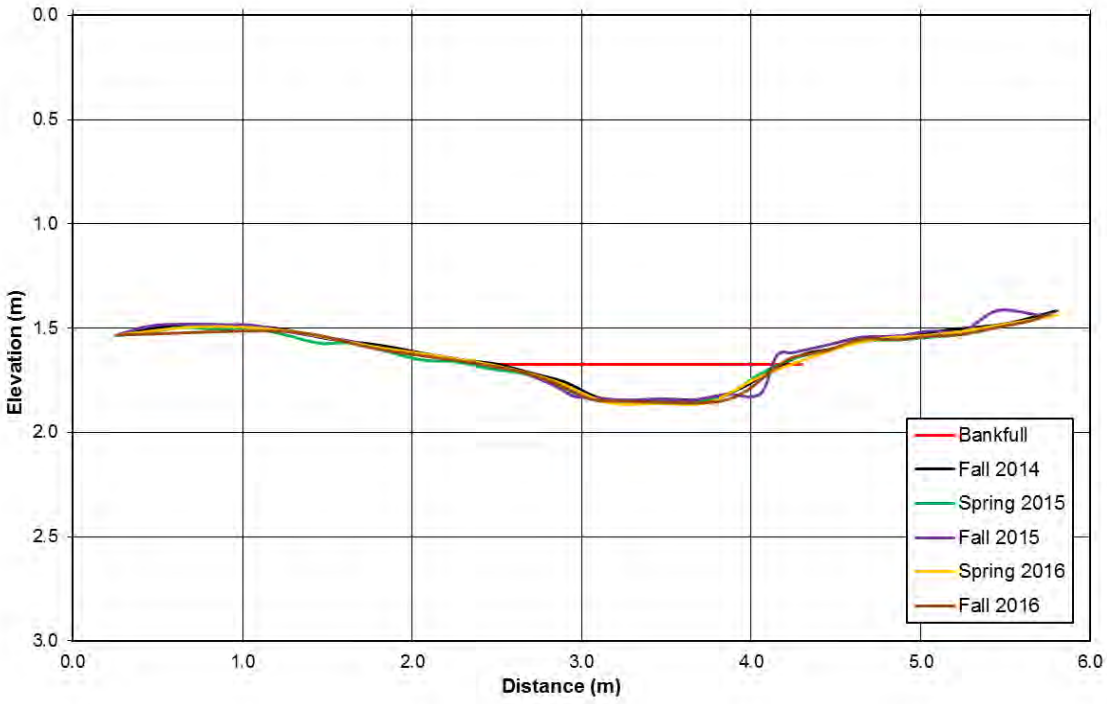
Reach MTS3: Downstream
Channel bed at downstream cross section for 2014 to 2016 site visits.

Figure 15



Reach MTS3-d: Cross section 2, pool
Channel bed and bank extent at cross section 2 for 2014 to 2016 site visits.

Figure 16



Reach MTS3-d: Cross section 6, riffle
Channel bed and bank extent at cross section 6 for 2014 to 2016 site visits.

Appendix E

Reach	Cross section	Bank Pin	Exposed Pin Length (m)					Difference* (m)	Activity
			Fall 2014	Spring 2015	Fall 2015	Spring 2016	Fall 2016		
MTN2	XS 1	Left Bank	0.20	0.21	0.17	0.22	0.28	-0.08	Erosion
		Right Bank	0.20	N/M	0.175	0.26	0.26	-0.06	Erosion
	XS 2	Left Bank	0.20	0.18	0.23	N/M	0.18	0.02	Deposition
		Right Bank	0.20	0.26	0.24	0.18	0.20	0.00	Stable
MTN3/4	XS 2	Left Bank	0.20	0.20	0.22	0.20	0.20	0.00	Stable
		Right Bank	0.20	0.20	0.21	0.21	0.22	-0.02	Erosion
	XS 3	Left Bank	0.20	0.20	0.20	0.215	0.21	-0.01	Erosion
		Right Bank	0.20	0.21	0.27	0.26	missing	-0.06	Erosion
MTN3-c	XS 5	Left Bank	0.20	0.30	0.215	0.29	0.31	-0.11	Erosion
		Right Bank	0.20	0.23	0.215	0.20	0.22	-0.02	Erosion
	XS 6	Left Bank	0.20	0.21	0.25	0.29	0.31	-0.11	Erosion
		Right Bank	0.20	0.215	0.20	0.255	0.28	-0.08	Erosion
MTS1	D/S XS	Left Bank	0.20	0.16	missing	missing	missing	0.04	Deposition
		Right Bank	0.20	0.22	missing	missing	missing	-0.02	Erosion
	U/S XS	Left Bank	0.20	0.27	missing	missing	missing	-0.07	Erosion
		Right Bank	0.20	0.25	missing	missing	missing	-0.05	Erosion
MTS2	XS 4	Left Bank	0.20	0.20	0.225	0.185	0.23	-0.03	Erosion
		Right Bank	0.20	0.20	0.19	0.19	0.20	0.00	Stable
	XS 5	Left Bank	0.20	0.20	0.19	0.185	0.18	0.02	Deposition
		Right Bank	0.20	0.195	0.18	0.20	0.18	0.02	Deposition
MTS2-2	D/S XS	Left Bank	Erosion pins were not installed due to poorly defined banks						
		Right Bank							
	U/S XS	Left Bank	Erosion pins were not installed due to poorly defined banks						
		Right Bank							
MTS3	D/S XS	Left Bank	Erosion pins were not installed due to poorly defined banks						
		Right Bank							
	U/S XS	Left Bank Right Bank	Erosion pins were not installed due to poorly defined banks						
MTS3-d	XS 2	Left Bank	0.20	0.20	missing	0.11	0.13	0.07	Deposition
		Right Bank	0.20	0.20	0.355	0.34	0.34	-0.14	Erosion
	XS 6	Left Bank	0.20	0.165	0.175	0.22	0.21	-0.01	Erosion
		Right Bank	0.20	0.18	0.20	0.215	0.225	-0.025	Erosion

**Difference is Fall 2014 − Fall 2016, if not applicable, first measurement − last measurement*

E

Appendix F

Reach	Cross-section	Particle Size (mm)	Particle Size at the Time of Assessment					Activity
			Fall 2014	Spring 2015	Fall 2015	Spring 2016	Fall 2016	
MTN2	XS 1	D50	0.425	0.400	0.280	0.225	No sample taken	Finer
		D84	0.580	4.750	0.500	0.400		Finer
	XS 2	D50	22.000	N/A	11.000	45.300	25.000	In transition
		D84	160.000	N/A	90.500	180.000	89.000	In transition
MTN3/4*	XS 2	D50	0.275	0.425	0.280	0.150	Sample awaiting analysis	TBD
		D84	0.550	0.200	0.475	0.275		TBD
	XS 3	D50	0.275	0.425	0.280	0.150		TBD
		D84	0.550	0.200	0.475	0.275		TBD
MTN3-c*	XS 5	D50	0.270	0.350	0.190	0.500	Sample awaiting analysis	TBD
		D84	0.550	0.200	0.315	1.090		TBD
	XS 6	D50	0.270	0.350	0.190	0.500		TBD
		D84	0.550	0.200	0.315	1.090		TBD
MTS1*	XS D/S	D50	3.000	N/A	6.000	N/A: Site not assessed due to flooding from beaver dams		N/A
		D84	9.000	N/A	0.860			N/A
	XS U/S	D50	6.400	N/A	6.000			N/A
		D84	15.000	N/A	0.860			N/A
MTS2	XS 4	D50	11.300	N/A	52.000	0.200*	8.700	In transition
		D84	25.000	N/A	31.000	0.300*	50.000	In transition
	XS 5	D50	0.570	N/A	0.440	0.200*	No sample taken	Finer
		D84	1.195	N/A	1.000	0.300*		Finer
MTS2-2	U/S XS	D50	Sample not taken due to poorly defined channel.					
		D84						
	D/S XS	D50	Sample not taken due to poorly defined channel.					
		D84						
MTS3	U/S XS	D50	Sample not taken due to poorly defined channel.					
		D84						
	D/S XS	D50	Sample not taken due to poorly defined channel.					
		D84						
MTS3-d	XS 2	D50	2.900	N/A	<2.000	<2.000	No sample taken	Finer
		D84	3.900	N/A	3.300	39.000		Coarser
	XS 6	D50	19.000	N/A	19.000	8.000	4.000	Finer
		D84	<2.000	N/A	<2.000	26.000	14.000	In transition

**composite sample results from grain size analysis*
TBD – to be determined after analysis

Geomorphological Monitoring of Willow and Black Creeks in Connection with Adaptive Management for the Doran and Carson Road Neighbourhoods Midhurst, Ontario

Final

Prepared for:
Midhurst Landowners Group
3190 Steeles Avenue East
Markham, Ontario
Canada, L3R 1G9

February 6, 2018
PN14028a

GEO MORPHIX
Geomorphology
Earth Science
Observations

Report Prepared by:	GEO Morphix Ltd. 2800 High Point Drive, Suite 100a Milton, ON L9T 6P4
Report Title:	Geomorphological Monitoring of Willow and Black Creeks in Connection with Adaptive Management for the Doran and Carson Road Neighbourhoods, Midhurst, Ontario
Project Number:	PN14028a
Status:	Final

Prepared by:	Ben Miller, Cara Hutton, Kat Woodrow
Approved by:	Paul Villard, Ph.D., P.Geo.
Approval Date:	February 6, 2017

Table of Contents

Appendices

1 Introduction

GEO Morphix Ltd. was retained by the Midhurst Landownsers Group (MLG) to complete baseline geomorphological monitoring for several reaches of Willow Creek and Black Creek in the Midhurst Secondary Plan Area, within the Township of Springwater, Ontario. Baseline geomorphological data collected through this program are in connection with the adaptive management plan associated with the Doran and Carson Road Neighbourhoods and will inform the Midhurst Master Drainage Plan.

Baseline monitoring data characterizes the range of natural geomorphic variability within selected channels. It also assists in identifying any changes to the hydrologic and sediment regime in the subcatchments that could be associated with development activities. Monitoring data also provides an opportunity to mitigate any impacts, should they be identified through an adaptive management approach.

An adaptive management monitoring approach was developed in the context of six stormwater management ponds. Four (4) ponds are associated with the Carson Road Neighbourhood and will discharge into Black Creek. Two (2) ponds are associated with the Doran Road Neighbourhood and will discharge into Willow Creek. The adaptive management plan is based on the BACI approach (Before-After-Control-Impact). Before (pre-development) and After (post-development) sampling can be used to determine how and if development changes the creek through time from its historical condition. Control and Impact sampling allows the effects of development to be discerned from natural variability and trends. Control sites act as a reference for the system's natural state. These sites are not impacted by development (i.e. changes in flow). Impact sites are those that may potentially see changes as a result of development (i.e. downstream of development, may experience changes in flow). The potentially impacted sites and reference sites are monitored with the same protocol (methods, frequency, and timing) to allow for paired comparison of changes among the sites. This approach provides a mechanism to adapt designs should future monitoring indicate the occurrence of unacceptable erosion impacts.

GEO Morphix Ltd. has developed a baseline monitoring program to characterize the existing geomorphology within Willow Creek, Black Creek, and their tributaries downstream of the respective development sites. Sites were selected based on proximity to the proposed pond outlets and sensitive reaches identified through the desktop assessment. Sites were also selected to provide coverage across a range of geomorphologically distinct reaches, where public or roadside access was available. Our desktop examination of slope and geology suggested that road side and public access could bring us within proximity of the most sensitive channels and provide a diverse collection of observations.

This second year monitoring report outlines all geomorphological monitoring that has occurred to date. This includes fluvial geomorphological monitoring, and more specifically, addresses potential adjustment in channel geometry, rates of change with regards to channel adjustment, and instream sediment characteristics. Erosion thresholds were determined as part of the first report submitted August 22, 2016, titled *Geomorphological Monitoring of Willow and Black Creek in support of Adaptive Management for the Dorn and Carson Road Development, Midhurst, Ontario*.

2 Background Review

The Carson Road Neighbourhood falls within the Willow Creek Subwatershed and the Midhurst Secondary Plan Area. Flows from the proposed lands naturally drain into four locations on the main stem of Black Creek.

Black Creek provides coldwater habitat for various fish species and substantial discharge to the Nottawasaga River system. The upstream section of Black Creek falls within an area of ice-contact stratified deposits of sand and gravel with minor amounts of silt, clay, and till. The Carson Road Neighbourhood is located in the upstream portion of the catchment that drains to the main stem of Black Creek. Proposed stormwater management for the development includes four stormwater ponds that will drain into the main stem of Black Creek. The proposed ponds are located alongside the western boundary of the future development.

The Doran Road Neighbourhood is located in the upstream tributaries of the Willow Creek Subwatershed and the Midhurst Secondary Plan area. The main branch of Willow Creek is a coldwater system the contributes flow within the larger Nottawasaga watershed. Willow Creek passes through modern alluvial deposits of clay, silt, sand, and gravel. These types of systems are less resilient to changes in flow, as fine materials are more easily transported.

In order to mitigate impacts within Willow Creek the Doran Road Neighbourhood includes LID and SWM outlet control practices to reduce volume and peak flows. The stormwater management plan for the development includes two stormwater ponds at Pooles Road and Russel Road that will drain into a tributary of Willow Creek.

Preliminary reach delineation for Willow and Black Creeks were completed by desktop analysis. Reach delineation is a prerequisite of a geomorphological assessment. Reaches divide watercourses into homogeneous channel segments having similar inputs, outputs, and controls. Indicators for reach breaks include:

- Channel planform;
- Channel gradient;
- Physiography;
- Land cover (land use or vegetation);
- Flow, due to tributary inputs;
- Soil type and surficial geology; and
- Certain types of channel modifications by humans.

A reach map is provided in Appendix A. Only those reaches considered relevant to the proposed SWM plan were further assessed in the field.

3 Geomorphological Monitoring

The geomorphological monitoring program was created to characterize baseline conditions within the Willow Creek and Black Creek subwatersheds. The program follows an adaptive management approach within the context of the proposed stormwater pond outlets. As such, data collected will assist in identifying and mitigating any potential impacts to watercourses that may occur in relation to the proposed future development.

Monitoring sites were established in Fall 2014. These monitoring sites were reassessed twice annually, in the Spring and Fall of 2015 and 2016. This report summarizes and compares all data spanning 2014 to 2016.

3.1 Monumented Cross-sections

Monumented cross-sections were established and reassessed at each instream monitoring location. These locations include sites measured and characterized during prior detailed assessments and additional sites selected to provide a more robust and spatially varied characterization of the subwatersheds. A map of the monitoring locations is included in Appendix A.

Site selection was based on the background review completed in 2014. These locations were selected based on sensitivity of the watercourses, proximity to the proposed pond outlets and development areas, and to represent a range of environmental conditions that exist within the subcatchments. Property access was a contributing, but not a limiting, factor.

Monitoring sites were first established in the Fall of 2014. Site establishment included:

- Establishment and measurement of permanent monumented cross-sections to assess changes in channel and bankfull geometry over time;
- Establishment of erosion pins at each cross-sections (one in each bank) to assess erosion/deposition rates over time;
- Grain size analysis using the modified Wolman (1954) pebble count or a bed material sample at each monumented cross-section to assess changes in substrate composition over time; and
- Monumented photographs at each cross-section location.

Monumented cross-sections involved the installation of permanent bank pins at two cross-sections per monitoring location. Cross-section location was chosen to monitor a variety of characteristic geomorphic environments, where they were present (i.e., riffles, pools, runs). During each monitoring event, cross-sections were measured using a survey level from left to right bank pin while facing downstream.

All monitoring data collected are presented in the following appendices: a photographic record showing each cross-section for Willow Creek locations is presented in Appendix B and for Black Creek locations in Appendix C; and a graphical representation of monumented cross-section geometry for Willow Creek locations is presented in Appendix E and for Black Creek locations in Appendix F.

Over the monitoring period there has been times when particular sites were unable to be monitored, these occurrences are summarized below:

- Retaining wall construction by others near the downstream location of BC8 was in progress during Fall 2016 monitoring. As a result, cross-sections were not monitored. The cross-sections were not affected by construction, and monitoring proceeded in spring 2017.
- Beaver dams were built between Fall 2015 and the Spring 2016 visits at reach WC3. One dam was built immediately upstream of the downstream cross-section and another dam 10 m upstream of the upstream cross-section. These did not affect monitoring; however, it may cause changes in channel geometry and substrate distributions.
- Cross-section 7, at reach WC5, was removed due to construction of an armour stone wall by others to stabilize the slope. The riffle cross-section was relocated upstream in Spring 2016.
- A pin at the downstream cross-section, at WC8, was removed and the cross-section was re-established in Spring 2016.
- Monitoring at WC9 has been discontinued due to inability to re-survey the site. WC9 is located in a wetland, and cross-section pins continue to sink into the wetland. As a result,

we are unable to complete repeated surveys of the same cross-sections. There is an existing monitoring site near by at WC8.

3.1.1 Erosion Pins

Erosion pins were installed at each monitoring location in Fall of 2014. Two bank pins were installed at each monumented cross-section: one on the right bank and one on the left bank.

Each erosion pin was installed by hammering a rebar segment into the lower section of the bank. Bank pin location was selected in areas of the bank that appeared sensitive to localized erosion or deposition. Upon installation, a typical exposure length of 0.20 m was left as a baseline for future monitoring. Bank pins were measured again during each monitoring event.

Repeated measurements of erosion pins helps gauge baseline variability and note any changes in erosion or deposition over time. Progressive change in erosion or deposition may be indicative of localized geomorphic instability. In combination with other geomorphic measurements, this data may be used to infer larger scale geomorphic processes.

A tabular summary of changes in bank pin exposure for each cross-section is presented in Appendix G.

3.1.2 Substrate

Bed material sampling was completed at each monumented cross-section using a modified Wolman (1954) pebble count technique, where applicable. For cross-sections that contained fine substrate, such as sand or silts, a bed sample was collected and sent for laboratory analysis.

Median grain size (D_{50}) as determined through pebble counts or sediment sample analysis represents the size of sediment that is transported during bankfull (channel forming) conditions. In terms of monitoring sediment data, a change in D_{50} over time may be indicative of a change in localized flow conditions. In combination with other geomorphic parameters, this data may be used to infer changes in channel processes and stability over time.

A tabular summary of sediment data for each cross-section is presented in Appendix H.

3.2 Detailed Geomorphological Assessments

Detailed assessments were completed in 2014 at a selection of sites throughout the study area. Sites for detailed assessment were selected in sensitive tributaries in proximity to the proposed outlet and to the development areas. The detailed field assessments provided bankfull and bed slope, bank and bed sediment characteristics, cross-sections' dimensions, and a visual assessment of channel roughness factors. Detailed assessments included the following observations:

- Longitudinal profile of the channel centre line;
- Eight (8) detailed cross-sectional surveys across the watercourse;
- Two (2) monumented cross-sections were installed and included erosion pins in both banks.
- Detailed instream measurements at each cross-section location including bankfull channel geometry, riparian conditions, bank material, bank height/angle, and bank root density;
- Bed material sampling at each cross-section following a modified Wolman's (1954) Pebble Count Technique or substrate sample; and
- Velocity, discharge and observations of active/inactive sediment transport at select representative cross-sections.

Detailed assessment summaries are provided in Appendix D. Locations at which detailed assessments took place are visually represented in the reach map presented in Appendix A. The two monumented cross-sections installed at all detailed assessment locations were revisited and recorded with the monumented cross-sections.

4 Summary and Conclusions

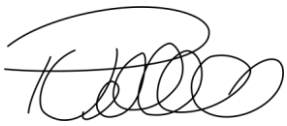
The Spring and Fall 2016 data show minor changes in channel conditions compared to those observed in Spring and Fall 2015 and in Fall 2014. Erosion and deposition were generally recorded in the range of a few centimetres at several erosion pin locations.

Overall, the channels have remained reasonably stable over the period of baseline monitoring. The slight variations documented are all within the natural variability of the system.

Further monitoring will be completed in Spring and Fall of 2017. Additional updates will be provided upon completion of 2017 monitoring activities.

We trust this report meets your requirements. Should you have any questions, please do not hesitate to contact the undersigned.

Respectfully submitted,



Paul Villard Ph.D., P.Geo., CAN-CISEC
Director, Principal Geomorphologist

Kat Woodrow, M.Sc.
Environmental Scientist

5 References

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Appendix A

LEGEND

- Detailed site
- Cross-section site
- MTS3 — Reach break and label
- Watercourse
- Waterbody
- Subcatchment boundary (approx.)
- Neighbourhood boundary
- Proposed SWM pond and outlet (approx. locations)
- Proposed and existing outlets (approx. locations)
- Proposed flow route

Reach Gradients (m/m)

- Insufficient contour detail
- 0.000000 - 0.005534
- 0.005535 - 0.019086
- 0.019087 - 0.032781
- 0.032782 - 0.058221
- 0.058222 - 0.113619

N

0 0.5 1

Kilometres

Baseline Monitoring

Matheson Creek Tributaries, and Main Branches of Willow Creek and Black Creek

GEO MORPHIX

Geomorphology Earth Science Observations

Imagery: Google Earth Pro, 2014. Detailed site, Cross-section site, Reach break and label, and Reach Gradients: GEO Morphix Ltd., 2014. Watercourse: MNR, 2006, County of Simcoe, 2014, and C.F. Crozier & Associates Inc., 2014. Waterbody: MNR, 2006, and County of Simcoe, 2014. Subcatchment boundary: Willow Creek Subwatershed Study, Willow Creek Sub-catchments, Map 6, NVCA, 2001. Neighbourhood boundary: C.F. Crozier & Associates Inc., 2014, and EIS, Beacon Environmental, June 2009. Proposed SWM pond and outlet: SCS Consulting Group Ltd., 2009. Proposed and existing outlets, and Proposed flow route: C.F. Crozier & Associates Inc., 2014.

Appendix B

Photo 1	
	Dec 22, 2014: Reach WC, cross-section 2 at a run. Photograph taken facing downstream.
Photo 2	
	Nov 9, 2015: Reach WC, cross-section 2 at a run. Photograph taken facing downstream.

Photo 3	
	Nov 14, 2016: Reach WC, cross-section 2 at a run. Photograph taken facing downstream.
Photo 4	
	Dec 22, 2014: Reach WC, cross-section 7 at a run. Photograph taken facing the left bank.

Photo 5	
	Nov 9, 2015: Reach WC, cross-section 7 at a run. Photograph taken facing downstream.
Photo 6	
	Nov 14, 2016: Reach WC, cross-section 7 at a run. Photograph taken facing downstream.

Photo 7	
	Nov 21, 2014: Reach WC1, cross-section at a pool. Photograph taken facing upstream.
Photo 8	
	Nov 6, 2015: Reach WC1, cross-section at a pool. Photograph taken facing upstream.

Photo 9	
	Nov 14, 2016: Reach WC1, cross-section at a pool. Photograph taken facing upstream.
Photo 10	
	Nov 20, 2014: Reach WC1, cross-section a run. Photograph taken facing downstream/left bank.

Photo 11	
	Nov 6, 2015: Reach WC1, cross-section at a run. Photograph taken facing downstream.
Photo 12	
	Nov 14, 2016: Reach WC1, cross-section at a run. Photograph taken facing downstream.

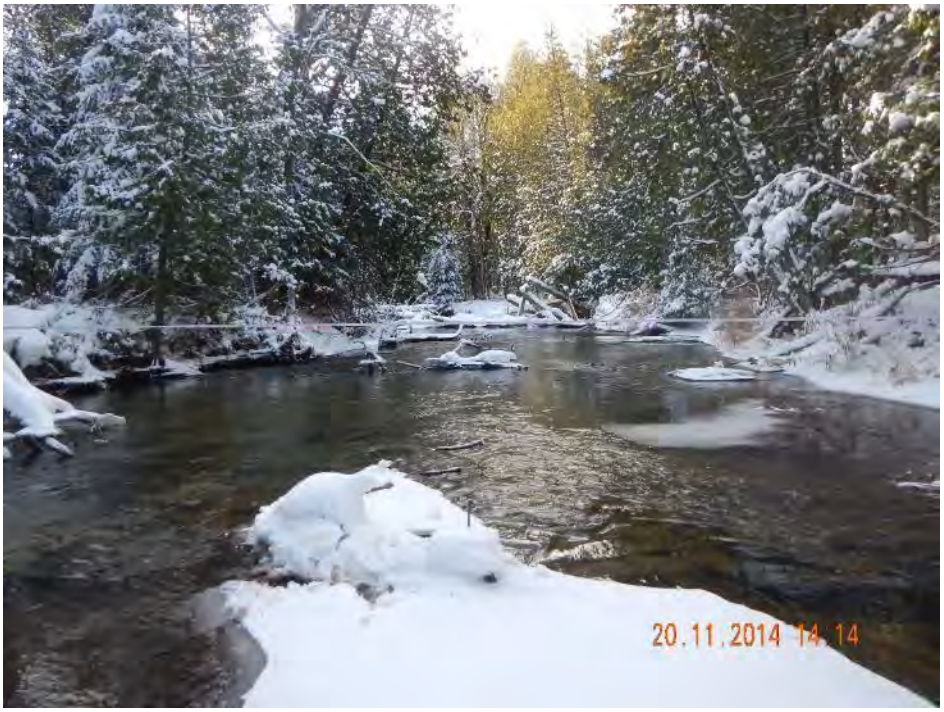
Photo 13	
	Nov 20, 2014: Reach WC3, cross-section at a riffle. Photograph taken facing downstream.
Photo 14	
	Nov 6, 2015: Reach WC3, cross-section at a riffle. Photograph taken facing downstream.

Photo 15	
	Nov 15, 2016: Reach WC3, cross-section at a riffle. Photograph taken facing downstream.
Photo 16	
	Nov 20, 2014: Reach WC3, cross-section at a pool. Photograph taken facing upstream.

Photo 17	
	Nov 6, 2015: Reach WC3, cross-section at a pool. Photograph taken facing upstream.
Photo 18	
	Nov 15, 2016: Reach WC3, cross-section at a pool. Photograph taken facing upstream.

Photo 19	
	Dec 9, 2014: Reach WC5, cross-section 2 at a pool. Photograph taken facing the left bank.
Photo 20	
	Nov 10, 2015: Reach WC5, cross-section 2 at a pool. Photograph taken facing the left bank.

Photo 21	
	Nov 15, 2016: Reach WC5, cross-section 2 at a pool. Photograph taken facing the left bank.
Photo 22	
	Nov 10, 2015: Reach WC5, cross-section 7 removed from construction Photograph taken facing downstream. A new cross section will be established spring 2016.

Photo 23	
	June 16, 2016: Reach WC5, cross-section 1 at a riffle. New cross-section established in replacement of 7. Photograph taken facing downstream.
Photo 24	
	Nov 15, 2016: Reach WC5, cross-section 1 at a riffle. Photograph taken facing downstream.

Photo 25	
	Dec 8, 2014: Reach WC6, cross-section 2 at a riffle. Photograph taken facing downstream.
Photo 26	
	Nov 6, 2015: Reach WC6, cross-section 2 at a riffle. Photograph taken facing downstream.

Photo 27	
	Nov 16, 2016: Reach WC6, cross-section 2 at a riffle. Photograph taken facing downstream.
Photo 28	
	Dec 8, 2014: Reach WC6, cross-section 5 at a pool. Photograph taken facing the left bank.

Photo 29	
	Nov 6, 2015: Reach WC6, cross-section 5 at a pool. Photograph taken facing the left bank.
Photo 30	
	Nov 16, 2016: Reach WC6, cross-section 5 at a pool. Photograph taken facing the left bank.

Photo 31	
	Nov 28, 2014: Reach WC8, cross-section downstream of road crossing at a pool. Photograph taken facing downstream.
Photo 32	
	Nov 10, 2015: Reach WC8, cross-section downstream of road crossing at a pool. Photograph taken facing downstream.

Photo 33	
	Nov 15, 2016: Reach WC8, cross-section downstream of road crossing at a pool. Photograph taken facing downstream.
Photo 34	
	Nov 28, 2014: Reach WC8, cross-section upstream of road crossing at a run. Photograph taken facing upstream.

Photo 35	
	Nov 10, 2015: Reach WC8, cross-section upstream of road crossing at a run. Photograph taken facing upstream.
Photo 36	
	Nov 15, 2016: Reach WC8, cross-section upstream of road crossing at a run. Photograph taken facing upstream.

Photo 37	
	May 28, 2015: Reach WC9, cross-section 7 at a run. Cross-section was established in Spring 2015. Photograph taken facing downstream.
Photo 38	
	Nov 30, 2015: Reach WC9, cross-section 7 at a run. Photograph taken facing downstream.

Photo 39	
	May 28, 2015: Reach WC9, cross-section 4 at a run. Cross-section was established in Spring 2015. Photograph taken facing downstream.
Photo 40	
	Nov 15, 2016: Both cross-sections could not be found.

Appendix C

Photo 1	
	Nov 28, 2014: Reach BC2, cross-section 1 at a run. Photo taken facing downstream.
Photo 2	
	Nov 9, 2015: Reach BC2, cross-section 1 at a run. Photograph taken facing downstream.

Photo 3	
	Nov 14, 2016: Reach BC2, cross-section 1 at a run. Photograph taken facing downstream.
Photo 4	
	Nov 28, 2014: Reach BC2, cross-section 2 at a pool. Photograph taken facing downstream.

Photo 5	
	Nov 9, 2015: Reach BC2, cross-section 2 at a pool. Photograph taken facing downstream.
Photo 6	
	Nov 14, 2016: Reach BC2, cross-section 2 at a pool. Photograph taken facing downstream.

Photo 7	
	Nov 28, 2014: Reach BC7, cross-section 5 at a pool. Photograph taken facing downstream.
Photo 8	
	Nov 10, 2015: Reach BC7, cross-section 5 at a pool. Photograph taken facing upstream.

Photo 9	
	Nov 15, 2016: Reach BC7, cross-section 5 at a pool. Photograph taken facing upstream.
Photo 10	
	Nov 11, 2014: Reach BC7, cross-section 4 at a riffle. Photograph taken facing downstream.

Photo 11	
	Nov 10, 2015: Reach BC7, cross-section 4 at a riffle. Photograph taken facing downstream.
Photo 12	
	Nov 15, 2016: Reach BC7, cross-section 4 at a riffle. Photograph taken facing downstream.

Photo 13	
	Nov 21, 2014: Reach BC8 (downstream section), pool cross-section. Photograph taken facing upstream.
Photo 14	
	Nov 10, 2015: Reach BC8 (downstream section), pool cross-section. Photograph taken facing upstream.

Photo 15	
	Nov 21, 2014: Reach BC8 (downstream section), riffle cross-section. Photograph taken facing downstream.
Photo 16	
	Nov 10, 2015: Reach BC8 (downstream section), riffle cross-section. Photograph taken facing downstream.

Photo 17	
	Nov 15, 2016: Reach BC8 (downstream section). Unable to access site due to construction. Photograph taken facing downstream.
Photo 18	
	Nov 26, 2014: Reach BC8 (upstream section), cross-section 2 at a pool. Photograph taken facing upstream.

Photo 19	
	Nov 9, 2015: Reach BC8 (upstream section), cross-section 2 at a pool. Photograph taken facing upstream.
Photo 20	
	Nov 15, 2016: Reach BC8 (upstream section), cross-section 2 at a pool. Photograph taken facing upstream.

Photo 21	
	Nov 26, 2014: Reach BC8 (upstream section), cross-section 4 at a riffle. Photograph taken facing upstream. No photo for July 3, 2015.
Photo 22	
	Nov 9, 2015: Reach BC8 (upstream section), cross-section 4 at a riffle. Photograph taken facing downstream.

Photo 23	
	Nov 15, 2016: Reach BC8 (upstream section), cross-section 4 at a riffle. Photograph taken facing downstream.
Photo 24	
	Nov 27, 2014: Reach BC10, cross-section 1 at a riffle. Photograph taken facing downstream.

Photo 25	
	Nov 9, 2015: Reach BC10, cross-section 1 at a riffle. Photograph taken facing downstream.
Photo 26	
	Nov 15, 2016: Reach BC10, cross-section 1 at a riffle. Photograph taken facing upstream.

Photo 27	
	Nov 27, 2014: Reach BC10, cross-section 2 at a pool. Photograph taken facing downstream.
Photo 28	
	Nov 9, 2015: Reach BC10, cross-section 2 at a pool. Photograph taken facing downstream.

Photo 29	
	Nov 15, 2016: Reach BC10, cross-section 2 at a pool. Photograph taken facing upstream.

Appendix D

Detailed Geomorphological Assessment Summary

Project Number:	14028a	**Date:**	November 28, 2014
Client:	Geranium Corporation	**Length Surveyed (m):**	102.1
Location:	BC7, Black Creek, Midhurst, ON	**# of Cross-Sections:**	8

Reach Characteristics

Drainage Area:	N/A	**Dominant Riparian Vegetation Type:**	Trees and shrubs
Geology/Soils:	Glaciolacustrine deposits	**Extent of Riparian Cover:**	Continuous
Surrounding Land Use:	Forest	**Width of Riparian Cover:**	>10 channel widths
Valley Type:	Confined	**Age Class of Riparian Vegetation:**	Mature (>30 yrs)
Dominant Instream Vegetation Type:	None	**Extent of Encroachment into Channel:**	Minimal
Portion of Reach with Vegetation:	N/A	**Density of Woody Debris:**	Low

Hydrology

Measured Discharge (m^3/s):	0.06	**Calculated Bankfull Discharge (m^3/s):**	1.32
Modelled 2-year Discharge (m^3/s):	Not modelled	**Calculated Bankfull Velocity (m/s):**	1.60
Modelled 2-year Velocity (m/s):	Not modelled		

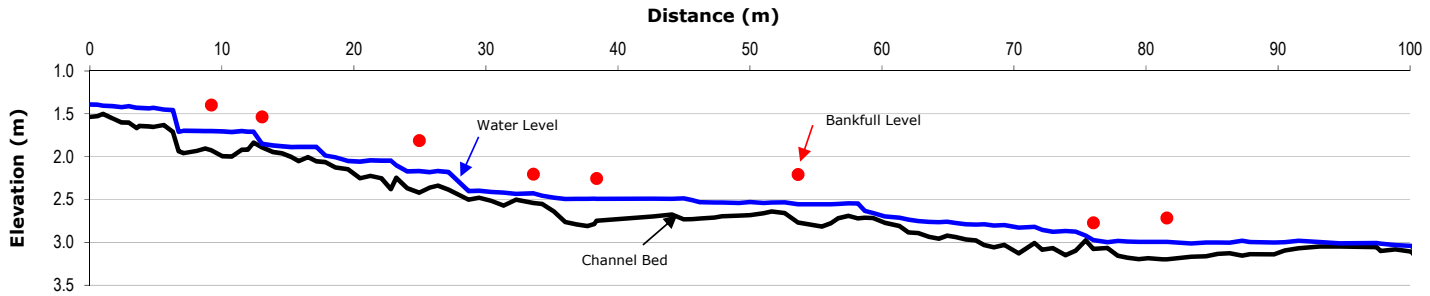
Profile Characteristics

Bankfull Gradient (%):	1.78
Channel Bed Gradient (%):	1.61
Riffle Gradient (%):	6.69
Riffle Length (m):	1.74
Riffle-Pool Spacing (m):	2.70

Planform Characteristics

Sinuosity:	1.41
Meander Belt Width (m):	Not measured
Radius of Curvature (m):	Not measured
Meander Amplitude (m):	Not measured
Meander wavelength (m):	Not measured

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	0.30	4.00	1.39
Bank Angle (deg):	30	90	59
Root Depth (m):	0.10	2.00	0.63
Root Density (%):	10	100	67
Bank Undercut (m):		No undercuts	

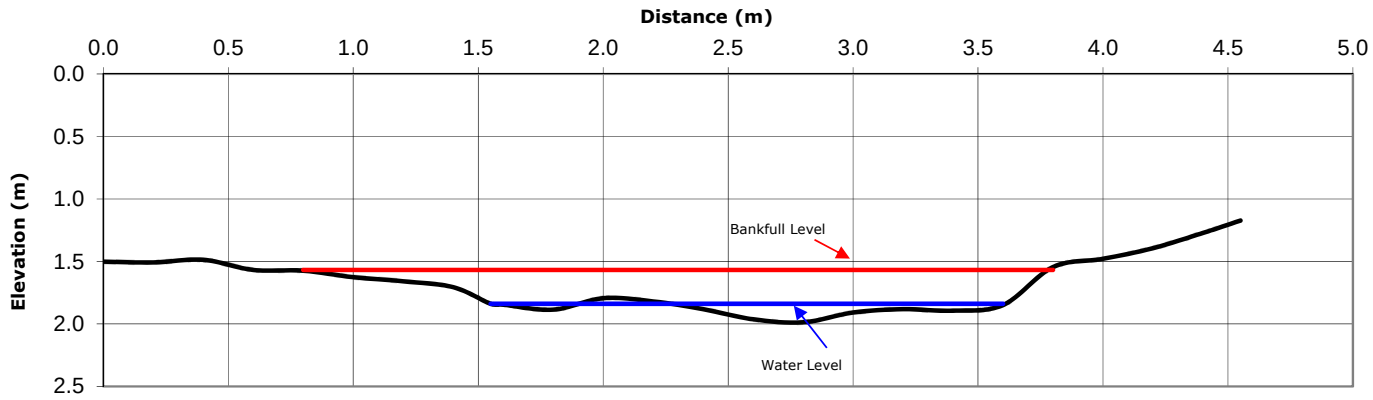
	Minimum	Maximum	Average
Torvane Value (kg/cm^2):		Not measured	
Penetrometer Value (kg/cm^3):		Not measured	
Bank Material (range):		Till, silt to small cobbles	

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	1.30	3.60	3.03
Average Bankfull Depth (m):	0.21	0.35	0.27
Bankfull Width/Depth (m/m):	4	16	12
Wetted Width (m):	1.10	2.20	1.91
Average Water Depth (m):	0.05	0.21	0.11
Wetted Width/Depth (m/m):	7	43	21
Entrenchment (m):		Not measured	
Entrenchment Ratio (m/m):		Not measured	
Maximum Water Depth (m):	0.11	0.30	0.18
Manning's *n* :		0.035	

Photograph of cross section 7 (looking downstream)

Representative Cross-Section 2



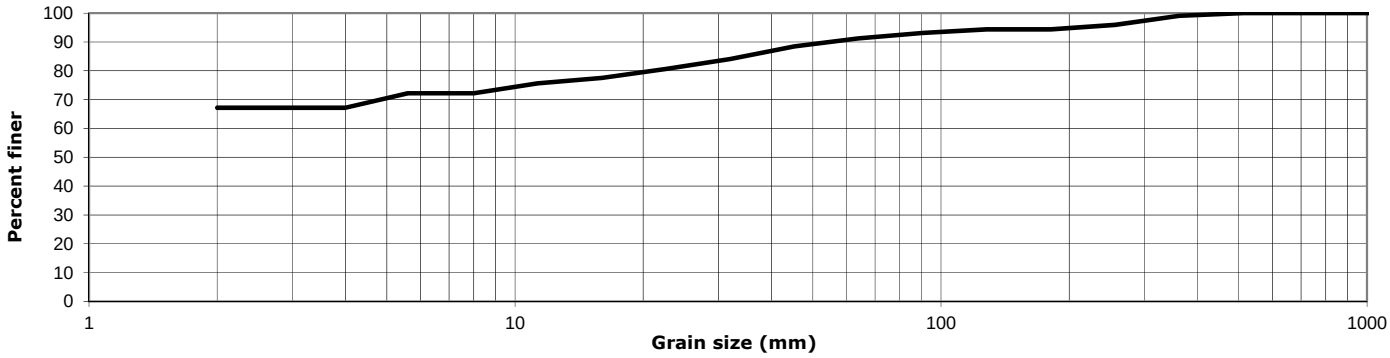
Substrate Characteristics

Particle Size (mm)

D_{10} :	<2.0
D_{50} :	<2.0
D_{84} :	32.0

Subpavement:	Till
Particle shape:	Subrounded
Embeddedness (%):	20 to 70
Particle range (riffle):	Medium sand to boulders
Particle Range (pool):	Silt and sand, few small boulders

Cumulative Particle Size Distribution



Channel Thresholds

Flow Competency (m/s):		**Tractive Force at Bankfull (N/m^2):**	47.51
for D_{50}:	2.26	**Tractive Force at 2-year flow (N/m^2):**	Not modelled
for D_{84}:	0.97	**Critical Shear Stress (D_{50}) (N/m^2):**	145.68
Unit Stream Power at Bankfull (W/m^2):	76.02		

General Field Observations

Channel Description

This reach was steep and confined. The channel is in contact with the valley walls on both sides. The continuous riparian vegetation consisted of mature trees. The average bankfull width and depth were 3.03 m and 0.27 m, respectively. Riffle substrate consisted of medium sand to boulders. Pool substrate consisted of silt and sand. A few small boulders were found in one pool. Recent slumping was observed at the valley wall contact located at the upstream extent of the survey. Till was exposed in the bed and banks. There were also two knickpoints with heights of approximately 0.25 m.

Cross Section 6 - Looking Downstream

Detailed Geomorphological Assessment Summary

Project Number:	PN14028a	**Date:**	November 26, 2014
Client:	Geranium Corporation	**Length Surveyed (m):**	99.3
Location:	BC8, Black Creek, Midhurst, ON	**# of Cross-Sections:**	8

Reach Characteristics

Drainage Area:	N/A	**Dominant Riparian Vegetation Type:**	Grasses and trees
Geology/Soils:	Glaciolacustrine deposits	**Extent of Riparian Cover:**	Continuous
Surrounding Land Use:	Forest	**Width of Riparian Cover:**	>10 channel widths
Valley Type:	Confined	**Age Class of Riparian Vegetation:**	Mature (>30 yrs)
Dominant Instream Vegetation Type:	Rooted submergent	**Extent of Encroachment into Channel:**	Minimal
Portion of Reach with Vegetation:	10%	**Density of Woody Debris:**	Moderate

Hydrology

Measured Discharge (m^3/s):	0.06	**Calculated Bankfull Discharge (m^3/s):**	1.90
Modelled 2-year Discharge (m^3/s):	Not modelled	**Calculated Bankfull Velocity (m/s):**	1.72
Modelled 2-year Velocity (m/s):	Not modelled		

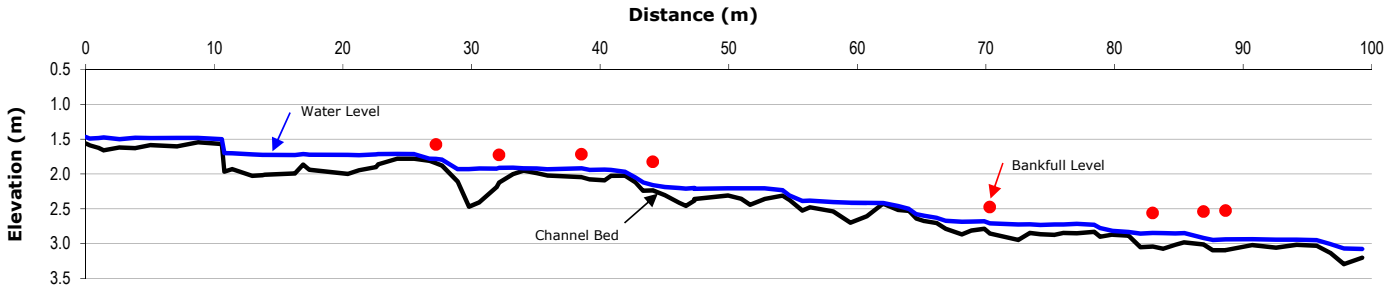
Profile Characteristics

Bankfull Gradient (%):	1.66
Channel Bed Gradient (%):	1.28
Riffle Gradient (%):	1.90
Riffle Length (m):	1.26
Riffle-Pool Spacing (m):	3.83

Planform Characteristics

Sinuosity:	1.50
Meander Belt Width (m):	Not measured
Radius of Curvature (m):	Not measured
Meander Amplitude (m):	Not measured
Meander wavelength (m):	Not measured

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	0.30	0.60	0.41
Bank Angle (deg):	20	90	59
Root Depth (m):	0.10	0.50	0.26
Root Density (%):	10	100	62
Bank Undercut (m):	0.10	0.19	0.03

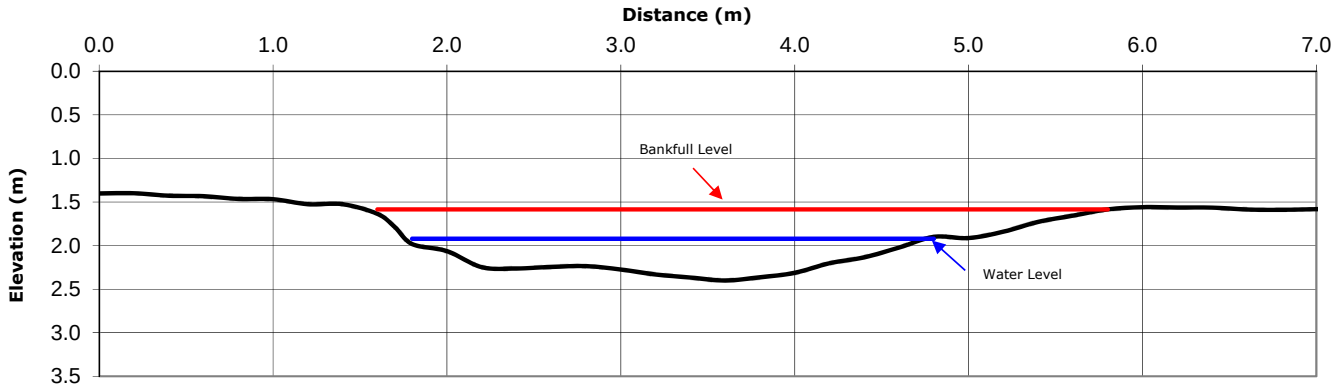
	Minimum	Maximum	Average
Torvane Value (kg/cm^2):		Not measured	
Penetrometer Value (kg/cm^3):		Not measured	
Bank Material (range):		Clay to gravel	

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	2.00	4.20	3.08
Average Bankfull Depth (m):	0.22	0.54	0.36
Bankfull Width/Depth (m/m):	4	17	10
Wetted Width (m):	0.80	3.00	1.73
Average Water Depth (m):	0.04	0.33	0.13
Wetted Width/Depth (m/m):	5	41	19
Entrenchment (m):		Not measured	
Entrenchment Ratio (m/m):		Not measured	
Maximum Water Depth (m):	0.07	0.48	0.19
Manning's *n*:		0.038	

Photograph at cross section 7 (looking downstream)

Representative Cross-Section 2



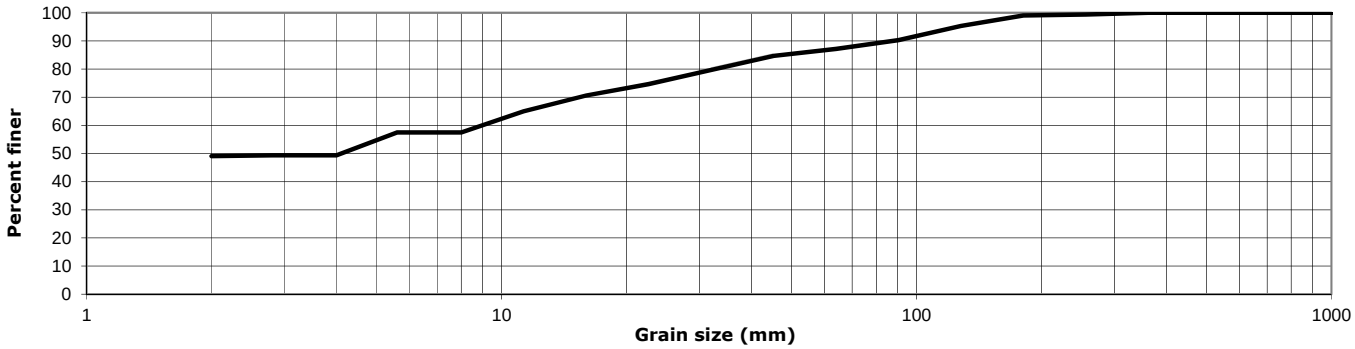
Substrate Characteristics

Particle Size (mm)

D_{10} :	<2.00
D_{50} :	4.10
D_{90} :	90.00

Subpavement:	Coarse sand, gravel, cobbles
Particle shape:	Sub-rounded to sub-angular
Embeddedness (%):	30 to 100
Particle range (riffle):	Coarse sand to boulders
Particle Range (pool):	Sand to cobbles

Cumulative Particle Size Distribution



Channel Thresholds

Flow Competency (m/s):		**Tractive Force at Bankfull (N/m^2):**	58.63
for D_{50}:	0.38	**Tractive Force at 2-year flow (N/m^2):**	Not modelled
for D_{84}:	1.14	**Critical Shear Stress (D_{50}) (N/m^2):**	2.99
Unit Stream Power at Bankfull (W/m^2):	100.57		

General Field Observations

Channel Description

The reach was in a confined valley with mature riparian vegetation. The reach had a steep gradient, high sinuosity, and consisted of well defined riffle-pool sequences. Average bankfull width and depth were 0.31 m and 0.36 m, respectively. Bank material consisted of clay to gravel. Riffle substrate consisted of coarse sand to boulders. Pool substrate consisted of sand to cobbles. Both leaning trees and woody debris were observed in the channel and cutbank. Erosion and exposed roots were noted along both sides of the banks. Watercress was present, indicating groundwater inputs.

Cross-Section 6 - Looking Downstream

Detailed Geomorphological Assessment Summary

Project Number:	PN14028a	**Date:**	November 27, 2014
Client:	Geranium Corporation	**Length Surveyed (m):**	89.3
Location:	BC10, Black Creek, Midhurst, ON	**# of Cross-Sections:**	8

Reach Characteristics

Drainage Area:	N/A	**Dominant Riparian Vegetation Type:**	Grasses
Geology/Soils:	Older alluvial deposits and till	**Extent of Riparian Cover:**	Continuous
Surrounding Land Use:	Forest	**Width of Riparian Cover:**	>10 channel widths
Valley Type:	Unconfined	**Age Class of Riparian Vegetation:**	Immature (<5 yrs)
Dominant Instream Vegetation Type:	Rooted submergent	**Extent of Encroachment into Channel:**	Minimal
Portion of Reach with Vegetation:	20%	**Density of Woody Debris:**	Low

Hydrology

Measured Discharge (m^3/s):	0.07	**Calculated Bankfull Discharge (m^3/s):**	1.01
Modelled 2-year Discharge (m^3/s):	Not modelled	**Calculated Bankfull Velocity (m/s):**	1.70
Modelled 2-year Velocity (m/s):	Not modelled		

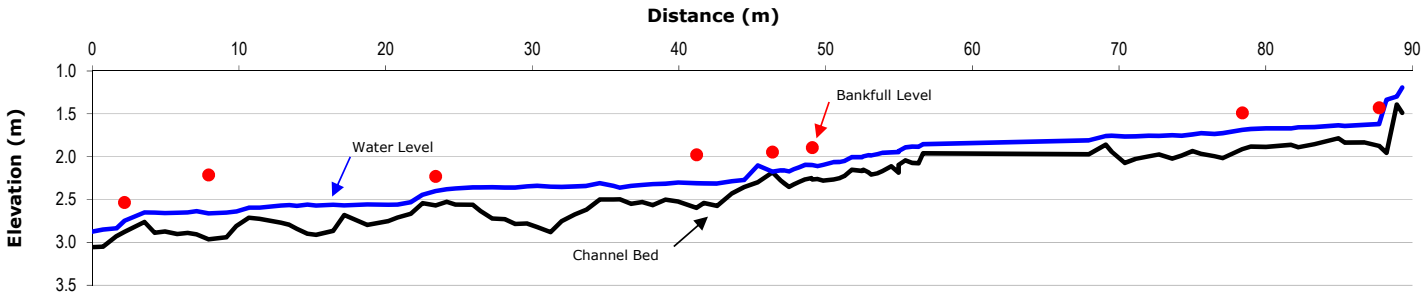
Profile Characteristics

Bankfull Gradient (%):	1.19
Channel Bed Gradient (%):	1.45
Riffle Gradient (%):	4.61
Riffle Length (m):	1.72
Riffle-Pool Spacing (m):	6.51

Planform Characteristics

Sinuosity:	1.32
Meander Belt Width (m):	Not measured
Radius of Curvature (m):	Not measured
Meander Amplitude (m):	Not measured
Meander wavelength (m):	Not measured

Longitudinal Profile



Bank Characteristics

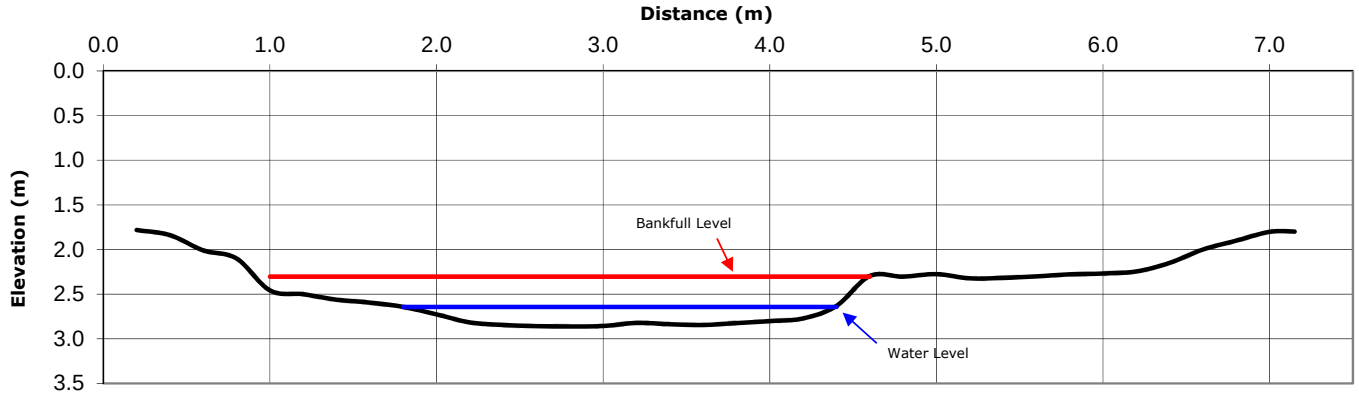
	Minimum	Maximum	Average		Minimum	Maximum	Average
Bank Height (m):	0.2	1.00	0.38				
Bank Angle (deg):	25	75	55	**Torvane Value (kg/cm^2):**		Not measured	
Root Depth (m):	0.10	0.10	0.10	**Penetrometer Value (kg/cm^3):**		Not measured	
Root Density (%):	100	100	100	**Bank Material (range):**		Clay to gravel	
Bank Undercut (m):	0.00	0.10	0.01				

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	0.90	3.60	1.86
Average Bankfull Depth (m):	0.22	0.50	0.32
Bankfull Width/Depth (m/m):	3	12	6
Wetted Width (m):	0.5	2.6	1.3
Average Water Depth (m):	0.06	0.22	0.15
Wetted Width/Depth (m/m):	2	31	11
Entrenchment (m):		Not measured	
Entrenchment Ratio (m/m):		Not measured	
Maximum Water Depth (m):	0.09	0.28	0.19
Manning's *n* :		0.030	

Photograph shows cross section 8 (looking upstream)

Representative Cross-Section 2



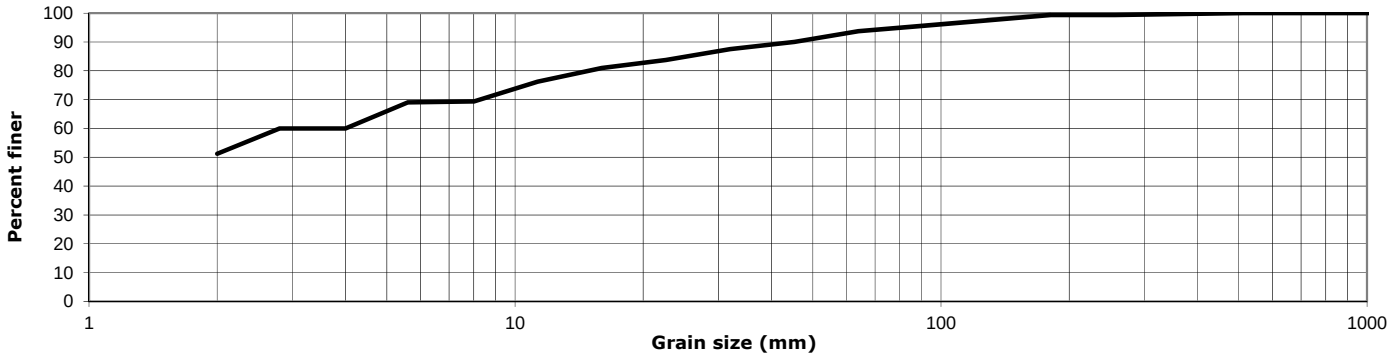
Substrate Characteristics

Particle Size (mm)

D_{10} :	<2.00
D_{50} :	2.00
D_{90} :	45.30

Subpavement:	Coarse sand and bedrock
Particle shape:	Sub-rounded
Embeddedness (%):	0 to 30
Particle range (riffle):	Coarse sand to boulders
Particle Range (pool):	Sand

Cumulative Particle Size Distribution



Channel Thresholds

Flow Competency (m/s):		**Tractive Force at Bankfull (N/m^2):**	37.23
for D_{50}:	0.27	**Tractive Force at 2-year flow (N/m^2):**	Not modelled
for D_{84}:	0.83	**Critical Shear Stress (D_{50}) (N/m^2):**	1.46
Unit Stream Power at Bankfull (W/m^2):	63.16		

General Field Observations

Channel Description

The reach was in an unconfined valley with riparian vegetation consisting of grass. The reach had a moderate gradient, high sinuosity, and consisted of riffle-pool sequences. Average bankfull width and depth were 1.86 m and 0.32 m, respectively. Bank material consisted of clay to sand. Riffle substrate consisted of coarse sand to boulders. Pool substrate consisted of mostly sand. Watercress was observed in the channel indicating groundwater inputs. Banks were steep with little undercutting averaging 0.01 m. A knickpoint was noted at the upstream section approximately 0.6 m high. Woody debris was observed at the downstream extent of survey.

Cross-Section 1 - Looking Downstream

Detailed Geomorphological Assessment Summary

Project Number:	PN14028a	**Date:**	December 22, 2014
Client:	Gernaium Corporation	**Length Surveyed (m):**	185.3
Location:	WC, Willow Creek, Midhurst, ON	**# of Cross-Sections:**	8

Reach Characteristics

Drainage Area:	N/A	**Dominant Riparian Vegetation Type:**	Grasses and few trees
Geology/Soils:	Organic deposits	**Extent of Riparian Cover:**	Continuous
Surrounding Land Use:	Pasture/forest	**Width of Riparian Cover:**	4 - 10 channel widths
Valley Type:	Unconfined	**Age Class of Riparian Vegetation:**	Immature (<5 yrs)
Dominant Instream Vegetation Type:	None	**Extent of Encroachment into Channel:**	None
Portion of Reach with Vegetation:	None	**Density of Woody Debris:**	None

Hydrology

Measured Discharge (m^3/s):	2.81	**Calculated Bankfull Discharge (m^3/s):**	13.90
Modelled 2-year Discharge (m^3/s):	Not modelled	**Calculated Bankfull Velocity (m/s):**	0.78
Modelled 2-year Velocity (m/s):	Not modelled		

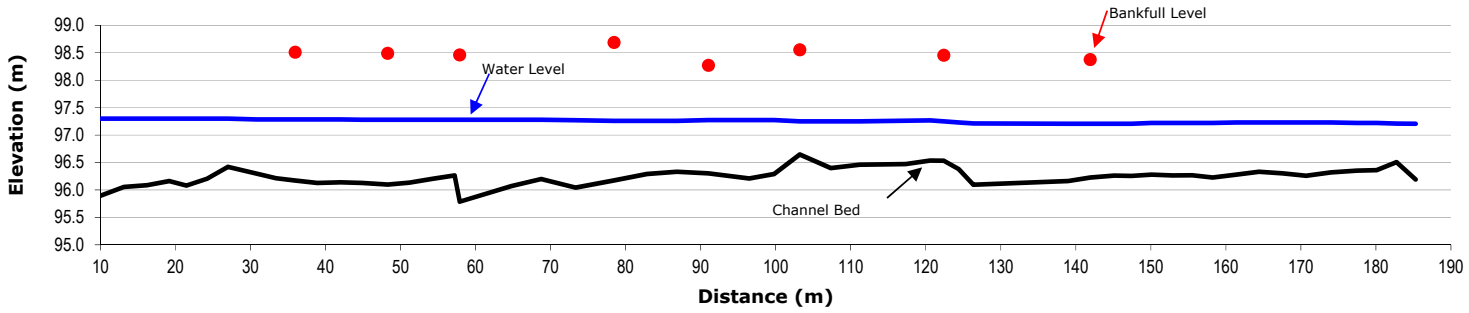
Profile Characteristics

Bankfull Gradient (%):	0.10
Channel Bed Gradient (%):	0.04
Riffle Gradient (%):	N/A: no riffles
Riffle Length (m):	N/A: no riffles
Riffle-Pool Spacing (m):	N/A: no riffle-pool spacing

Planform Characteristics

Sinuosity:	1.18
Meander Belt Width (m):	Not measured
Radius of Curvature (m):	Not measured
Meander Amplitude (m):	Not measured
Meander wavelength (m):	Not measured

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	1.00	2.50	1.78
Bank Angle (deg):	45	60	52
Root Depth (m):	0.05	0.05	0.05
Root Density (%):	75	85	78
Bank Undercut (m):		No undercuts	

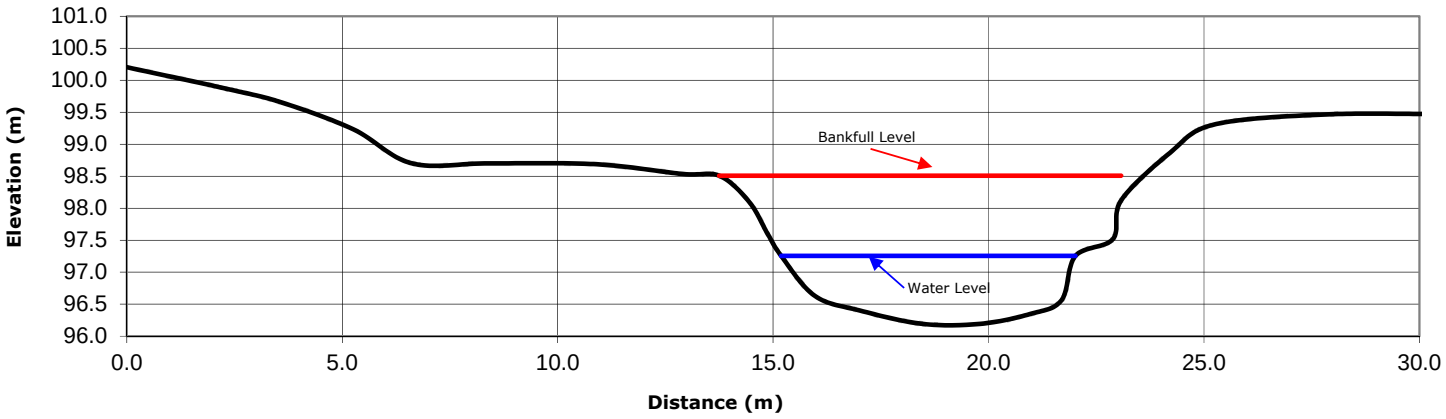
	Minimum	Maximum	Average
Torvane Value (kg/cm^2):		Not measured	
Penetrometer Value (kg/cm^3):		Not measured	
Bank Material (range):		Clay, silt, and sand	

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	9.33	16.93	12.00
Average Bankfull Depth (m):	1.25	1.77	1.49
Bankfull Width/Depth (m/m):	6	12	8
Wetted Width (m):	6.17	10.70	7.84
Average Water Depth (m):	0.70	0.98	0.82
Wetted Width/Depth (m/m):	8	15	10
Entrenchment (m):		Not measured	
Entrenchment Ratio (m/m):		Not measured	
Maximum Water Depth (m):	0.83	1.31	1.05
Manning's *n* :		0.035	

Photograph at cross section 1 (looking upstream)

Representative Cross-Section 1

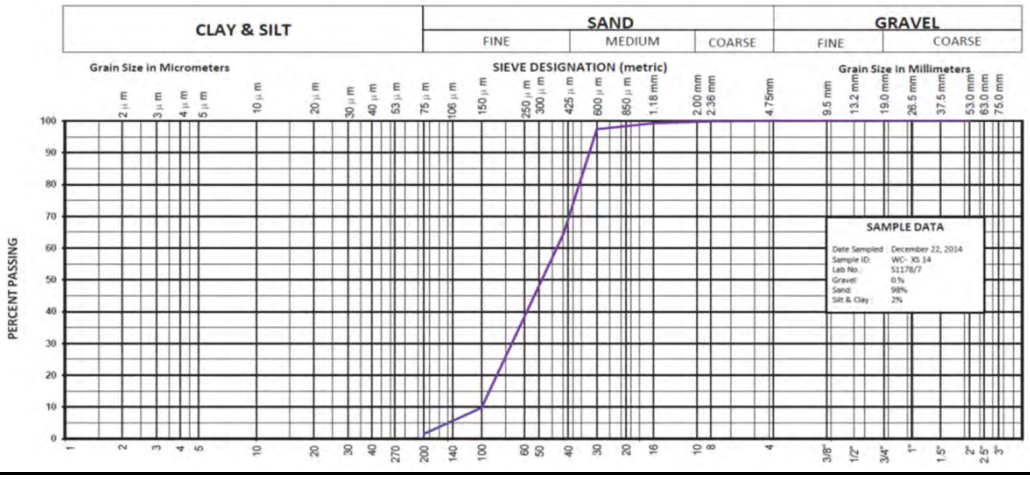


Substrate Characteristics

Particle Size (mm)

D_{10} :	0.150
D_{50} :	0.310
D_{90} :	0.550

Subpavement:	Sand, gravel, and till
Particle shape:	Sub-rounded
Embeddedness (%):	90
Particle range (riffle):	N/A
Particle Range (pool):	Sand and gravel



Samples were taken and analyzed by SHAD and Associtates Inc.

Channel Thresholds

Flow Competency (m/s):		**Tractive Force at Bankfull (N/m^2):**	6.39
for D_{50}:	N/A	**Tractive Force at 2-year flow (N/m^2):**	Not modelled
for D_{84}:	N/A	**Critical Shear Stress (D_{50}) (N/m^2):**	225.80
Unit Stream Power at Bankfull (W/m^2):	4.97		

General Field Observations

Channel Description

This unconfined reach is downstream of Vespra Valley Road. The reach had a moderate sinusity and a low gradient. There are new tree plantings but the dominant riparian vegetation are grasses. A few mature trees and shrubs were observed along the left bank. The average bankfull width and depth are 12.0 and 1.5 m, respectively. Riffles were not observed in this reach; runs and pools were dominant. There were two large pools at the meander bends. The bed consists mostly of sand with some gravel and exposed till.

Upstream View from Cross-section 4

GEO MORPHIX

Detailed Geomorphological Assessment Summary

Project Number:	PN14028a	**Date:**	December 9, 2014
Client:	Geranium Corporation	**Length Surveyed (m):**	164.7
Location:	WC5, Willow Creek, Midhurst, ON	**# of Cross-Sections:**	8

Reach Characteristics

Drainage Area:	N/A	**Dominant Riparian Vegetation Type:**	Trees
Geology/Soils:	Modern alluvial deposits	**Extent of Riparian Cover:**	Continuous
Surrounding Land Use:	Forest	**Width of Riparian Cover:**	>10 channel widths
Valley Type:	Partially confined	**Age Class of Riparian Vegetation:**	Mature (>30 yrs)
Dominant Instream Vegetation Type:	None	**Extent of Encroachment into Channel:**	None
Portion of Reach with Vegetation:	N/A	**Density of Woody Debris:**	Low

Hydrology

Measured Discharge (m^3/s):	1.56	**Calculated Bankfull Discharge (m^3/s):**	9.24
Modelled 2-year Discharge (m^3/s):	Not modelled	**Calculated Bankfull Velocity (m/s):**	1.46
Modelled 2-year Velocity (m/s):	Not modelled		

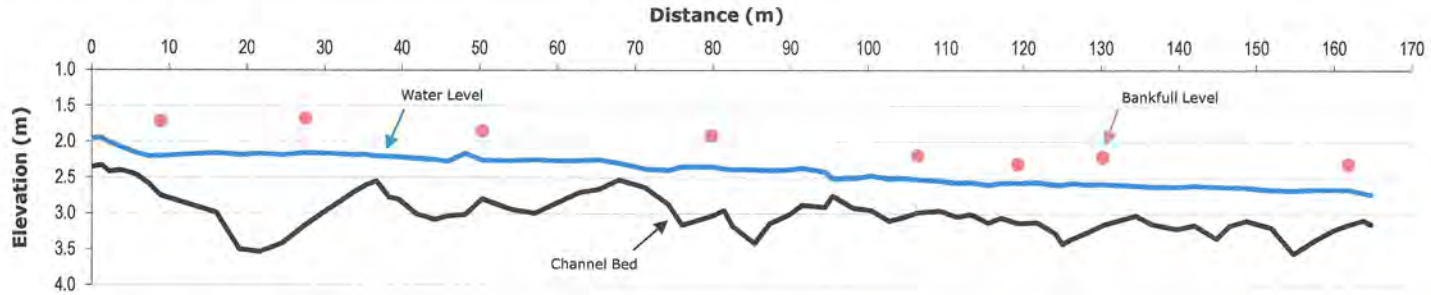
Profile Characteristics

Bankfull Gradient (%):	0.47
Channel Bed Gradient (%):	0.19
Riffle Gradient (%):	2.28
Riffle Length (m):	5.16
Riffle-Pool Spacing (m):	8.90

Planform Characteristics

Sinuosity:	1.26
Meander Belt Width (m):	Not measured
Radius of Curvature (m):	Not measured
Meander Amplitude (m):	Not measured
Meander wavelength (m):	Not measured

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	0.20	3.50	1.35
Bank Angle (deg):	10	90	60
Root Depth (m):	0.00	1.50	0.37
Root Density (%):	0	80	39
Bank Undercut (m):	0.00	0.15	0.01

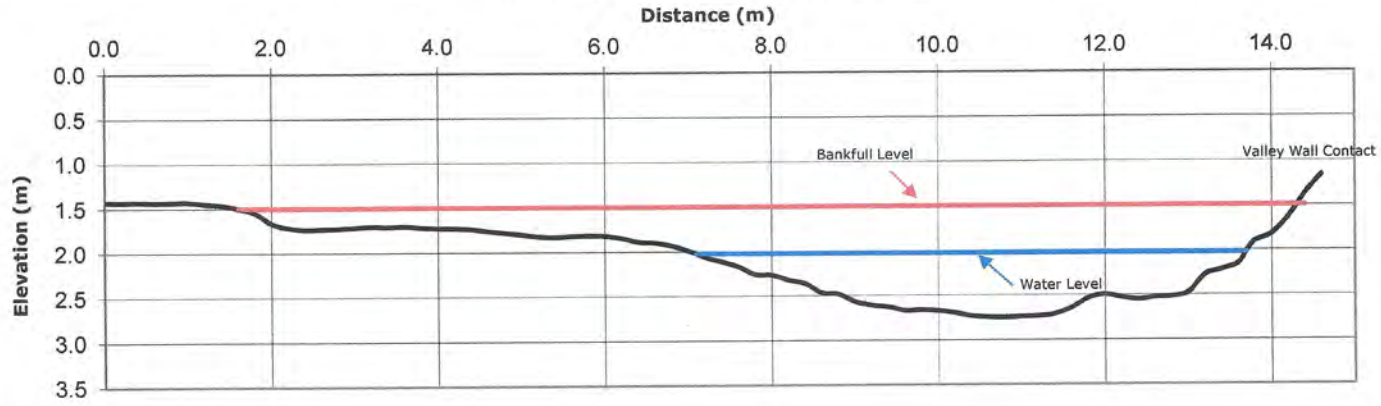
	Minimum	Maximum	Average
Torvane Value (kg/cm^2):	Not measured		
Penetrometer Value (kg/cm^3):	Not measured		
Bank Material (range):	Till, silt to small cobble		

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	7.60	13.20	9.89
Average Bankfull Depth (m):	0.47	0.84	0.64
Bankfull Width/Depth (m/m):	12	20	16
Wetted Width (m):	5.55	12.40	7.43
Average Water Depth (m):	0.28	0.50	0.40
Wetted Width/Depth (m/m):	12	27	19
Entrenchment (m):		Not measured	
Entrenchment Ratio (m/m):		Not measured	
Maximum Water Depth (m):	0.42	1.06	0.64
Manning's *n*:		0.035	

Photograph shows left bank at cross section 3

Representative Cross-Section 4



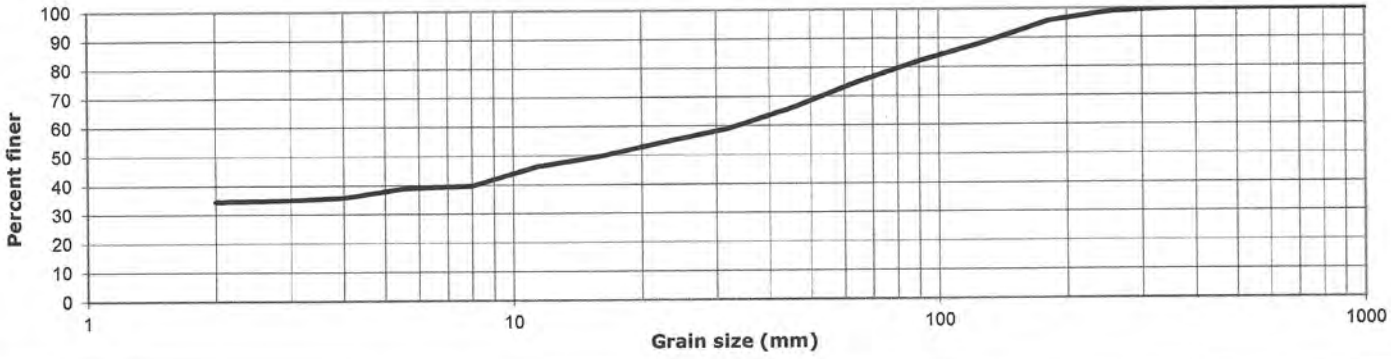
Substrate Characteristics

Particle Size (mm)

D_{10}:	<2.0
D_{50}:	16.2
D_{90}:	150.0

Subpavement:	Gravel and till
Particle shape:	Sub-rounded
Embeddedness (%):	20 to 50
Particle range (riffle):	Medium sand to boulders
Particle Range (pool):	Sand with exposed till

Cumulative Particle Size Distribution



Channel Thresholds

Flow Competency (m/s):		**Tractive Force at Bankfull (N/m^2):**	29.56
for D_{50}:	0.71	**Tractive Force at 2-year flow (N/m^2):**	Not modelled
for D_{84}:	1.58	**Critical Shear Stress (D_{50}) (N/m^2):**	11.80
Unit Stream Power at Bankfull (W/m^2):	43.04		

General Field Observations

Channel Description

The reach was in a confined valley with a riparian area consisting of trees and grasses. The reach had a high sinuosity and a moderate gradient. Average bankfull width and depth were 9.89 m and 0.64 m, respectively. Bank material consisted of silt to small cobbles with areas of exposed till. Riffle substrate consisted of coarse sand to boulders. Pool substrate consisted of sand and exposed till. Large valley wall contacts were observed at the downstream extent and half-way through the survey at cross-section 4. Bank erosion, woody debris, and leaning trees were also noted.

Cross Section 8 - Looking Downstream

Detailed Geomorphological Assessment Summary

Project Number:	PN14028a	**Date:**	December 8, 2014
Client:	Geranium Corporation	**Length Surveyed (m):**	181.0
Location:	WC6, Willow Creek, Midhurst, ON	**# of Cross-Sections:**	8

Reach Characteristics

Drainage Area:	N/A	**Dominant Riparian Vegetation Type:**	Trees
Geology/Soils:	Modern alluvial deposits	**Extent of Riparian Cover:**	Continuous
Surrounding Land Use:	Forest	**Width of Riparian Cover:**	>10 channel widths
Valley Type:	Partially confined	**Age Class of Riparian Vegetation:**	Mature (>30 yrs)
Dominant Instream Vegetation Type:	None	**Extent of Encroachment into Channel:**	None
Portion of Reach with Vegetation:	N/A	**Density of Woody Debris:**	Low

Hydrology

Measured Discharge (m^3/s):	5.08	**Calculated Bankfull Discharge (m^3/s):**	8.87
Modelled 2-year Discharge (m^3/s):	Not modelled	**Calculated Bankfull Velocity (m/s):**	1.05
Modelled 2-year Velocity (m/s):	Not modelled		

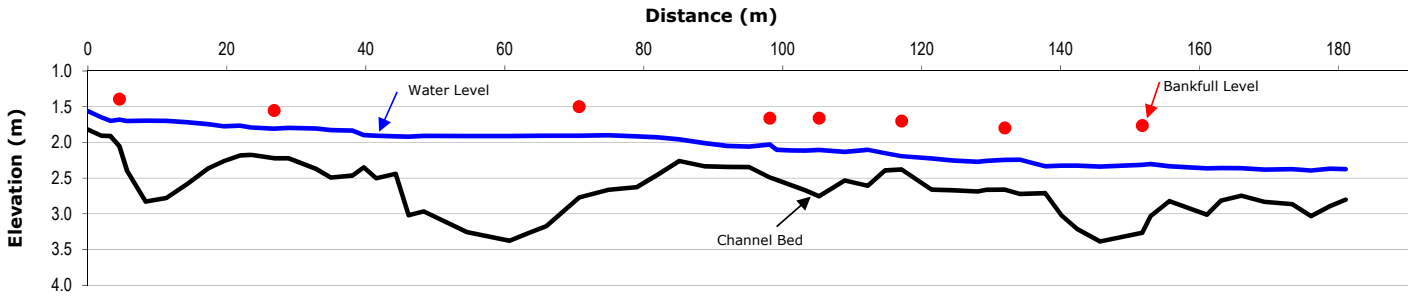
Profile Characteristics

Bankfull Gradient (%):	0.25
Channel Bed Gradient (%):	0.19
Riffle Gradient (%):	1.58
Riffle Length (m):	14.05
Riffle-Pool Spacing (m):	43.93

Planform Characteristics

Sinuosity:	1.09
Meander Belt Width (m):	Not measured
Radius of Curvature (m):	Not measured
Meander Amplitude (m):	Not measured
Meander wavelength (m):	Not measured

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	0.60	3.00	1.60
Bank Angle (deg):	5	90	65
Root Depth (m):	0.05	1.90	0.50
Root Density (%):	0	100	50
Bank Undercut (m):	0	0.4	0.04

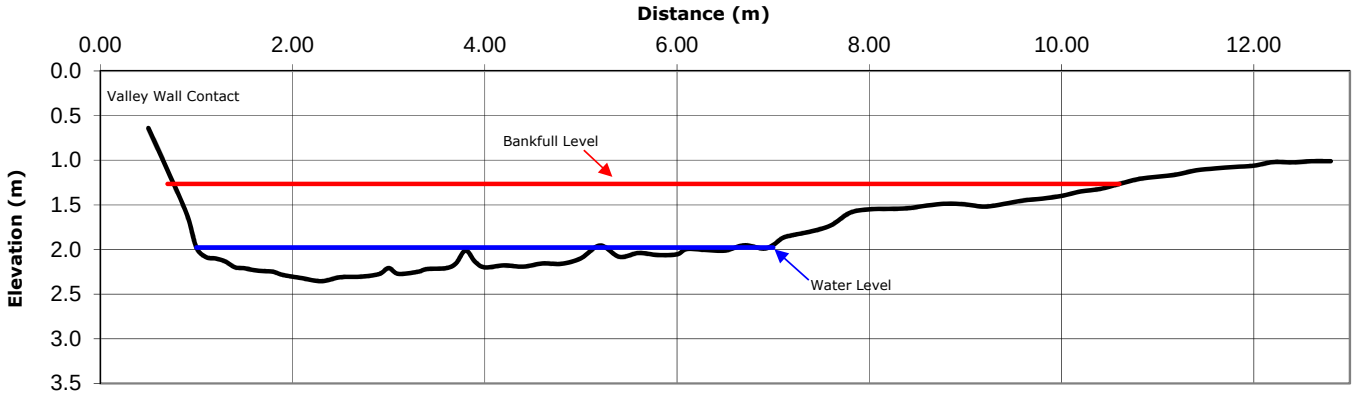
	Minimum	Maximum	Average
Torvane Value (kg/cm^2):		Not measured	
Penetrometer Value (kg/cm^3):		Not measured	
Bank Material (range):		Clay to small cobbles	

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	9.90	13.20	11.03
Average Bankfull Depth (m):	0.69	0.83	0.77
Bankfull Width/Depth (m/m):	13	16	14
Wetted Width (m):	6.00	9.28	7.16
Average Water Depth (m):	0.18	0.59	0.35
Wetted Width/Depth (m/m):	16	34	24
Entrenchment (m):		Not measured	
Entrenchment Ratio (m/m):		Not measured	
Maximum Water Depth (m):	0.33	0.77	0.54
Manning's *n* :		0.040	

Photograph at cross section 5 (looking downstream)

Representative Cross-Section 2



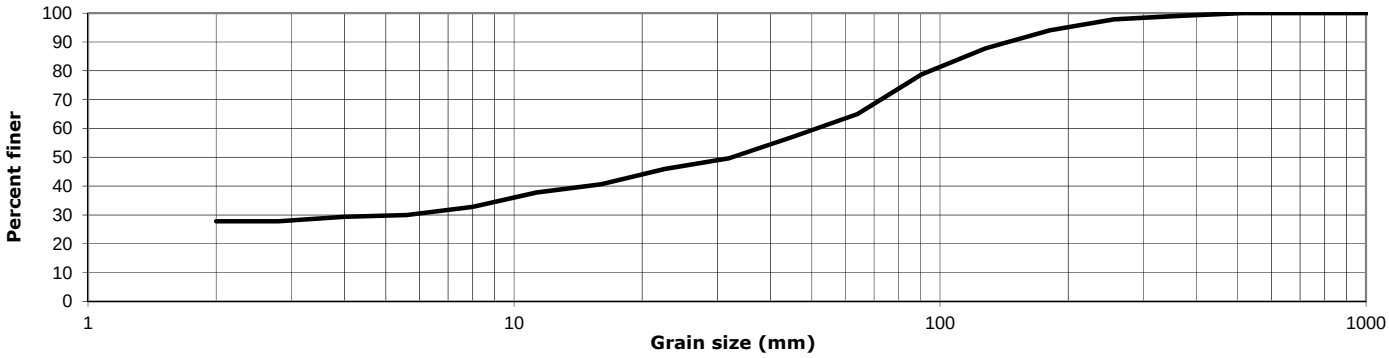
Substrate Characteristics

Particle Size (mm)

D_{10} :	<2.0
D_{50} :	32.0
D_{90} :	155.0

Subpavement:	Sand and gravel
Particle shape:	Sub-rounded to sub-angular
Embeddedness (%):	0 to 65
Particle range (riffle):	Coarse sand to boulders
Particle Range (pool):	Fine sand with a few boulders

Cumulative Particle Size Distribution



Channel Thresholds

Flow Competency (m/s):		**Tractive Force at Bankfull (N/m^2):**	18.82
for D_{50}:	0.97	**Tractive Force at 2-year flow (N/m^2):**	Not modelled
for D_{84}:	1.72	**Critical Shear Stress (D_{50}) (N/m^2):**	23.31
Unit Stream Power at Bankfull (W/m^2):	19.71		

General Field Observations

Channel Description

The reach was in a confined valley and had a moderate sinuosity and gradient. The riparian vegetation was continuous and consisted of trees. Average bankfull width and depth were 10.9 m and 0.94 m, respectively. Bank material consisted of clay to small cobbles. Riffles substrate consisted of coarse sand to boulders. Pool substrate consisted of fine sand with a few boulders. There were steep riffles, eroded banks, sand deposits, and deep pools. There was a valley wall contact along the right bank at the upstream extent and the left bank at the downstream extent of the survey.

Cross Section 6 - Looking Downstream

Detailed Geomorphological Assessment Summary

Project Number:	PN14028a	**Date:**	May 28, 2015
Client:	Geranium Corporation	**Length Surveyed (m):**	207.2
Location:	WC9, Willow Creek, Midhurst, ON	**# of Cross-Sections:**	8

Reach Characteristics

Drainage Area:	N/A	**Dominant Riparian Vegetation Type:**	Grasses
Geology/Soils:	Organic deposits	**Extent of Riparian Cover:**	None
Surrounding Land Use:	Forest	**Width of Riparian Cover:**	>10 channel widths
Valley Type:	Unconfined	**Age Class of Riparian Vegetation:**	Immature (<5 yrs)
Dominant Instream Vegetation Type:	Rooted submerged	**Extent of Encroachment into Channel:**	Moderate
Portion of Reach with Vegetation:	25%	**Density of Woody Debris:**	Low

Hydrology

Measured Discharge (m^3/s):	1.03	**Calculated Bankfull Discharge (m^3/s):**	3.72
Modelled 2-year Discharge (m^3/s):	Not modelled	**Calculated Bankfull Velocity (m/s):**	0.29
Modelled 2-year Velocity (m/s):	Not modelled		

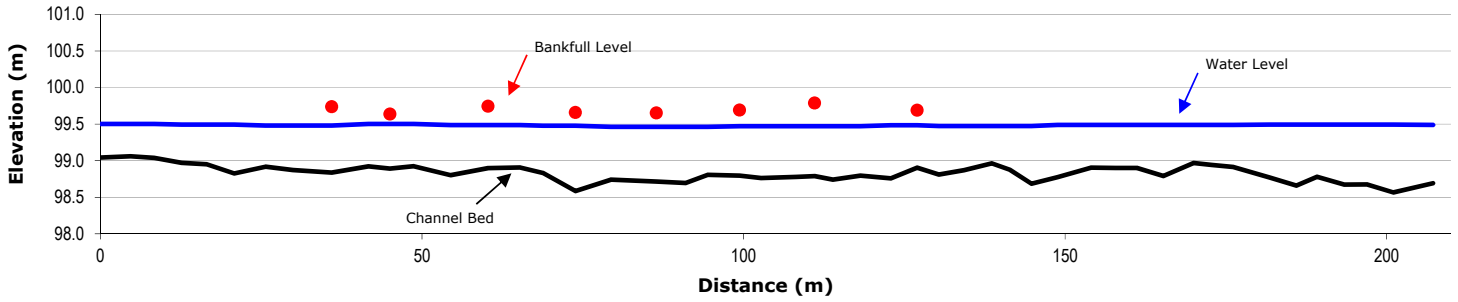
Profile Characteristics

Bankfull Gradient (%):	0.02
Channel Bed Gradient (%):	0.09
Riffle Gradient (%):	N/A: no riffles
Riffle Length (m):	N/A: no riffles
Riffle-Pool Spacing (m):	N/A: no riffle-pool spacing

Planform Characteristics

Sinuosity:	1.11
Meander Belt Width (m):	Not measured
Radius of Curvature (m):	Not measured
Meander Amplitude (m):	Not measured
Meander wavelength (m):	Not measured

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	0.73	0.97	0.85
Bank Angle (deg):	30	60	34
Root Depth (m):	0.10	0.10	0.10
Root Density (%):	80	80	80
Bank Undercut (m):		No undercuts	

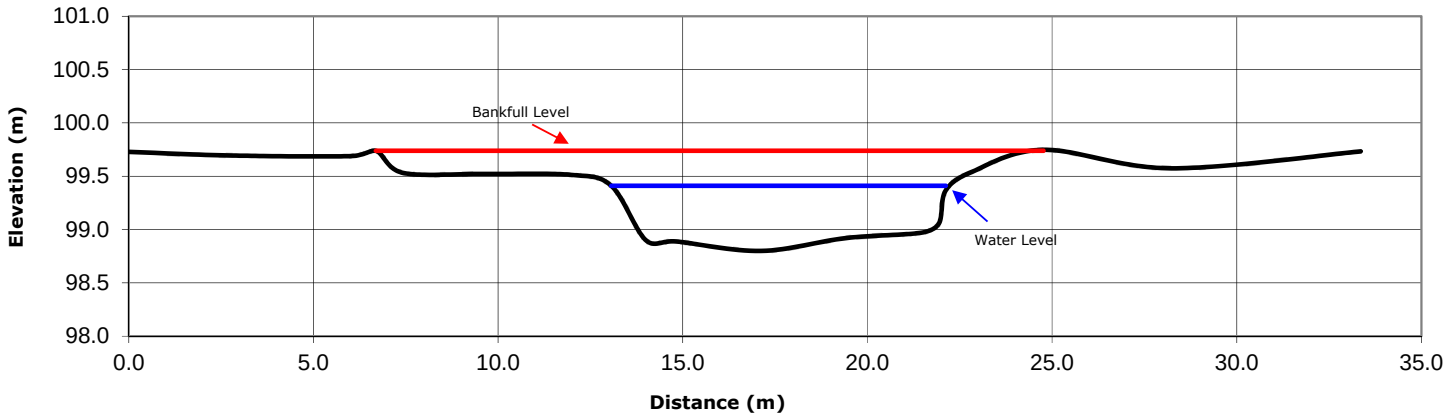
	Minimum	Maximum	Average
Torvane Value (kg/cm^2):		Not measured	
Penetrometer Value (kg/cm^3):		Not measured	
Bank Material (range):		Clay to sand	

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	18.07	25.16	21.87
Average Bankfull Depth (m):	0.52	0.78	0.60
Bankfull Width/Depth (m/m):	27	47	38
Wetted Width (m):	9.05	15.81	12.07
Average Water Depth (m):	0.46	0.69	0.54
Wetted Width/Depth (m/m):	19	30	22
Entrenchment (m):		Not measured	
Entrenchment Ratio (m/m):		Not measured	
Maximum Water Depth (m):	0.61	0.87	0.69
Manning's *n* :		0.035	

Photograph at cross section 4 (looking at left bank)

Representative Cross-Section 1

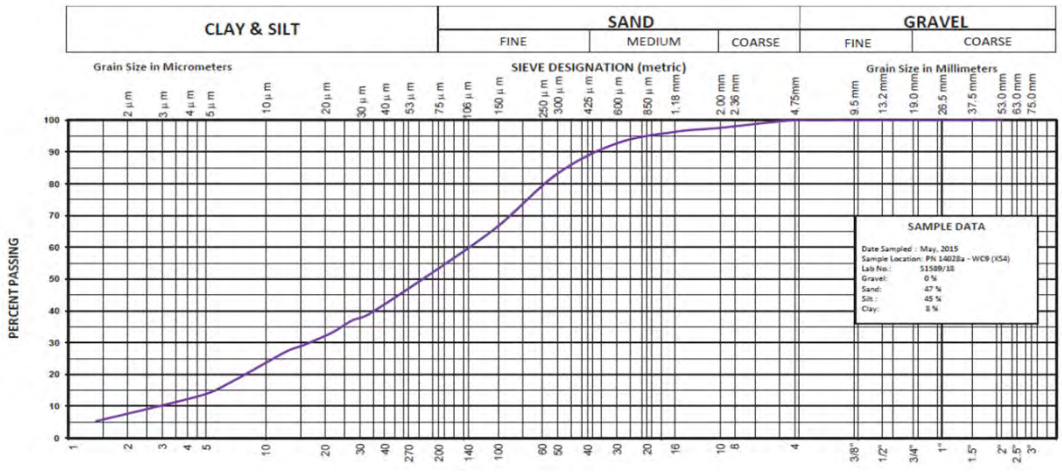


Substrate Characteristics

Particle Size (mm)

D_{10} :	0.003
D_{50} :	0.060
D_{84} :	0.320

Subpavement:	Organics
Particle shape:	N/A: fines only
Embeddedness (%):	N/A: fines only
Particle range (riffle):	Silt, sand, and organics
Particle Range (pool):	Silt, sand, and organics



Samples were taken and analyzed by SHAD and Associtates Inc.

Channel Thresholds

Flow Competency (m/s):		**Tractive Force at Bankfull (N/m^2):**	1.17
for D_{50}:	0.27	**Tractive Force at 2-year flow (N/m^2):**	Not modelled
for D_{84}:	0.27	**Critical Shear Stress (D_{50}) (N/m^2):**	1.46
Unit Stream Power at Bankfull (W/m^2):	0.33		

General Field Observations

Channel Description

The reach flowed through an unconfined wetland. The reach has a low sinusity and gradient. The riparian area was wide and the vegetation consisted of mainly of grasses. Average bankfull width and depth were 21.87 m and 0.60 m, respectively. Bank material consisted of clay, silt, and sand. There was no riffle-pool development. The reach consisted of a plain bed. Bed substrate consisted of silt, sand, and organics. The bed material was soft especially near the banks. Little to no erosion was observed.

Cross Section 6 - Looking Downstream

Appendix E

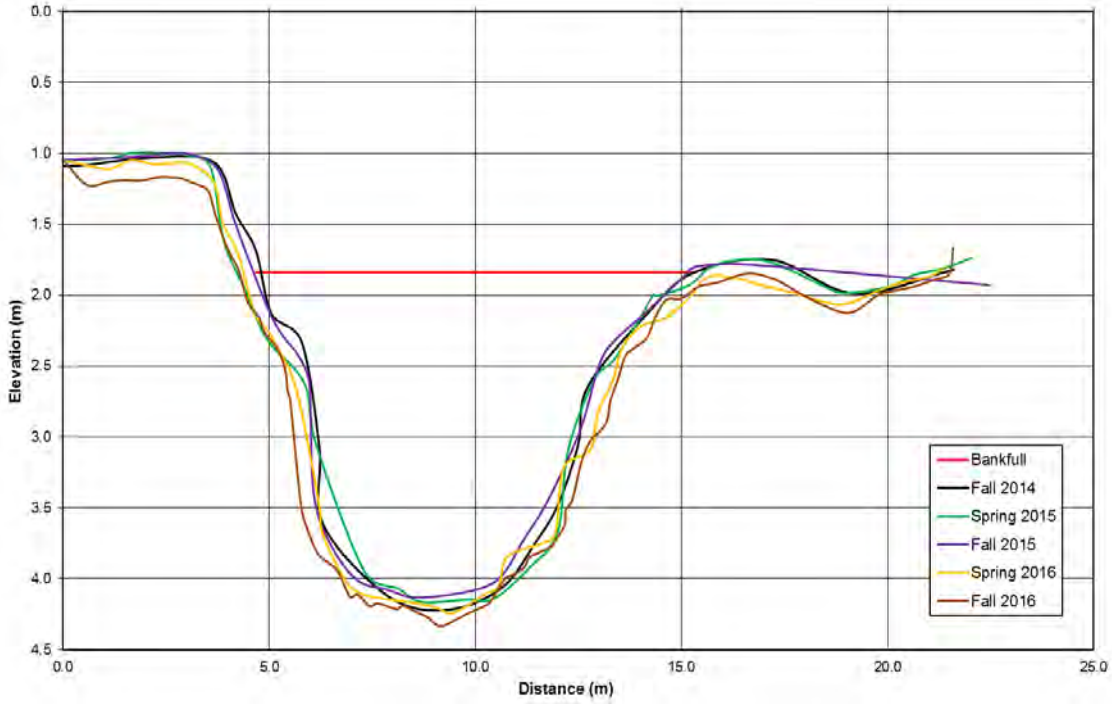
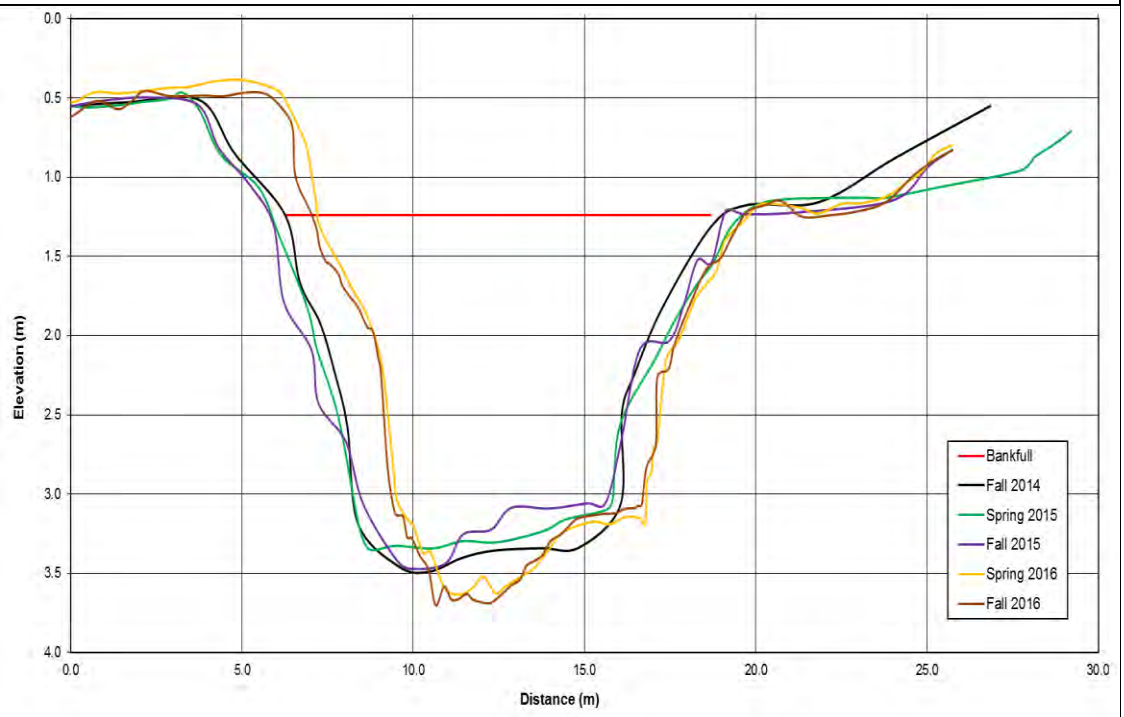
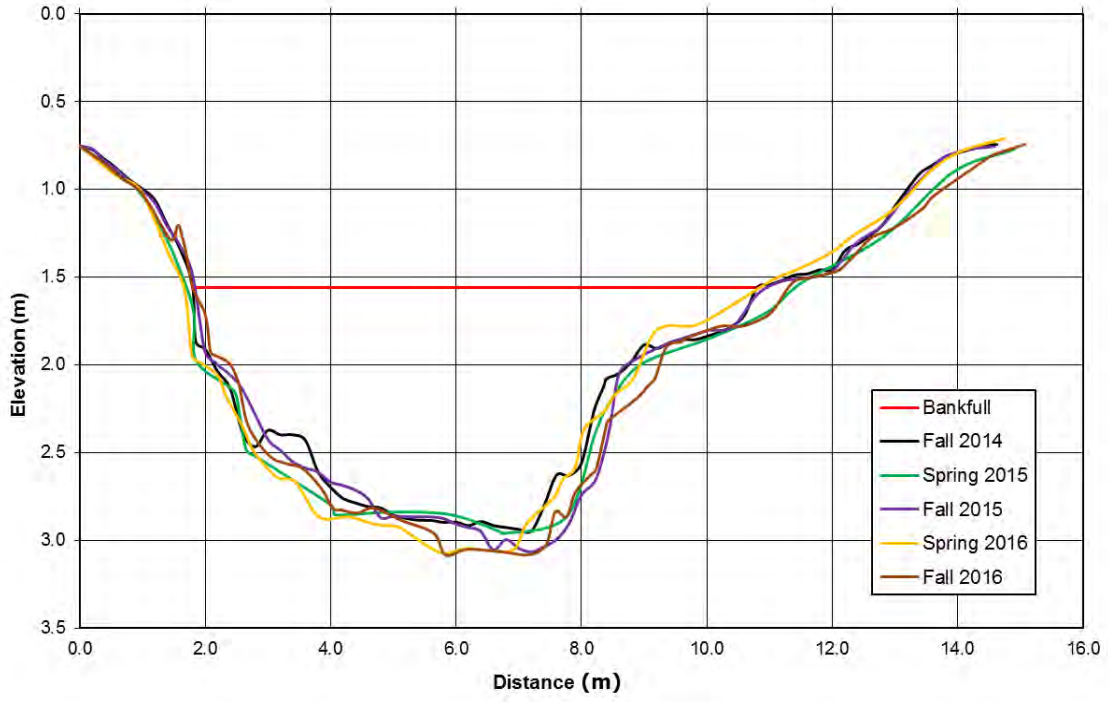
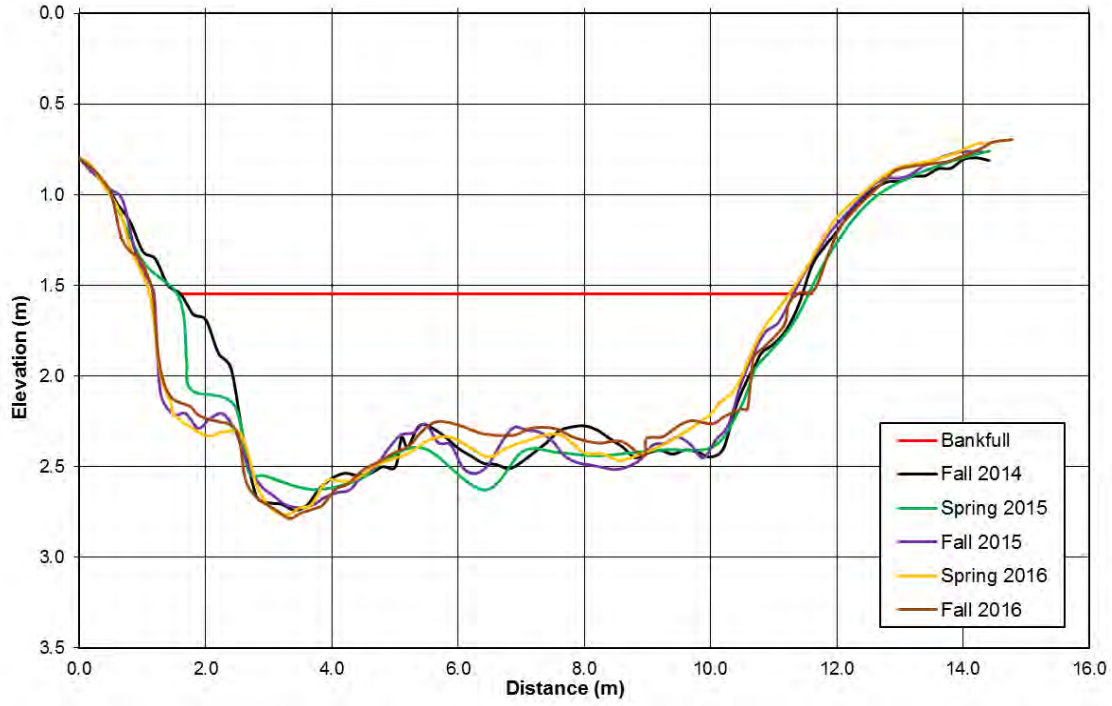
Figure 1	 Reach WC: XS2 (Run) Channel bed and bank extent at cross-section 2 for 2014 to 2016 site visits.
Figure 2	 Reach WC: XS7 (Run) Channel bed and bank extent at cross-section 7 for 2014 to 2016 site visits.

Figure 3



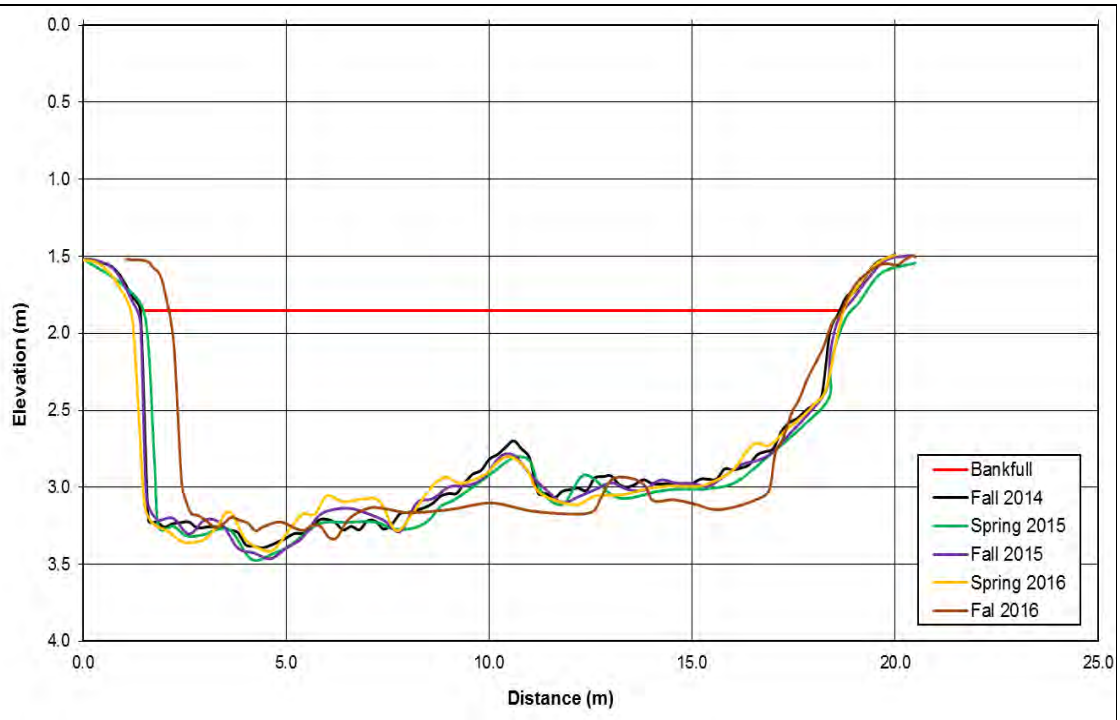
Reach WC1: US (Pool)
Channel bed and bank extent at upstream cross-section for 2014 to 2016 site visits.

Figure 4



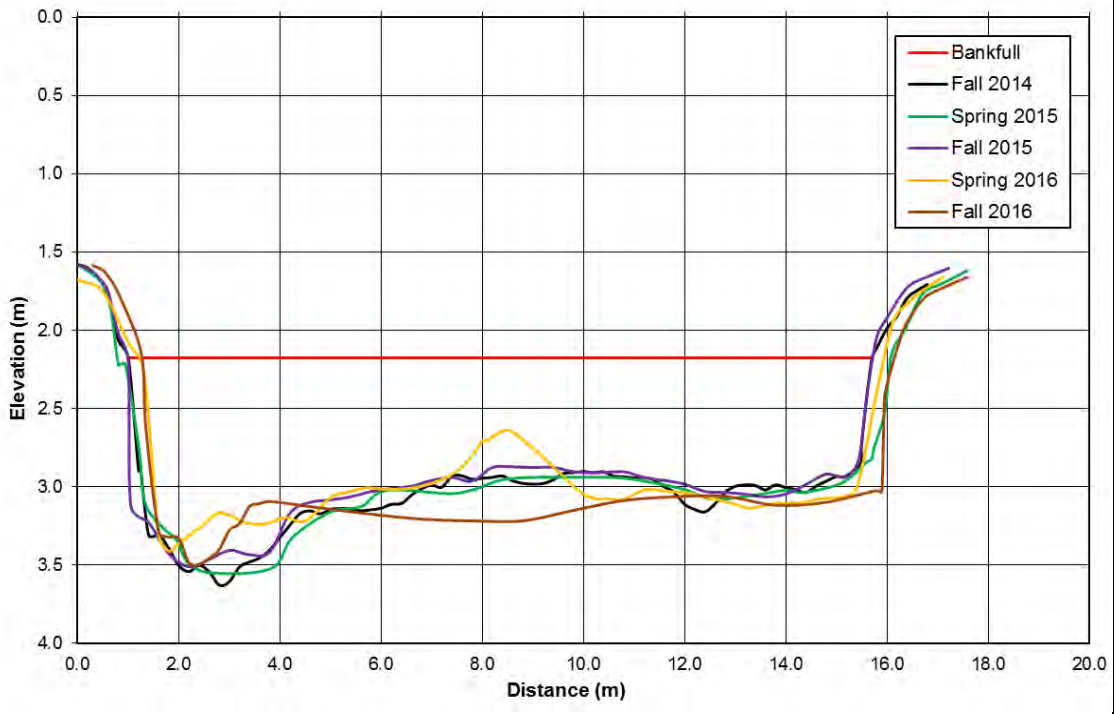
Reach WC1: DS (Run)
Channel bed and bank extent at downstream cross-section for 2014 to 2016 site visits.

Figure 5



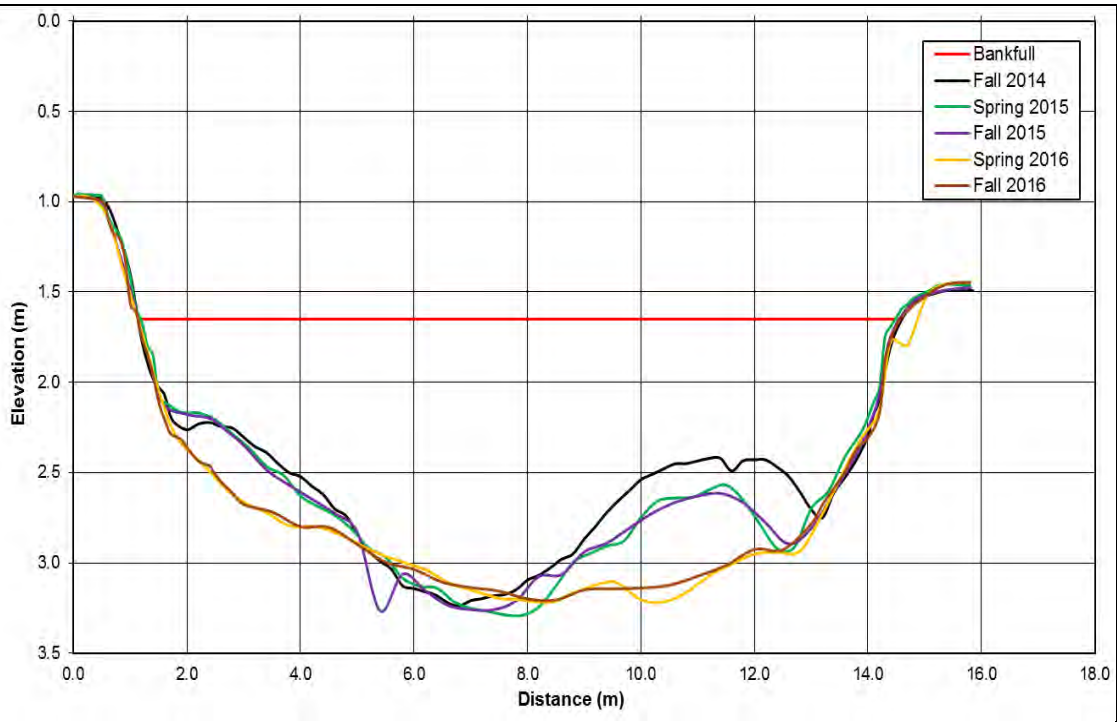
Reach WC3: DS (Riffle)
Channel bed and bank extent at downstream cross-section for 2014 to 2016 site visits.

Figure 6



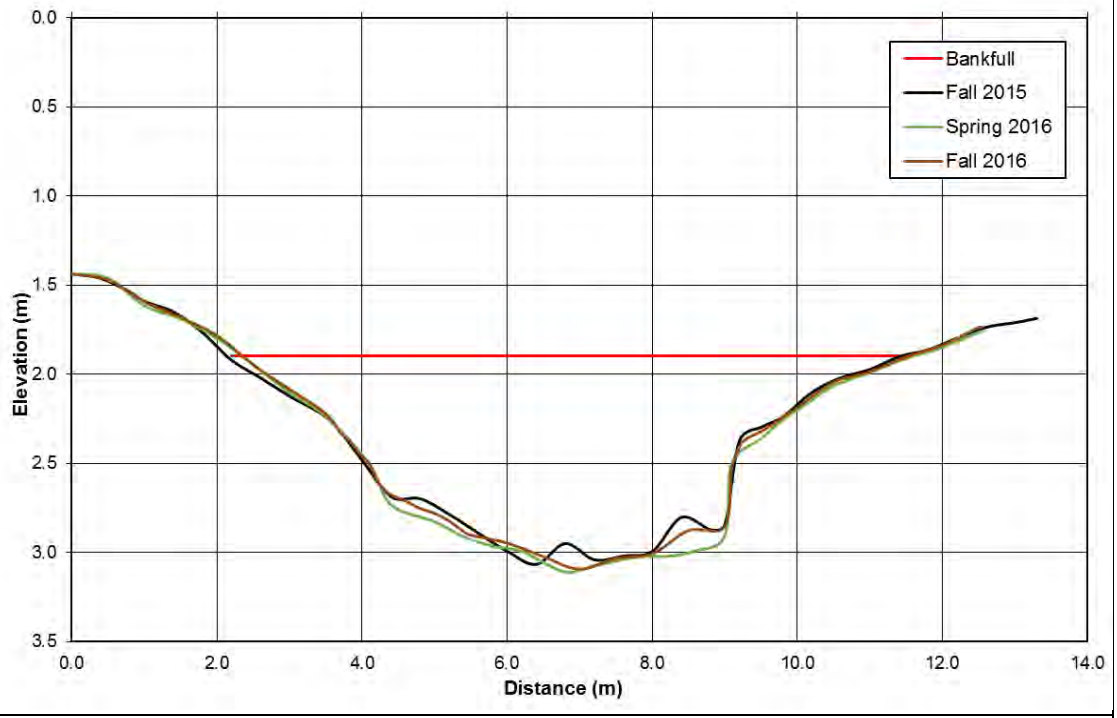
Reach WC3: US (Pool)
Channel bed and bank extent at upstream cross-section for 2014 to 2016 site visits.

Figure 7



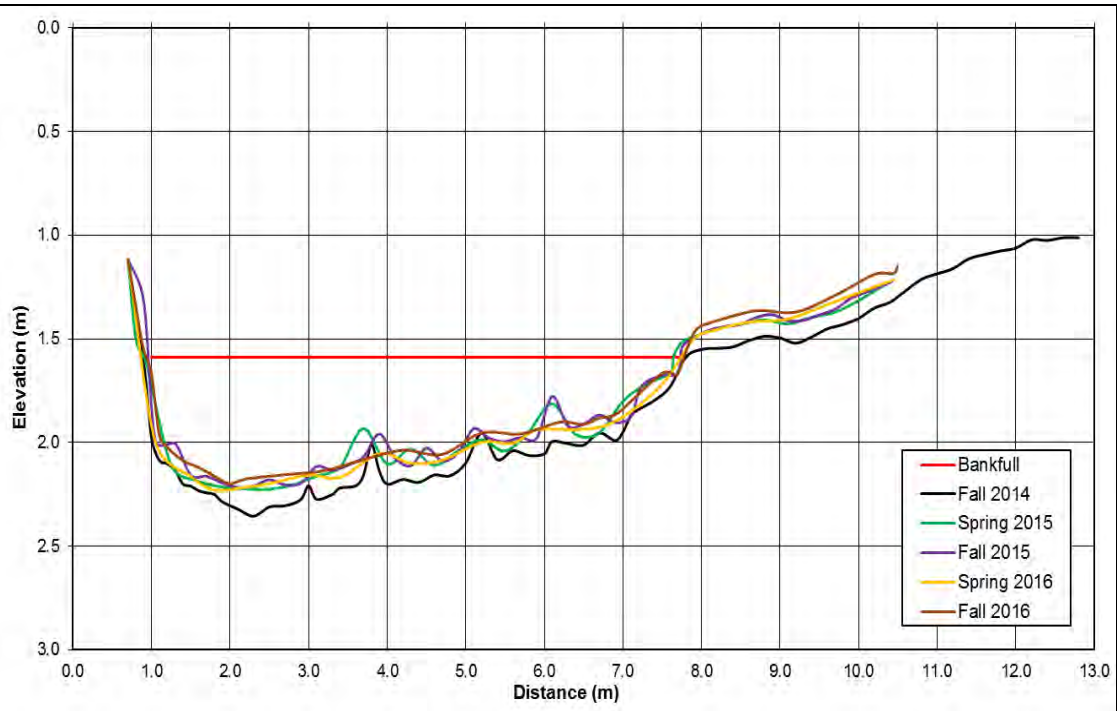
Reach WC5: XS2 (Pool)
Channel bed and bankfull extent at cross-section 2 for 2014 to 2016 site visits.

Figure 8



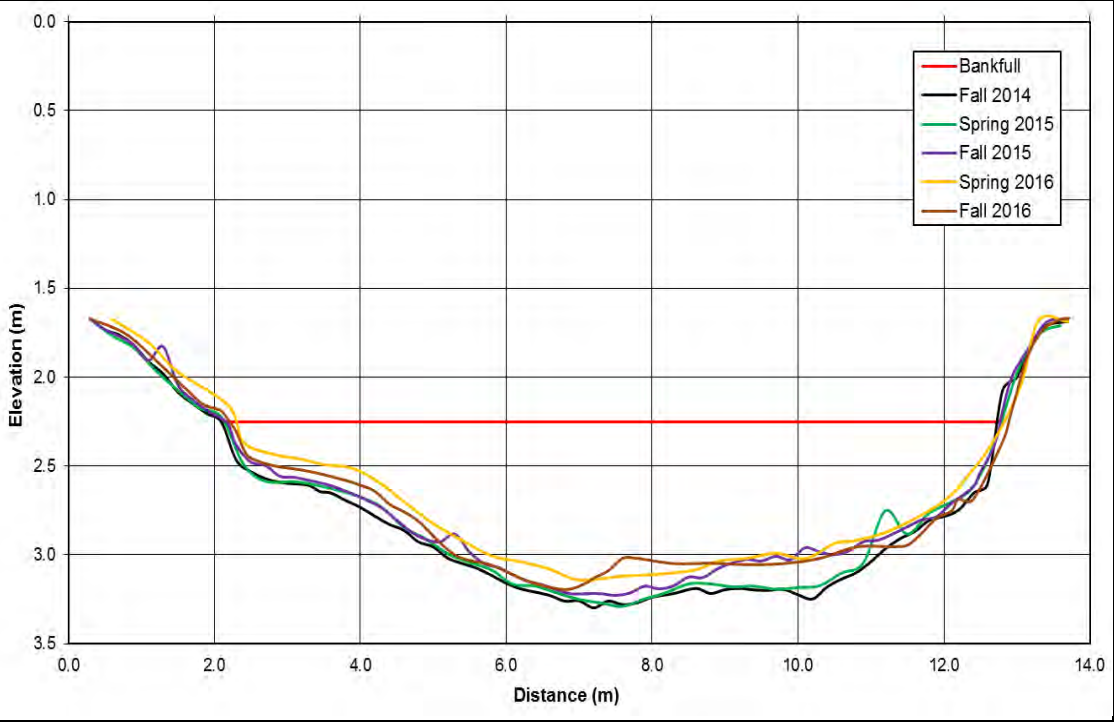
Reach WC5: XS1 (Riffle)
Channel bed and bank extent at cross-section 1 for 2015 to 2016 site visits.

Figure 9



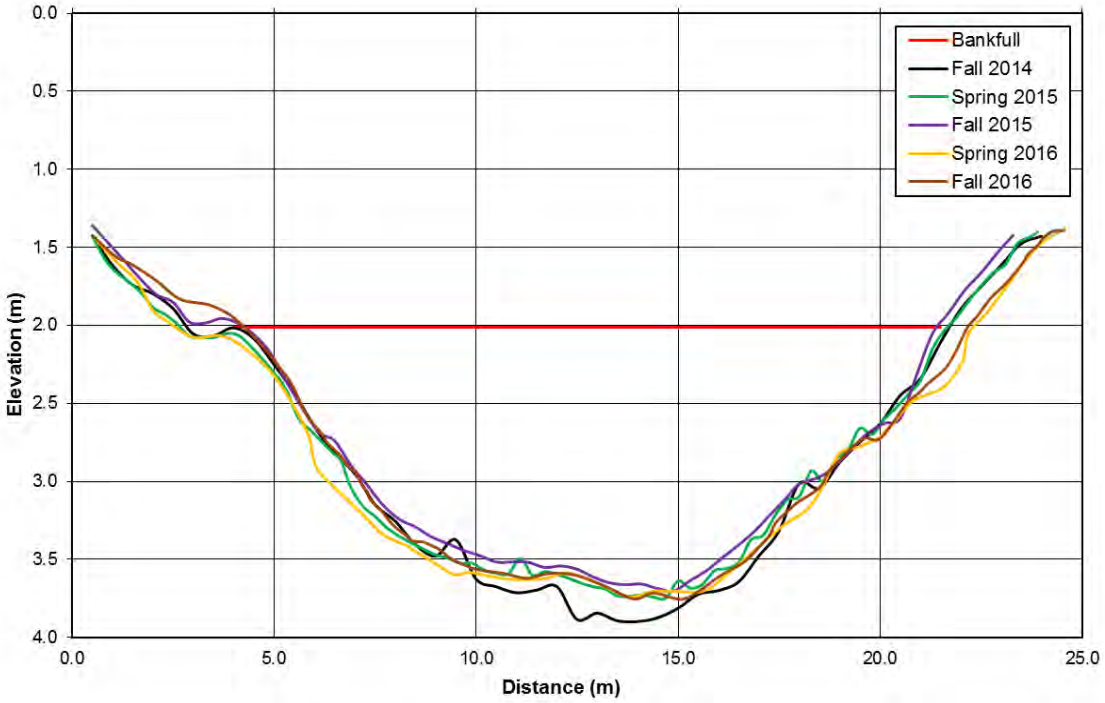
Reach WC6: XS2 (Riffle)
Channel bed and bank extent at cross-section 2 for 2014 to 2016 site visits.

Figure 10



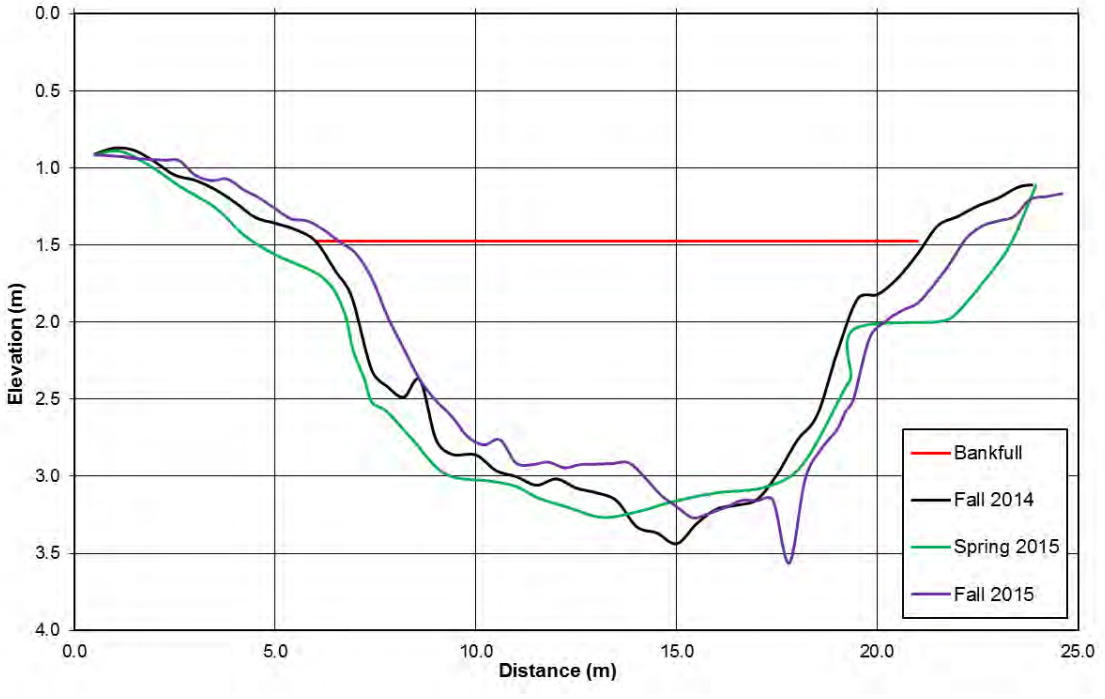
Reach WC6: XS5 (Pool)
Channel bed and bank extent at cross-section 5 for 2014 to 2016 site visits.

Figure 11



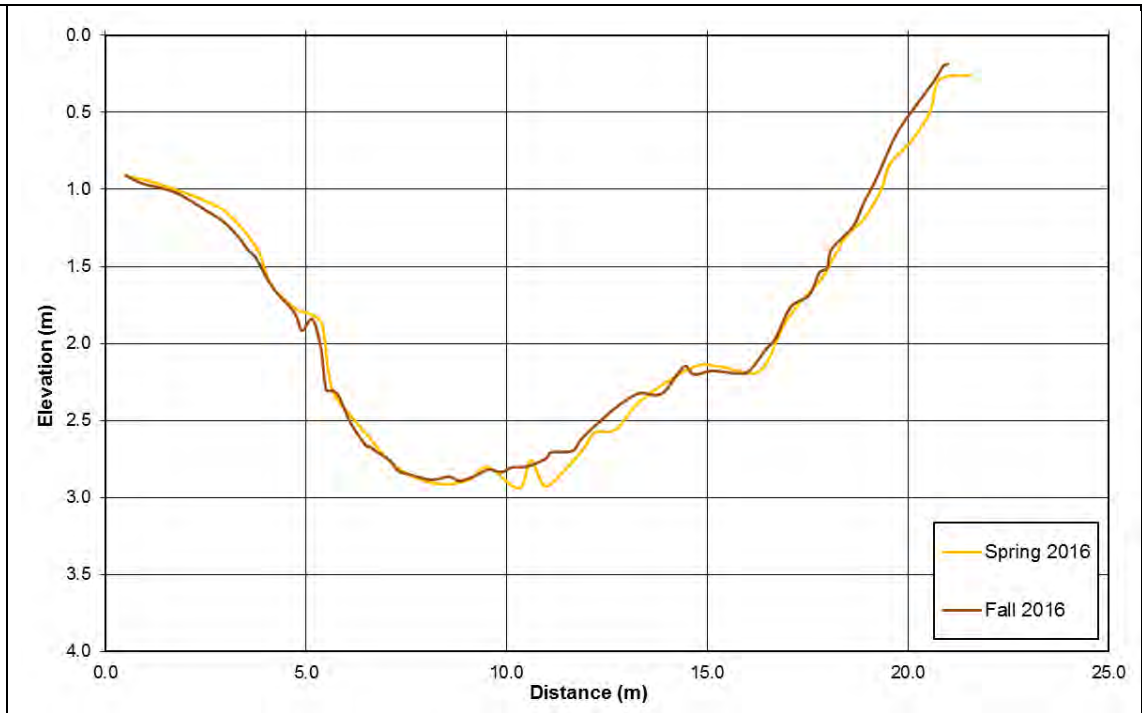
Reach WC8: US (Pool)
Channel bed and bank extent at upstream cross-section for 2014 to 2016 site visits.

Figure 12



Reach WC8: DS (Run)
Channel bed and bank extent at downstream cross-section for 2014 to 2015 site visits.

Figure 13



Reach WC8: DS (Run)
Channel bed and bank extent at downstream cross-section for 2016 site visits.
Cross-section was re-established due to missing rebar.

Appendix F

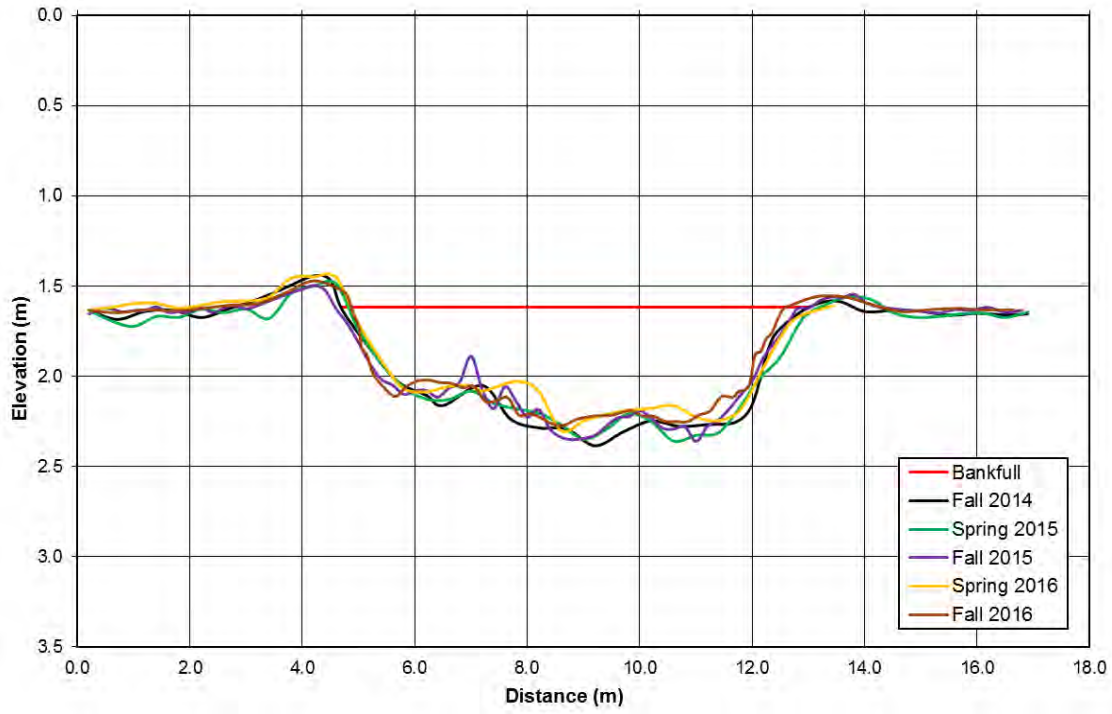
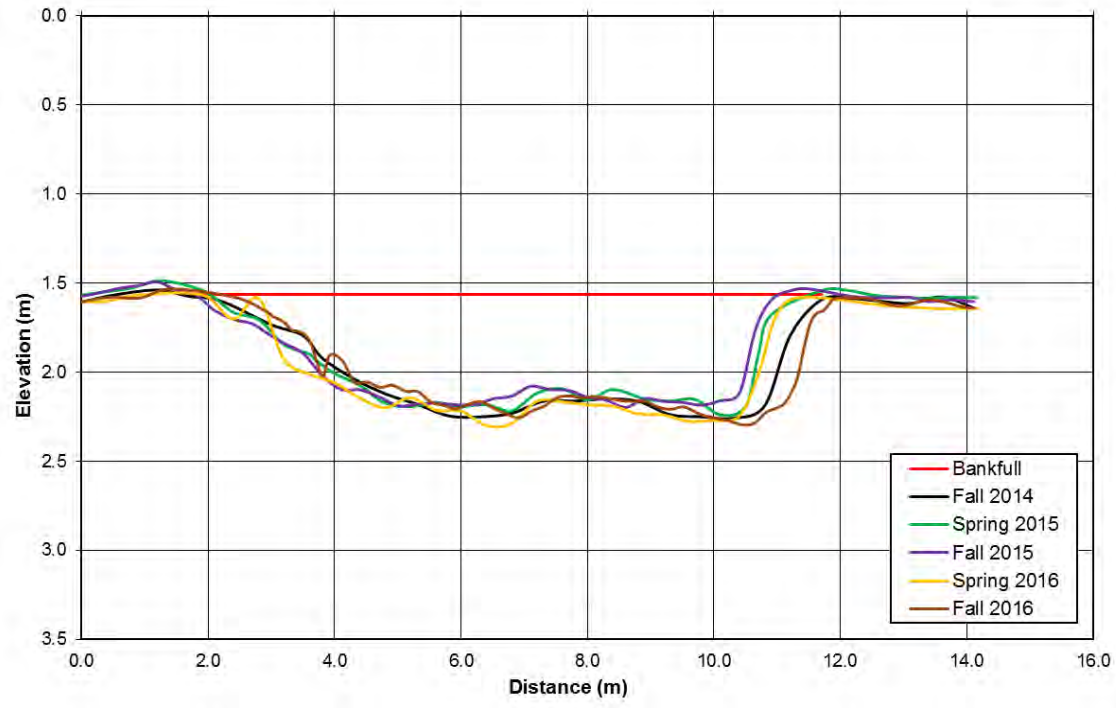
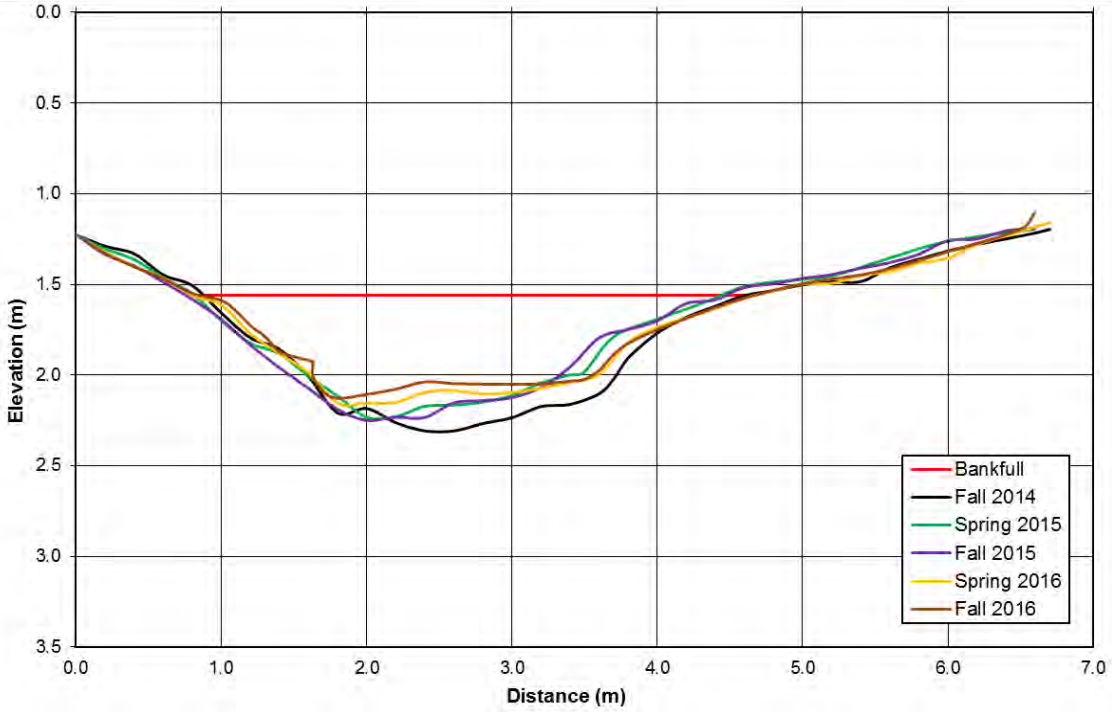
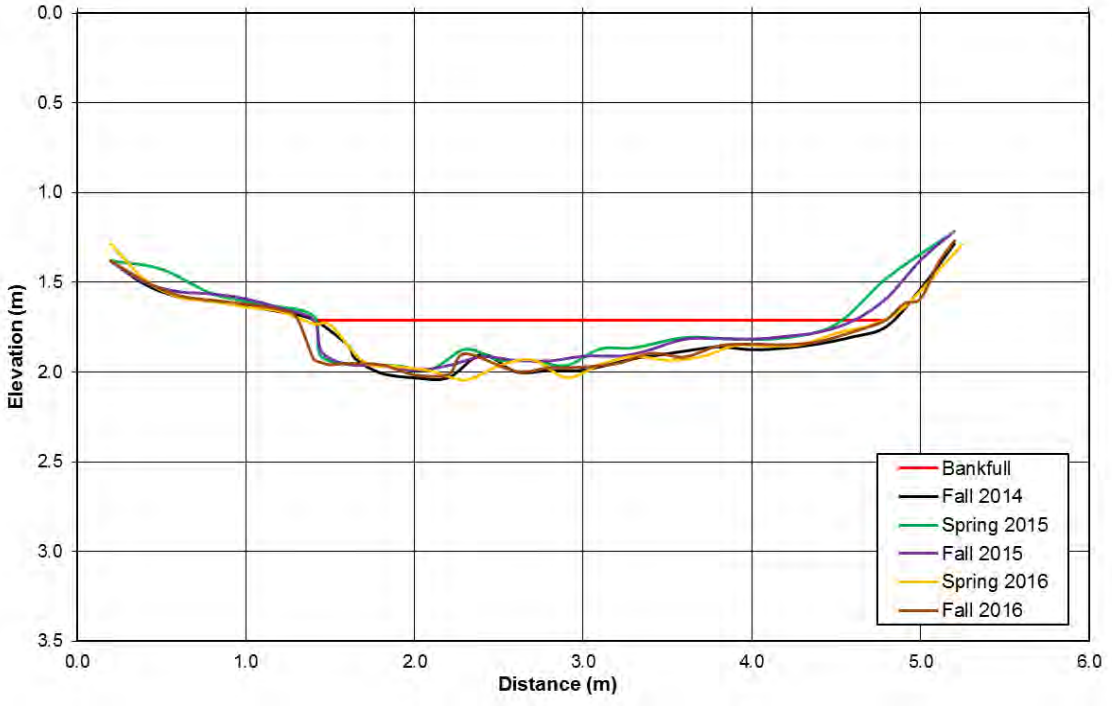
Figure 1	 Reach BC2: XS1 (Run) Channel bed and bank extent at cross-section 1 for 2014 to 2016 site visits.
Figure 2	 Reach BC2: XS2 (Pool) Channel bed and bank extent at cross-section 2 for 2014 to 2016 site visits.

Figure 3



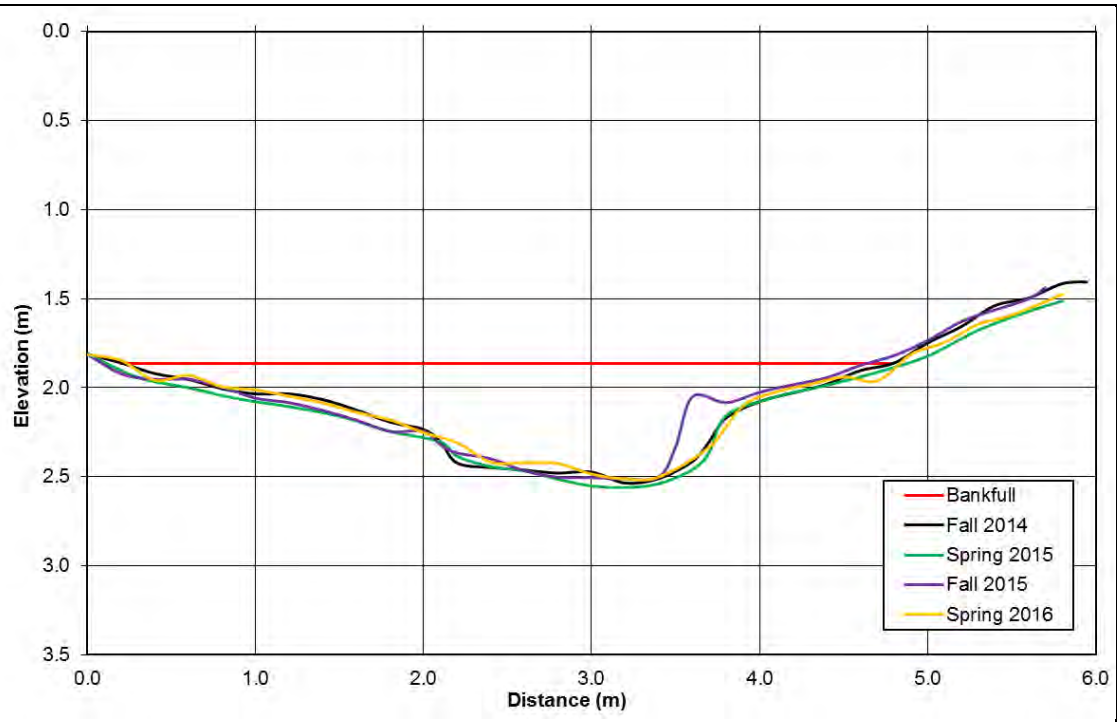
Reach BC7: XS5 (Pool)
Channel bed and bank extent at cross-section 5 for 2014 to 2016 site visits.

Figure 4



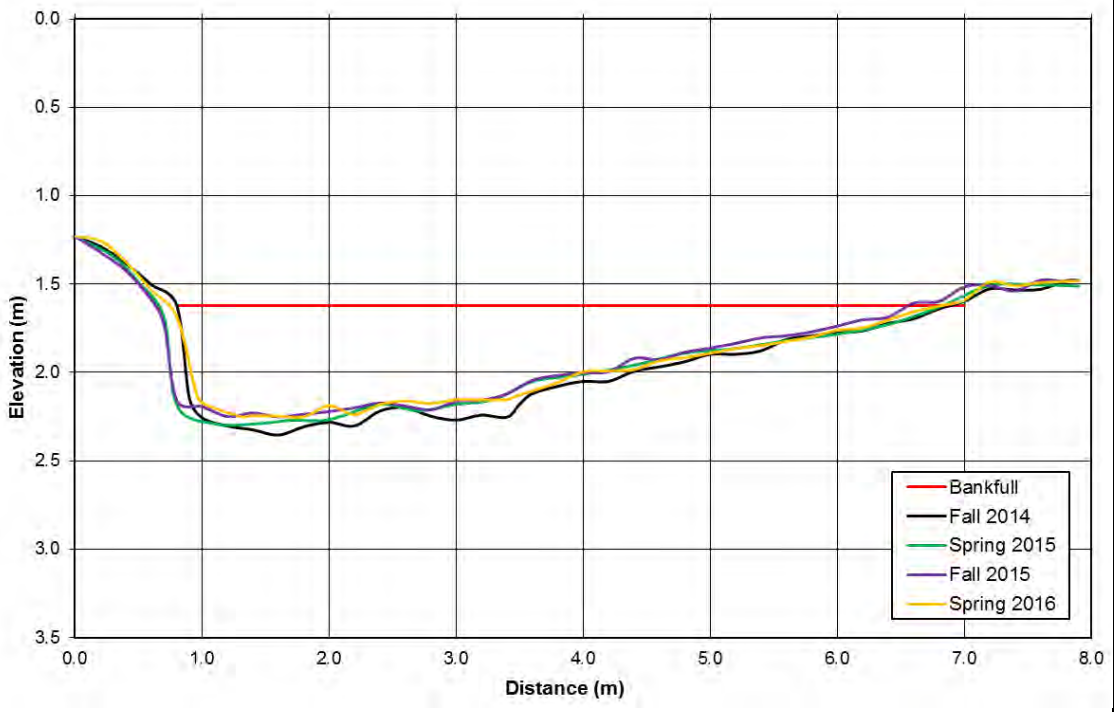
Reach BC7: XS4 (Riffle)
Channel bed and bankl extent at cross-section 4 for 2014 to 2016 site visits.

Figure 5



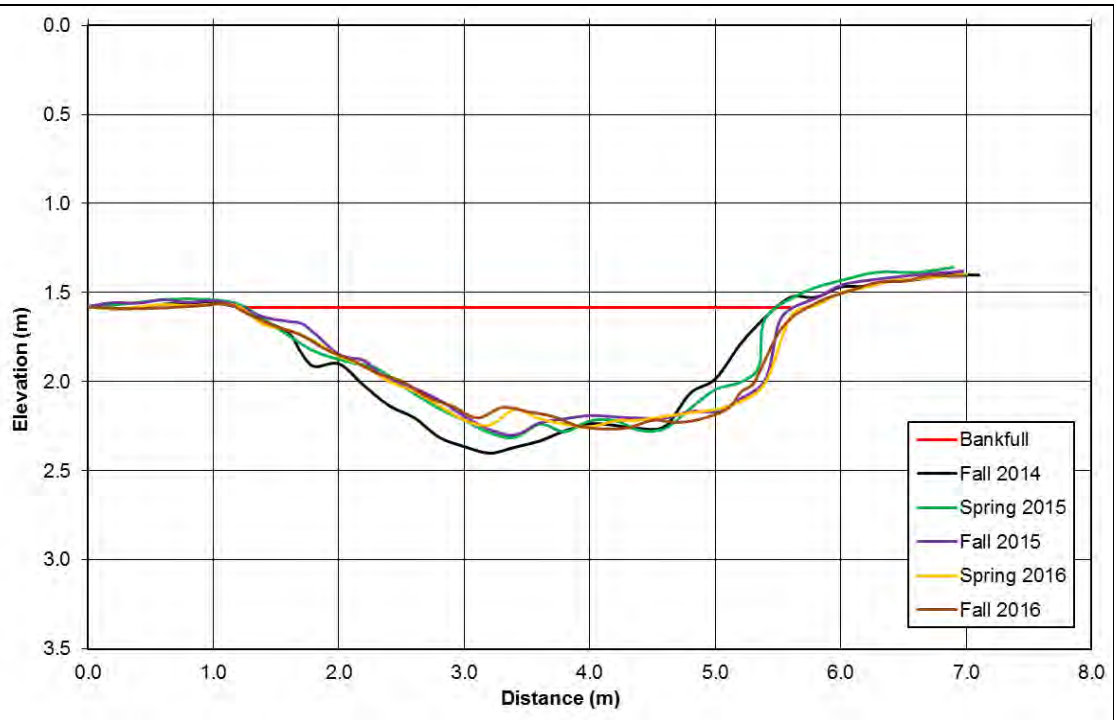
Reach BC8: D/S (Pool)
Channel bed and bank extent at downstream cross-section for 2014 to 2016 site visits.

Figure 6



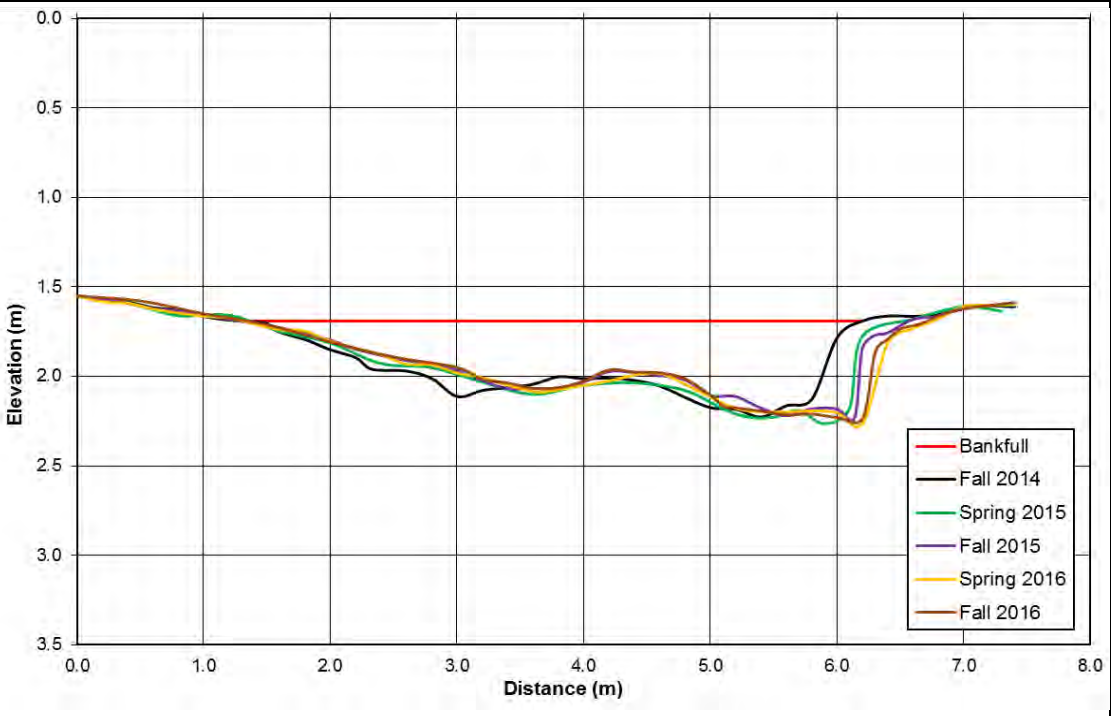
Reach BC8: U/S (Riffle)
Channel bed and bank extent at upstream cross-section for 2014 to 2016 site visits.

Figure 7



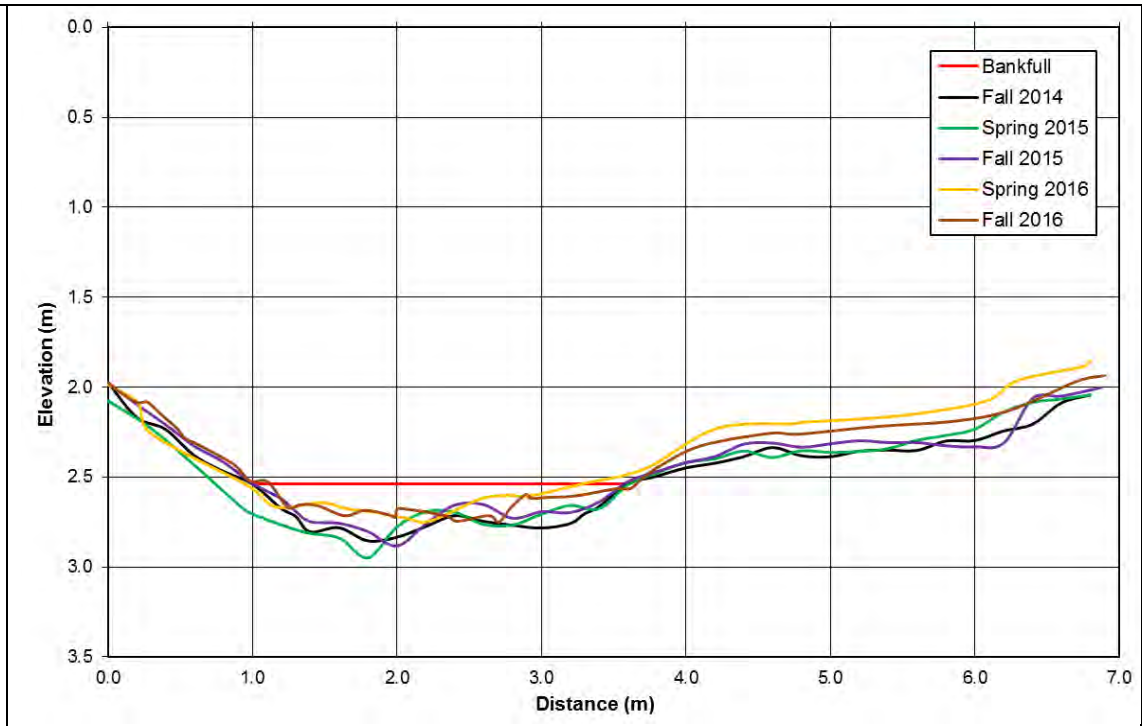
Reach BC8: XS2 (Pool)
Channel bed and bank extent at upstream cross-section for 2014 to 2016 site visits.

Figure 8



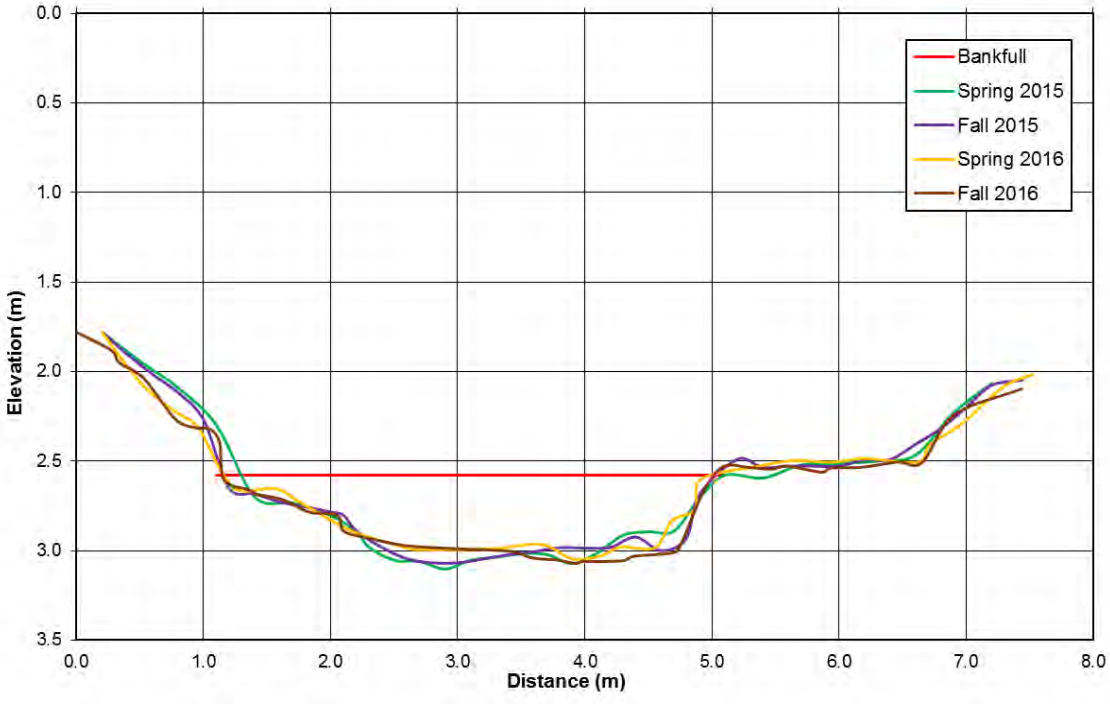
Reach BC8: XS4 (Riffle)
Channel bed and bank extent at downstream cross-section for 2014 to 2016 site visits.

Figure 9



Reach BC10: XS1 (Riffle)
Channel bed and bank extent at cross-section 4 for 2014 to 2016 site visits.

Figure 10



Reach BC10: XS2 (Pool)
Channel bed and bank extent at cross-section 5 for 2014 to 2016 site visits.

Appendix G

Reach	Cross-section	Bank Pin	Exposed Pin Length (m)					Difference* (m)	Activity
			Fall 2014	Spring 2015	Fall 2015	Spring 2016	Fall 2016		
BC2	XS 1	Left Bank	0.20	0.22	0.20	0.22	0.23	-0.03	Erosion
		Right Bank	0.20	0.20	0.21	0.17	0.17	0.03	Deposition
	XS 2	Left Bank	0.20	0.22	0.17	0.27	0.27	-0.07	Erosion
		Right Bank	0.20	0.19	0.175	0.18	0.185	0.015	Deposition
BC7	XS 4	Left Bank	0.20	0.275	0.26	0.24	0.25	-0.05	Erosion
		Right Bank	0.20	0.215	0.20	0.20	0.20	0.00	In transition
	XS 5	Left Bank	0.20	0.17	0.20	0.20	0.23	-0.03	Erosion
		Right Bank	0.20	0.23	0.19	0.17	0.18	0.02	Deposition
BC8 (down-stream section)	XS D/S	Left Bank	0.20	0.249	0.24	missing	N/A	-0.04	Erosion
		Right Bank	0.20	0.217	0.20	0.18	N/A	0.02	Deposition
	XS U/S	Left Bank	0.20	0.257	0.26	0.28	N/A	-0.08	Erosion
		Right Bank	0.20	0.21	0.23	missing	N/A	-0.03	Erosion
BC8 (up-stream section)	XS 2	Left Bank	0.20	0.034	missing	missing	missing	0.166	Deposition
		Right Bank	0.20	0.157	0.16	0.16	0.16	0.04	Deposition
	XS 4	Top of LB	0.20	0.331	missing	missing	missing	-0.131	Erosion
		Bottom of LB	0.20	0.515	missing	missing	missing	-0.315	Erosion
BC10	XS 1	Left Bank	0.20	0.21	0.21	0.21	0.225	-0.025	Erosion
		Right Bank	0.20	0.17	0.165	0.17	0.17	0.03	Deposition
	XS 2	Left Bank	0.20	0.21	0.21	0.13	0.135	0.065	Deposition
		Right Bank	0.20	0.135	0.21	0.20	0.17	0.03	Deposition

**Difference is Fall 2014 − Fall 2016, if not applicable, first measurement − last measurement*
N/M: not measured
N/A: No access due to construction

Reach	Cross-section	Bank Pin	Exposed Pin Length (m)					Difference* (m)	Activity
			Fall 2014	Spring 2015	Fall 2015	Spring 2016	Fall 2016		
WC	XS 2	Left Bank	0.20	0.215	0.17	0.24	0.25	-0.05	Erosion
		Right Bank	0.20	0.205	0.20	0.28	0.28	-0.08	Erosion
	XS 7	Left Bank	0.20	0.20	0.175	0.18	0.20	0.00	Stable
		Right Bank	0.20	0.20	0.185	Not found	0.25	-0.05	Erosion
WC1	D/S XS	Left Bank	0.20	0.17	0.41	0.27	0.28	-0.08	Erosion
		Right Bank	0.20	0.18	0.125	missing	missing	0.075	Deposition
	U/S XS	Left Bank	0.20	0.185	0.16	0.09	0.08	0.12	Deposition
		Right Bank	0.20	0.082	0.07	0.23	0.23	-0.03	Erosion
WC3	D/S XS	Left Bank	0.20	0.254	0.26	0.45	0.46	-0.26	Erosion
		Right Bank	0.20	0.238	0.21	0.23	0.22	-0.02	Erosion
	U/S XS	Left Bank	0.20	0.352	0.45	0.47	0.87	-0.67	Erosion
		Right Bank	0.20	0.457	0.28	0.35	0.26	-0.06	Erosion
WC5	XS 2	Left Bank	0.20	0.197	0.20	0.19	0.20	0.00	Stable
		Right Bank	0.20	0.24	0.24	N/M	0.60	-0.40	Erosion
	XS 7	Left Bank	0.20	0.193	Removed	Removed	Removed	0.007	Deposition
		Right Bank	0.20	0.114	Removed	Removed	Removed	0.086	Deposition
WC6	XS 2	Left Bank	0.20	0.216	0.22	0.18	0.19	0.01	Deposition
		Right Bank	0.20	0.27	0.315	0.38	0.40	-0.20	Erosion
	XS 5	Top of RB	0.20	0.193	0.20	0.34	0.48	-0.28	Erosion
		Bottom of RB	0.20	0.114	0.13	0.11	0.11	0.09	Deposition
WC8	D/S XS	Left Bank	0.20	N/M	missing	missing	missing	N/A	N/A
		Right Bank	0.20	N/M	0.18	0.21	0.19	0.01	Deposition
	U/S XS	Left Bank	0.20	0.175	0.20	missing	missing	0.00	In transition
		Right Bank	0.20	missing	missing	missing	missing	N/A	N/A

**Difference is Spring 2015 − Fall 2016, if not applicable last measurement − the most recent measurement*
N/M: not measured

Appendix H

Reach	Cross-section	Particle Size (mm)	Particle Size at the Time of Assessment					Activity
			Fall 2014	Spring 2015	Fall 2015	Spring 2016	Fall 2016	
BC2*	XS 1	D50	0.175	<2.000	0.250	No sample taken	Sample awaiting analysis	TBD
		D84	0.575	<2.000	0.525			TBD
	XS 2	D50	0.175	<2.000	0.250			TBD
		D84	0.575	<2.000	0.525			TBD
BC7	XS 4	D50	21.000	45.300	5.600	12.000	16.000	In transition
		D84	250.000	160.000	70.000	120.000	120.000	In transition
	XS 5	D50	0.340	1.000	<2.000	0.400*	Sample awaiting analysis	TBD
		D84	0.580	32.000	5.000	0.640*		TBD
BC8 (down-stream section)	XS D/S	D50	0.500	2.000	2.000	7.000	No access	TBD
		D84	1.000	44.000	22.000	50.000		TBD
	XS U/S	D50	20.000	39.000	11.000	45.000		TBD
		D84	90.000	100.000	35.000	90.000		TBD
BC8 (up-stream section)	XS 2	D50	<2.000	2.000	0.280	<2.000	Sample awaiting analysis	TBD
		D84	<2.000	1.900	0.630	13.000		TBD
	XS 4	D50	32.000	22.600	11.300	25.000	25.000	In transition
		D84	120.000	99.000	38.000	72.000	68.000	In transition
BC10	XS 1	D50	5.200	13.000	8.500	25.000	33.000	Coarser
		D84	25.000	40.000	35.000	60.000	80.000	Coarser
	XS 2	D50	0.490	0.425	0.275	<2.000	6.200	Coarser
		D84	1.150	0.700	1.600	14.000	17.000	Coarser

**composite sample results from grain size analysis*
TBD – to be determined after analysis

Reach	Cross-section	Particle Size (mm)	Particle Size at the Time of Assessment					Activity
			Fall 2014	Spring 2015	Fall 2015	Spring 2016	Fall 2016	
WC*	XS 2	D50	0.310	0.350	0.270	0.260	Sample awaiting analysis	TBD
		D84	0.555	0.530	0.540	0.590		TBD
	XS 7	D50	0.310	0.350	0.270	0.260		TBD
		D84	0.555	0.530	0.540	0.590		TBD
WC1*	D/S XS	D50	0.275	0.510	0.260	0.350	Sample awaiting analysis	TBD
		D84	0.200	0.340	0.180	1.150		TBD
	U/S XS	D50	0.275	0.510	0.260	0.350		TBD
		D84	0.200	0.340	0.180	1.150		TBD
WC3*	D/S XS	D50	0.425	0.400	0.520	Sample awaiting analysis	Sample awaiting analysis	TBD
		D84	3.000	2.700	0.325			TBD
	U/S XS	D50	0.225	0.225	0.520			TBD
		D84	0.345	0.340	0.325			TBD
WC5	XS 2	D50	0.275	8.000	0.475	<2.000	Sample awaiting analysis	TBD
		D84	0.450	26.000	0.325	33.000		TBD
	XS 1	D50	N/A: cross-section 7 removed	N/A: cross-section 7 removed	N/A: cross-section 7 removed	Rip-rap	Rip-rap	N/A
		D84						N/A
WC6	XS 2	D50	64.000	120.000	15.000	75.000	51.000	In transition
		D84	120.000	225.000	80.000	150.000	225.000	In transition
	XS 5	D50	<2.000	2.000	<2.000	18.000	<2.000	In transition
		D84	80.000	31.000	50.000	140.000	<2.000	In transition
WC8	D/S XS	D50	N/A: could not sample, water levels beyond bankfull	0.350	0.375	No sample taken	No sample taken	Similar
		D84		9.500	0.630			finer
	U/S XS	D50		0.850	2.000	2.000		Coarser
		D84		13.500	15.000	50.000		Coarser

**composite sample results from grain size analysis*
TBD – to be determined after analysis

Appendix L

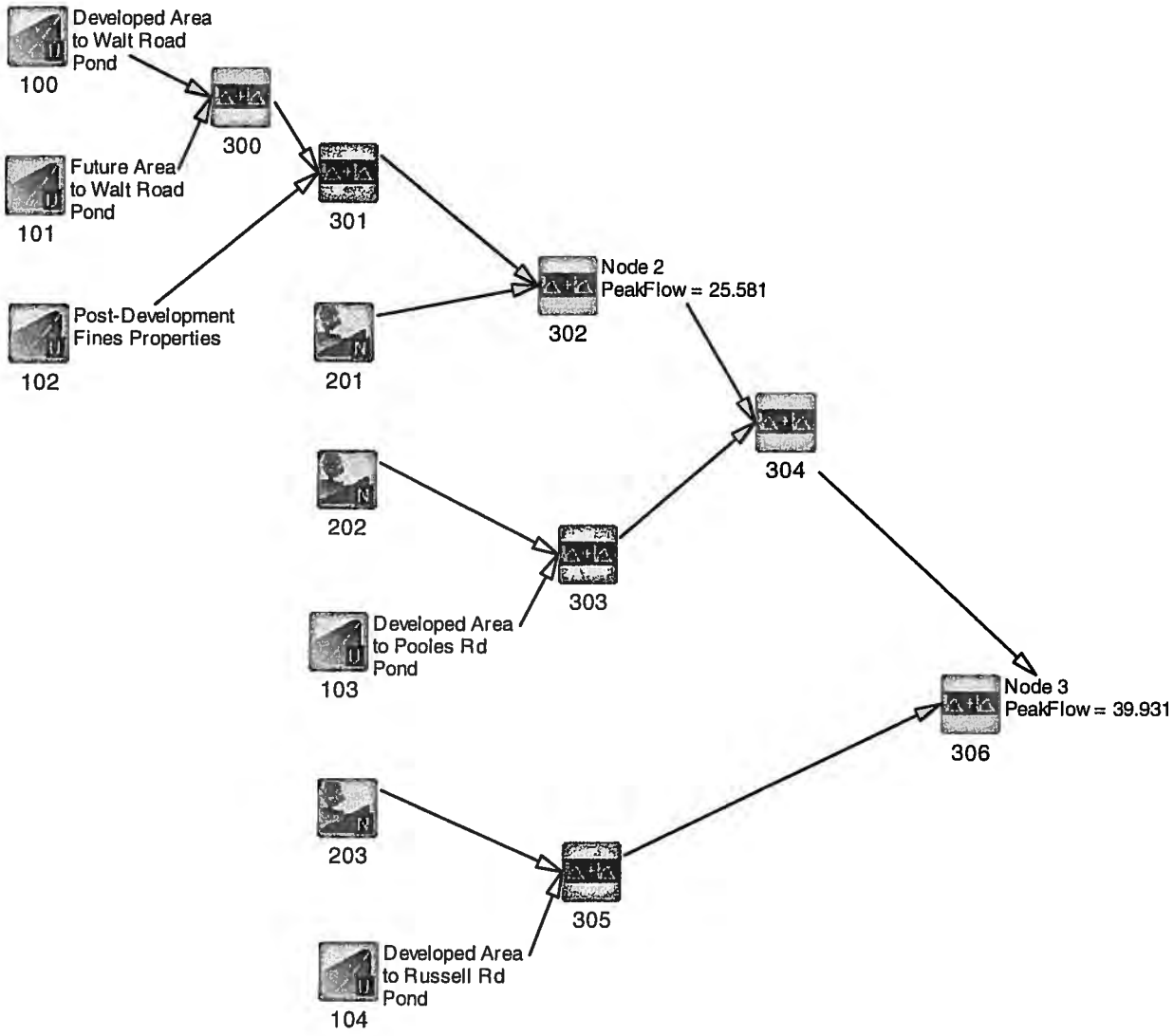
Hydraulic Model for Black Creek

APPENDIX H

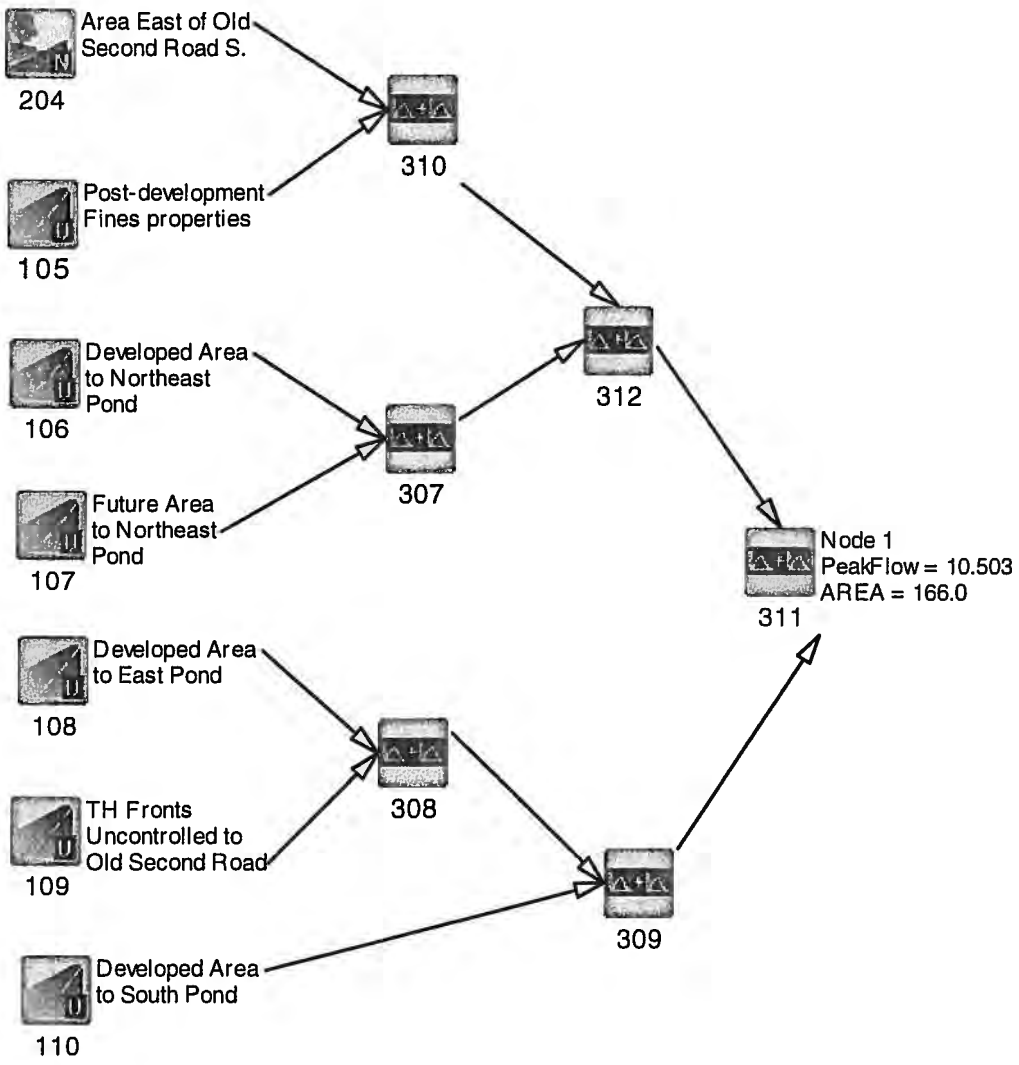
HYDRAULIC MODELLING AND CALCULATIONS

SCS consulting group ltd

VO2 Schematic – Floodplain Mapping – Fines Reach



VO2 Schematic – Floodplain Mapping – Jones Reach

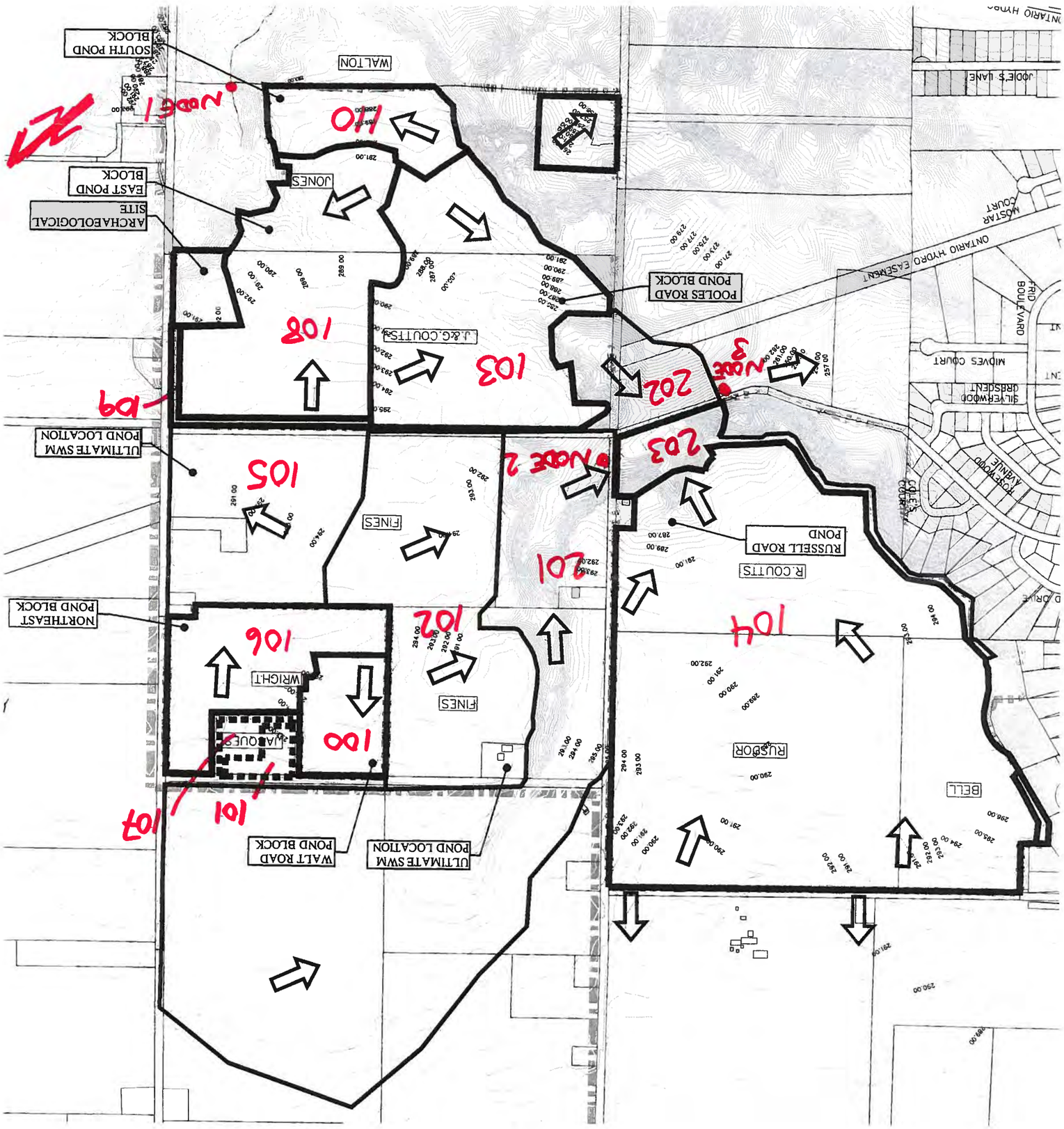


FLOODPLAIN DRAINAGE PLAN 1

MIDHURST DEVELOPMENT
DORAN ROAD
(MDDR1)

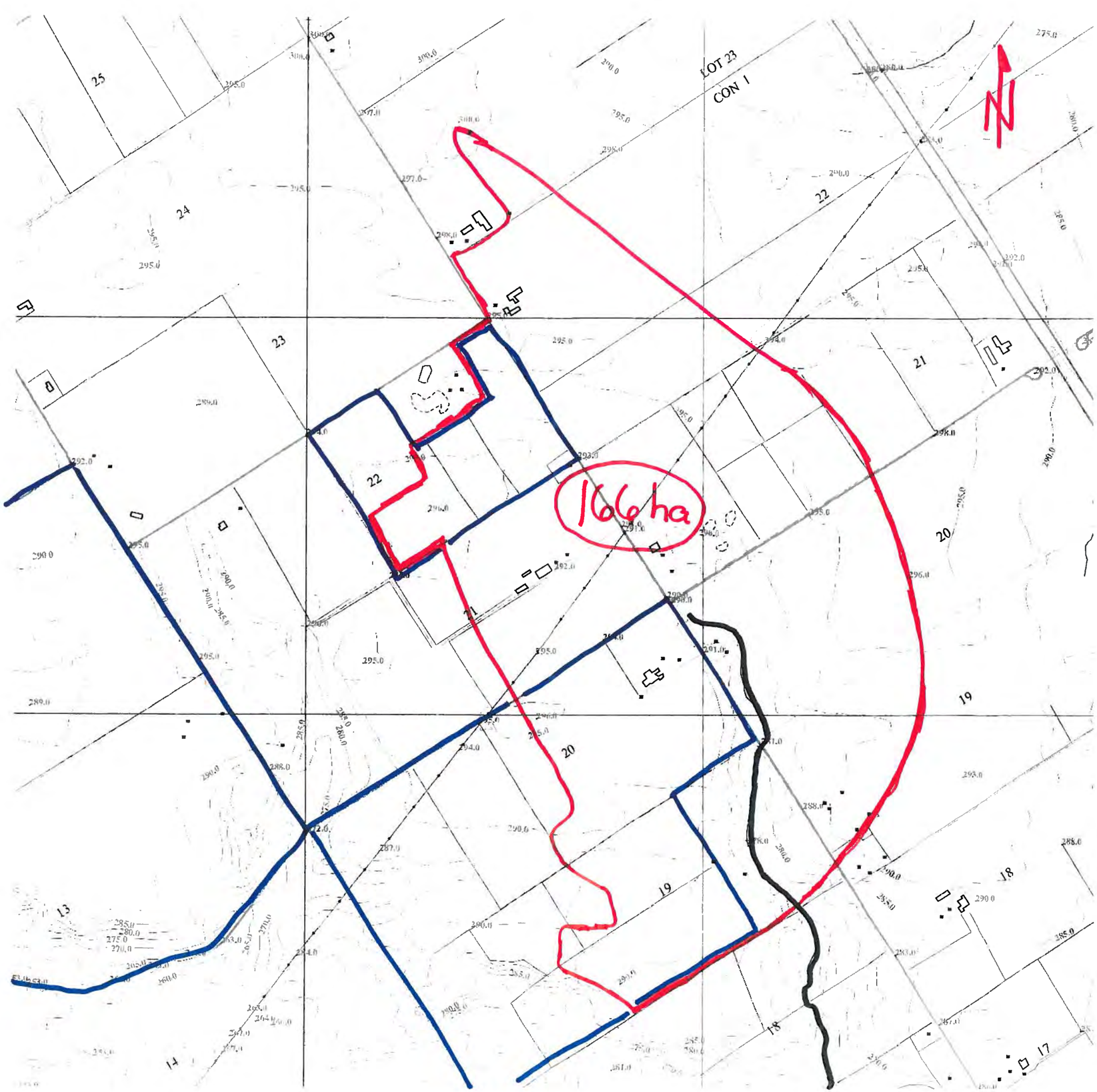
109 CATCHMENT ID

— DRAINAGE BOUNDARY



FLOODPLAIN DRAINAGE PLAN.

MIDHURST DEVELOPMENT **DORAN** ROAD INC. (MDDRI)



APPROX. LIMIT OF DEVELOPMENT
WATERCOURSE
EXISTING DRAINAGE AREA

SCALE: 1:10,000

HEC-RAS Plan: Plan 03 River: Tibutary to Will Reach: Jones Property Profile: PF 1

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)	
Jones Property	1526	PF 1	10.50	281.00	281.18	281.14	281.22	0.017944	1.24	15.63	86.70	0.92
Jones Property	1474.5	PF 1	10.50	280.00	280.15	280.15	280.22	0.022952	1.20	8.89	62.17	1.00
Jones Property	1464.5	PF 1	10.50	279.50	279.84	279.86	279.96	0.028580	1.52	6.90	39.00	1.15
Jones Property	1389.5	PF 1	10.50	278.50	279.22	278.85	279.24	0.001295	0.82	19.25	39.41	0.31
Jones Property	1257	PF 1	10.50	278.50	278.71	278.71	278.81	0.019663	1.43	8.29	45.03	0.99
Jones Property	1148.5	PF 1	10.50	274.00	274.47	274.70	275.21	0.062694	4.31	3.93	12.79	2.01
Jones Property	1087.5	PF 1	10.50	273.10	273.53	273.53	273.65	0.020340	1.53	6.90	31.38	1.02
Jones Property	1038	PF 1	10.50	270.70	271.13	271.31	271.73	0.082444	3.47	3.27	15.46	2.11
Jones Property	1000	PF 1	10.50	270.50	270.85	270.85	270.99	0.016212	1.82	8.63	35.56	0.98

HEC-RAS Plan: Plan 03 River: Tibutary to Will Reach: Fines Property Profile: PF 1

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)	
Fines Property	2261	PF 1	25.58	269.00	269.42	269.42	269.63	0.016548	2.00	12.82	31.91	1.01
Fines Property	2220	PF 1	25.58	267.85	268.53	268.59	268.90	0.018238	2.75	9.74	18.30	1.13
Fines Property	2176	PF 1	39.93	267.00	267.58	267.68	267.95	0.023309	3.05	15.75	38.43	1.27
Fines Property	2086	PF 1	39.93	265.40	266.09	266.09	266.39	0.013373	2.46	16.84	28.92	0.98
Fines Property	2000	PF 1	39.93	262.00	262.96	263.30	264.22	0.058841	5.59	9.35	24.99	2.09

Appendix M

Environmental Monitoring Matrix

Hutchinson
Environmental Sciences Ltd.

1-5 Chancery Lane, Bracebridge, ON P1L 2E3 | 705-645-0021
www.environmentalsciences.ca

Memorandum

Date: **August 13, 2018**

To: **Vimal Patel**

From: **Brent Parsons and Neil Hutchinson**

Re: **Midhurst Overall Drainage Study – Status Update – Aquatic Baseline**

Please find below our response to the email correspondence provided by the Ainley Group on June 4, 2018. We have addressed the comments on the Adaptive Management Plan. The Ainley Group commented:

To all,
We have recently received various requests from the group regarding the status of this project. Since we have now completed the review of the geomorphology baseline study and the first Engineering submission for the Midhurst Heights development, we provide the following on the status of some of the key outstanding items for the Overall Drainage Study:

...

2. *Adaptive Management Plan: We have not received any comments from the NVCA regarding the Aquatic baseline studies which were provided in January. As such, we assume that the parameters tested are acceptable. However, we note that no continuous monitoring has occurred at this point, which was originally requested by the NVCA. Similar to the geomorphology study, no impact assessment has been provided with respect to the proposed development. This will be an important part of the AMP since it will establish that the proposed infiltration and on-site quality controls are sufficient to maintain water quality in the receiving watercourses. In addition, there had been some discussion that MDG was to provide some examples of the AMP that was utilized for the Friday Harbour project, so that we could advance the Overall Drainage Study sufficiently without finalizing the AMP with respect to the details of the monitoring program. To complete this task we will require the impact assessment portion of the aquatic study as well as the example AMP so that we can review and discuss with the NVCA to ensure that it is acceptable. As previously discussed the AMP will be developed as construction proceeds and based on the monitoring results over time. At this stage, we do need to develop a preliminary framework for this process so that it can be outlined in the Drainage Study.*

Response – At this point we can speak only to the Monitoring and Adaptive Management Program as we have not been made aware of Ainley's or NVCA's requirements for the "impact assessment" portion of the MDP. Please clarify the "impact assessment" comment that is now being requested.

Based on Ainley's and NVCA's requirements, we have completed:

- NVCA's requirement for a phosphorus budget study and recommendations for "no net increase" in phosphorus loading to Willow Creek from the combined management and discharge of storm water and treated WWTP effluent,
- The Final Assimilative Capacity Study and impact assessment for the discharge of treated WWTP effluent, which was provided to Ainley and submitted as part of the Final ESR for the Class EA on

June 5, 2018.This material also included an impact assessment of the potential for changes in temperature and water level relating to the use of groundwater for the Midhurst SPA municipal water supply.

Baseline monitoring of the Midhurst Development areas was initiated by Gartner Lee Limited in 2008 to characterize existing conditions in various watercourses that could be impacted by development associated with the proposed Midhurst Secondary Plan. Building on the data collected in 2008, Hutchinson Environmental Sciences Ltd. expanded the monitoring program and have collected baseline data annually since 2014. Baseline sampling is ongoing in 2018. Sampling includes collection and interpretation of water quality, flows, water levels, benthic invertebrates and fisheries at 12 sampling stations to characterise the aquatic environment prior to any construction activity or stormwater management. Sampling includes real time sampling and deployment of continuous water temperature, dissolved oxygen and level loggers to characterize long term water quality and water level conditions. Sampling locations and period of sampling include:

- 3 sampling locations in Matheson Creek (2015-2018),
- 3 sampling locations in an unnamed creek that drains to Little Lake from the Doran Development Area (2008, 2014-2018),
- 2 sampling locations in Willow Creek within the Village of Midhurst (2015-2018)
- 4 sampling locations in Willow Creek in the vicinity of the proposed WWTP downstream of the Village of Midhurst in 2008, 2009, 2013-2014, 2017-2018, and
- 4 sampling locations in a tributary to Black Creek that drains from the Carson Road Development Area (2008, 2014-2018)

The dataset describes natural seasonal and inter-annual variation within the watercourses and provides a robust description of baseline water quality and ecological condition for future assessment as part of the Adaptive Monitoring and Management Plan during construction and post development. Baseline monitoring reports were completed in early 2018 to characterize aquatic conditions in each of the 4 different watercourses under investigation using data current to the end of 2016. These were provided to Ainley and have apparently been submitted to the NVCA by Ainley. These reports are currently being updated with the 2017 data. After completion of baseline monitoring in 2018, all data will be used to update the baseline monitoring reports and inform the Adaptive Monitoring and Management targets for the MSP. At this point we will recommend targets to maintain water quality, flow and ecological indicators, adaptive management triggers for specific parameters to ensure that the creeks remain within target levels, construction and post-construction aquatic monitoring plans and associated mitigation measures as part of the Adaptive Monitoring and Management Plan.

At this point we are preceding with the understanding that the development and associated measures will protect the aquatic system. These include storm water management plans which will infiltrate the first 23mm of each precipitation event and other Best Management Practices for the development such as stream setbacks and protection of sensitive areas, along with the high level of treatment proposed for wastewater. The Ainley correspondence has requested "*To complete this task we will require the impact assessment portion of the aquatic study as well as the example AMP so that we can review and discuss with the NVCA to ensure that it is acceptable."* As requested previously, a Draft Adaptive Management

Monitoring Plan was prepared for the Midhurst Secondary Plan, based on the Friday Harbour Environmental Monitoring Matrix and Marina Basin Monitoring and Adaptive Management Plan. This was submitted to Ainley on October 30, 2015, June 26, 2017, and again on January 31, 2018. No comments have been received to date by Ainley. We have appended a copy of the "Environmental Monitoring Matrix" for the Midhurst SPA and "Marina Basin Monitoring and Adaptive Management Plan" for the Friday Harbour Resort for reference. We recommend that any discussion with the NVCA not proceed without our involvement and that any "impact assessment" not proceed without first meeting directly with the Midhurst Development Group, NVCA and the Ainley Group to clarify the need for it and expectations of its contents.

Attachments.

1. "Environmental Monitoring Matrix" and Site Map for the Midhurst SPA. This is current to April 2015 and additional sites have been added since that time (there are now 18 surface water sites vs the 7 AMP sites described in the documentation. Details are documented in the HESL Baseline Reports.
2. "Marina Basin Monitoring and Adaptive Management Plan" for the Friday Harbour Resort

Midhurst Secondary Plan – Monitoring Requirements – Master Drainage Plan

Note: Location of all proposed monitoring equipment per attached figure, April 2015.

A. Rainfall
April 10, 2015

Component	Monitoring Protocol			Reporting Protocol		Agent Responsible			
	Methods	Frequency/Timing	Duration	Content	Reporting Period				
Rainfall	Rain Gauge Tipping Bucket	Rainfall measured every 15 minutes on-site. Downloaded prior to reporting.	Initiated immediately and throughout the monitoring duration of the infiltration practices.	Rainfall data to support SWM Pond, Infiltration, Nutrient and Geomorphology monitoring.	N/A	SCS/Crozier			

B & D. Stormwater Management Facilities (incl. Pond Cooling Trenches)
April 10, 2015

Component	Monitoring Protocol			Reporting Protocol		Agent Responsible			
	Methods	Frequency/Timing	Duration	Content	Reporting Period				
Temperature	Install temperature monitors at inlet and outlet of SWM Pond.	Temperature measured every 15 minutes on-site. Downloaded prior to reporting.	Initialized upon stabilization of ultimate SWM Pond (one per development) and associated landscaping for a period of 2 years.	Report effect SWM Pond has on temperature.	Annually	SCS/Crozier			
Operation	Visual Inspections	After significant rainfall events (10 mm)	Initialized upon stabilization of ultimate SWM Pond (one per development) and associated landscaping for a period of 2 years.	Report on pond operation with respect to blockage, erosion and vegetation establishment.	Annually	SCS/Crozier			
Flow Monitoring	Level logger in main SWM Pond Cell to determine inlet volumes and release rates.	Logger to measure depth every 10 minutes on-site. Downloaded prior to reporting.	Initialized upon stabilization of ultimate SWM Pond (one per development) and associated landscaping for a period of 2 years after upstream infiltration practices are operational.	Report performance of SWM Pond with respect to outlet rate and frequency as well as volume relative to design criteria.	Annually	SCS/Crozier			

C. Infiltration Facilities
April 10, 2015

Component	Monitoring Protocol			Reporting Protocol		Agent Responsible			
	Methods	Frequency/Timing	Duration	Content	Reporting Period				
Flow Monitoring	Level logger in all large municipal LID installations.	Logger to measure depth every 10 minutes on-site. Downloaded prior to reporting.	Initiated once upstream area is stabilized and LID is operational for a period of 2 years.	Report on effectiveness of LID's with respect to performance versus design criteria.	Annually	SCS/Crozier			

E. Downstream Watercourses
April 10, 2015

Component	Monitoring Protocol			Reporting Protocol		Agent Responsible			
	Methods	Frequency/Timing	Duration	Content	Reporting Period				
Temperature	Install temperature monitors upstream and downstream of each proposed SWM Pond outlet within receiving watercourse (not applicable to Willow Creek).	Temperature measured every 15 minutes on-site. Downloaded prior to reporting.	Initialized upon stabilization of ultimate SWM Pond (one per development) and associated landscaping for a period of 2 years.	Report on effect SWM Ponds have on in-situ creek temperatures in relation to background conditions and requirements of resident fish species.	Annually	Hutchinson/GeoMorphix			
Bank Erosion	Visit sites during different flows to field-truth the modelled erosion thresholds.	As required.	Initialized immediately to obtain baseline information and continues for 2 years past 80% build-out of first development phase for each watercourse.	Report on effect development has (if any) on existing watercourses (Matheson, Black, Willow and tributary to Willow) with respect to bank erosion.	Annually	GeoMorphix			

Water Quality	Field measurements of water temperature, pH, conductivity and dissolved oxygen and collection of water samples for TP, TSS and turbidity. Flow measurements during sample collection. Install level loggers at surface water sampling sites.	Monthly (May to October)	Initialized immediately to obtain baseline information and continues for 2 years past 80% build-out of first development phase for each watercourse.	Report on effect development has (if any) on existing watercourses (Matheson, Black, Willow and tributary to Willow) with respect to TP, TSS & Turbidity.	Annually	Hutchinson			
Benthic Macroinvertebrate	Field collection through fixed-time kick-and-sweep surveys following OBBN protocol.	Annually (spring or fall)	Initialized immediately to obtain baseline information and continues for 2 years past 80% build-out of first development phase for each watercourse.	Report on effect development has (if any) on existing watercourses (Matheson, Black, Willow and tributary to Willow) with respect to benthic habitat and benthic invertebrate composition as a biomonitoring tool for water and sediment quality.	Annually	Hutchinson			
Fish	Field collection through fixed time backpack electrofishing following OSAP protocol.	Annually (late summer)	Initialized immediately to obtain baseline information and continues for 2 years past 80% build-out of first development phase for each watercourse.	Report on effect development has (if any) on existing watercourses (Matheson, Black, Willow and tributary to Willow) with respect to fish assemblages and fish habitat.	Annually	Hutchinson			

Midhurst Adaptive Management Plan

10-Dec-14

Watercourse Monitoring

				Water Quality *				Benthics	
Location	Description	Real Time (RT) Download (DL	Flow	DO, pH, Conductivity, Turbidity	Rain	Air Temperature	Water Temperature	(Spring & Fall)	Fish (Annually)
AMP 1	Willow Creek at Vespra Valley Rd	RT	y	y			y	y	y
AMP 2	WSC Gauge at Golf Course Road	RT	y	y	y	y	y	y	y
AMP 3	Aunt Maggies Tibutary at Gill Road	RT	y	y			y	y	y
AMP 4	Willow Creek at Willow Landing Road Downstream of Storm Sewer Outlet	RT	y	y			y	y	y
AMP 5	Little Lake Tributary DS of Old Second	RT	y	y	y	y	y	y	y
AMP 6	Black Creek Downstream of Wilson Drive	RT	y	y	y	y	y	y	y
AMP 7	Black Creek at Carson Road Downstream of Outlets	RT	y	y			y	y	y

SWM Pond Monitoring

Location	Description	Real Time (RT Download (DL	continuous Flow	event Phosphorus & TSS	Rain	Air Temperature	continuous Water Temperature	Benthics (Spring & Fall)	Fish (Annually)
All	All SWM Pond Outlets	DL	y	Sampler			y		

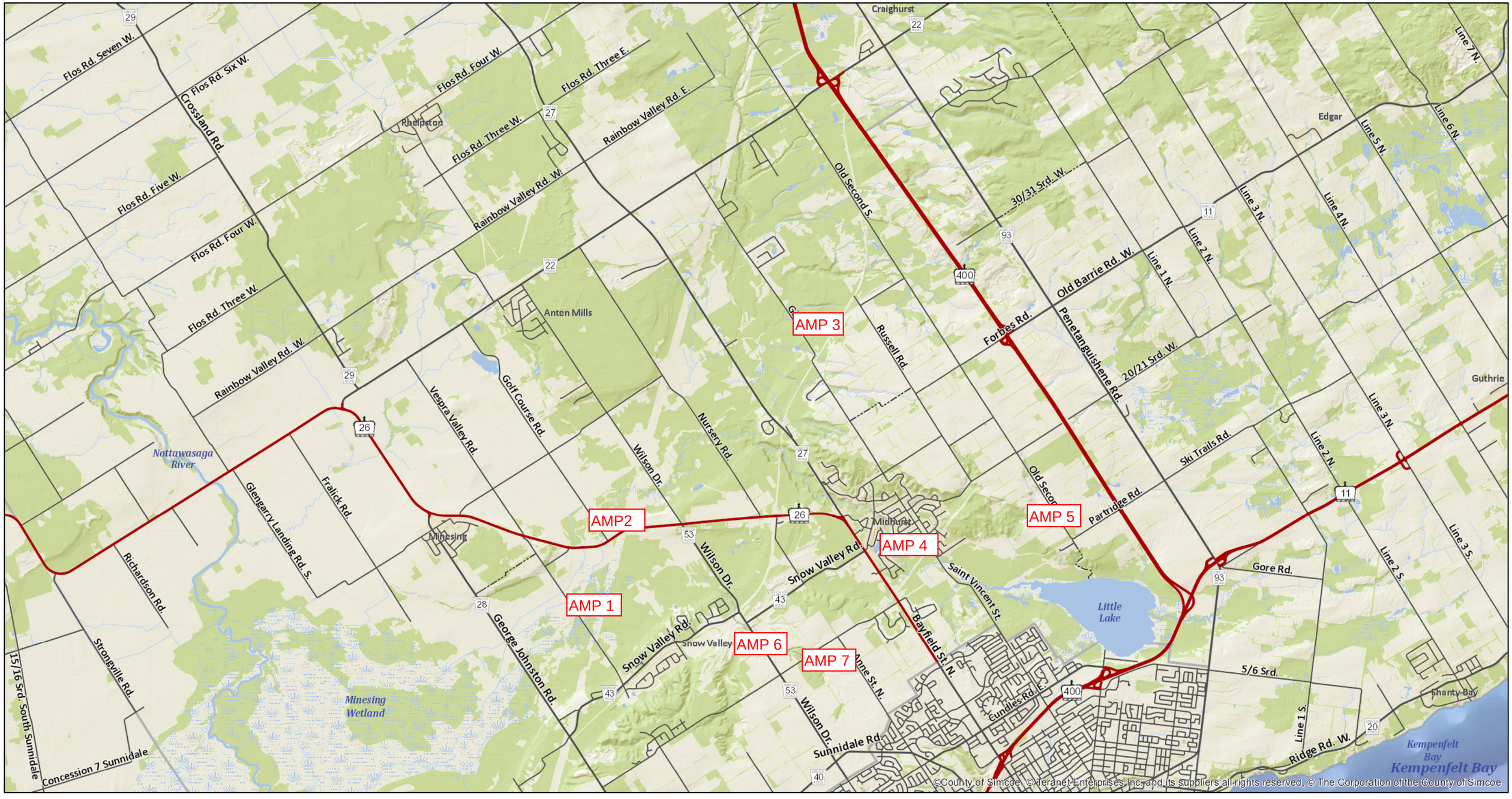
Restoration Sites

Location	Description	Monitoring
All	All Restoration Sites	Varies as per maintenance Plan (minimum annually)

Groundwater Sites

Location	Description	Monitoring
	To be determined	To be determined

Midhurst AMP



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- Municipal Border
- Contour - 2 Meter
- Trail
- RailLine
- Highway
- Major Road
- Ramp
- Local Roads
- Unassumed and Seasonal Roads
- Water Line, Intermittent
- Water Line, Permanent
- Building Footprint
- Provincial Park
- Water Area, Permanent
- Wetland Area, Permanent
- Wooded Area
- Cartographic Urban Area
- Cemetery - Polygon
- First Nations Land
- Municipal Park

Landuse

- Amusement Park
- Commercial
- Educational
- Golf Course
- Government
- Industrial
- Medical

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COUNTY OF SIMCOE

December 10, 2014

Appendix N

Nutrient Management

SCS consulting group ltd

File #: 1212
Date: June 5, 2014

Mr. Glenn Switzer, P. Eng.
Director of Engineering and Technical Services
Nottawasaga Conservation Authority
8195 8th Line
Utopia, Ontario, L0M 1T0

Dear Mr. Switzer:

Re: **Midhurst Master Drainage Plan – Phase 1**
Item #1 – Nutrient Loading
Midhurst, Ontario

Further to our submission of May 2, 2014, please accept the following supplemental information on behalf of the Midhurst Landowner Group in support of the Nutrient Loading Assessment (Item #1) of the Phase 1 work program for the Master Drainage Plan for your review and approval.

As per NVCA's correspondence of May 29, 2014, the Nutrient Loading target statement is:

> *No additional nutrient loading downstream from both the land development and the WWTP. The loading from the WWTP could be pro-rated back to each of the development lands for mitigation.*

The Phosphorous Budget for the Midhurst Secondary Plan has been prepared and updated by Hutcheson Environmental Services. The complete report is attached for your review.

In summary:

- The original report dated May 2, 2014 was updated to reflect the infiltration potential of the currently proposed enhanced Low Impact Development techniques (LIDs). A conservative infiltration rate of the 20mm rainfall event was modelled, which is anticipated to accommodate the runoff from 83% of rainfall runoff, with the remaining 17% being treated by the enhanced level SWM ponds.
- The total Phosphorous export from current land uses in the Midhurst Secondary Plan area is 144 kg/year.
- The total Phosphorous export from the developed Secondary Plan lands recognizing the enhanced infiltration LIDs and enhanced level stormwater management control throughout the Secondary Plan area and including 135 kg/yr from the WWTP is 204 kg/yr.
- The 60 kg/yr phosphorous budget difference can be mitigated through phosphorous off-setting opportunities based on the >560 kg/yr of offsetting opportunities identified by Greenland (2013).

On this basis, we submit that the overall Secondary Plan can reasonably achieve a total Phosphorous balance.

Please call the undersigned if you have any questions or require any additional information.

Sincerely,

SCS Consulting Group Ltd.

Steve Schaefer, P. Eng.
Principal
sschaefer@scsconsultinggroup.com

Attachments: Phosphorus Budget for Midhurst Secondary Plan, Hutchinson Environmental Sciences Ltd., June 5, 2014

c. Mr. Wayne Wilson, NVCA
Mr. Chris Hibbard, NVCA
Mr. Brad Sokach, Township of Springwater
Mr. Brent Spagnol, Township of Springwater
Mr. Joe Mullan, Ainley
Mr. Greg Marek, Simcoe County
Ms. Shauna Dudding, Geranium Corporation
Mr. Alex Troop, Rose Alliance
Ms. Michelle Tremblay, MNT Consulting Group
Mr. Chris Crozier, Crozier Associates
Mr. Matthew Cory, Malone Given Parsons
Mr. Neil Hutchinson, Hutchinson Environmental Sciences

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