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Technical Memorandum

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Subject: **Ottawa River Flood Risk Mapping from Shirley's Bay to Cumberland**

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Executive Summary

This report provides a summary of the analytical methods used and underlying assumptions applied in the preparation of flood plain mapping for the Ottawa River from Shirley's Bay to Cumberland. The project has been done in accordance with the technical guidelines set out under the Canada-Ontario Flood Damage Reduction Program (FDRP) (MNR, 1986), and the technical guide for the flood hazard delineation in Ontario (MNR, 2002) as laid out by the Ontario Ministry of Natural Resources. The 1:100 year flood lines delineated here are suitable for use in the RVCA's regulation limits mapping (referred to in Section 12 of Ontario Regulation 174/06) and in municipal land use planning and development approval processes under the Planning Act.

[1] We gratefully acknowledge the guidance provided by Bruce Reid.

Contents

Introduction

In 2012, The City of Ottawa and three conservation authorities (Mississippi, Rideau and South Nation) initiated a program for flood risk mapping within the boundary of the City. A five-year plan for mapping a number of high priority rivers and streams was made. As part of this program, the RVCA has identified 12 stream reaches, where the existing mapping would be updated or new mapping will be created for the first time. The Ottawa River was mapped during the first year of this project and this is the project completion report.

The 1984 mapping study by MacLaren Plansearch Inc. is now nearly 30 years old, and changes in the landscape have taken place along the shoreline and floodplain, giving rise to occasional mismatch between plotted flood limits and current lay of the land. A new study was thus deemed necessary to bring the mapping up to date. Hence the present study was undertaken. The primary objective of the project has been to map the expected extent of inundation during a 1:100 year flood – the regulatory flood event – as required for municipal land use planning purposes, using the most up-to-date topographic mapping information. Prior to doing so, the hydrologic and hydraulic computations performed to estimate flood discharges and associated water level for various return period (or flood frequencies) have also been reviewed and updated.

This report provides a summary of the analytical methods used and underlying assumptions applied in the preparation of flood plain mapping for the Ottawa River from Cumberland to Shirley's Bay (Figures 1 and 2), i.e., the entire reach of the River within RVCA jurisdiction. The project has been done in accordance with the technical guidelines set out under the Canada-Ontario Flood Damage Reduction Program (FDRP) (MNR, 1986), and the technical guide for the flood hazard delineation in Ontario (MNR, 2002) as laid out by the Ontario Ministry of Natural Resources. The 1:100 year flood lines delineated here are suitable for use in the RVCA's regulation limits mapping (referred to in Section 12 of Ontario Regulation 174/06) and in municipal land use planning and development approval processes under the Planning Act.

The MacLaren Plansearch mapping has been used by RVCA and the City of Ottawa in the land use planning and development process since 1985. In 2006, the mapping was formally used in the establishment of "regulation limits mapping" associated with the RVCA's "Development, Alteration and Interference Regulation (O.Reg. 174/06) made under Section 28 of the Conservation Authorities Act. The present mapping, when endorsed by RVCA's Board of Directors, will supersede the 1984 MacLaren Plansearch Inc. mapping, in its fundamental purpose which is to describe the extent of the flood plain of that portion of the Ottawa River that is within the area of jurisdiction of the RVCA, under 1:100 year flood conditions (the regulatory flood event standard for this part of Ontario, as prescribed by Provincial Government policy).

Study Area

The study area extends along a 60 km reach of the Ottawa River from Shirley's Bay to Cumberland (Figures 1 and 2). No other river or tributary is included in this study.

All the area mapped falls within the boundaries of the City of Ottawa.

Previous Studies

A previous flood mapping study of the Ottawa River was conducted by MacLaren Plansearch Inc. (1984) and was funded under the Canada-Ontario Flood Damage Reduction Program (FDRP). This study was based on available flow monitoring data with topographic mapping produced by Northway-Gestalt Survey Corporation Limited. The study area extended from Cumberland to Arnprior encompassing the entire reach of the River within the City of Ottawa (formerly the Regional Municipality of Ottawa-Carleton). The study was commissioned jointly by the RVCA, the Mississippi Valley Conservation and the RMOC, and managed on their behalf by the MVCA.

The hydrologic analysis involved a detailed examination of historical streamflow data from three gauge locations: Chats Falls, Britannia and Grenville/Carillon (see Figure 2 for locations). It was determined that the 20 year record at Britannia would not be used in the hydraulic modeling. A statistical analysis was performed for gauge records to verify that the records were stationary, without significant trend, and from the same underlying distribution and random. It was found that the records adhered to these criteria, and were thus suitable for standard flood frequency analysis. A frequency analysis was done to determine discharges for the 2, 5, 10, 25, 50 and 100 year return periods at Chats Falls and Grenville/Carillon.

Hydraulic computations were done using the November 1976 version of the US Army Corps of Engineers' HEC-2 software (USACE, 1990). Water surface profiles for 2, 5, 10, 25, 50 and 100 year return periods were estimated. Wave run-up analysis was completed for Marshalls' Bay, Shirley's Bay, Constance Bay and Britannia Bay. The HEC-2 model results were used to plot the 1:100 year flood risk limits.

A recent study mapping the Quebec side of the Ottawa River was completed by the Centre d'expertise hydrique du Québec (2008). (Détermination des cotes de crues correspondant à la zone de grand courant et à la zone de faible courant, CHEQ 07-014) The purpose of this study was to update the water level estimate for the 1:20 and 1:100 year floods along the Quebec side of the Ottawa River from Carillon Dam up to Waltham, QC. Stage-stage relationships were developed for each pair of adjacent gauges and then an interpolation between gauge locations was used to estimate 1:20 and 1:100 year flood water levels. The methodology first determined non-exceedance probabilities for water levels recorded at hydrometric stations, and then relationships were determined between these stations and other locations within the reach. Sites 19 to 42 noted in the report are located within the current study area and may be of interest for comparison purposes.

Baird Associates (2010) completed a study delineating intake protection zones at the Britannia and Lemieux Island Water Purification Plants. The study identified the areas susceptible to contamination near the intake locations for these two plants. As part of the study, Baird undertook a hydrographic survey of the Ottawa River between Chaudière Dam and Deschenes Rapids to define river bathymetry.

Data Used

LIDAR: High quality topography is the key to high quality flood risk mapping for two reasons:

- hydraulic computations (to estimate water surface elevations associated with flood discharges) are performed using numerical models in which the river and its flood plain are represented by a series of cross-sections; land elevations in the overbank areas (the flood plain) are taken from the best available topographic mapping or digital elevation models

- once the estimated water surface elevations are determined, the extent of the flood plain (inundation areas) is plotted using the same topographic mapping or digital elevation models.

For this study, digital elevation models and 25 cm elevation contours were derived from LIDAR data supplied by the City of Ottawa for the purposes of this study. The processing was done by the City and the final product was provided to RVCA. The exact date of when the LIDAR was flown is not known, but it appears to be sometime in 2007.

In some places, the LIDAR data was missing along the water line from the day(s) it was collected. This is because LIDAR returns for inundated areas are indicative of water surface elevation (not the underlying ground or riverbed elevation). If the LIDAR data were captured at a time when the river level was higher than it was at the time of the imagery onto which the LIDAR-derived elevation data (spot heights or contours) are projected, gaps will appear between the elevation data and the water's edge as seen in the imagery. Although, these gaps do not affect the location of the flood line, ground surveys were carried out by RVCA staff during April 2013 to collect data to augment the LIDAR data for the purposes of flood line delineation.

The accuracy of the LIDAR data and associated contour lines was checked in the field by RVCA technicians. The true elevations of features on the ground that are identifiable on the mapping were determined using RVCA's survey grade GPS equipment (Trimble R8), and compared with the elevations indicated by the LIDAR spot heights or elevation contours, to determine that any differences between mapped and true elevations were within the accuracy prescribed by the FDRP standards.

In total, 244 spot heights and 183 contour crossings were verified (see Tables 1 and 2; Figure 4). As described in the FDRP guidelines (MNR 1986), the spot height checks are considered satisfactory when 90% of the data points are within 0.33 m (one third of the contour interval) of the field measurement; for contour crossings, it is 0.50 m. (one half of the contour interval). As shown in Tables 1 and 2 these criteria have been adequately met. On average, the spot heights and contour crossings are within 6.4 and 9.5 cm respectively (Figure 4).

At the few locations where these criteria are not met, changes to the landscape since the date of the LIDAR flight have been identified as the probable cause of the discrepancy. In some places, the LIDAR-derived contour was incongruent with spot heights and field measurement. This happened along the river's edge, and/or near buildings and other man-made structures, and appears to be due to omitting appropriate break-line features. However, the problem was localized, easily detectable and, once detected, we used the LIDAR spot heights (primary data) and ignored the contour lines (derived data).

Air photo: High resolution digital air photo coverage of all of Eastern Ontario, including the RVCA's area of jurisdiction, was obtained through a collaborative project referred to as the DRAPE project (Digital Raster Acquisition Partnership East) in May-July 2008. The imagery was captured at a scale of 1:16,667. This high quality colored photo clearly shows the rivers, creeks, land use, houses, buildings, roads, infrastructure, vegetation and other details.

2011 air photo coverage was also available from the City of Ottawa. It is accurate, sharp and in colour, and shows various natural and man-made features clearly.

Building footprint: The 'building footprint' layer was provided by the City of Ottawa. It enables us to accurately draw flood lines around buildings. The data layer contained information collected over a number of years.

Streamflow data: Several active and discontinued hydrometric gauge locations are present along the Ottawa River around the study area (Table 3, Figure 2). As this study is an update of previous flood plain mapping, the same hydrometric stations were examined as used by MacLaren (1984).

Downstream from the study area, a combination of gauge data from Ottawa River at Grenville (Water Survey of Canada, 02LB001) and Ottawa River at Carillon Dam (Water Survey of Canada, 02LB024) were used to cover the period from 1933 to 1994. Additional data were obtained from the Ottawa River Regulatory Planning Board for

Carillon Dam discharge between 1994 and 2012. The Grenville and Carillon gauges are located about 62 km and 80 km downstream from the study limit (cross-section 1000) respectively. No value for 1961 is included because of transition in water level and discharge resulting from starting operations at Carillon Dam. Hereafter this combined station is referred to as Carillon.

Within the study area, Ottawa River at Britannia (Water Survey of Canada, 02KF005) is the only active station recording discharge and its record runs from 1960 to present, but 1960 is a partial year and was not used. Water level records span from 1915 to present at Britannia.

The Ottawa River at Chats Falls Dam gauge (Water Survey of Canada, 02KF009), located about 40 km upstream of the study area (cross-section 2018), provided data from 1915 to 1994. Additional data were obtained from Ontario Power Generation (OPG) for the 1994 to 2012 period. The above stations provide relatively long discharge records and Table 3 provides further details. Figure 2 shows a map of the above gauges.

There are additional discontinued gauges (discharge or level) along the Ottawa River, but all have much shorter record durations than Carillon and Chats Falls. The rating curve – that is, the relationship between discharge and water level derived from field measurement of discharge under a range of observed water level conditions – for the Britannia gauge location was obtained from WSC.

Water level data at Hull, QC (02LA015) are available from 1964 to present , and were used in calibration of the hydraulic model.

Hydrological Analysis

The hydrological analysis in this study has been similar to the MacLaren Plansearch (1984) study, but has taken into account 28 years of additional data that are now available. The analysis involved three main components: (a) statistical test of the data to verify its suitability for frequency analysis; (b) flood frequency analysis to estimate the discharges for selected return periods; and (c) correlation analysis of the discharges observed at the Chats Falls and Britannia hydrometric gauges.

Statistical analysis:

Analysis of the above stations was carried out to ensure that each data series was suitable for flood frequency analysis. According to standard hydrologic theory (e.g., Karney and Adams, 1993, p. 17; McCuen, 2003), these criteria must be satisfied:

- The data were generated by a random process,
- Individual values are independent,
- The time series is stationary, and
- Sampling is from a homogeneous population.

Five statistical tests were used for the analysis, which were the same tests used in MacLaren's 1984 study, and are as follows:

1) Spearman Rank Order Serial Correlation Coefficient test for independence,
2) Spearman Rank Order Correlation Coefficient test for trend,
3) Mann-Whitney split sample test for homogeneity,
4) Wald-Wolfowitz split sample test for homogeneity, and
5) Runs above and below the median for general randomness.

Details of statistical tests are available in Appendix A. A script was written to perform these tests and its output can be found in Appendix B. It was also used to replicate MacLaren's 1984 calculation, which it did accurately, thus confirming the script's validity. The analysis of all current data found that the annual peak flows at each gauge were independent, without trend, homogeneous and random at a 5% significance level, and were therefore suitable for flood frequency analysis without any adjustment.

Flood frequency analysis:

Frequency analysis was performed at three gauge locations (Table 4) using Consolidated Frequency Analysis 3.1 (CFA_3), a program from Environment Canada (Pilon and Harvey, 1993). The annual peak values for Carillon, Britannia and Chats Falls are included as Tables 5, 6 and 7. CFA_3 was used to fit the following distributions:

- Generalized Extreme Value (GEV),
- Three-Parameter Lognormal (3PLN),
- Log Pearson Type III (LP3), and
- Wakeby (WBY).

The previous study used the Log Pearson Type III distribution for Chats Falls and Carillon, but the longer record durations available now have a better fit using the three-parameter lognormal distribution for those stations. A generalized extreme value distribution fits the Britannia data best. Flow estimates are found in Table 4, while Figure 5 compares the MacLaren study distributions to the current distributions.

Estimated 1:100 year flood flows based on the longer historical streamflow records are about 3% to 6% lower than those estimated in the previous (1984) study.

<u>Correlation of Chats Falls and Britannia Discharges</u>:

When MacLaren completed their study, the record at Britannia (02KF005) was available for only 20 years (1960 to 1980) and the peak flows were very similar to those measured at Chats Falls. Now with a much longer 52 year flow record at Britannia (1960 to 2012), an assessment of whether the longer Chats Falls record should be used at Britannia was completed.

Figure 6 shows the annual peak flows at Chats Falls and Britannia and it reveals a strong correlation between the two stations, especially in the period since 1980. This correlation makes sense given the layout of the Ottawa River with relatively small inflows between these two gauge locations. As a result of the strong correlation and the underlying processes affecting it, it was decided that the longer record at Chats Falls (1915-2012) would be used for the entire reach upstream of Chaudière Dam. The longer Chats Falls record also includes higher floods that occurred before the Britannia record began; so these historical events will properly be included for the entire reach.

Based on the statistical and frequency analyses described above, the RVCA's 1:100 year flood estimates for Chats Falls and Carillon in Table 8 should be used for the purposes of floodplain mapping along the Ottawa River within RVCA's jurisdiction.

Estimated flood discharges for Chats Falls should be used for the section from the upstream study limit to Chaudière Dam, and the Carillon estimates should be used for the section downstream of Chaudière Dam to the downstream study limit. As discussed above, maximum daily peak discharge rates at Britannia and Chats Falls are strongly correlated, and the longer flow record at Chats Falls is used for both locations.

The flows listed in Table 8 have been used in the hydraulic analysis for the flood mapping of the Ottawa River from Shirley's Bay to Cumberland, as described in the following pages.

There are numerous dams along the Ottawa River. The Ottawa River Regulation Planning Board (ORRPB) coordinates their operation "to provide protection against flooding along the Ottawa River and its tributaries, particularly in the Montreal Region, and at the same time maintain the interests of the various users particularly in hydro-electric energy production" (ORRPB http://ottawariver.ca). In a meeting on October 26, 2012 with RVCA and MVC staff, the ORRPB staff stated that the coordination of dam operations is considered to have some beneficial (lessening) effect on frequently occurring runoff events but no perceptible effect on the moderate and rare events. This is to be expected when one considers the relatively small volume of storage that is managed at the dams for hydro-electric power generation purposes compared to the enormous volumes of runoff generated by snowmelt with or without concurrent rainfall throughout the Ottawa River watershed during a typical spring freshet. Therefore, we conclude that the annual maximum flow data and the flood estimates derived therefrom have not been influenced by the dam operations – in general, dam operations have not had the effect of reducing flood risks the study area, nor have they contributed to increased flood risk. Accordingly, dam operations have no significant influence on the regulatory flood limit delineation for the study area.

Hydraulic Computations

Following standard procedures (MNR, 1986; USACE, 1990, 2010), a steady-state hydraulic model of the Ottawa River was built (Figure 7). The steady-state hydraulic model developed in HEC-2 by MacLaren (1984) was converted to HEC-RAS and updated to present conditions. The HEC-RAS model (version 4.1.0) developed by the US

Army Corps of Engineers (USACE, 2010) was used. This uses the same backwater calculation procedure as HEC-2 (USACE, 1990) which has been the industry standard since the 1970s, but with improved data processing and graphical capabilities.

Cross-Sections: The cross-sections used in the modeling were imported from MacLaren's 1984 study HEC-2 files with stationing reversed to conform to the HEC-RAS left-to-right orientation standard when facing downstream. Table 9 lists the cross-sections that have undergone additional updates.

Bathymetry from Canadian Hydrographic Service digital charts (Canadian Hydrographic Service, 2011) was used to check a selection of cross-sections between Shirley's Bay and Cumberland. Additional bathymetry, from a Baird and Associates Ltd (2010) report (hereafter Baird (2010)), between Britannia and Lemieux Island was used to update the cross-sections along Lemieux Island. The Baird (2010) survey data were in line with expected river bed elevations from bridge as-built information. Cross-section 2103.1 from the HEC-2 model was renumbered as 2003.1 in the current model as HEC-RAS requires that cross-sections increase numerically in the upstream direction.

In total, 91 cross-sections within the RVCA area of jurisdiction were used in the model. Distances between sections along the stream center and left and right overbanks were calculated from the map. Figures 2 and 7 show the available hydrometric information and a schematic of the HEC-RAS model. Figures 10(a-e) show the location and alignments of the cross-sections in greater detail (at scales of 1:40,000 or 1:15,000), along with the computed Regulatory Flood Level (RFL) and flood risk limits.

Channel Roughness: Following standard procedures (Chow, 1959), the resistance of the channel under possible high water conditions was estimated from aerial photos and several field inspections. The Manning's roughness coefficient was generally 0.03 in the main channel, and varied from 0.05 to 0.08 for the floodplains. These values were consistent with those found appropriate in earlier studies (MacLaren, 1984), and were confirmed by the calibration process.

Bridges/Culverts: Within the model boundaries there are eight bridges (Table 10). MacLaren's model included six of these bridges. The Portage and Chaudière Bridges were not modeled due to a lack of bathymetric information and their proximity to Chaudière Dam. It was decided that the Portage Bridge should be included because of better bathymetric data availability and the receipt of plans for the structure. The Chaudière Bridge (Union Bridge) is not modeled in the current study as it does not affect upstream water level because of its proximity to Chaudière Dam.

As-built drawings for all the structures within the RVCA area of the model were requested and the new information for all except the plans for the Champlain Bridge warranted suitable updating of the hydraulic model. Changes made to the Champlain Bridge used DRAPE imagery (2008) as a reference to determine the location of piers along the cross-section. The other bridges and associated cross-sections were updated to match the as-built information. As-built information for bridges was obtained from:

- the City of Ottawa,
- the National Capital Commission, and
- Public Works and Government Services Canada.

Expansion (Ce) and contraction (Cc) coefficients were left at the values used by MacLaren (1984): 0.3 for expansion and 0.1 for contraction. These values are justified considering the large width of bridge constrictions relative to the river width (Dyhouse, Hatchett, and Benn, 2003, p. 194). However, at Lemieux Island, they were changed to 0.5 and 0.3, respectively, to match the present day practice as recommended in the HEC-RAS 4.1 Hydraulic Reference Manual (USACE, 2010, pp. 3-21).

Design Flows: The design flows from the hydrologic analysis (discussed above), with return periods ranging from 2 to 500 years (Tables 8 and 11), were used in the HEC-RAS model. The boundary conditions, i.e., water levels (Table 12) at the downstream end (cross-section 995), were estimated using an interpolation method similar to that of MacLaren (1984).

In the HEC-RAS modeling, from the upstream study limit to Chaudière Dam, the Chats Falls record is used. Downstream of Chaudière Dam to the downstream study limit, the combined record from Grenville and Carillon gauges is used.

Boundary conditions

Starting water levels are needed at three locations for the HEC-RAS model of Ottawa River:

- Downstream of Cumberland – most downstream, external boundary point

- Chaudière Dam – internal boundary point
- Above the Deschenes Rapids – internal boundary point

The downstream limit of the model (**cross-section 995**) is approximately 11 km downstream of Cumberland, and 55 km upstream of the Carillon dam. The relationship between the (currently discontinued) Cumberland (WSC 02LB010) and Grenville (WSC 02LB001) water level gauges, derived from observations during the 1970-1974 period, was used by MacLaren (1984) to estimate the cross-section 995 water level for a given flow.

For the current study, a relationship for the difference between Cumberland and Grenville water levels versus the flow at the Carillon dam was derived using data from 1965 to 1996. An envelope curve[2] was plotted (Figure 8) and values from this curve were used for interpolating between the two stations to get a starting water level at the downstream limit of the model. Table 12 shows the downstream water elevations used in the model.

At Chaudière Dam (**cross-section 2000**), the 1984 study used a constant surface elevation of 53.32 m for all flow rates though their report only notes that the Chaudière Dam is operated to maintain "a headwater level of approximately 52.70 meters" (MacLaren, 1984). The current operating rules for Chaudière dam are to target a minimum water level of 52.65 m and a maximum water level of 52.72 m, relative to the Geodetic Survey of Canada datum (Kropp, 2013). A maximum water level of 53.04 m is reported by Baird (2010), but this could not be verified. Correspondence with Energy Ottawa only noted, with respect to maximum operating level, that the top of the stoplogs are at 52.92 m (Kropp, 2013). Without being able to verify a justifiable alternative water level the MacLaren value of 53.32 m is used as the boundary condition to represent the 1:100 year flood scenario.

Above the Deschenes Rapids (**cross-section 2011**), a boundary condition based on an extrapolated rating curve at the Britannia gauge obtained from Environment Canada (02KF005) is used (Figure 9). The 1984 study used an older rating curve as its

[2] The data points including three annual peaks, which are above the envelop curve was scrutinized and found to have occurred during the sub-zero temperature and ice conditions; therefore, they do not affect the envelop curve used in the model meant to simulate 'open water' conditions.

boundary condition (MacLaren, 1984, pp. 3-9). Table 13 shows the water surface elevations used in the model at Britannia (cross-section 2011).

Once the model was set up, the computed profiles and other parameters were scrutinized to assess the reasonableness of model outputs. Special attention was given to the computed water level and energy profiles near bridges. Adjustments of model parameters – mainly the channel resistance and contraction and expansion coefficients – were made as necessary.

The final model was run with the estimated floods for 2, 5, 10, 20, 50, 100, 200 and 500 year return periods. The 1:100 year computed water surface elevations, energy grade and the Regulatory Flood Level (RFL) are shown in Table 14. Please note that RFLs have been only determined for the area within RVCA's jurisdiction. A few typical water surface profiles and all cross-sections are included in Appendix C.

Computed water surface elevations for various flood events with return periods ranging from 2 to 500 years are presented in Tables 15 and 16. It should be pointed out that the model has been built and calibrated to simulate the 1:100 year flood levels; therefore the water surface elevations for other events – simulated using the same parameters, especially the Manning's roughness coefficient – are only approximate, and should be used with caution. This is because the river roughness varies with flow magnitude, with higher resistance associated with lower flows.

Calibration

By virtue of being a slightly modified version of the well calibrated MacLaren's (1984) HEC-2 model, the current HEC-RAS model needed very little adjustment to be considered calibrated. The HEC-RAS model was calibrated by matching the model-generated water level to the water level records at Hull, and replicating the May 1974 flood event. Both confirmed the reasonableness of the model for the purposes of flood risk delineation.

MacLaren (1984) calibrated their HEC-2 model using the May 1974 flood event, for which flows in the tributaries and the water levels at Cumberland and the Rideau Locks were known. This allowed running the model with a variable discharge along the Ottawa River with a known boundary condition (measured water level of 43.40 m at section 995), and testing the computed water levels at Rideau Locks and Cumberland. As can be seen from Table 17, our HEC-RAS model was able to simulate the water level within 4 cm of the previous HEC-2 model. The observed water level values were not given in the MacLaren report; it was only mentioned that the HEC-2 generated values were within 1 cm of the observed values. Therefore, we infer that our model is within 0-5 cm of the observation.

Further confidence in the model was gained by using water level data from the Ottawa River at Hull gauge (WSC 02LA015) and comparing the HEC-RAS generated water levels with them. Figure 11 shows a plot of water level versus flow rate at Carillon dam, and it can be seen that the water levels estimated using HEC-RAS follow an envelope curve that encompasses the upper range of the stage-discharge relationship.

When compared to the MacLaren's (1984) results, our computation shows that the RFL has decreased (5 to 10 cm) along most of the river reach; this is mainly due to the 3-6% decrease of the design flows. Therefore, the two models give consistent and comparable results. We, therefore, concluded that the new HEC-RAS model is sufficiently calibrated and does not need further adjustment[3].

At two locations (Lemieux Island Road Bridge and Lemieux Island Pipe Bridge), we had to change the bridge modeling to conform to current standards (USACE, 2010), which has resulted in minor increase in water level at localized areas; but this has barely changed the location of the flood limit line and no private property has been affected.

Once calibrated, the model was run with the design floods. Selected outputs from the model are tabulated in Tables 14, 15 and 16. A few typical water surface profiles and all cross-sections are included in Appendix C.

[3] While we consider the model good enough for the purposes of floodplain mapping, we also recognize that further model adjustment/modification may be necessary for other purposes. It all depends on the purpose of the modeling and the features and phenomena a model is meant to capture. We therefore caution against using this model for other purposes without first confirming its suitability.

Sensitivity Analysis

A sensitivity analysis was conducted to determine how much the computed water surface elevations will vary with changes in the value used for the 1:100 year discharge. Six flow conditions were tested:

- 1:100 year flow increased by 5%
- 1:100 year flow increased by 10%
- 1:100 year flow increased by 20%
- 1:100 year flow decreased by 5%
- 1:100 year flow decreased by 10%
- 1:100 year flow decreased by 20%

Figures 12 and 13 show the computed water surface profiles and the differences in computed water levels for each condition. Figure 12 indicates that the computed water surface elevations are more sensitive to the discharge value in the steeper portion of the reach between the Champlain and Macdonald-Cartier Bridges. The sensitivity analysis indicates that the computed water level can vary by about 0.20 to 0.40 m for a 10% variation in flow, which is typical in the hydrologic estimation of design flow. For a 20% increase in flow, the water level can go up by 1 to 1.5 m just downstream of the Chaudière dam, but only by 0.45 m for areas with population adjacent to the flood plain upstream and by 0.80 m further downstream.

The sensitivity analysis has demonstrated that the RVCA's policy of requiring a minimum of 0.30 metres of freeboard in the design of flood-proofing measures for buildings and structures within or adjacent to flood prone areas will generally be sufficient. It also provides an indication of the potential effect of changes in the expected flood flows that might result from more gradual trends such as climate change, but it has been beyond the scope of this study to comment on or speculate about how the flood discharge vs. frequency relationship of the Ottawa River might change in the future as a result of ongoing and continued climate change.

Selection of Regulatory Flood Levels

As per Section 3 of the Provincial Policy Statement under the Planning Act (MMAH, 2005, 2014), the regulatory flood in Zone 2, which includes the RVCA, is the

1:100 year flood. Depending on the local hydraulic conditions, the computed water surface elevation, the energy grade or a value in between is generally taken as the Regulatory Flood Level (RFL). Engineering judgment is applied to recommend an appropriate value for the regulatory flood level at each cross-section, using the model outputs and considering hydraulic characteristics of the river reach, and the inherent limitations of the numerical model.

When the stream velocity is relatively low and varies only gradually over relatively long river reaches, the computed water surface elevation can generally be taken as the RFL.

However, near bridges, culverts and other water control structures and on steeper reaches where streamflow velocities are higher, and may change more abruptly, the computed water surface elevation may be substantially lower than the energy grade level, with the possibility that the water level may rise to the energy grade near obstacles and irregularities in the channel profile or cross-section which may not be represented in the hydraulic model. In such cases, the regulatory flood level is generally based on the computed energy grade as a conservative approach, given that the numerical model is less likely to be a true representation of reality in such situations.

Another possible situation arises when the computed water surface profile is undulating, with downstream water levels occasionally higher than upstream levels. When this occurs it is more often an artifact from the simplifying assumptions of the modeling scheme than a reliable prediction of the actual differences in streamflow velocity and depth (and hence energy state) from one cross-section to the next. Accordingly, the regulatory flood level at the upstream cross-section is taken to be equivalent to the downstream water surface elevation in these situations.

In all cases, the RFL is always between the computed water level and energy grade line. Hence, for the sake of simplicity, consistency and conservatism, the energy grade elevation is often used as the RFL as a standard practice in delineating flood hazard areas.

For the present study, the regulatory flood levels were set equal to the computed energy grade and are tabulated in Table 14, along with the computed water surface elevations and energy grades at each cross-section in the model.

Flood Line Delineation

Once the RFLs are established, the plotting of 1:100 year flood lines or flood risk limits is a relatively straightforward matter. Given the topographical information in the form of contour lines at 0.25 m interval and the LIDAR spot heights, the extent of the inundated areas that are associated with the RFLs can be easily delineated manually or by using automated computer programs. In the present case, it was done automatically using HEC Geo-RAS software of USACE (2011) and then checked manually with a focus on areas with complex topography, infrastructure, overbank flow paths. The raw LIDAR spot heights were used extensively in the plotting of flood risk limit.

Special attention was paid near the outfalls of the tributaries to the Ottawa River within the study area, since such areas are subjected to flood risk from two sources (backwater from a high Ottawa River level, or an extreme flood event on the tributary). The flood plain limits on tributaries have been plotted based only on the flood elevation of the Ottawa River – that is, assuming a horizontal water surface profile along and insignificant flow in the tributary, where it enters the Ottawa River. Caution needs to be applied when interpreting the flood line information produced in this study in the review of any development or watercourse alteration proposals on the downstream reaches of the tributaries, taking into consideration the potential effect of high flows originating in the tributary watershed, possibly in combination with high water levels on the Ottawa River (from the tributaries) in an appropriate manner.

Field surveys were conducted by RVCA staff on April 9 and 11, 2013 to supplement LIDAR data. The survey primarily checked invert elevations of culverts near flood damage centres near Lac Deschenes and east of Cumberland. Table 18 provides details of the survey. This information was used to identify hydraulic connectivity through culvert opening and flood prone areas.

The record of site specific surveys conducted for flood line amendment purposes have been reviewed and none were found for the Ottawa River flood line. Site specific information was reviewed where available for locations listed in Table 19.

Buildings in the floodplain:

Presence of existing buildings within the floodplain and associated variation in the way a building could be exposed to flood risk required special attention. In general, we have drawn flood lines around a building (keeping it outside floodplain) if it is surrounded by high ground. We did the same if a building is partly tied to high ground but is exposed to flood water along other edges. However, we have left in the floodplain a building which is located in the floodplain without being tied to high ground. Due to the limitations of the data and methodology used in the current mapping done at a large scale, and the small degree of (inevitable) subjectivity in drawing flood lines around buildings at a smaller scale, RVCA recommends that, should the need arises for accurate flood line delineation near buildings, site-specific information be taken into account when dealing with flood risk at these locations. It is the practice of RVCA to refine flood lines when more accurate information becomes available.

Britannia Village Area:

The flood risk at Britannia Village is complicated by the presence of the rapids along the river, existing development and a few spill sections (Figure 14). Mapping of this area therefore required special attention and engineering judgement. If any development in this area is envisaged in future, a closer scrutiny using site-specific information and analysis would be advisable.

The regulatory flood lines and cross-sections have been incorporated as separate layers in RVCA's Geographical Information System (GIS). In this system, one can view the flood lines, cross-sections, design flow, water level, energy grade, RFL, and other computed parameters. The flood lines can be overlain on the aerial photography or any other base mapping layers that are in the system and at any scale that suits the user's need.

The regulatory flood line layer is maintained, and updated as required according to the established procedures of the RVCA (RVCA 2005).

Project Deliverables

The key information or knowledge products generated from this project are:

1) The Flood Mapping Report (this Technical Memorandum) – which summarizes the analytical methods that were used and the underlying assumptions
2) The flood risk limit lines in GIS format (shape files) – identifying the extent of lands which are considered to be vulnerable to flooding during a regulatory flood event (1:100 year flood on the Ottawa River)
3) The HEC-RAS model files (input and output)
4) The position and orientation of cross-sections used in the HEC-RAS model, in GIS format (shape files) – which, when used in conjunction with the HEC-RAS model output files and Table 14, informs the user as to the estimated 1:100 year water surface elevation and the regulatory flood level for any location in the study area

A "documentation folder" containing working notes and relevant background information accumulated during the study process is maintained by the water resources engineering unit within RVCA's Watershed Science and Engineering Services department.

Closure

The hydrotechnical and cartographic procedures used in this study generally conform to present day standards for flood hazard delineation, as set out in the MNR's Natural Hazards Technical Guide (MNR, 2002). The resulting 1:100 year flood lines are suitable for use in the RVCA's regulation limits mapping (referred to in Section 12 of Ontario Regulation 174/06) and in municipal land use planning and development approval processes under the Planning Act.

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Senior Water Resources Engineer

References:

1. Baird and Associates Ltd. (2010). Surface Water Vulnerability Analysis: IPZ Delineation for Lemieux Island and Britannia Water Purification Plants. Prepared for the City of Ottawa. Ottawa: Baird and Associates.
2. Calenge, C. (2006). The package adehabitat for the R software: tool for the analysis of space and habitat use by animals. Ecological Modelling, 197, 1035.
3. Canadian Hydrographic Service. (2011 October 7). Digital Charts. CEN08 Rideau Canal - Ottawa River. Ottawa, Ontario, Canada.
4. Centre D'Expertise Hydrique du Québec. (2008). Détermination des cotes de crues correspondant à la zone de grand courant et à la zone de faible courant. CEHQ 07-014. CEHQ : Quebec City, QC.
5. Chow, V. T. (1959). Open-Channel Hydraulics. McGraw-Hill, New York, NY.
6. Conservation Ontario (2005). Guidelines for Developing Schedules of Regulated Areas. October 2005.
7. Dyhouse, G., Hatchett, J., & Benn, J. (2003). Floodplain Modeling Using HEC-RAS. (C. Totz, Ed.) Waterbury, CT: Haestad Methods, Inc.
8. Karney, B., & Adams, B. (1993). Statistical Analysis of Hydrologic Data. Toronto.
9. Kropp, F. (2013, February 5). RE: Chaudière Ring Dam Operating Policy. Personal communication. Ottawa, ON, Canada: Energy Ottawa.
10. Machiwal, D., & Jha, M. (2012). Hydrologic Time Series Analysis: Theory and Practice. Dordrecht, The Netherlands: Springer.
11. MacLaren Plansearch Inc. (1984). Ottawa River Flood Plain Mapping. Report to Mississippi Valley Conservation Authority, Rideau Valley Conservation Authority, Regional Municipality of Ottawa-Carleton, Ontario Ministry of Natural Resources and Environment Canada. Ottawa: MacLaren Plansearch.

12. Maidment, D. R. (Ed.). (1992). Handbook of Hydrology. New York: McGraw-Hill.

13. McCuen, R. H. (2003). Modeling Hydrologic Change: Statistical Methods. Boca Raton, Florida: Lewis Publishers.

14. MMAH (2005). 2005 Provincial Policy Statement. Ontario Ministry of Municipal Affairs and Housing, Queen’s Printer, Toronto, Ontario, 2005.

15. MMAH (2014). 2014 Provincial Policy Statement. Ontario Ministry of Municipal Affairs and Housing, Toronto, Ontario, 30 April 2014.

16. MNR (1986). Flood Plain Management in Ontario – Technical Guidelines. Ontario Ministry of Natural Resources, Conservation Authorities and Water Management Branch, Toronto.

17. MNR (2002). Technical Guide – River & Stream systems: Flooding Hazard Limit. Ontario Ministry of Natural Resources, Water Resources Section, Peterborough, Ontario, 2002.

18. Ontario Power Generation (2013 January 25). Email communication with Marc Bisson: RE: Chats Falls GS Forebay operating policy. Ottawa, Ontario, Canada.

19. Pilon, P. J., and Harvey, D. (1993). CFA – Consolidated Frequency Analysis version 3.1. Environment Canada, Surveys and Information Systems Branch, Ottawa, March 1993.

20. R Core Team. (2012). R: A Language and Environment for Statistical. Vienna: R Foundation for Statistical Computing. Retrieved from http://www.R-project.org

21. RVCA (2005). RVCA Methods for Delineation of Regulation Limits in Accordance with Ontario Regulation 97/04. Rideau Valley Conservation Authority, Manotick, Ontario, November 16, 2005.

22. USACE (1990). HEC-2 – Water Surface Profiles – User’s Manual. US Army Corps of Engineers, Hydrologic Engineering Center, Davis, CA, September 1990.

23. USACE (2010). HEC-RAS – River Analysis System – Hydraulic Reference Manual version 4.1.0, US Army Corps of Engineers, Hydrologic Engineering Center, Davis, CA, January 2010.

24. USACE (2011). HEC-GeoRAS – GIS Tools for Support of HEC-RAS Using ArcGIS – User's Manual Version 4.3.93, US Army Corps of Engineers, Hydrologic Engineering Center, Davis, CA, February 2011.

Table 1 Field verification of LIDAR data (spot heights)

	Lidar Points	2013 RVCA Field Survey - Ottawa River									
Location ID	Z (m)	X (m)	Y (m)	Z (m)	Horizontal Accuracy (m)	Veritcal Accuracy (m)	Date/Time	Field Observations	△Z (m)	|△Z | (cm)	|△Z| > 0.33m
area1-spot1	59.26	435105.03	5022390.12	59.34	0.008	0.013	05/29/2013 09:22:11		-0.084	8.4	
area1-spot2	59.50	435103.44	5022389.11	59.54	0.007	0.012	05/29/2013 09:23:19		-0.040	4.0	
area1-spot3	60.79	435093.12	5022382.39	60.70	0.007	0.012	05/29/2013 09:23:51		0.089	8.9	
area1-spot4	61.52	435084.70	5022374.29	61.45	0.007	0.012	05/29/2013 09:24:15		0.071	7.1	
area1-spot5	62.09	435075.11	5022365.54	62.01	0.007	0.012	05/29/2013 09:24:42		0.077	7.7	
area1-spot6	62.07	435073.63	5022359.20	61.93	0.007	0.012	05/29/2013 09:25:07		0.142	14.2	
area1-spot7	61.69	435104.23	5022311.40	61.60	0.007	0.012	05/29/2013 09:27:39		0.091	9.1	
area-spot1	57.66	438947.42	5025380.49	57.69	0.006	0.010	05/29/2013 09:42:00		-0.029	2.9	
area-spot2	57.48	438949.09	5025393.29	57.55	0.006	0.010	05/29/2013 09:42:47		-0.065	6.5	
area-spot3	57.46	438952.74	5025402.80	57.51	0.006	0.010	05/29/2013 09:43:15		-0.047	4.7	
area-spot4	57.14	438940.02	5025409.42	57.15	0.006	0.010	05/29/2013 09:44:17		-0.008	0.8	
area-spot6	57.86	438959.08	5025390.12	57.82	0.009	0.014	05/29/2013 09:45:55		0.038	3.8	
area-spot7	58.44	438962.29	5025389.77	58.48	0.009	0.014	05/29/2013 09:46:18		-0.036	3.6	
area-spot8	57.87	438944.90	5025364.02	57.87	0.008	0.013	05/29/2013 09:47:14		-0.003	0.3	
area3-spot1	60.49	440362.72	5027279.59	60.42	0.007	0.010	05/29/2013 09:56:17		0.074	7.4	
area3-spot2	60.73	440367.73	5027270.44	60.58	0.006	0.010	05/29/2013 09:56:48		0.152	15.2	
area3-spot3	60.31	440361.40	5027257.91	60.26	0.007	0.011	05/29/2013 09:57:50		0.049	4.9	
area3-spot4	60.30	440352.01	5027268.10	60.11	0.007	0.010	05/29/2013 09:58:19		0.195	19.5	
area3-spot5	60.14	440347.90	5027264.12	60.05	0.007	0.010	05/29/2013 09:58:43		0.090	9.0	
area3-spot6	56.30	441068.03	5028157.66	56.24	0.007	0.010	05/29/2013 10:06:01		0.061	6.1	
area3-spot7	56.28	441068.86	5028163.15	56.33	0.007	0.010	05/29/2013 10:06:21		-0.050	5.0	
area3-spot8	55.39	441075.66	5028171.07	56.05	0.008	0.011	05/29/2013 10:06:45	grassed area under tree cover	-0.661	66.1	Y
spot1	57.28	441776.72	5028835.27	57.15	0.011	0.016	05/29/2013 10:15:54		0.132	13.2	
spot2	57.40	441765.37	5028834.51	57.38	0.008	0.012	05/29/2013 10:16:48		0.017	1.7	
spot3	57.33	441761.27	5028832.87	57.22	0.008	0.012	05/29/2013 10:17:07		0.115	11.5	
spot4	57.17	441758.00	5028831.16	57.05	0.008	0.012	05/29/2013 10:17:27		0.124	12.4	
spot5	56.78	441753.71	5028828.92	56.77	0.012	0.016	05/29/2013 10:17:50		0.008	0.8	
spot6	56.62	441747.39	5028824.90	56.56	0.007	0.011	05/29/2013 10:18:21		0.056	5.6	
spot7	56.50	441741.53	5028820.25	56.49	0.009	0.014	05/29/2013 10:18:45		0.014	1.4	
spot8	56.45	441736.45	5028815.85	56.42	0.008	0.011	05/29/2013 10:19:14		0.028	2.8	
spot9	57.14	441742.24	5028768.54	57.10	0.007	0.010	05/29/2013 10:21:27		0.045	4.5	
spot10	47.92	444356.71	5030028.49	47.92	0.011	0.016	05/29/2013 10:44:28		-0.003	0.3	
spot11	48.20	444335.14	5030019.93	48.15	0.010	0.015	05/29/2013 10:45:42		0.052	5.2	
spot12	48.72	444332.57	5030017.61	48.64	0.011	0.017	05/29/2013 10:46:23		0.078	7.8	
spot13	49.17	444325.64	5030012.43	49.09	0.011	0.017	05/29/2013 10:46:48		0.076	7.6	
spot14	49.55	444316.66	5030004.43	49.47	0.011	0.017	05/29/2013 10:47:18		0.084	8.4	
spot15	50.39	444307.98	5029995.83	50.07	0.012	0.017	05/29/2013 10:47:46		0.322	32.2	
spot16	50.39	444303.62	5029988.42	50.36	0.012	0.017	05/29/2013 10:48:11		0.026	2.6	
spot17	56.59	445842.27	5032003.17	56.47	0.010	0.014	05/29/2013 11:17:44	bench mark	0.121	12.1	
spot22	57.53	445831.34	5031992.87	57.52	0.009	0.013	05/29/2013 11:35:00		0.015	1.5	
spot23	57.02	445830.49	5031986.65	57.08	0.009	0.014	05/29/2013 11:35:24		-0.059	5.9	
spot24	56.28	445833.96	5031984.01	56.24	0.010	0.015	05/29/2013 11:35:46		0.039	3.9	
spot28	60.77	446177.65	5033601.75	60.80	0.009	0.018	05/29/2013 12:54:34		-0.028	2.8	
spot29	60.67	446183.91	5033604.81	60.59	0.011	0.021	05/29/2013 12:55:08		0.080	8.0	
spot30	59.41	446193.90	5033611.58	59.43	0.010	0.020	05/29/2013 12:55:35		-0.017	1.7	
spot31	58.22	446204.78	5033617.60	58.19	0.010	0.019	05/29/2013 12:56:06		0.034	3.4	
spot33	56.69	446217.88	5033625.24	56.69	0.010	0.020	05/29/2013 12:57:31		0.004	0.4	
spot34	55.53	446228.48	5033633.88	55.45	0.011	0.020	05/29/2013 12:58:41		0.077	7.7	
spot35	47.85	446249.19	5033687.03	47.79	0.011	0.020	05/29/2013 13:02:10		0.063	6.3	
spot36	54.51	447548.09	5033979.03	54.43	0.008	0.015	05/29/2013 13:13:29		0.081	8.1	
spot37	54.75	447564.31	5033978.56	54.71	0.012	0.020	05/29/2013 13:14:13		0.036	3.6	
spot38	54.34	447574.81	5034005.79	54.26	0.011	0.020	05/29/2013 13:15:28		0.079	7.9	
spot39	54.20	447591.99	5034018.83	54.14	0.009	0.018	05/29/2013 13:16:04		0.063	6.3	
spot40	54.51	447610.33	5034011.37	54.48	0.009	0.018	05/29/2013 13:16:44		0.029	2.9	
spot41	54.04	448209.50	5034162.33	54.02	0.010	0.020	05/29/2013 13:27:26		0.016	1.6	
spot42	53.95	448208.94	5034164.30	53.86	0.009	0.018	05/29/2013 13:27:49		0.088	8.8	
spot43	53.60	448208.08	5034167.44	53.53	0.007	0.015	05/29/2013 13:28:40		0.067	6.7	
spot44	52.99	448206.97	5034171.34	53.06	0.007	0.015	05/29/2013 13:29:05		-0.068	6.8	
spot45	52.68	448206.41	5034174.96	52.64	0.007	0.015	05/29/2013 13:29:30		0.039	3.9	
spot46	52.16	448205.74	5034178.92	52.17	0.007	0.014	05/29/2013 13:29:52		-0.006	0.6	
spot47	51.69	448205.24	5034182.69	51.67	0.007	0.015	05/29/2013 13:30:16		0.022	2.2	
spot48	51.17	448204.76	5034187.37	51.24	0.009	0.018	05/29/2013 13:30:46		-0.069	6.9	
spot49	50.65	448204.81	5034191.91	50.71	0.009	0.019	05/29/2013 13:31:08		-0.063	6.3	
spot50	50.05	448205.16	5034196.41	50.14	0.010	0.020	05/29/2013 13:31:32		-0.086	8.6	
spot51	49.71	448205.77	5034200.57	49.65	0.011	0.020	05/29/2013 13:32:10		0.061	6.1	
spot52	49.04	448206.39	5034205.24	48.95	0.011	0.019	05/29/2013 13:33:24		0.094	9.4	
spot53	45.42	448213.40	5034238.73	45.43	0.011	0.019	05/29/2013 13:34:35		-0.011	1.1	
spot54	45.15	448196.78	5034233.68	45.23	0.010	0.020	05/29/2013 13:36:26		-0.082	8.2	
spot55	52.18	454526.03	5034969.30	52.24	0.006	0.009	05/29/2013 13:56:25		-0.059	5.9	
spot56	52.30	454513.31	5034988.83	52.32	0.005	0.011	05/29/2013 13:57:23		-0.019	1.9	
spot57	51.87	454515.87	5034998.66	51.81	0.006	0.012	05/29/2013 13:57:58		0.061	6.1	
spot58	51.85	454512.17	5035001.60	51.82	0.006	0.012	05/29/2013 13:58:24		0.032	3.2	
spot59	51.80	454508.12	5035004.37	51.77	0.006	0.012	05/29/2013 13:58:55		0.031	3.1	
spot60	51.79	454504.28	5035006.98	51.77	0.006	0.012	05/29/2013 13:59:15		0.021	2.1	
spot61	51.78	454499.84	5035009.89	51.81	0.006	0.012	05/29/2013 13:59:41		-0.027	2.7	
spot62	51.86	454495.59	5035012.87	51.86	0.006	0.012	05/29/2013 14:00:03		0.002	0.2	
spot63	51.90	454490.52	5035017.01	51.92	0.006	0.012	05/29/2013 14:00:28		-0.024	2.4	
spot64	51.96	454486.41	5035021.90	51.92	0.007	0.013	05/29/2013 14:00:54		0.036	3.6	
spot65	51.99	454483.73	5035027.79	51.94	0.006	0.012	05/29/2013 14:01:18		0.053	5.3	
spot66	51.19	454475.16	5035057.85	51.21	0.006	0.012	05/29/2013 14:02:08		-0.024	2.4	
spot67	51.18	454474.47	5035059.68	51.18	0.008	0.012	05/29/2013 14:02:31		0.004	0.4	
spot68	53.02	452186.46	5034639.49	52.99	0.010	0.018	05/29/2013 14:10:09		0.031	3.1	
spot70	53.17	452178.16	5034637.25	53.12	0.009	0.016	05/29/2013 14:10:55		0.046	4.6	
spot71	52.99	452175.21	5034629.60	53.02	0.008	0.013	05/29/2013 14:11:27		-0.030	3.0	
spot72	53.12	452171.57	5034628.49	53.08	0.008	0.014	05/29/2013 14:11:49		0.037	3.7	
spot73	52.97	452180.99	5034630.89	52.94	0.009	0.015	05/29/2013 14:12:18		0.031	3.1	
spot74	53.36	452173.49	5034633.68	53.30	0.009	0.016	05/29/2013 14:13:05		0.059	5.9	
spot75	53.31	452172.18	5034634.89	53.28	0.009	0.016	05/29/2013 14:13:25		0.030	3.0	
spot76	53.20	452170.96	5034636.06	53.22	0.009	0.017	05/29/2013 14:13:44		-0.023	2.3	
spot77	52.94	452169.00	5034636.68	53.03	0.008	0.015	05/29/2013 14:14:05		-0.094	9.4	
spot78	45.10	451052.30	5034572.39	45.11	0.011	0.020	05/29/2013 14:31:14		-0.009	0.9	
spot79	44.66	451102.75	5034574.50	44.72	0.011	0.020	05/29/2013 14:36:16		-0.055	5.5	
spot80	42.83	451103.44	5034599.63	42.75	0.014	0.020	05/29/2013 14:40:14		0.083	8.3	
spot81	44.74	451053.30	5034579.04	44.79	0.014	0.020	05/29/2013 14:43:43		-0.046	4.6	
spot82	45.10	451052.02	5034573.43	45.04	0.014	0.020	05/29/2013 14:44:58		0.064	6.4	
spot83	45.39	451050.39	5034567.37	45.36	0.014	0.020	05/29/2013 14:45:53		0.026	2.6	

Table 1 Field verification of LIDAR data (spot heights)

	Lidar Points	2013 RVCA Field Survey - Ottawa River									
Location ID	Z (m)	X (m)	Y (m)	Z (m)	Horizontal Accuracy (m)	Veritcal Accuracy (m)	Date/Time	Field Observations	△Z (m)	|△Z| (cm)	|△Z| > 0.33m
spot84	45.59	451048.90	5034561.09	45.54	0.012	0.020	05/29/2013 14:47:58		0.054	5.4	
spot85	45.86	451046.60	5034553.71	45.90	0.009	0.020	05/29/2013 14:49:41		-0.035	3.5	
spot86	46.19	451042.56	5034545.84	46.25	0.013	0.019	05/29/2013 14:50:18		-0.061	6.1	
spot87	50.36	456314.75	5036175.97	50.37	0.006	0.009	3/6/2013 9:47		-0.013	1.3	
spot89	50.56	456323.27	5036174.90	50.58	0.007	0.011	3/6/2013 9:48		-0.023	2.3	
spot90	50.50	456333.64	5036171.09	50.54	0.007	0.011	3/6/2013 9:49		-0.043	4.3	
spot91	50.48	456333.91	5036171.15	50.49	0.007	0.010	3/6/2013 9:49		-0.009	0.9	
spot92	50.34	456312.04	5036201.09	50.40	0.008	0.012	3/6/2013 9:51		-0.064	6.4	
spot93	50.04	456303.53	5036215.61	50.05	0.008	0.011	3/6/2013 9:51		-0.007	0.7	
spot94	49.89	456298.05	5036224.47	49.88	0.008	0.011	3/6/2013 9:52		0.008	0.8	
spot95	49.75	456293.45	5036231.28	49.81	0.009	0.013	3/6/2013 9:52		-0.064	6.4	
spot96	49.64	456290.21	5036236.18	49.72	0.009	0.013	3/6/2013 9:53		-0.077	7.7	
spot97	45.86	458297.63	5036990.91	45.66	0.010	0.020	3/6/2013 10:17		0.198	19.8	
spot98	45.55	458291.22	5036995.35	45.54	0.015	0.020	3/6/2013 10:21		0.012	1.2	
spot99	44.90	458302.42	5037026.15	45.00	0.014	0.019	3/6/2013 10:24		-0.101	10.1	
spot100	44.80	458302.43	5037028.26	44.88	0.015	0.020	3/6/2013 10:24		-0.076	7.6	
spot101	44.65	458302.49	5037029.99	44.75	0.014	0.019	3/6/2013 10:25		-0.101	10.1	
spot102	44.62	458302.55	5037032.03	44.64	0.011	0.020	3/6/2013 10:26		-0.021	2.1	
spot103	43.58	458301.68	5037052.17	43.78	0.013	0.019	3/6/2013 10:27		-0.198	19.8	
spot104	43.55	458301.00	5037055.04	43.69	0.013	0.019	3/6/2013 10:28		-0.136	13.6	
spot105	43.42	458300.25	5037057.54	43.69	0.013	0.019	3/6/2013 10:28		-0.271	27.1	
spot106	43.40	458299.33	5037060.03	43.69	0.013	0.019	3/6/2013 10:28		-0.290	29.0	
spot107	43.56	458298.37	5037062.40	43.70	0.013	0.020	3/6/2013 10:29		-0.136	13.6	
spot108	43.59	458297.10	5037064.96	43.70	0.013	0.019	3/6/2013 10:29		-0.109	10.9	
spot109	43.60	458295.95	5037067.19	43.76	0.015	0.020	3/6/2013 10:30		-0.159	15.9	
spot110	49.60	457175.51	5036721.82	49.58	0.013	0.019	3/6/2013 10:48		0.023	2.3	
spot111	49.44	457175.19	5036723.62	49.37	0.014	0.020	3/6/2013 10:49		0.073	7.3	
spot112	49.22	457175.29	5036725.33	49.19	0.013	0.019	3/6/2013 10:49		0.027	2.7	
spot113	49.03	457175.37	5036727.07	49.02	0.012	0.017	3/6/2013 10:49		0.013	1.3	
spot114	48.76	457175.10	5036729.59	48.76	0.013	0.018	3/6/2013 10:50		0.005	0.5	
spot115	48.55	457174.76	5036731.94	48.55	0.011	0.016	3/6/2013 10:50		-0.002	0.2	
spot116	48.36	457174.35	5036734.23	48.35	0.011	0.016	3/6/2013 10:50		0.015	1.5	
spot117	48.22	457173.77	5036736.61	48.14	0.011	0.016	3/6/2013 10:50		0.078	7.8	
spot118	47.99	457173.23	5036738.70	48.00	0.011	0.016	3/6/2013 10:51		-0.007	0.7	
spot119	47.89	457172.54	5036741.21	47.83	0.012	0.017	3/6/2013 10:51		0.057	5.7	
spot120	47.65	457171.82	5036743.79	47.68	0.011	0.016	3/6/2013 10:51		-0.030	3.0	
spot121	47.56	457171.17	5036746.11	47.53	0.010	0.015	3/6/2013 10:52		0.032	3.2	
spot122	47.40	457170.53	5036748.51	47.38	0.011	0.016	3/6/2013 10:52		0.023	2.3	
spot123	47.30	457169.69	5036751.37	47.22	0.011	0.016	3/6/2013 10:52		0.083	8.3	
spot124	47.09	457168.68	5036754.01	47.05	0.011	0.016	3/6/2013 10:53		0.037	3.7	
spot125	46.82	457167.33	5036757.47	46.83	0.011	0.016	3/6/2013 10:53		-0.005	0.5	
spot126	56.45	460155.71	5037390.37	56.44	0.013	0.020	3/6/2013 11:06		0.010	1.0	
spot127	56.57	460157.65	5037387.17	56.56	0.013	0.020	3/6/2013 11:07		0.007	0.7	
spot128	56.63	460159.32	5037383.78	56.70	0.013	0.020	3/6/2013 11:07		-0.065	6.5	
spot129	56.80	460160.86	5037380.13	56.83	0.013	0.020	3/6/2013 11:08		-0.031	3.1	
spot130	56.91	460162.41	5037375.75	56.98	0.013	0.020	3/6/2013 11:08		-0.071	7.1	
spot131	57.12	460163.99	5037371.80	57.07	0.012	0.019	3/6/2013 11:09		0.049	4.9	
spot132	57.20	460165.74	5037367.30	57.23	0.012	0.018	3/6/2013 11:09		-0.034	3.4	
spot133	57.38	460167.25	5037362.91	57.38	0.012	0.018	3/6/2013 11:09		0.005	0.5	
spot134	57.59	460169.03	5037358.12	57.55	0.013	0.020	3/6/2013 11:10		0.041	4.1	
spot135	57.69	460170.61	5037353.42	57.73	0.012	0.018	3/6/2013 11:10		-0.035	3.5	
spot136	57.98	460171.68	5037349.19	57.92	0.014	0.020	3/6/2013 11:11		0.065	6.5	
spot137	58.12	460172.84	5037345.80	58.07	0.013	0.019	3/6/2013 11:12		0.053	5.3	
spot138	58.25	460173.96	5037341.18	58.29	0.012	0.020	3/6/2013 11:13		-0.040	4.0	
spot139	43.43	461581.38	5039216.15	43.41	0.013	0.020	3/6/2013 11:26		0.016	1.6	
spot140	43.56	461577.82	5039221.52	43.51	0.011	0.018	3/6/2013 11:27		0.049	4.9	
spot141	43.55	461580.14	5039224.43	43.60	0.011	0.017	3/6/2013 11:27		-0.046	4.6	
spot142	43.76	461582.90	5039227.08	43.66	0.011	0.017	3/6/2013 11:27		0.102	10.2	
spot143	43.82	461585.75	5039230.87	43.79	0.010	0.016	3/6/2013 11:28		0.035	3.5	
spot144	43.93	461588.25	5039235.07	43.93	0.010	0.016	3/6/2013 11:28		0.001	0.1	
spot145	44.08	461589.12	5039239.21	44.05	0.010	0.016	3/6/2013 11:28		0.029	2.9	
spot146	44.17	461588.15	5039245.04	44.19	0.010	0.016	3/6/2013 11:29		-0.023	2.3	
spot147	44.19	461585.07	5039248.22	44.20	0.012	0.018	3/6/2013 11:29		-0.012	1.2	
spot148	44.16	461580.69	5039250.49	44.18	0.012	0.018	3/6/2013 11:30		-0.015	1.5	
spot149	44.03	461575.89	5039251.12	44.07	0.013	0.019	3/6/2013 11:30		-0.043	4.3	
spot150	43.92	461571.38	5039250.09	43.97	0.013	0.020	3/6/2013 11:31		-0.048	4.8	
spot151	43.81	461568.14	5039247.84	43.88	0.013	0.020	3/6/2013 11:34		-0.066	6.6	
spot152	43.76	461565.34	5039244.68	43.84	0.012	0.020	3/6/2013 11:37		-0.076	7.6	
spot153	43.62	461562.54	5039240.70	43.72	0.012	0.020	3/6/2013 11:37		-0.098	9.8	
spot154	43.61	461561.25	5039235.81	43.66	0.012	0.020	3/6/2013 11:38		-0.046	4.6	
spot155	43.44	461562.63	5039230.52	43.57	0.013	0.020	3/6/2013 11:40		-0.133	13.3	
spot156	43.43	461565.01	5039226.73	43.54	0.012	0.019	3/6/2013 11:41		-0.107	10.7	
spot157	51.19	464539.31	5040228.03	51.11	0.010	0.017	3/6/2013 11:58		0.085	8.5	
spot159	51.44	464537.81	5040224.55	51.51	0.008	0.014	3/6/2013 11:59		-0.071	7.1	
spot160	51.80	464535.20	5040224.11	51.76	0.008	0.014	3/6/2013 11:59		0.039	3.9	
spot161	52.01	464532.67	5040223.78	51.97	0.008	0.014	3/6/2013 12:00		0.038	3.8	
spot162	51.88	464524.47	5040226.20	51.86	0.008	0.014	3/6/2013 12:00		0.019	1.9	
spot163	51.72	464519.66	5040227.33	51.62	0.009	0.015	3/6/2013 12:01		0.101	10.1	
spot164	51.25	464512.95	5040228.34	51.19	0.008	0.015	3/6/2013 12:01		0.060	6.0	
spot165	50.98	464509.85	5040228.75	50.98	0.008	0.015	3/6/2013 12:01		-0.003	0.3	
spot166	50.79	464506.52	5040228.98	50.69	0.009	0.016	3/6/2013 12:02		0.097	9.7	
spot167	50.47	464504.20	5040229.11	50.51	0.009	0.016	3/6/2013 12:02		-0.040	4.0	
spot168	50.36	464501.87	5040229.49	50.32	0.010	0.017	3/6/2013 12:03		0.039	3.9	
spot169	50.01	464498.86	5040229.97	50.04	0.010	0.017	3/6/2013 12:03		-0.033	3.3	
spot170	49.82	464496.34	5040230.24	49.85	0.009	0.018	3/6/2013 12:03		-0.028	2.8	
spot171	49.73	464494.20	5040230.38	49.68	0.010	0.017	3/6/2013 12:04		0.050	5.0	
spot172	49.50	464491.75	5040230.80	49.50	0.012	0.020	3/6/2013 12:04		-0.003	0.3	
spot173	49.33	464489.48	5040230.88	49.29	0.012	0.020	3/6/2013 12:05		0.042	4.2	
spot174	55.17	466465.27	5040439.65	55.21	0.010	0.020	3/6/2013 12:34		-0.042	4.2	
spot175	54.99	466464.26	5040442.26	54.92	0.010	0.020	3/6/2013 12:35		0.072	7.2	
spot176	54.60	466461.74	5040443.71	54.60	0.010	0.019	3/6/2013 12:36		-0.004	0.4	
spot178	54.38	466430.83	5040449.73	54.12	0.010	0.018	3/6/2013 12:48		0.262	26.2	
spot179	54.02	466427.12	5040452.00	53.98	0.008	0.015	3/6/2013 12:48		0.044	4.4	
spot181	53.95	466425.58	5040454.26	53.70	0.010	0.020	3/6/2013 12:51		0.249	24.9	
spot182	53.68	466424.06	5040456.47	53.55	0.008	0.016	3/6/2013 12:51		0.135	13.5	
spot184	52.93	466422.14	5040460.14	52.79	0.009	0.018	3/6/2013 12:52		0.142	14.2	

Table 1 Field verification of LIDAR data (spot heights)

	Lidar Points	2013 RVCA Field Survey - Ottawa River									
Location ID	Z (m)	X (m)	Y (m)	Z (m)	Horizontal Accuracy (m)	Veritcal Accuracy (m)	Date/Time	Field Observations	△Z (m)	|△Z | (cm)	|△Z| > 0.33m
spot185	52.28	466420.02	5040462.75	52.13	0.009	0.018	3/6/2013 12:52		0.149	14.9	
spot186	51.69	466419.31	5040464.27	51.64	0.009	0.018	3/6/2013 12:52		0.052	5.2	
spot187	50.72	466418.58	5040466.77	50.76	0.009	0.017	3/6/2013 12:53		-0.044	4.4	
spot188	49.85	466418.80	5040468.70	50.04	0.010	0.018	3/6/2013 12:53		-0.192	19.2	
spot189	42.95	467779.86	5040903.50	42.90	0.007	0.015	3/6/2013 13:04		0.046	4.6	
spot190	43.46	467780.97	5040899.99	43.37	0.007	0.015	3/6/2013 13:04		0.093	9.3	
spot191	43.72	467782.66	5040898.10	43.61	0.009	0.019	3/6/2013 13:05		0.115	11.5	
spot192	43.96	467784.35	5040895.86	43.82	0.009	0.019	3/6/2013 13:05		0.136	13.6	
spot193	44.07	467784.68	5040893.29	44.04	0.007	0.015	3/6/2013 13:06		0.035	3.5	
spot194	44.39	467784.33	5040889.33	44.27	0.009	0.019	3/6/2013 13:07		0.116	11.6	
spot195	44.58	467785.05	5040887.39	44.49	0.009	0.018	3/6/2013 13:07		0.092	9.2	
spot196	44.91	467785.31	5040885.14	44.74	0.009	0.019	3/6/2013 13:07		0.173	17.3	
spot197	45.05	467785.80	5040883.00	45.01	0.008	0.017	3/6/2013 13:08		0.043	4.3	
spot198	45.34	467786.02	5040881.29	45.20	0.008	0.017	3/6/2013 13:08		0.145	14.5	
spot199	45.59	467786.39	5040878.60	45.47	0.008	0.017	3/6/2013 13:08		0.125	12.5	
spot200	45.92	467786.94	5040875.33	45.82	0.008	0.016	3/6/2013 13:09		0.096	9.6	
spot201	46.18	467787.28	5040872.65	46.09	0.008	0.016	3/6/2013 13:09		0.093	9.3	
spot202	52.95	473873.41	5041365.46	52.92	0.010	0.020	3/6/2013 13:24		0.035	3.5	
spot203	52.85	473888.14	5041371.71	52.82	0.009	0.019	3/6/2013 13:25		0.029	2.9	
spot204	52.76	473923.94	5041384.43	52.76	0.009	0.019	3/6/2013 13:25		0.000	0.0	
spot205	52.84	473941.86	5041390.79	52.75	0.009	0.020	3/6/2013 13:26		0.095	9.5	
spot206	52.79	473956.21	5041395.56	52.74	0.010	0.020	3/6/2013 13:28		0.054	5.4	
spot207	52.72	473974.75	5041402.22	52.67	0.008	0.016	3/6/2013 13:29		0.046	4.6	
spot208	53.28	473790.39	5041333.44	53.19	0.009	0.018	3/6/2013 13:32		0.095	9.5	
spot209	53.33	473768.65	5041329.54	53.29	0.010	0.020	3/6/2013 13:34		0.039	3.9	
spot210	53.26	473774.18	5041331.32	53.27	0.010	0.019	3/6/2013 13:34		-0.010	1.0	
spot211	53.28	473783.17	5041334.82	53.26	0.010	0.020	3/6/2013 13:35		0.020	2.0	
spot212	53.31	473791.66	5041337.91	53.26	0.010	0.019	3/6/2013 13:35		0.053	5.3	
spot213	53.30	473798.02	5041341.07	53.23	0.010	0.020	3/6/2013 13:36		0.075	7.5	
spot214	53.28	473808.01	5041344.51	53.22	0.010	0.020	3/6/2013 13:36		0.059	5.9	
spot215	53.23	473819.98	5041348.18	53.21	0.010	0.019	3/6/2013 13:37		0.023	2.3	
morinboise3	42.62	469885.42	5041027.34	42.57	0.014	0.017	04/29/2013 10:41:49		0.053	5.3	
granvw-rway-1	59.89	432598.32	5023594.71	59.91	0.012	0.020	9/4/2013 9:54		-0.023	2.3	
granvw-rway-2	60.34	432594.56	5023594.65	60.25	0.012	0.019	9/4/2013 9:56		0.092	9.2	
granvw-botcnl2	61.23	433088.45	5023267.76	61.15	0.009	0.015	9/4/2013 10:23		0.085	8.5	
granvw-path-1	62.34	433391.03	5023055.17	62.34	0.011	0.019	9/4/2013 10:39		-0.004	0.4	
granvw-path-2	61.38	433410.40	5023068.45	61.34	0.013	0.020	9/4/2013 10:40		0.042	4.2	
granvw-path-3	60.47	433421.90	5023075.66	60.48	0.013	0.020	9/4/2013 10:42		-0.014	1.4	
bm88u890-ottawa	61.72	436598.75	5022705.79	61.65	0.015	0.014	9/4/2013 12:01	bench mark - city of ottawa	0.070	7.0	
warmusm-1	53.96	443656.98	5029473.47	53.90	0.010	0.011	9/4/2013 14:31		0.057	5.7	
warmusm-2	54.52	443650.76	5029414.76	54.42	0.013	0.019	9/4/2013 14:33		0.100	10.0	
warmusm-3	54.24	443654.41	5029360.31	54.15	0.007	0.008	9/4/2013 14:35		0.094	9.4	
morin-road	44.70	469945.54	5040932.95	44.65	0.009	0.014	11/4/2013 9:51		0.048	4.8	
morin-drvway1	44.47	469945.16	5040924.95	44.73	0.012	0.020	11/4/2013 9:55		-0.259	25.9	
eastprk-path2	55.32	445898.76	5032170.42	55.31	0.012	0.020	04/29/2013 11:49:49		0.010	1.0	
eastprk-path3	55.28	445889.69	5032176.74	55.23	0.013	0.019	04/29/2013 11:52:48		0.053	5.3	
stanley-union-1	55.21	446010.70	5032140.13	55.23	0.013	0.020	04/29/2013 11:58:35		-0.023	2.3	
stanley-union-2	55.27	446025.49	5032133.11	55.23	0.013	0.020	04/29/2013 11:59:32		0.043	4.3	
stanley-rd1	55.75	446279.83	5032016.11	55.70	0.012	0.020	04/29/2013 12:12:29		0.050	5.0	
jamieson-1	60.08	437323.71	5024206.83	59.94	0.010	0.020	04/29/2013 14:44:32		0.138	13.8	
jamieson-2	60.14	437325.14	5024156.75	60.08	0.010	0.020	04/29/2013 14:46:13		0.056	5.6	
jamieson-3	60.12	437324.69	5024116.44	60.01	0.011	0.019	04/29/2013 14:48:02		0.107	10.7	
									Mean △Z :	6.4	1 yes out of 244
									Median△Z :	4.9	
									Max △Z :	66.1	
									Min △Z :	0.0	

Discarded Points

area-spot5	56.080	438939.599	5025409.504	56.624	0.006	0.01	05/29/2013 09:44:35	large boulders along shoreline	0.544	54.4	Y
spot183	53.73	466423.26	5040457.96	53.37	0.008	0.017	3/6/2013 12:51	sloped grassy area with undulation	-0.356	35.6	Y
eastprk-path1	55.22	445988.47	5032079.90	55.59	0.013	0.020	04/29/2013 11:45:32	sloped grassy area	0.367	36.7	Y

Table 2 Field verification of LIDAR data (contour crossings)

	Lidar Contour	2013 RVCA Field Survey - Ottawa River									
Location ID	Z (m)	X (m)	Y (m)	Z (m)	Horizontal Accuracy (m)	Veritcal Accuracy (m)	Date/Time	Field Observations	△Z (m)	|△Z | (cm)	|△Z| > 0.50m
area1-spot1	59.25	5022390.12	435105.03	59.34	0.008	0.013	05/29/2013 09:22:11		-0.094	9.4	
area1-spot2	59.50	5022389.11	435103.44	59.54	0.007	0.012	05/29/2013 09:23:19		-0.040	4.0	
area1-spot3	60.75	5022382.39	435093.12	60.70	0.007	0.012	05/29/2013 09:23:51		0.049	4.9	
area1-spot4	61.50	5022374.29	435084.70	61.45	0.007	0.012	05/29/2013 09:24:15		0.051	5.1	
area1-spot6	62.00	5022359.20	435073.63	61.93	0.007	0.012	05/29/2013 09:25:07		0.072	7.2	
area1-spot7	61.75	5022311.40	435104.23	61.60	0.007	0.012	05/29/2013 09:27:39		0.151	15.1	
area-spot1	57.75	5025380.49	438947.42	57.69	0.006	0.010	05/29/2013 09:42:00		0.061	6.1	
area-spot2	57.50	5025393.29	438949.09	57.55	0.006	0.010	05/29/2013 09:42:47		-0.045	4.5	
area-spot3	57.50	5025402.80	438952.74	57.51	0.006	0.010	05/29/2013 09:43:15		-0.007	0.7	
area-spot4	56.75	5025409.42	438940.02	57.15	0.006	0.010	05/29/2013 09:44:17		-0.398	39.8	
area-spot5	56.50	5025409.50	438939.60	56.62	0.006	0.010	05/29/2013 09:44:35		-0.124	12.4	
area-spot6	57.75	5025390.12	438959.08	57.82	0.009	0.014	05/29/2013 09:45:55		-0.072	7.2	
area-spot7	58.25	5025389.77	438962.29	58.48	0.009	0.014	05/29/2013 09:46:18		-0.226	22.6	
area-spot8	58.00	5025364.02	438944.90	57.87	0.008	0.013	05/29/2013 09:47:14		0.127	12.7	
area3-spot1	60.50	5027279.59	440362.72	60.42	0.007	0.010	05/29/2013 09:56:17		0.084	8.4	
area3-spot2	60.75	5027270.44	440367.73	60.58	0.006	0.010	05/29/2013 09:56:48		0.172	17.2	
area3-spot3	60.50	5027257.91	440361.40	60.26	0.007	0.011	05/29/2013 09:57:50		0.239	23.9	
area3-spot4	60.25	5027268.10	440352.01	60.11	0.007	0.010	05/29/2013 09:58:19		0.145	14.5	
area3-spot5	60.00	5027264.12	440347.90	60.05	0.007	0.010	05/29/2013 09:58:43		-0.050	5.0	
area3-spot6	56.25	5028157.66	441068.03	56.24	0.007	0.010	05/29/2013 10:06:01		0.011	1.1	
area3-spot8	55.75	5028171.07	441075.66	56.05	0.008	0.011	05/29/2013 10:06:45		-0.301	30.1	
spot1	57.25	5028835.27	441776.72	57.15	0.011	0.016	05/29/2013 10:15:54		0.102	10.2	
spot2	57.50	5028834.51	441765.37	57.38	0.008	0.012	05/29/2013 10:16:48		0.117	11.7	
spot3	57.25	5028832.87	441761.27	57.22	0.008	0.012	05/29/2013 10:17:07		0.035	3.5	
spot4	57.00	5028831.16	441758.00	57.05	0.008	0.012	05/29/2013 10:17:27		-0.046	4.6	
spot5	56.75	5028828.92	441753.71	56.77	0.012	0.016	05/29/2013 10:17:50		-0.022	2.2	
spot6	56.50	5028824.90	441747.39	56.56	0.007	0.011	05/29/2013 10:18:21		-0.064	6.4	
spot11	48.25	5030019.93	444335.14	48.15	0.010	0.015	05/29/2013 10:45:42		0.102	10.2	
spot12	48.50	5030017.61	444332.57	48.64	0.011	0.017	05/29/2013 10:46:23		-0.142	14.2	
spot13	49.00	5030012.43	444325.64	49.09	0.011	0.017	05/29/2013 10:46:48		-0.094	9.4	
spot14	49.50	5030004.43	444316.66	49.47	0.011	0.017	05/29/2013 10:47:18		0.034	3.4	
spot15	50.00	5029995.83	444307.98	50.07	0.012	0.017	05/29/2013 10:47:46		-0.068	6.8	
spot16	50.25	5029988.42	444303.62	50.36	0.012	0.017	05/29/2013 10:48:11		-0.114	11.4	
spot17	55.50	5032003.17	445842.27	56.47	0.010	0.014	05/29/2013 11:17:44	bench mark	-0.969	96.9	Y
spot22	57.50	5031992.87	445831.34	57.52	0.009	0.013	05/29/2013 11:35:00		-0.015	1.5	
spot23	57.00	5031986.65	445830.49	57.08	0.009	0.014	05/29/2013 11:35:24		-0.079	7.9	
spot24	56.25	5031984.01	445833.96	56.24	0.010	0.015	05/29/2013 11:35:46		0.009	0.9	
spot28	60.75	5033601.75	446177.65	60.80	0.009	0.018	05/29/2013 12:54:34		-0.048	4.8	
spot29	60.50	5033604.81	446183.91	60.59	0.011	0.021	05/29/2013 12:55:08		-0.088	8.8	
spot30	59.50	5033611.58	446193.90	59.43	0.010	0.020	05/29/2013 12:55:35		0.073	7.3	
spot31	58.25	5033617.60	446204.78	58.19	0.010	0.019	05/29/2013 12:56:06		0.064	6.4	
spot33	56.75	5033625.24	446217.88	56.69	0.010	0.020	05/29/2013 12:57:31		0.064	6.4	
spot34	55.50	5033633.88	446228.48	55.45	0.011	0.020	05/29/2013 12:58:41		0.047	4.7	
spot35	47.75	5033687.03	446249.19	47.79	0.011	0.020	05/29/2013 13:02:10		-0.037	3.7	
spot36	54.50	5033979.03	447548.09	54.43	0.008	0.015	05/29/2013 13:13:29		0.071	7.1	
spot37	54.75	5033978.56	447564.31	54.71	0.012	0.020	05/29/2013 13:14:13		0.036	3.6	
spot38	54.25	5034005.79	447574.81	54.26	0.011	0.020	05/29/2013 13:15:28		-0.011	1.1	
spot39	54.00	5034018.83	447591.99	54.14	0.009	0.018	05/29/2013 13:16:04		-0.137	13.7	
spot40	54.50	5034011.37	447610.33	54.48	0.009	0.018	05/29/2013 13:16:44		0.019	1.9	
spot41	54.00	5034162.33	448209.50	54.02	0.010	0.020	05/29/2013 13:27:26		-0.024	2.4	
spot42	53.75	5034164.30	448208.94	53.86	0.009	0.018	05/29/2013 13:27:49		-0.112	11.2	
spot43	53.50	5034167.44	448208.08	53.53	0.007	0.015	05/29/2013 13:28:40		-0.033	3.3	
spot44	53.00	5034171.34	448206.97	53.06	0.007	0.015	05/29/2013 13:29:05		-0.058	5.8	
spot45	52.75	5034174.96	448206.41	52.64	0.007	0.015	05/29/2013 13:29:30		0.109	10.9	
spot46	52.25	5034178.92	448205.74	52.17	0.007	0.014	05/29/2013 13:29:52		0.084	8.4	
spot47	51.75	5034182.69	448205.24	51.67	0.007	0.015	05/29/2013 13:30:16		0.082	8.2	
spot48	51.00	5034187.37	448204.76	51.24	0.009	0.018	05/29/2013 13:30:46		-0.239	23.9	
spot49	50.50	5034191.91	448204.81	50.71	0.009	0.019	05/29/2013 13:31:08		-0.213	21.3	
spot50	50.00	5034196.41	448205.16	50.14	0.010	0.020	05/29/2013 13:31:32		-0.136	13.6	
spot51	49.50	5034200.57	448205.77	49.65	0.011	0.020	05/29/2013 13:32:10		-0.149	14.9	
spot52	49.00	5034205.24	448206.39	48.95	0.011	0.019	05/29/2013 13:33:24		0.054	5.4	
spot53	45.50	5034238.73	448213.40	45.43	0.011	0.019	05/29/2013 13:34:35		0.069	6.9	
spot54	45.25	5034233.68	448196.78	45.23	0.010	0.020	05/29/2013 13:36:26		0.018	1.8	
spot55	52.25	5034969.30	454526.03	52.24	0.006	0.009	05/29/2013 13:56:25		0.011	1.1	
spot56	52.25	5034988.83	454513.31	52.32	0.005	0.011	05/29/2013 13:57:23		-0.069	6.9	
spot57	51.75	5034998.66	454515.87	51.81	0.006	0.012	05/29/2013 13:57:58		-0.059	5.9	
spot58	51.75	5035001.60	454512.17	51.82	0.006	0.012	05/29/2013 13:58:24		-0.068	6.8	
spot59	51.75	5035004.37	454508.12	51.77	0.006	0.012	05/29/2013 13:58:55		-0.019	1.9	
spot60	51.75	5035006.98	454504.28	51.77	0.006	0.012	05/29/2013 13:59:15		-0.019	1.9	
spot61	51.75	5035009.89	454499.84	51.81	0.006	0.012	05/29/2013 13:59:41		-0.057	5.7	
spot62	51.75	5035012.87	454495.59	51.86	0.006	0.012	05/29/2013 14:00:03		-0.108	10.8	
spot63	52.00	5035017.01	454490.52	51.92	0.006	0.012	05/29/2013 14:00:28		0.076	7.6	
spot64	52.00	5035021.90	454486.41	51.92	0.007	0.013	05/29/2013 14:00:54		0.076	7.6	
spot65	52.00	5035027.79	454483.73	51.94	0.006	0.012	05/29/2013 14:01:18		0.063	6.3	
spot66	51.25	5035057.85	454475.16	51.21	0.006	0.012	05/29/2013 14:02:08		0.036	3.6	
spot67	51.00	5035059.68	454474.47	51.18	0.008	0.012	05/29/2013 14:02:31		-0.176	17.6	
spot68	53.00	5034639.49	452186.46	52.99	0.010	0.018	05/29/2013 14:10:09		0.011	1.1	
spot70	53.25	5034637.25	452178.16	53.12	0.009	0.016	05/29/2013 14:10:55		0.126	12.6	
spot71	53.00	5034629.60	452175.21	53.02	0.008	0.013	05/29/2013 14:11:27		-0.020	2.0	
spot72	53.25	5034628.49	452171.57	53.08	0.008	0.014	05/29/2013 14:11:49		0.167	16.7	
spot73	53.00	5034630.89	452180.99	52.94	0.009	0.015	05/29/2013 14:12:18		0.061	6.1	
spot74	53.25	5034633.68	452173.49	53.30	0.009	0.016	05/29/2013 14:13:05		-0.051	5.1	
spot75	53.25	5034634.89	452172.18	53.28	0.009	0.016	05/29/2013 14:13:25		-0.030	3.0	
spot76	53.25	5034636.06	452170.96	53.22	0.009	0.017	05/29/2013 14:13:44		0.027	2.7	
spot77	53.00	5034636.68	452169.00	53.03	0.008	0.015	05/29/2013 14:14:05		-0.034	3.4	
spot78	45.00	5034572.39	451052.30	45.11	0.011	0.020	05/29/2013 14:31:14		-0.109	10.9	
spot79	44.75	5034574.50	451102.75	44.72	0.011	0.020	05/29/2013 14:36:16		0.035	3.5	
spot80	42.75	5034599.63	451103.44	42.75	0.014	0.020	05/29/2013 14:40:14		0.003	0.3	
spot81	44.75	5034579.04	451053.30	44.79	0.014	0.020	05/29/2013 14:43:43		-0.036	3.6	

Table 2 Field verification of LIDAR data (contour crossings)

	Lidar Contour	2013 RVCA Field Survey - Ottawa River									
Location ID	**Z (m)**	**X (m)**	**Y (m)**	**Z (m)**	**Horizontal Accuracy (m)**	**Veritcal Accuracy (m)**	**Date/Time**	**Field Observations**	**△Z (m)**	**|△Z| (cm)**	**|△Z| > 0.50m**
spot82	45.00	5034573.43	451052.02	45.04	0.014	0.020	05/29/2013 14:44:58		-0.036	3.6	
spot83	45.50	5034567.37	451050.39	45.36	0.014	0.020	05/29/2013 14:45:53		0.136	13.6	
spot84	45.75	5034561.09	451048.90	45.54	0.012	0.020	05/29/2013 14:47:58		0.214	21.4	
spot85	46.00	5034553.71	451046.60	45.90	0.009	0.020	05/29/2013 14:49:41		0.105	10.5	
spot86	46.25	5034545.84	451042.56	46.25	0.013	0.019	05/29/2013 14:50:18		-0.001	0.1	
spot87	50.50	5036175.97	456314.75	50.37	0.006	0.009	3/6/2013 9:47		0.127	12.7	
spot89	50.50	5036174.90	456323.27	50.58	0.007	0.011	3/6/2013 9:48		-0.083	8.3	
spot90	50.50	5036171.09	456333.64	50.54	0.007	0.011	3/6/2013 9:49		-0.043	4.3	
spot92	50.25	5036201.09	456312.04	50.40	0.008	0.012	3/6/2013 9:51		-0.154	15.4	
spot93	50.00	5036215.61	456303.53	50.05	0.008	0.011	3/6/2013 9:51		-0.047	4.7	
spot94	49.75	5036224.47	456298.05	49.88	0.008	0.011	3/6/2013 9:52		-0.132	13.2	
spot95	49.75	5036231.28	456293.45	49.81	0.009	0.013	3/6/2013 9:52		-0.064	6.4	
spot96	49.75	5036236.18	456290.21	49.72	0.009	0.013	3/6/2013 9:53		0.033	3.3	
spot97	45.75	5036990.91	458297.63	45.66	0.010	0.020	3/6/2013 10:17		0.088	8.8	
spot98	45.50	5036995.35	458291.22	45.54	0.015	0.020	3/6/2013 10:21		-0.038	3.8	
spot99	45.00	5037026.15	458302.42	45.00	0.014	0.019	3/6/2013 10:24		-0.001	0.1	
spot100	44.75	5037028.26	458302.43	44.88	0.015	0.020	3/6/2013 10:24		-0.126	12.6	
spot101	44.75	5037029.99	458302.49	44.75	0.014	0.019	3/6/2013 10:25		-0.001	0.1	
spot102	44.50	5037032.03	458302.55	44.64	0.011	0.020	3/6/2013 10:26		-0.141	14.1	
spot103	43.75	5037052.17	458301.68	43.78	0.013	0.019	3/6/2013 10:27		-0.028	2.8	
spot104	43.50	5037055.04	458301.00	43.69	0.013	0.019	3/6/2013 10:28		-0.186	18.6	
spot105	43.50	5037057.54	458300.25	43.69	0.013	0.019	3/6/2013 10:28		-0.191	19.1	
spot107	43.50	5037062.40	458298.37	43.70	0.013	0.020	3/6/2013 10:29		-0.196	19.6	
spot108	43.50	5037064.96	458297.10	43.70	0.013	0.019	3/6/2013 10:29		-0.199	19.9	
spot109	43.50	5037067.19	458295.95	43.76	0.015	0.020	3/6/2013 10:30		-0.259	25.9	
spot110	49.50	5036721.82	457175.51	49.58	0.013	0.019	3/6/2013 10:48		-0.077	7.7	
spot111	49.50	5036723.62	457175.19	49.37	0.014	0.020	3/6/2013 10:49		0.133	13.3	
spot117	48.25	5036736.61	457173.77	48.14	0.011	0.016	3/6/2013 10:50		0.108	10.8	
spot118	48.00	5036738.70	457173.23	48.00	0.011	0.016	3/6/2013 10:51		0.003	0.3	
spot120	47.75	5036743.79	457171.82	47.68	0.011	0.016	3/6/2013 10:51		0.070	7.0	
spot123	47.25	5036751.37	457169.69	47.22	0.011	0.016	3/6/2013 10:52		0.033	3.3	
spot125	46.75	5036757.47	457167.33	46.83	0.011	0.016	3/6/2013 10:53		-0.075	7.5	
spot127	56.50	5037387.17	460157.65	56.56	0.013	0.020	3/6/2013 11:07		-0.063	6.3	
spot133	57.25	5037362.91	460167.25	57.38	0.012	0.018	3/6/2013 11:09		-0.125	12.5	
spot134	57.50	5037358.12	460169.03	57.55	0.013	0.020	3/6/2013 11:10		-0.049	4.9	
spot135	57.75	5037353.42	460170.61	57.73	0.012	0.018	3/6/2013 11:10		0.025	2.5	
spot137	58.00	5037345.80	460172.84	58.07	0.013	0.019	3/6/2013 11:12		-0.067	6.7	
spot138	58.25	5037341.18	460173.96	58.29	0.012	0.020	3/6/2013 11:13		-0.040	4.0	
spot139	43.50	5039216.15	461581.38	43.41	0.013	0.020	3/6/2013 11:26		0.086	8.6	
spot142	43.75	5039227.08	461582.90	43.66	0.011	0.017	3/6/2013 11:27		0.092	9.2	
spot144	44.00	5039235.07	461588.25	43.93	0.010	0.016	3/6/2013 11:28		0.071	7.1	
spot152	43.75	5039244.68	461565.34	43.84	0.012	0.020	3/6/2013 11:37		-0.086	8.6	
spot155	43.50	5039230.52	461562.63	43.57	0.013	0.020	3/6/2013 11:40		-0.073	7.3	
spot157	51.25	5040228.03	464539.31	51.11	0.010	0.017	3/6/2013 11:58		0.145	14.5	
spot159	51.50	5040224.55	464537.81	51.51	0.008	0.014	3/6/2013 11:59		-0.011	1.1	
spot160	51.75	5040224.11	464535.20	51.76	0.008	0.014	3/6/2013 11:59		-0.011	1.1	
spot163	51.50	5040227.33	464519.66	51.62	0.009	0.015	3/6/2013 12:01		-0.119	11.9	
spot164	51.25	5040228.34	464512.95	51.19	0.008	0.015	3/6/2013 12:01		0.060	6.0	
spot166	50.75	5040228.98	464506.52	50.69	0.009	0.016	3/6/2013 12:02		0.057	5.7	
spot167	50.50	5040229.11	464504.20	50.51	0.009	0.016	3/6/2013 12:02		-0.010	1.0	
spot170	49.75	5040230.24	464496.34	49.85	0.009	0.018	3/6/2013 12:03		-0.098	9.8	
spot172	49.50	5040230.80	464491.75	49.50	0.012	0.020	3/6/2013 12:04		-0.003	0.3	
spot174	55.25	5040439.65	466465.27	55.21	0.010	0.020	3/6/2013 12:34		0.038	3.8	
spot175	55.00	5040442.26	466464.26	54.92	0.010	0.020	3/6/2013 12:35		0.082	8.2	
spot176	54.75	5040443.71	466461.74	54.60	0.010	0.019	3/6/2013 12:36		0.146	14.6	
spot178	54.25	5040449.73	466430.83	54.12	0.010	0.018	3/6/2013 12:48		0.132	13.2	
spot179	54.25	5040452.00	466427.12	53.98	0.008	0.015	3/6/2013 12:48		0.274	27.4	
spot181	54.00	5040454.26	466425.58	53.70	0.010	0.020	3/6/2013 12:51		0.299	29.9	
spot182	53.75	5040456.47	466424.06	53.55	0.008	0.016	3/6/2013 12:51		0.205	20.5	
spot183	53.50	5040457.96	466423.26	53.37	0.008	0.017	3/6/2013 12:51		0.126	12.6	
spot184	53.00	5040460.14	466422.14	52.79	0.009	0.018	3/6/2013 12:52		0.212	21.2	
spot185	52.25	5040462.75	466420.02	52.13	0.009	0.018	3/6/2013 12:52		0.119	11.9	
spot186	51.75	5040464.27	466419.31	51.64	0.009	0.018	3/6/2013 12:52		0.112	11.2	
spot188	50.00	5040468.70	466418.80	50.04	0.010	0.018	3/6/2013 12:53		-0.042	4.2	
spot189	43.00	5040903.50	467779.86	42.90	0.007	0.015	3/6/2013 13:04		0.096	9.6	
spot190	43.50	5040899.99	467780.97	43.37	0.007	0.015	3/6/2013 13:04		0.133	13.3	
spot191	43.75	5040898.10	467782.66	43.61	0.009	0.019	3/6/2013 13:05		0.145	14.5	
spot192	44.00	5040895.86	467784.35	43.82	0.009	0.019	3/6/2013 13:05		0.176	17.6	
spot198	45.25	5040881.29	467786.02	45.20	0.008	0.017	3/6/2013 13:08		0.055	5.5	
spot199	45.50	5040878.60	467786.39	45.47	0.008	0.017	3/6/2013 13:08		0.035	3.5	
spot200	46.00	5040875.33	467786.94	45.82	0.008	0.016	3/6/2013 13:09		0.176	17.6	
spot201	46.25	5040872.65	467787.28	46.09	0.008	0.016	3/6/2013 13:09		0.163	16.3	
spot203	52.75	5041371.71	473888.14	52.82	0.009	0.019	3/6/2013 13:25		-0.071	7.1	
spot204	52.75	5041384.43	473923.94	52.76	0.009	0.019	3/6/2013 13:25		-0.010	1.0	
spot205	52.75	5041390.79	473941.86	52.75	0.009	0.020	3/6/2013 13:26		0.005	0.5	
spot209	53.25	5041329.54	473768.65	53.29	0.010	0.020	3/6/2013 13:34		-0.041	4.1	
spot210	53.25	5041331.32	473774.18	53.27	0.010	0.019	3/6/2013 13:34		-0.020	2.0	
spot211	53.25	5041334.82	473783.17	53.26	0.010	0.020	3/6/2013 13:35		-0.010	1.0	
granvw-rway-1	60.00	5023594.71	432598.32	59.91	0.012	0.020	9/4/2013 9:54		0.087	8.7	
granvw-rway-2	60.25	5023594.65	432594.56	60.25	0.012	0.019	9/4/2013 9:56		0.002	0.2	
granvw-botcnl2	61.50	5023267.76	433088.45	61.15	0.009	0.015	9/4/2013 10:23		0.355	35.5	
granvw-path-2	61.50	5023068.45	433410.40	61.34	0.013	0.020	9/4/2013 10:40		0.162	16.2	
granvw-path-3	60.50	5023075.66	433421.90	60.48	0.013	0.020	9/4/2013 10:42		0.016	1.6	
bm88u890-ottawa	61.25	5022705.79	436598.75	61.65	0.015	0.014	9/4/2013 12:01	benchmark- city of ottawa	-0.400	40.0	
warmusm-1	54.00	5029473.47	443656.98	53.90	0.010	0.011	9/4/2013 14:31		0.097	9.7	
eastprk-path1	55.25	5032079.90	445988.47	55.59	0.013	0.020	04/29/2013 11:45:32		-0.337	33.7	
eastprk-path2	55.25	5032170.42	445898.76	55.31	0.012	0.020	04/29/2013 11:49:49		-0.060	6.0	
eastprk-path3	55.25	5032176.74	445889.69	55.23	0.013	0.019	04/29/2013 11:52:48		0.023	2.3	
stanley-union-1	55.25	5032140.13	446010.70	55.23	0.013	0.020	04/29/2013 11:58:35		0.017	1.7	

Table 2 Field verification of LIDAR data (contour crossings)

	Lidar Contour	2013 RVCA Field Survey - Ottawa River									
Location ID	**Z (m)**	**X (m)**	**Y (m)**	**Z (m)**	**Horizontal Accuracy (m)**	**Veritcal Accuracy (m)**	**Date/Time**	**Field Observations**	**△Z (m)**	**|△Z| (cm)**	**|△Z| > 0.50m**
stanley-union-2	55.25	5032133.11	446025.49	55.23	0.013	0.020	04/29/2013 11:59:32		0.023	2.3	
stanley-rd1	55.75	5032016.11	446279.83	55.70	0.012	0.020	04/29/2013 12:12:29		0.050	5.0	
jamieson-1	60.00	5024206.83	437323.71	59.94	0.010	0.020	04/29/2013 14:44:32		0.058	5.8	
jamieson-2	60.25	5024156.75	437325.14	60.08	0.010	0.020	04/29/2013 14:46:13		0.166	16.6	
jamieson-3	60.00	5024116.44	437324.69	60.01	0.011	0.019	04/29/2013 14:48:02		-0.013	1.3	
									Mean △Z :	9.5	1 yes out of 183
									Median△Z :	7.1	
									Max △Z :	96.9	
									Min △Z :	0.1	

Table 3 Hydrometric Data Availability

Location	Station Number	Water Level		Flow		Data Provider
		Start	End	Start	End	
Ottawa River at Chats Falls	02KF009			1915	1994	Water Survey of Canada
Ottawa River at Chats Falls	02KF009			1994	2012	Ontario Power Generation
Ottawa River at Britannia	02KF005	1915	2012	1960	2012	Water Survey of Canada
Ottawa River at Hull	02LA015	1964	2011			Water Survey of Canada
Ottawa River at Cumberland	02LB010	1918	1996			Water Survey of Canada
Ottawa River at Grenville	02LB001	1933	1999			Water Survey of Canada
Ottawa River at Carillon	02LB024			1962	1994	Water Survey of Canada
Ottawa River at Carillon	02LB024			1994	2012	ORRPB

Table 4 Results of Flood Frequency Analysis

Location	**Chats Falls**		**Grenville/Carillon**		**Britannia**
Catchment Area	89,600 sq. km		143,000 sq. km		90,900 sq. km
	MacLaren 1984	RVCA 2014	MacLaren 1984	RVCA 2014	RVCA 2014
	1915-1980	1915-2012	1911-1980	1933-2012	1961-2012
Return Period (year)					
2	3300	3180	5200	5160	3190
5	4210	4020	6520	6280	3900
10	4770	4560	7360	7010	4320
20	5280	5070	8130	7700	4670
50	5920	5700	9120	8580	5070
100	6370	6180	9840	9240	5340
200	-	6640	-	9890	5580
500	-	7260	-	10800	5860
Distribution	LP3	3PLN	LP3	3PLN	GEV

Table 5 Annaul Maximun Flow at Carillon/Grenville

Gauge	Year	Annual Daily Peak (cms)
Carillon	1933	6216
Carillon	1934	6524
Carillon	1935	3474
Carillon	1936	7666
Carillon	1937	5240
Carillon	1938	6370
Carillon	1939	5520
Carillon	1940	4860
Carillon	1941	5864
Carillon	1942	4880
Carillon	1943	7781
Carillon	1944	3640
Carillon	1945	5340
Carillon	1946	3438
Carillon	1947	8188
Carillon	1948	3700
Carillon	1949	4940
Carillon	1950	3980
Carillon	1951	8750
Carillon	1952	5770
Carillon	1953	5914
Carillon	1954	5602
Carillon	1955	6710
Carillon	1956	4456
Carillon	1957	4632
Carillon	1958	3931
Carillon	1959	4434
Carillon	1960	7354
Carillon	1962	1740
Carillon	1963	4226
Carillon	1964	3727
Carillon	1965	3672
Carillon	1966	5410
Carillon	1967	5407
Carillon	1968	4653
Carillon	1969	5134
Carillon	1970	4990
Carillon	1971	5704
Carillon	1972	6329
Carillon	1973	5703
Carillon	1974	8105
Carillon	1975	5790
Carillon	1976	8190
Carillon	1977	5062
Carillon	1978	4668
Carillon	1979	6686
Carillon	1980	5329
Carillon	1981	6222
Carillon	1982	4585
Carillon	1983	6907
Carillon	1984	5568
Carillon	1985	6004
Carillon	1986	4647
Carillon	1987	4767
Carillon	1988	4665
Carillon	1989	3883
Carillon	1990	4562
Carillon	1991	6728
Carillon	1992	5337
Carillon	1993	5454
Carillon	1994	4600
Carillon	1995	3976
Carillon	1996	5722
Carillon	1997	6382
Carillon	1998	7239
Carillon	1999	5401
Carillon	2000	4274
Carillon	2001	4081
Carillon	2002	5894
Carillon	2003	4718
Carillon	2004	4909
Carillon	2005	4824
Carillon	2006	4587
Carillon	2007	3635
Carillon	2008	6053
Carillon	2009	5617
Carillon	2010	3922
Carillon	2011	4931
Carillon	2012	4810

Table 6 Annual Maximum Flow at Britannia

Gauge	Year	Annual Instanteneous Peak (cms)
Britannia	1961	1762
Britannia	1962	2989
Britannia	1963	1893
Britannia	1964	2335
Britannia	1965	2567
Britannia	1966	3583
Britannia	1967	3865
Britannia	1968	2718
Britannia	1969	2788
Britannia	1970	2748
Britannia	1971	3613
Britannia	1972	4076
Britannia	1973	3442
Britannia	1974	4529
Britannia	1975	3342
Britannia	1976	3855
Britannia	1977	3090
Britannia	1978	3151
Britannia	1979	5110
Britannia	1980	3390
Britannia	1981	4100
Britannia	1982	2930
Britannia	1983	4400
Britannia	1984	3190
Britannia	1985	4450
Britannia	1986	2760
Britannia	1987	2650
Britannia	1988	2820
Britannia	1989	2700
Britannia	1990	2910
Britannia	1991	3680
Britannia	1992	3410
Britannia	1993	2030
Britannia	1994	2270
Britannia	1995	2800
Britannia	1996	4090
Britannia	1997	4117
Britannia	1998	4386
Britannia	1999	2920
Britannia	2000	2420
Britannia	2001	2590
Britannia	2002	4440
Britannia	2003	2890
Britannia	2004	3090
Britannia	2005	3240
Britannia	2006	3553
Britannia	2007	2280
Britannia	2008	3780
Britannia	2009	3610
Britannia	2010	2129
Britannia	2011	3475
Britannia	2012	3432

Table 7 Annual Maximum Flow at Chats Falls

Gauge	Year	Annual Daily Peak (cms)
Chats Falls	1915	1630
Chats Falls	1916	4080
Chats Falls	1917	3140
Chats Falls	1918	2400
Chats Falls	1919	4790
Chats Falls	1920	2250
Chats Falls	1921	3510
Chats Falls	1922	5070
Chats Falls	1923	3620
Chats Falls	1924	3030
Chats Falls	1925	2490
Chats Falls	1926	3090
Chats Falls	1927	2440
Chats Falls	1928	5750
Chats Falls	1929	4470
Chats Falls	1930	2970
Chats Falls	1931	2010
Chats Falls	1932	3110
Chats Falls	1933	4220
Chats Falls	1934	4420
Chats Falls	1935	2310
Chats Falls	1936	4560
Chats Falls	1937	3430
Chats Falls	1938	4160
Chats Falls	1939	3650
Chats Falls	1940	3450
Chats Falls	1941	4500
Chats Falls	1942	3230
Chats Falls	1943	4670
Chats Falls	1944	2570
Chats Falls	1945	3170
Chats Falls	1946	2260
Chats Falls	1947	4840
Chats Falls	1948	2560
Chats Falls	1949	3450
Chats Falls	1950	2550
Chats Falls	1951	5550
Chats Falls	1952	3170
Chats Falls	1953	3790
Chats Falls	1954	3110
Chats Falls	1955	3820
Chats Falls	1956	2790
Chats Falls	1957	3480
Chats Falls	1958	2170
Chats Falls	1959	2490
Chats Falls	1960	5800
Chats Falls	1961	1890
Chats Falls	1962	3230
Chats Falls	1963	1950
Chats Falls	1964	2210
Chats Falls	1965	2400
Chats Falls	1966	3770
Chats Falls	1967	4110
Chats Falls	1968	2750
Chats Falls	1969	2820
Chats Falls	1970	2770
Chats Falls	1971	3910
Chats Falls	1972	4280
Chats Falls	1973	3540
Chats Falls	1974	4810
Chats Falls	1975	3280
Chats Falls	1976	3820
Chats Falls	1977	2970
Chats Falls	1978	3030
Chats Falls	1979	5410
Chats Falls	1980	3270
Chats Falls	1981	3500
Chats Falls	1982	2840
Chats Falls	1983	4260
Chats Falls	1984	2980
Chats Falls	1985	4460
Chats Falls	1986	2640
Chats Falls	1987	2600
Chats Falls	1988	2710
Chats Falls	1989	2610
Chats Falls	1990	2740
Chats Falls	1991	3400
Chats Falls	1992	3220
Chats Falls	1993	2020
Chats Falls	1994	2020
Chats Falls	1995	2611
Chats Falls	1996	3897
Chats Falls	1997	3858
Chats Falls	1998	4220
Chats Falls	1999	2664
Chats Falls	2000	2191
Chats Falls	2001	2438
Chats Falls	2002	4404
Chats Falls	2003	2671
Chats Falls	2004	3030
Chats Falls	2005	3023
Chats Falls	2006	3315
Chats Falls	2007	2189
Chats Falls	2008	3675
Chats Falls	2009	3441
Chats Falls	2010	2030
Chats Falls	2011	3485
Chats Falls	2012	3284

Table 8 Flood Flows Used in HEC-RAS Model

Location	**Chats Falls**	**Grenville/ Carillon**
	(cms)	(cms)
	1915-2012	1933-2012
Return Period (years)		
2	3180	5160
5	4020	6280
10	4560	7010
20	5070	7700
50	5700	8580
100	6180	9240
200	6640	9890
500	7260	10800
Distribution	3PLN	3PLN

Table 9 List of Modified Cross-Sections

Cross-section	Reason for change
1041.1	MacDonald-Cartier Bridge updated from as-built drawings (2011)
1041.2	
1043.1	Alexandra Bridge updated from as-built drawings (2012)
1043.2	
1045	New cross-section for adding Portage Bridge – as-built drawings (1975)
1045.1	
1045.2	
2000.1	Updated Prince of Wales Bridge from as-built drawings (1926)
2000.2	
2000.3	
2000.4	
2000.5	Bathymetry updated based on Baird (2010) survey
2000.6	Bathymetry updated based on Baird (2010) survey + Lemieux Island Bridges as-built drawings (1936)
2000.7	
2000.8	
2000.9	
2001	Bathymetry updated based on Baird (2010) survey + Lemieux Island Bridges as-built drawings (1991)
2001.1	
2001.2	
2001.3	
2003.2	Champlain Bridge updated based on DRAPE imagery (2008)
2003.4	

Table 10 Bridge Details

Reach	Name	Chainage (m)	Bounding Cross Sections	Deck Top (m)	Low Chord (m)	Deck Width (m)	Cc	Ce	Source
Ottawa River	Macdonald-Cartier Bridge	37043	1041.2 & 1041.1	64.0	50.3	30.5	0.1	0.3	PWGSC (2011)
Ottawa River	Alexandra Bridge	37775	1043.2 & 1043.1	58.6	56.2	18	0.1	0.3	PWGSC (2012)
Ottawa River	Portage Bridge	39074	1045.1 & 1045	55.0	48.5	32	0.1	0.3	National Capital Commission (1975)
Ottawa River	Chaudière Bridge/Booth Street		Not modelled - Due to proximity to Chaudière Falls						PWGSC (2001, 2012)
Ottawa River	Prince of Wales Bridge (rail)	40543	2000.3 & 2000.2	58.2	57.9	6	0.1	0.3	City of Ottawa (1926)
Ottawa River	Pipe Bridge to Lemieux Island	40782	2000.8 & 2000.7	58.5	54.7	7	0.3	0.5	City of Ottawa (1936)
Ottawa River	Lemieux Island Bridge	40851	2001.2 & 2001.1	60.1	57.0	7	0.3	0.5	City of Ottawa (1991)
Ottawa River	Champlain Bridge	43361	2003.4 & 2003.1	62.1	55.8	14	0.1	0.3	DRAPE Imagery (2008), MacLaren (1984)

Notation
Cc - coefficient of contraction,
Ce - coefficient of expansion
PWGSC - Public Works and Government Services Canada

Table 11 Flood flows (in cms) used in HEC-RAS model

		Return Period (year)							
River	**Station ID**	**2**	**5**	**10**	**20**	**50**	**100**	**200**	**500**
Ottawa River	2022	3180	4020	4560	5070	5700	6180	6640	7260
Ottawa River	1045.2	5160	6280	7010	7700	8580	9240	9890	10800

Table 12 - Downstream Boundary Condition (XS 995)

Return Period (years)	Flow at Grenville/Carillon	Water Level at Grenville	Cumberland-Grenville WL Difference	Water Level at Section 995
	(cms)	(m)	(m)	(m)
	estimated by CFA analysis		estimated from envelop curve	estimated by interpolation
2	5160	41.42	0.975	42.24
5	6280	41.86	1.065	42.75
10	7010	42.14	1.102	43.06
20	7700	42.41	1.138	43.36
50	8580	42.76	1.190	43.76
100	9240	43.02	1.214	44.04
200	9890	43.27	1.235	44.31
500	10800	43.63	1.265	44.69

Table 13 - Water Level Change at Britannia (XS 2011)

Return Period (years)	Flow at Britannia	Water Level at Britannia
	(cms)	(m)
	estimated from CFA analysis	estimated from EC rating curve
2	3180	59.4175
5	4020	59.8015
10	4560	60.0325
20	5070	60.2415
50	5700	60.4890
100	6180	60.6710
200	6640	60.8403
500	7260	61.0623

Table 14 Regulatory Flood Levels for 1:100 Year Flood Event

River	Reach	Xsec ID	Q Total (m^3/s)	Computed W.S. E.L. (m)	EGL (m)	RFL (m)
Ottawa River	Ottawa	2022	6180	60.76	60.76	
Ottawa River	Ottawa	2021	6180	60.75	60.76	
Ottawa River	Ottawa	2020	6180	60.75	60.75	
Ottawa River	Ottawa	2019	6180	60.75	60.75	
Ottawa River	Ottawa	2018	6180	60.75	60.75	60.75
Ottawa River	Ottawa	2017	6180	60.74	60.75	60.75
Ottawa River	Ottawa	2016	6180	60.74	60.74	60.74
Ottawa River	Ottawa	2015	6180	60.74	60.74	60.74
Ottawa River	Ottawa	2014	6180	60.74	60.74	60.74
Ottawa River	Ottawa	2013	6180	60.73	60.74	60.74
Ottawa River	Ottawa	2012	6180	60.73	60.74	60.74
Ottawa River	Ottawa	2011	6180	60.67	60.73	60.73
Ottawa River	Ottawa	2010	6180	57.45	57.54	57.54
Ottawa River	Ottawa	2009	6180	57.48	57.50	57.5
Ottawa River	Ottawa	2008	6180	57.47	57.48	57.48
Ottawa River	Ottawa	2007	6180	57.47	57.48	57.48
Ottawa River	Ottawa	2006	6180	57.46	57.47	57.47
Ottawa River	Ottawa	2005	6180	57.45	57.47	57.47
Ottawa River	Ottawa	2004	6180	57.36	57.43	57.43
Ottawa River	Ottawa	2003.5	6180	57.22	57.34	57.34
Ottawa River	Ottawa	2003.4	6180	57.04	57.29	57.29
Ottawa River	Ottawa	2003.25	Champlain Bridge			
Ottawa River	Ottawa	2003.2	6180	56.99	57.25	57.25
Ottawa River	Ottawa	2003.1	6180	56.53	57.17	57.17
Ottawa River	Ottawa	2003	6180	56.13	56.16	56.16
Ottawa River	Ottawa	2002	6180	56.01	56.12	56.12
Ottawa River	Ottawa	2001.5	6180	54.93	55.88	55.88
Ottawa River	Ottawa	2001.4	6180	53.96	54.00	54.00
Ottawa River	Ottawa	2001.3	6180	53.29	53.92	53.92
Ottawa River	Ottawa	2001.2	6180	53.29	53.92	53.92
Ottawa River	Ottawa	2001.15	Lemieux Island Bridge			
Ottawa River	Ottawa	2001.1	6180	53.24	53.89	53.89
Ottawa River	Ottawa	2001	6180	53.41	53.72	53.72
Ottawa River	Ottawa	2000.9	6180	53.47	53.65	53.65
Ottawa River	Ottawa	2000.8	6180	53.47	53.65	53.65
Ottawa River	Ottawa	2000.75	Pipe Bridge to Lemieux Island			
Ottawa River	Ottawa	2000.7	6180	53.46	53.65	53.65
Ottawa River	Ottawa	2000.6	6180	53.46	53.65	53.65
Ottawa River	Ottawa	2000.5	6180	53.46	53.60	53.60
Ottawa River	Ottawa	2000.4	6180	53.33	53.55	53.55

River	Reach	Xsec ID	Q Total (m^3/s)	Computed W.S. E.L. (m)	EGL (m)	RFL (m)
Ottawa River	Ottawa	2000.3	6180	53.33	53.55	53.55
Ottawa River	Ottawa	2000.25	Prince of Wales Bridge (rail)			
Ottawa River	Ottawa	2000.2	6180	53.31	53.54	53.54
Ottawa River	Ottawa	2000.1	6180	53.31	53.54	53.54
Ottawa River	Ottawa	2000	6180	53.32	53.40	53.40
Ottawa River	Ottawa	1045.2	9240	47.08	49.46	49.46
Ottawa River	Ottawa	1045.1	9240	46.53	49.18	49.18
Ottawa River	Ottawa	1045.05	Portage Bridge			
Ottawa River	Ottawa	1045	9240	44.64	48.67	48.67
Ottawa River	Ottawa	1044	9240	45.89	46.05	46.05
Ottawa River	Ottawa	1043.2	9240	45.92	46.00	46.00
Ottawa River	Ottawa	1043.15	Alexandra Bridge			
Ottawa River	Ottawa	1043.1	9240	45.91	46.00	46.00
Ottawa River	Ottawa	1042	9240	45.90	45.99	45.99
Ottawa River	Ottawa	1041.2	9240	45.90	45.96	45.96
Ottawa River	Ottawa	1041.15	Macdonald-Cartier Bridge			
Ottawa River	Ottawa	1041.1	9240	45.90	45.96	45.96
Ottawa River	Ottawa	1040	9240	45.88	45.96	45.96
Ottawa River	Ottawa	1039	9240	45.86	45.93	45.93
Ottawa River	Ottawa	1038	9240	45.85	45.90	45.90
Ottawa River	Ottawa	1037	9240	45.79	45.88	45.88
Ottawa River	Ottawa	1036	9240	45.67	45.85	45.85
Ottawa River	Ottawa	1035	9240	45.72	45.78	45.78
Ottawa River	Ottawa	1034	9240	45.69	45.73	45.73
Ottawa River	Ottawa	1033	9240	45.62	45.68	45.68
Ottawa River	Ottawa	1032	9240	45.59	45.64	45.64
Ottawa River	Ottawa	1031	9240	45.55	45.59	45.59
Ottawa River	Ottawa	1030	9240	45.53	45.56	45.56
Ottawa River	Ottawa	1029	9240	45.49	45.53	45.53
Ottawa River	Ottawa	1028	9240	45.47	45.51	45.51
Ottawa River	Ottawa	1027	9240	45.43	45.48	45.48
Ottawa River	Ottawa	1026	9240	45.40	45.45	45.45
Ottawa River	Ottawa	1025	9240	45.38	45.42	45.42
Ottawa River	Ottawa	1024	9240	45.36	45.38	45.38
Ottawa River	Ottawa	1023	9240	45.30	45.35	45.35
Ottawa River	Ottawa	1022	9240	45.23	45.30	45.30
Ottawa River	Ottawa	1021	9240	45.20	45.25	45.25
Ottawa River	Ottawa	1020	9240	45.15	45.21	45.21
Ottawa River	Ottawa	1019	9240	45.12	45.17	45.17
Ottawa River	Ottawa	1018	9240	45.09	45.13	45.13
Ottawa River	Ottawa	1017	9240	45.05	45.09	45.09
Ottawa River	Ottawa	1016	9240	44.99	45.05	45.05

River	Reach	Xsec ID	Q Total (m^3/s)	Computed W.S. E.L. (m)	EGL (m)	RFL (m)
Ottawa River	Ottawa	1015	9240	44.92	45.00	45.00
Ottawa River	Ottawa	1014	9240	44.90	44.94	44.94
Ottawa River	Ottawa	1013	9240	44.83	44.89	44.89
Ottawa River	Ottawa	1012	9240	44.78	44.85	44.85
Ottawa River	Ottawa	1011	9240	44.72	44.79	44.79
Ottawa River	Ottawa	1010	9240	44.70	44.76	44.76
Ottawa River	Ottawa	1009	9240	44.63	44.72	44.72
Ottawa River	Ottawa	1008	9240	44.56	44.64	44.64
Ottawa River	Ottawa	1007	9240	44.55	44.62	44.62
Ottawa River	Ottawa	1006	9240	44.51	44.58	44.58
Ottawa River	Ottawa	1005	9240	44.47	44.54	44.54
Ottawa River	Ottawa	1004	9240	44.42	44.50	44.50
Ottawa River	Ottawa	1003	9240	44.41	44.46	44.46
Ottawa River	Ottawa	1002	9240	44.38	44.43	44.43
Ottawa River	Ottawa	1001	9240	44.34	44.39	44.39
Ottawa River	Ottawa	1000	9240	44.29	44.35	44.35
Ottawa River	Ottawa	999	9240	44.27	44.30	
Ottawa River	Ottawa	998	9240	44.21	44.25	
Ottawa River	Ottawa	997	9240	44.16	44.23	
Ottawa River	Ottawa	996	9240	44.09	44.17	
Ottawa River	Ottawa	995	9240	44.04	44.12	

NOTE:

RFL - Regulatory Flood Levels
EGL - Energy Grade Elevation
WSEL - Water Surface Elevation

Table 15 Level (m) for 50 year to 500 year Flood Events

River	Reach	Xsec ID	Flow (m3/s) and Computed Water Level (m) for different Flood Events							
			Q500	**WL500**	**Q200**	**WL200**	**Q100**	**WL100**	**Q50**	**WL50**
Ottawa River	Ottawa	2022	7260	61.17	6640	60.93	6180	60.76	5700	60.57
Ottawa River	Ottawa	2021	7260	61.16	6640	60.93	6180	60.75	5700	60.56
Ottawa River	Ottawa	2020	7260	61.16	6640	60.93	6180	60.75	5700	60.56
Ottawa River	Ottawa	2019	7260	61.15	6640	60.92	6180	60.75	5700	60.56
Ottawa River	Ottawa	2018	7260	61.15	6640	60.92	6180	60.75	5700	60.56
Ottawa River	Ottawa	2017	7260	61.15	6640	60.92	6180	60.74	5700	60.55
Ottawa River	Ottawa	2016	7260	61.15	6640	60.92	6180	60.74	5700	60.55
Ottawa River	Ottawa	2015	7260	61.14	6640	60.91	6180	60.74	5700	60.55
Ottawa River	Ottawa	2014	7260	61.14	6640	60.91	6180	60.74	5700	60.55
Ottawa River	Ottawa	2013	7260	61.14	6640	60.91	6180	60.73	5700	60.55
Ottawa River	Ottawa	2012	7260	61.14	6640	60.91	6180	60.73	5700	60.54
Ottawa River	Ottawa	2011	7260	61.06	6640	60.84	6180	60.67	5700	60.49
Ottawa River	Ottawa	2010	7260	57.71	6640	57.56	6180	57.45	5700	57.33
Ottawa River	Ottawa	2009	7260	57.75	6640	57.60	6180	57.48	5700	57.36
Ottawa River	Ottawa	2008	7260	57.73	6640	57.58	6180	57.47	5700	57.35
Ottawa River	Ottawa	2007	7260	57.73	6640	57.58	6180	57.47	5700	57.35
Ottawa River	Ottawa	2006	7260	57.72	6640	57.58	6180	57.46	5700	57.34
Ottawa River	Ottawa	2005	7260	57.70	6640	57.56	6180	57.45	5700	57.33
Ottawa River	Ottawa	2004	7260	57.59	6640	57.46	6180	57.36	5700	57.25
Ottawa River	Ottawa	2003.5	7260	57.43	6640	57.31	6180	57.22	5700	57.12
Ottawa River	Ottawa	2003.4	7260	57.22	6640	57.12	6180	57.04	5700	56.96
Ottawa River	Ottawa	2003.25	Champlain Bridge							
Ottawa River	Ottawa	2003.2	7260	57.16	6640	57.07	6180	56.99	5700	56.91
Ottawa River	Ottawa	2003.1	7260	56.67	6640	56.59	6180	56.53	5700	56.46
Ottawa River	Ottawa	2003	7260	56.48	6640	56.29	6180	56.13	5700	55.97
Ottawa River	Ottawa	2002	7260	56.33	6640	56.15	6180	56.01	5700	55.86
Ottawa River	Ottawa	2001.5	7260	55.15	6640	55.01	6180	54.93	5700	54.83
Ottawa River	Ottawa	2001.4	7260	54.22	6640	54.06	6180	53.96	5700	53.86
Ottawa River	Ottawa	2001.3	7260	53.29	6640	53.29	6180	53.29	5700	53.29
Ottawa River	Ottawa	2001.2	7260	53.28	6640	53.28	6180	53.29	5700	53.29
Ottawa River	Ottawa	2001.15	Lemieux Island Bridge							
Ottawa River	Ottawa	2001.1	7260	53.21	6640	53.23	6180	53.24	5700	53.26
Ottawa River	Ottawa	2001	7260	53.45	6640	53.43	6180	53.41	5700	53.40
Ottawa River	Ottawa	2000.9	7260	53.53	6640	53.49	6180	53.47	5700	53.45
Ottawa River	Ottawa	2000.8	7260	53.53	6640	53.49	6180	53.47	5700	53.45
Ottawa River	Ottawa	2000.75	Pipe Bridge to Lemieux Island							
Ottawa River	Ottawa	2000.7	7260	53.52	6640	53.48	6180	53.46	5700	53.44
Ottawa River	Ottawa	2000.6	7260	53.52	6640	53.48	6180	53.46	5700	53.44
Ottawa River	Ottawa	2000.5	7260	53.51	6640	53.48	6180	53.46	5700	53.44
Ottawa River	Ottawa	2000.4	7260	53.33	6640	53.33	6180	53.33	5700	53.33
Ottawa River	Ottawa	2000.3	7260	53.33	6640	53.33	6180	53.33	5700	53.33
Ottawa River	Ottawa	2000.25	Prince of Wales Bridge (rail)							
Ottawa River	Ottawa	2000.2	7260	53.31	6640	53.31	6180	53.31	5700	53.31
Ottawa River	Ottawa	2000.1	7260	53.31	6640	53.31	6180	53.31	5700	53.31
Ottawa River	Ottawa	2000	7260	53.32	6640	53.32	6180	53.32	5700	53.32
Ottawa River	Ottawa	1045.2	10800	48.15	9890	47.53	9240	47.08	8580	46.62
Ottawa River	Ottawa	1045.1	10800	47.59	9890	46.98	9240	46.53	8580	46.07
Ottawa River	Ottawa	1045.05	Portage Bridge							
Ottawa River	Ottawa	1045	10800	45.53	9890	45.02	9240	44.64	8580	44.26
Ottawa River	Ottawa	1044	10800	46.61	9890	46.20	9240	45.89	8580	45.55
Ottawa River	Ottawa	1043.2	10800	46.64	9890	46.23	9240	45.92	8580	45.58
Ottawa River	Ottawa	1043.15	Alexandra Bridge							
Ottawa River	Ottawa	1043.1	10800	46.64	9890	46.23	9240	45.91	8580	45.57
Ottawa River	Ottawa	1042	10800	46.63	9890	46.22	9240	45.90	8580	45.56
Ottawa River	Ottawa	1041.2	10800	46.63	9890	46.22	9240	45.90	8580	45.56
Ottawa River	Ottawa	1041.15	Macdonald-Cartier Bridge							
Ottawa River	Ottawa	1041.1	10800	46.63	9890	46.22	9240	45.90	8580	45.56
Ottawa River	Ottawa	1040	10800	46.60	9890	46.20	9240	45.88	8580	45.55

River	Reach	Xsec ID	Flow (m3/s) and Computed Water Level (m) for different Flood Events							
			Q500	WL500	Q200	WL200	Q100	WL100	Q50	WL50
Ottawa River	Ottawa	1039	10800	46.59	9890	46.18	9240	45.86	8580	45.53
Ottawa River	Ottawa	1038	10800	46.57	9890	46.17	9240	45.85	8580	45.52
Ottawa River	Ottawa	1037	10800	46.51	9890	46.11	9240	45.79	8580	45.46
Ottawa River	Ottawa	1036	10800	46.37	9890	45.97	9240	45.67	8580	45.35
Ottawa River	Ottawa	1035	10800	46.44	9890	46.04	9240	45.72	8580	45.40
Ottawa River	Ottawa	1034	10800	46.41	9890	46.00	9240	45.69	8580	45.37
Ottawa River	Ottawa	1033	10800	46.33	9890	45.93	9240	45.62	8580	45.30
Ottawa River	Ottawa	1032	10800	46.30	9890	45.89	9240	45.59	8580	45.26
Ottawa River	Ottawa	1031	10800	46.26	9890	45.86	9240	45.55	8580	45.23
Ottawa River	Ottawa	1030	10800	46.24	9890	45.84	9240	45.53	8580	45.21
Ottawa River	Ottawa	1029	10800	46.20	9890	45.80	9240	45.49	8580	45.17
Ottawa River	Ottawa	1028	10800	46.18	9890	45.78	9240	45.47	8580	45.14
Ottawa River	Ottawa	1027	10800	46.14	9890	45.74	9240	45.43	8580	45.11
Ottawa River	Ottawa	1026	10800	46.11	9890	45.71	9240	45.40	8580	45.08
Ottawa River	Ottawa	1025	10800	46.09	9890	45.69	9240	45.38	8580	45.06
Ottawa River	Ottawa	1024	10800	46.07	9890	45.67	9240	45.36	8580	45.03
Ottawa River	Ottawa	1023	10800	46.00	9890	45.61	9240	45.30	8580	44.98
Ottawa River	Ottawa	1022	10800	45.93	9890	45.54	9240	45.23	8580	44.91
Ottawa River	Ottawa	1021	10800	45.91	9890	45.51	9240	45.20	8580	44.88
Ottawa River	Ottawa	1020	10800	45.85	9890	45.46	9240	45.15	8580	44.84
Ottawa River	Ottawa	1019	10800	45.82	9890	45.43	9240	45.12	8580	44.81
Ottawa River	Ottawa	1018	10800	45.79	9890	45.39	9240	45.09	8580	44.77
Ottawa River	Ottawa	1017	10800	45.74	9890	45.35	9240	45.05	8580	44.73
Ottawa River	Ottawa	1016	10800	45.68	9890	45.29	9240	44.99	8580	44.67
Ottawa River	Ottawa	1015	10800	45.61	9890	45.22	9240	44.92	8580	44.60
Ottawa River	Ottawa	1014	10800	45.60	9890	45.21	9240	44.90	8580	44.58
Ottawa River	Ottawa	1013	10800	45.52	9890	45.13	9240	44.83	8580	44.52
Ottawa River	Ottawa	1012	10800	45.47	9890	45.08	9240	44.78	8580	44.46
Ottawa River	Ottawa	1011	10800	45.41	9890	45.02	9240	44.72	8580	44.41
Ottawa River	Ottawa	1010	10800	45.38	9890	45.00	9240	44.70	8580	44.38
Ottawa River	Ottawa	1009	10800	45.31	9890	44.93	9240	44.63	8580	44.33
Ottawa River	Ottawa	1008	10800	45.23	9890	44.86	9240	44.56	8580	44.25
Ottawa River	Ottawa	1007	10800	45.22	9890	44.84	9240	44.55	8580	44.24
Ottawa River	Ottawa	1006	10800	45.19	9890	44.81	9240	44.51	8580	44.21
Ottawa River	Ottawa	1005	10800	45.16	9890	44.76	9240	44.47	8580	44.17
Ottawa River	Ottawa	1004	10800	45.11	9890	44.71	9240	44.42	8580	44.12
Ottawa River	Ottawa	1003	10800	45.10	9890	44.70	9240	44.41	8580	44.11
Ottawa River	Ottawa	1002	10800	45.08	9890	44.67	9240	44.38	8580	44.09
Ottawa River	Ottawa	1001	10800	45.04	9890	44.63	9240	44.34	8580	44.04
Ottawa River	Ottawa	1000	10800	44.97	9890	44.57	9240	44.29	8580	43.99
Ottawa River	Ottawa	999	10800	44.96	9890	44.55	9240	44.27	8580	43.97
Ottawa River	Ottawa	998	10800	44.90	9890	44.50	9240	44.21	8580	43.92
Ottawa River	Ottawa	997	10800	44.83	9890	44.44	9240	44.16	8580	43.87
Ottawa River	Ottawa	996	10800	44.75	9890	44.36	9240	44.09	8580	43.81
Ottawa River	Ottawa	995	10800	44.69	9890	44.31	9240	44.04	8580	43.76

NOTE:

Vater Surface Elevation
ate of a 500 year flood event
ce Elevation of 500 year flood event
ate of a 200 year flood event
ce Elevation of 200 year flood event
ate of a 100 year flood event
ce Elevation of 100 year flood event
ate of a 50 year flood event
ce Elevation of 50 year flood event

Table 16 Flow (m^3/s) and Computed Water Level (m) for 2 year to 20 year Flood Events

River	Reach	Xsec ID	Flow (m3/s) and Computed Water Level (m) for different Flood Events							
			Q20	WL20	Q10	WL10	Q5	WL5	Q2	WL2
Ottawa River	Ottawa	2022	5070	60.31	4560	60.09	4020	59.85	3180	59.45
Ottawa River	Ottawa	2021	5070	60.30	4560	60.09	4020	59.85	3180	59.45
Ottawa River	Ottawa	2020	5070	60.30	4560	60.09	4020	59.85	3180	59.45
Ottawa River	Ottawa	2019	5070	60.30	4560	60.08	4020	59.85	3180	59.45
Ottawa River	Ottawa	2018	5070	60.30	4560	60.08	4020	59.84	3180	59.45
Ottawa River	Ottawa	2017	5070	60.30	4560	60.08	4020	59.84	3180	59.45
Ottawa River	Ottawa	2016	5070	60.30	4560	60.08	4020	59.84	3180	59.45
Ottawa River	Ottawa	2015	5070	60.29	4560	60.08	4020	59.84	3180	59.45
Ottawa River	Ottawa	2014	5070	60.29	4560	60.08	4020	59.84	3180	59.44
Ottawa River	Ottawa	2013	5070	60.29	4560	60.08	4020	59.84	3180	59.44
Ottawa River	Ottawa	2012	5070	60.29	4560	60.07	4020	59.84	3180	59.44
Ottawa River	Ottawa	2011	5070	60.24	4560	60.03	4020	59.80	3180	59.42
Ottawa River	Ottawa	2010	5070	57.17	4560	57.03	4020	56.88	3180	56.63
Ottawa River	Ottawa	2009	5070	57.19	4560	57.05	4020	56.90	3180	56.64
Ottawa River	Ottawa	2008	5070	57.18	4560	57.05	4020	56.89	3180	56.64
Ottawa River	Ottawa	2007	5070	57.18	4560	57.04	4020	56.89	3180	56.64
Ottawa River	Ottawa	2006	5070	57.18	4560	57.04	4020	56.89	3180	56.64
Ottawa River	Ottawa	2005	5070	57.17	4560	57.03	4020	56.88	3180	56.63
Ottawa River	Ottawa	2004	5070	57.10	4560	56.97	4020	56.83	3180	56.60
Ottawa River	Ottawa	2003.5	5070	56.98	4560	56.87	4020	56.74	3180	56.52
Ottawa River	Ottawa	2003.4	5070	56.84	4560	56.74	4020	56.62	3180	56.44
Ottawa River	Ottawa	2003.25	Champlain Bridge							
Ottawa River	Ottawa	2003.2	5070	56.80	4560	56.71	4020	56.60	3180	56.42
Ottawa River	Ottawa	2003.1	5070	56.36	4560	56.29	4020	56.20	3180	56.05
Ottawa River	Ottawa	2003	5070	55.75	4560	55.56	4020	55.35	3180	55.01
Ottawa River	Ottawa	2002	5070	55.65	4560	55.48	4020	55.28	3180	54.96
Ottawa River	Ottawa	2001.5	5070	54.69	4560	54.58	4020	54.45	3180	54.25
Ottawa River	Ottawa	2001.4	5070	53.75	4560	53.66	4020	53.59	3180	53.49
Ottawa River	Ottawa	2001.3	5070	53.29	4560	53.30	4020	53.30	3180	53.31
Ottawa River	Ottawa	2001.2	5070	53.29	4560	53.30	4020	53.30	3180	53.31
Ottawa River	Ottawa	2001.15	Lemieux Island Bridge							
Ottawa River	Ottawa	2001.1	5070	53.27	4560	53.28	4020	53.29	3180	53.30
Ottawa River	Ottawa	2001	5070	53.38	4560	53.37	4020	53.36	3180	53.34
Ottawa River	Ottawa	2000.9	5070	53.42	4560	53.40	4020	53.38	3180	53.36
Ottawa River	Ottawa	2000.8	5070	53.42	4560	53.40	4020	53.38	3180	53.36
Ottawa River	Ottawa	2000.75	Pipe Bridge to Lemieux Island							
Ottawa River	Ottawa	2000.7	5070	53.41	4560	53.40	4020	53.38	3180	53.36
Ottawa River	Ottawa	2000.6	5070	53.41	4560	53.40	4020	53.38	3180	53.36
Ottawa River	Ottawa	2000.5	5070	53.41	4560	53.39	4020	53.38	3180	53.35
Ottawa River	Ottawa	2000.4	5070	53.33	4560	53.32	4020	53.32	3180	53.32
Ottawa River	Ottawa	2000.3	5070	53.33	4560	53.32	4020	53.32	3180	53.32
Ottawa River	Ottawa	2000.25	Prince of Wales Bridge (rail)							
Ottawa River	Ottawa	2000.2	5070	53.32	4560	53.32	4020	53.32	3180	53.32
Ottawa River	Ottawa	2000.1	5070	53.31	4560	53.32	4020	53.32	3180	53.32
Ottawa River	Ottawa	2000	5070	53.32	4560	53.32	4020	53.32	3180	53.32
Ottawa River	Ottawa	1045.2	7700	45.97	7010	45.45	6280	44.87	5160	43.95
Ottawa River	Ottawa	1045.1	7700	45.42	7010	44.90	6280	44.33	5160	43.40
Ottawa River	Ottawa	1045.05	Portage Bridge							
Ottawa River	Ottawa	1045	7700	43.73	7010	43.29	6280	42.82	5160	42.05
Ottawa River	Ottawa	1044	7700	45.07	7010	44.70	6280	44.29	5160	43.61
Ottawa River	Ottawa	1043.2	7700	45.10	7010	44.72	6280	44.31	5160	43.63
Ottawa River	Ottawa	1043.15	Alexandra Bridge							
Ottawa River	Ottawa	1043.1	7700	45.09	7010	44.71	6280	44.30	5160	43.62
Ottawa River	Ottawa	1042	7700	45.09	7010	44.71	6280	44.30	5160	43.62
Ottawa River	Ottawa	1041.2	7700	45.08	7010	44.70	6280	44.29	5160	43.62
Ottawa River	Ottawa	1041.15	Macdonald-Cartier Bridge							
Ottawa River	Ottawa	1041.1	7700	45.08	7010	44.70	6280	44.29	5160	43.62
Ottawa River	Ottawa	1040	7700	45.07	7010	44.69	6280	44.28	5160	43.61

River	Reach	Xsec ID	Flow (m3/s) and Computed Water Level (m) for different Flood Events							
			Q20	WL20	Q10	WL10	Q5	WL5	Q2	WL2
Ottawa River	Ottawa	1039	7700	45.05	7010	44.67	6280	44.26	5160	43.59
Ottawa River	Ottawa	1038	7700	45.04	7010	44.67	6280	44.26	5160	43.58
Ottawa River	Ottawa	1037	7700	44.99	7010	44.62	6280	44.22	5160	43.56
Ottawa River	Ottawa	1036	7700	44.90	7010	44.54	6280	44.15	5160	43.51
Ottawa River	Ottawa	1035	7700	44.94	7010	44.57	6280	44.17	5160	43.52
Ottawa River	Ottawa	1034	7700	44.90	7010	44.54	6280	44.14	5160	43.49
Ottawa River	Ottawa	1033	7700	44.84	7010	44.47	6280	44.08	5160	43.43
Ottawa River	Ottawa	1032	7700	44.80	7010	44.44	6280	44.05	5160	43.40
Ottawa River	Ottawa	1031	7700	44.77	7010	44.41	6280	44.01	5160	43.37
Ottawa River	Ottawa	1030	7700	44.75	7010	44.39	6280	44.00	5160	43.35
Ottawa River	Ottawa	1029	7700	44.71	7010	44.35	6280	43.96	5160	43.32
Ottawa River	Ottawa	1028	7700	44.69	7010	44.33	6280	43.94	5160	43.29
Ottawa River	Ottawa	1027	7700	44.65	7010	44.29	6280	43.90	5160	43.26
Ottawa River	Ottawa	1026	7700	44.62	7010	44.26	6280	43.87	5160	43.24
Ottawa River	Ottawa	1025	7700	44.60	7010	44.24	6280	43.86	5160	43.22
Ottawa River	Ottawa	1024	7700	44.58	7010	44.21	6280	43.83	5160	43.19
Ottawa River	Ottawa	1023	7700	44.52	7010	44.16	6280	43.78	5160	43.14
Ottawa River	Ottawa	1022	7700	44.46	7010	44.10	6280	43.72	5160	43.09
Ottawa River	Ottawa	1021	7700	44.43	7010	44.07	6280	43.69	5160	43.06
Ottawa River	Ottawa	1020	7700	44.38	7010	44.03	6280	43.65	5160	43.03
Ottawa River	Ottawa	1019	7700	44.35	7010	44.00	6280	43.62	5160	43.00
Ottawa River	Ottawa	1018	7700	44.32	7010	43.96	6280	43.59	5160	42.96
Ottawa River	Ottawa	1017	7700	44.27	7010	43.92	6280	43.54	5160	42.92
Ottawa River	Ottawa	1016	7700	44.21	7010	43.86	6280	43.49	5160	42.87
Ottawa River	Ottawa	1015	7700	44.15	7010	43.80	6280	43.43	5160	42.82
Ottawa River	Ottawa	1014	7700	44.13	7010	43.78	6280	43.42	5160	42.81
Ottawa River	Ottawa	1013	7700	44.07	7010	43.72	6280	43.35	5160	42.75
Ottawa River	Ottawa	1012	7700	44.01	7010	43.67	6280	43.30	5160	42.71
Ottawa River	Ottawa	1011	7700	43.96	7010	43.62	6280	43.26	5160	42.67
Ottawa River	Ottawa	1010	7700	43.94	7010	43.59	6280	43.23	5160	42.65
Ottawa River	Ottawa	1009	7700	43.89	7010	43.55	6280	43.20	5160	42.62
Ottawa River	Ottawa	1008	7700	43.82	7010	43.49	6280	43.14	5160	42.57
Ottawa River	Ottawa	1007	7700	43.81	7010	43.48	6280	43.13	5160	42.56
Ottawa River	Ottawa	1006	7700	43.78	7010	43.45	6280	43.10	5160	42.54
Ottawa River	Ottawa	1005	7700	43.74	7010	43.41	6280	43.07	5160	42.51
Ottawa River	Ottawa	1004	7700	43.70	7010	43.38	6280	43.04	5160	42.48
Ottawa River	Ottawa	1003	7700	43.68	7010	43.36	6280	43.02	5160	42.47
Ottawa River	Ottawa	1002	7700	43.66	7010	43.34	6280	43.00	5160	42.45
Ottawa River	Ottawa	1001	7700	43.62	7010	43.30	6280	42.96	5160	42.42
Ottawa River	Ottawa	1000	7700	43.57	7010	43.25	6280	42.92	5160	42.38
Ottawa River	Ottawa	999	7700	43.55	7010	43.23	6280	42.90	5160	42.36
Ottawa River	Ottawa	998	7700	43.50	7010	43.18	6280	42.86	5160	42.32
Ottawa River	Ottawa	997	7700	43.45	7010	43.14	6280	42.82	5160	42.29
Ottawa River	Ottawa	996	7700	43.40	7010	43.10	6280	42.78	5160	42.27
Ottawa River	Ottawa	995	7700	43.36	7010	43.06	6280	42.75	5160	42.24

NOTE:
WSEL - Water Surface Elevation
Q20 - Flow rate of a 20 year flood event
WL20 - Water Surface Elevation of 20 year flood event
Q10 - Flow rate of a 10 year flood event
WL10 - Water Surface Elevation of 10 year flood event
Q5 - Flow rate of a 5 year flood event
WL5 - Water Surface Elevation of 5 year flood event
Q2 - Flow rate of a 2 year flood event
WL2 - Water Surface Elevation of 2 year flood event

Table 17 Calibration of the May 1974 flood event

Input to hydraulic model

cross-section	flow rate (cms)	water level (m)
995		43.40
	7825	
1010		
	6983	
1037		
	4517	
1040		
	4440	
1044		

Note: flow at Corrilon Dam = 8030 cms

Output from hydraulic model

cross-section	water level (m)	water level (m)	difference (m)
	MacLaren HEC-2 (1984)	RVCA HEC-RAS (2014)	
Cumberland			
1007	43.87	43.86	-0.01
1008	43.89	43.87	-0.02
Rideau Locks			
1042	44.94	44.96	0.02
1043	44.94	44.97	0.03
1043.2	44.94	44.97	0.03
1044	44.94	44.98	0.04

Table 18 Culvert data from field checks

Culvert	Downstream		Upstream		Diameter (cm)	Shape	RFL (m)	Location
	Invert (m)	Obvert (m)	Invert (m)	Obvert (m)				
1	58.729	59.406			63	Circular	60.57	300 Grandview Road
2			60.082		24	Circular	60.57	263 Grandview Road
3				60.07	50	Circular	60.57	204 Grandview Road
4	60.149	60.633	60.249	60.812	54	Circular	60.57	Under Grandview Road at 119
5	60.006	60.546	60.084	60.614	54	Circular	60.57	US along 119 Grandview Road
6	59.756	60.27	59.783	60.322	54	Circular	60.57	DS along 119 Grandview Road
7	60.261	60.567	60.365	60.653	30	Circular	60.57	118 Grandview Road
8	60.388				15	Circular	60.57	114 Grandview Road
9		61.91		61.936	63	Circular	60.57	57 Grandview Road
10				61.393	H 157, W 198	Box	60.56	Maplehurst Road Box Culvert under River Pathway
11		59.669			28	Circular	60.56	Maplehurst Road along pathway
12	43.705	43.886	43.721	44.013	22	Circular	44.51	1105 Morin Road
13	44.024	44.374			36	Circular	44.51	1106 Morin Road
14	44.54	44.977	44.521	44.974	44	Circular	44.51	1114 Morin Road
15	43.859	44.431	43.949	44.504	58	Circular	44.51	Under Phillip Road at Morin Road
16	44.177	44.471	44.357	44.682	30	Circular	44.51	DS 1117 Morin Road
17	44.653	44.975	44.697	45.018	32	Circular	44.51	US 1117 Morin Road
18		44.265			30	Circular	44.51	Phillip Road under mailboxes
19	43.228	43.667	43.522	43.888	48	Circular	44.51	1107 Armstrong Road
20	44.069	44.454	44.155	44.488	36	Circular	44.51	DS 1113 Armstrong Road
21	44.127	44.546			38	Circular	44.51	US 1113 Armstrong Road
22	44.269	44.609	44.5	44.903	38	Circular	44.51	1121 Armstrong Road
23	43.738	44.208			48	Circular	44.51	Under Armstrong Road at Phillip Road
24	44.008	44.856	43.838	44.786	96	Circular	45.28	Under Hiawatha Park Road
25				44.546	124	Circular	45.28	Under path east of Hiawatha Park Road (2 culverts)
26		45.035			63	Circular	45.28	Under path along Beauchamp Avenue (2 culverts)

Table 19 List of Site Specific Information

Location	Survey/Plan	Year	Flood Line Change	Note
5 Nesbitt	Plan	2007	No	
73 Grandview	Plan	2007	No	
27 Nesbitt	Survey	2012	No	Engineering Survey
99 Grandview	Plan	2012	No	

* from RVCA planningand regulation files since 2007

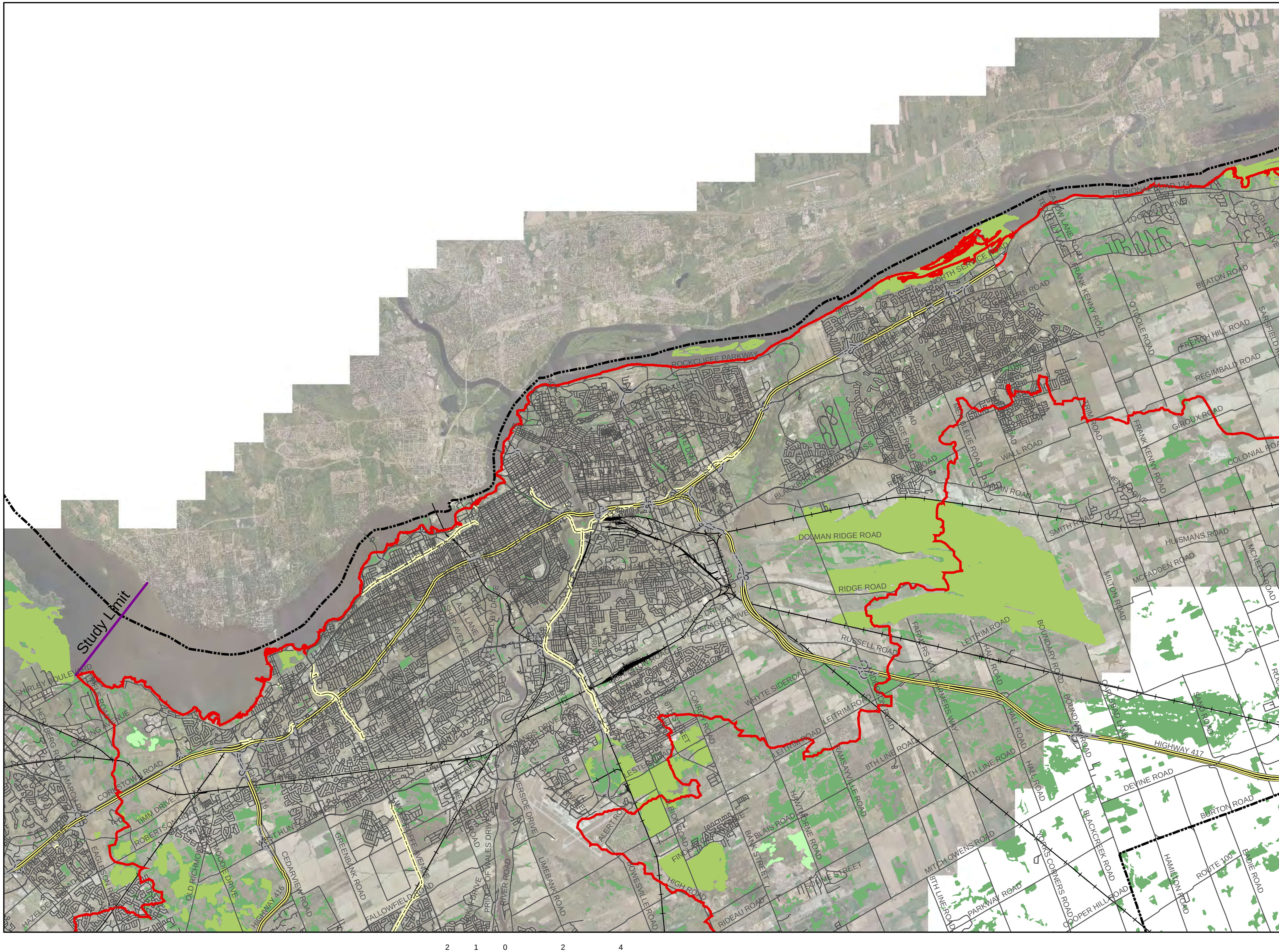


Figure 1: Ottawa River Study Area

- Study Limits
- Ottawa Boundary
- RVCA Boundary

Roads

- Freeway
- Expressway / Highway
- Collector
- Local / Street
- Local / Strata
- Local / Unknown
- Arterial
- Alleyway / Laneway
- Ramp
- Rapid Transit
- Service
- Railway

Wetlands

Significance

- Provincial
- Other
- Not Evaluated

RIDEAU VALLEY CONSERVATION AUTHORITY

Map Scale: 1:125,000

Projection note: U.T.M. Zone 18 - NAD 83 Datum

N S W E

Created by: dmikalson

Date Modified: 2013-05-08 1:38:13 PM

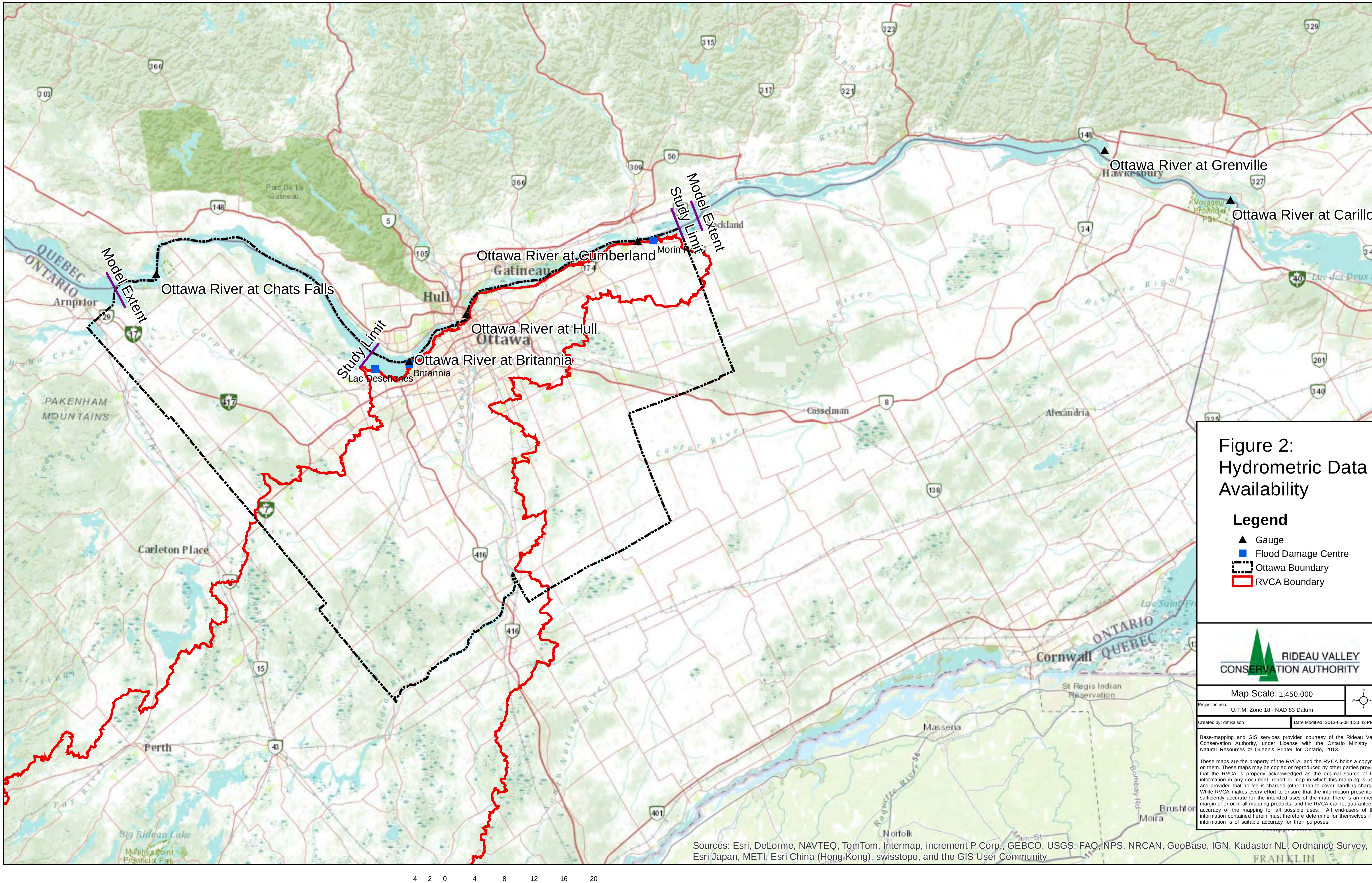


Figure 2: Hydrometric Data Availability

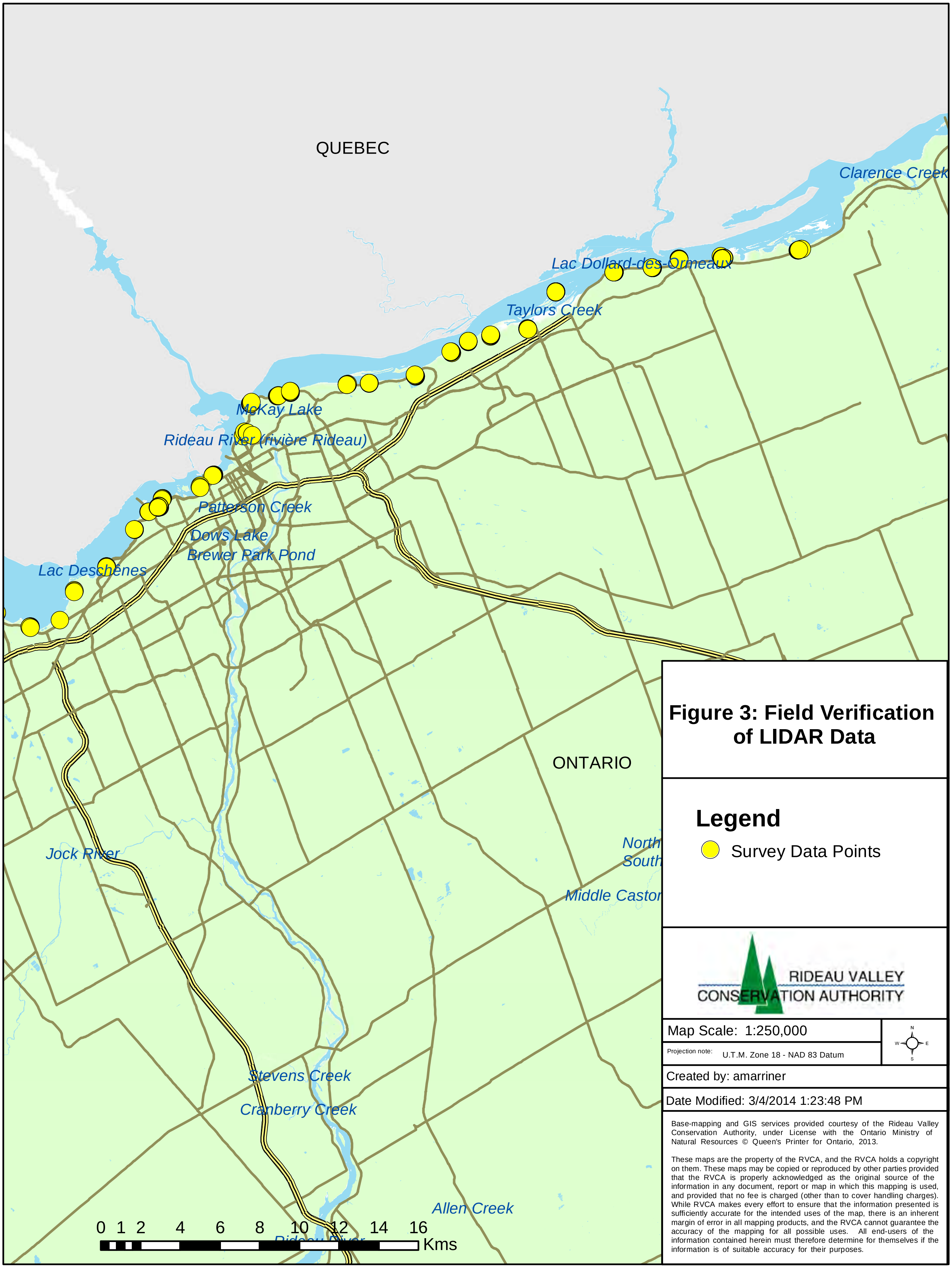


Figure 3: Field Verification of LIDAR Data

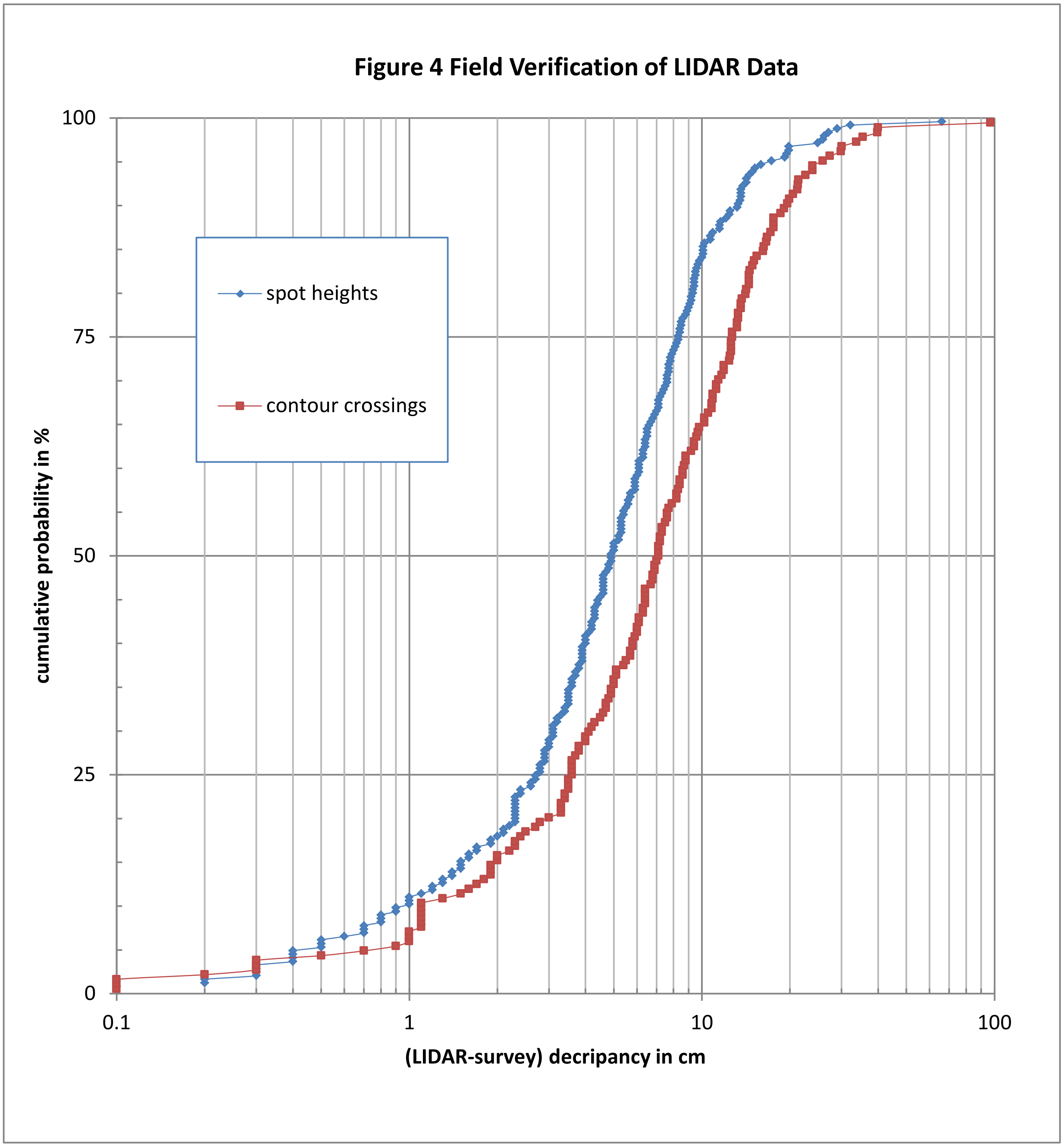


Figure 4 Field Verification of LIDAR Data
spot heights
contour crossings
cumulative probability in %
(LIDAR-survey) decripancy in cm
0
25
50
75
100
0.1
1
10
100

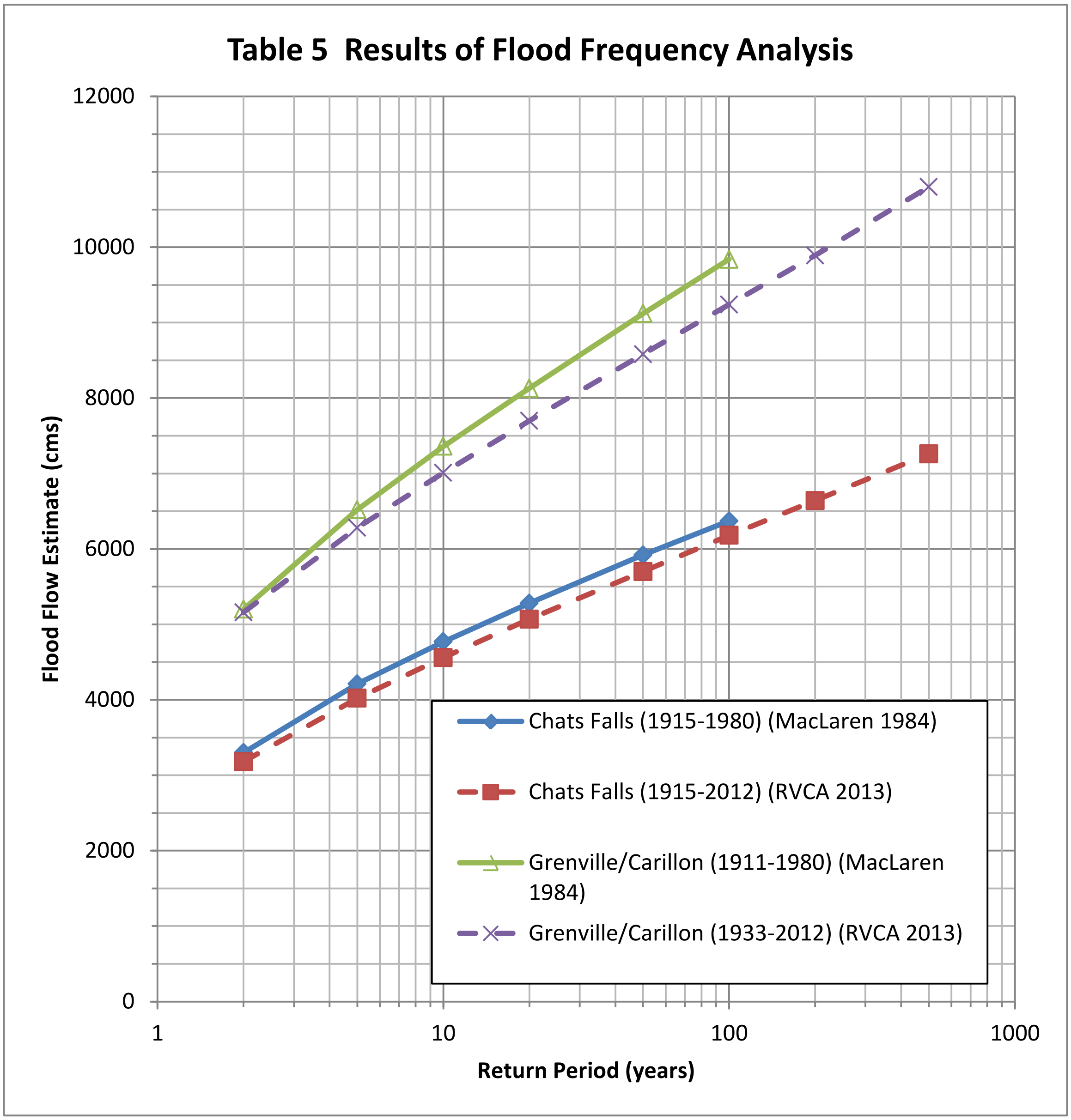


Table 5 Results of Flood Frequency Analysis
12000
10000
8000
6000
4000
2000
0
Flood Flow Estimate (cms)
1
10
100
1000
Return Period (years)
Chats Falls (1915-1980) (MacLaren 1984)
Chats Falls (1915-2012) (RVCA 2013)
Grenville/Carillon (1911-1980) (MacLaren 1984)
Grenville/Carillon (1933-2012) (RVCA 2013)

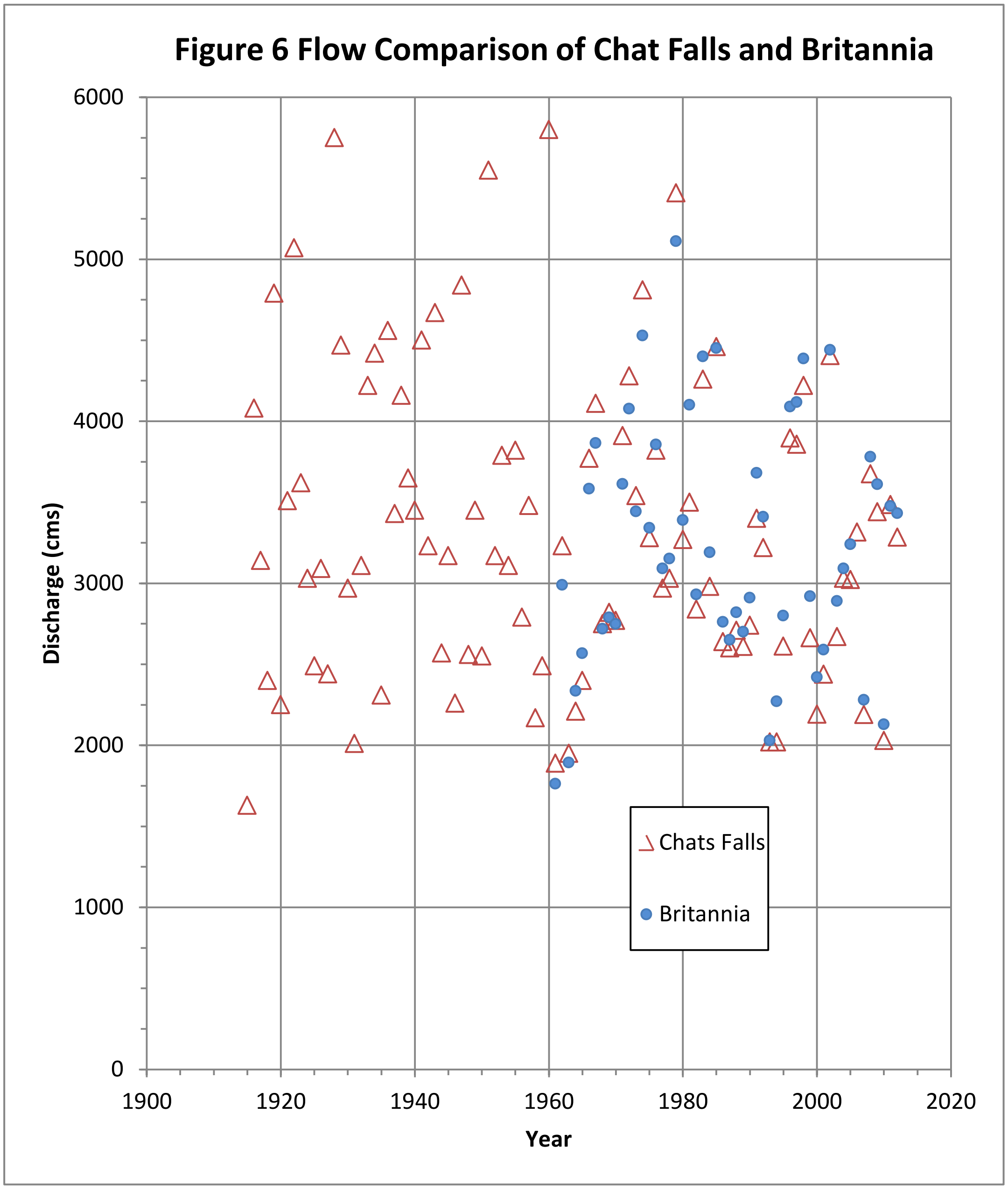


Figure 6 Flow Comparison of Chat Falls and Britannia
Discharge (cms)
6000
5000
4000
3000
2000
1000
0
1900
1920
1940
1960
1980
2000
2020
Year
Chats Falls
Britannia

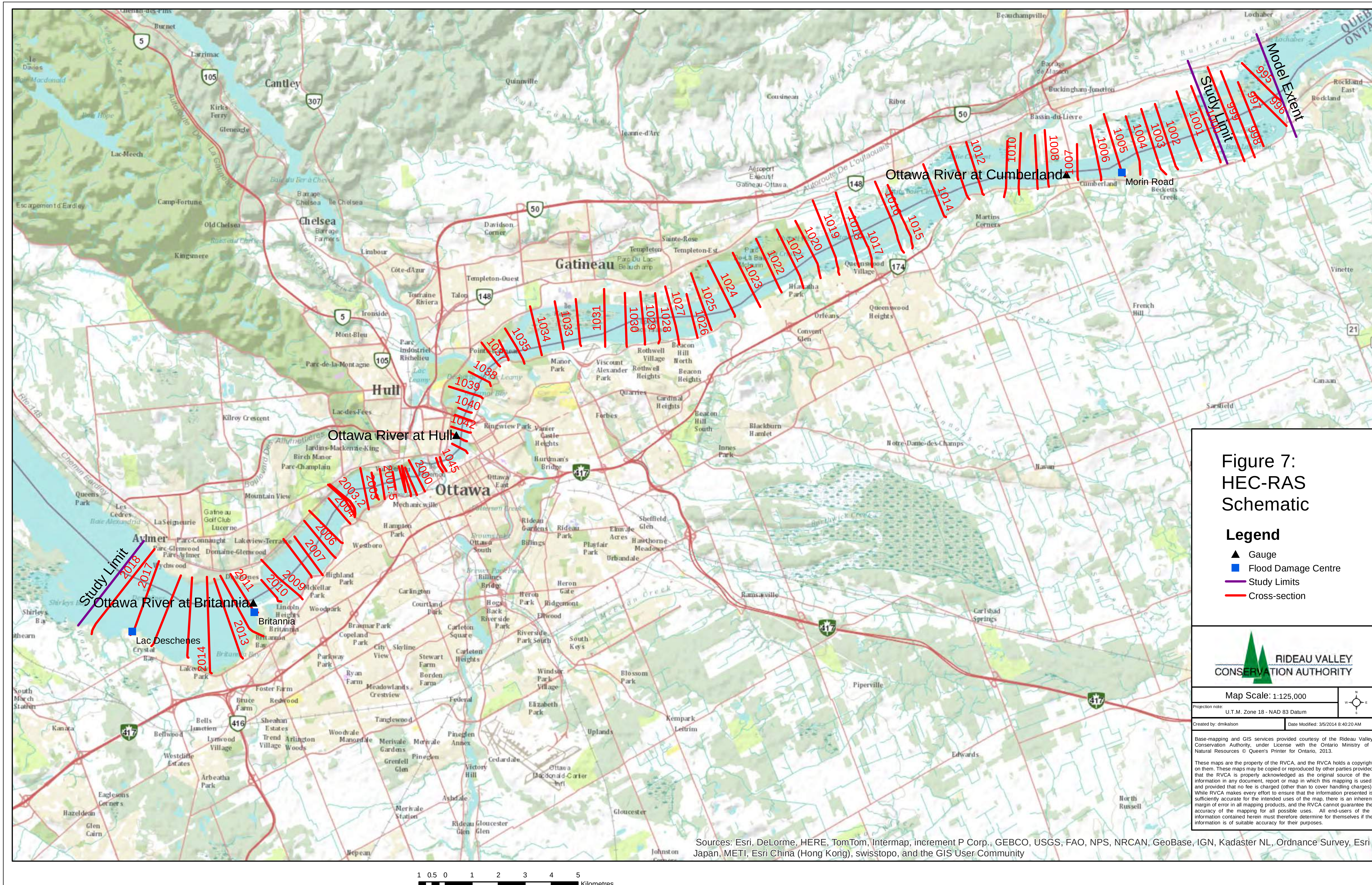


Figure 7: HEC-RAS Schematic

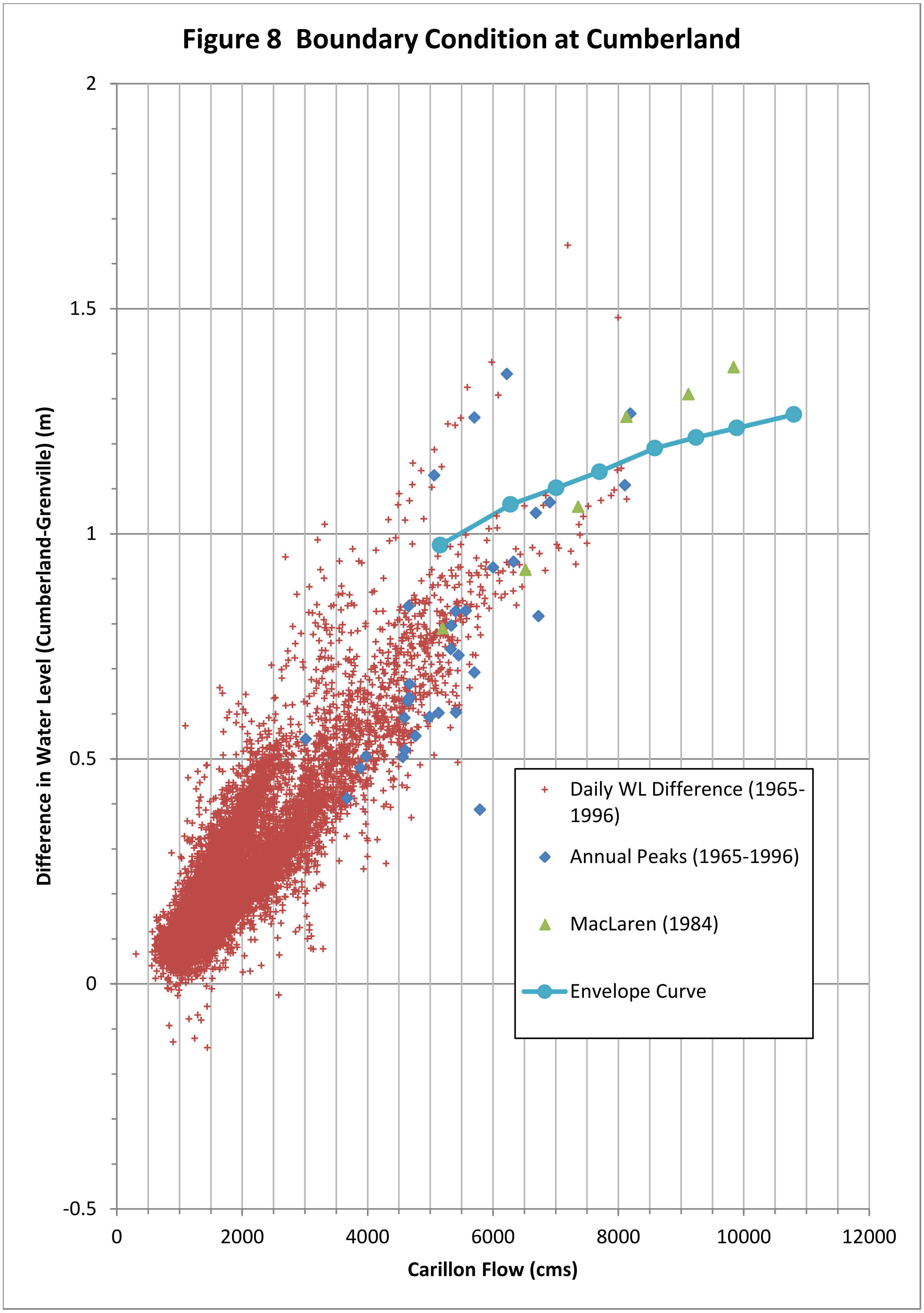


Figure 8 Boundary Condition at Cumberland
Difference in Water Level (Cumberland-Grenville) (m)
2
1.5
1
0.5
0
-0.5
0
2000
4000
6000
8000
10000
12000
Carillon Flow (cms)
Daily WL Difference (1965-1996)
Annual Peaks (1965-1996)
MacLaren (1984)
Envelope Curve

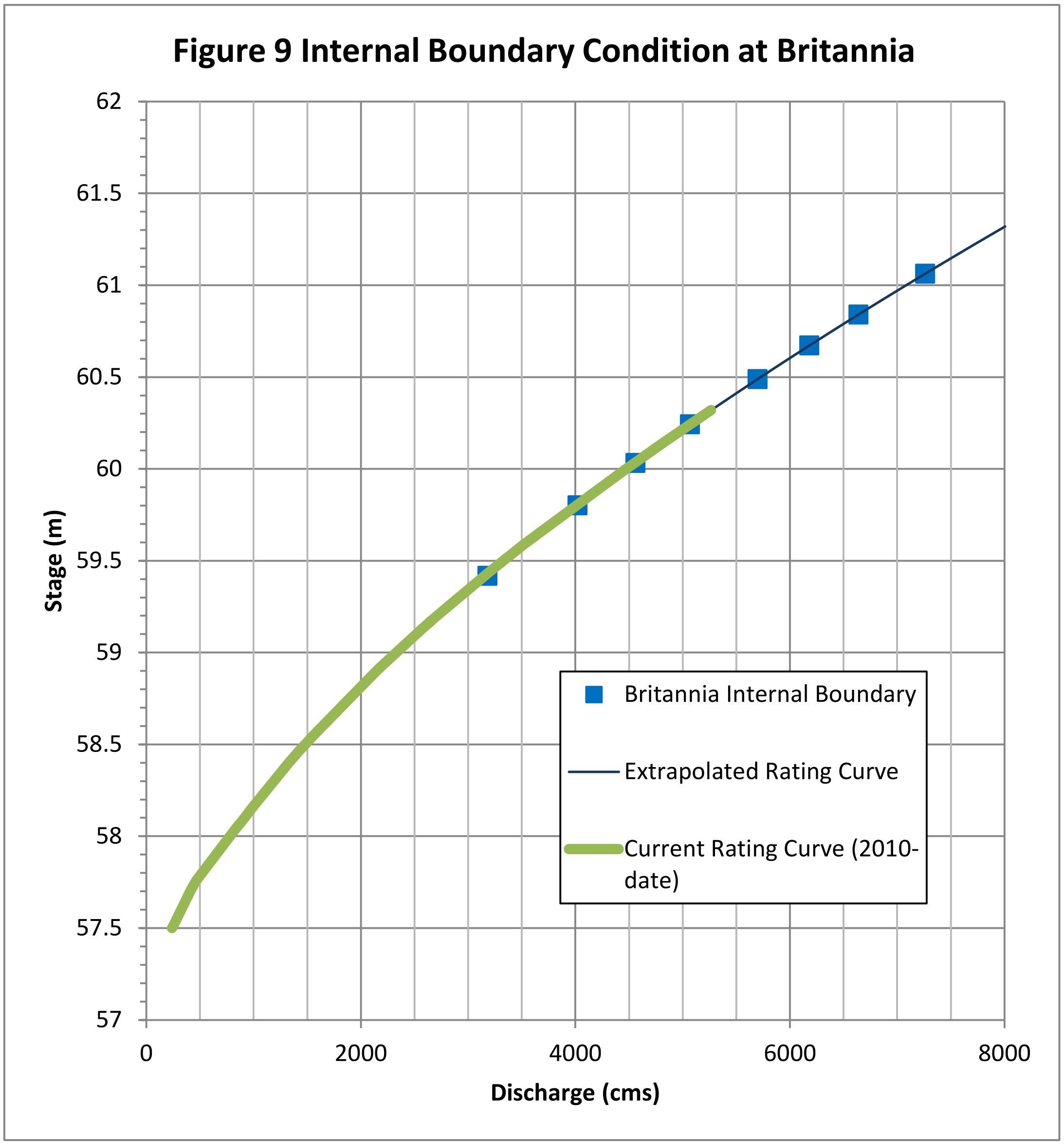
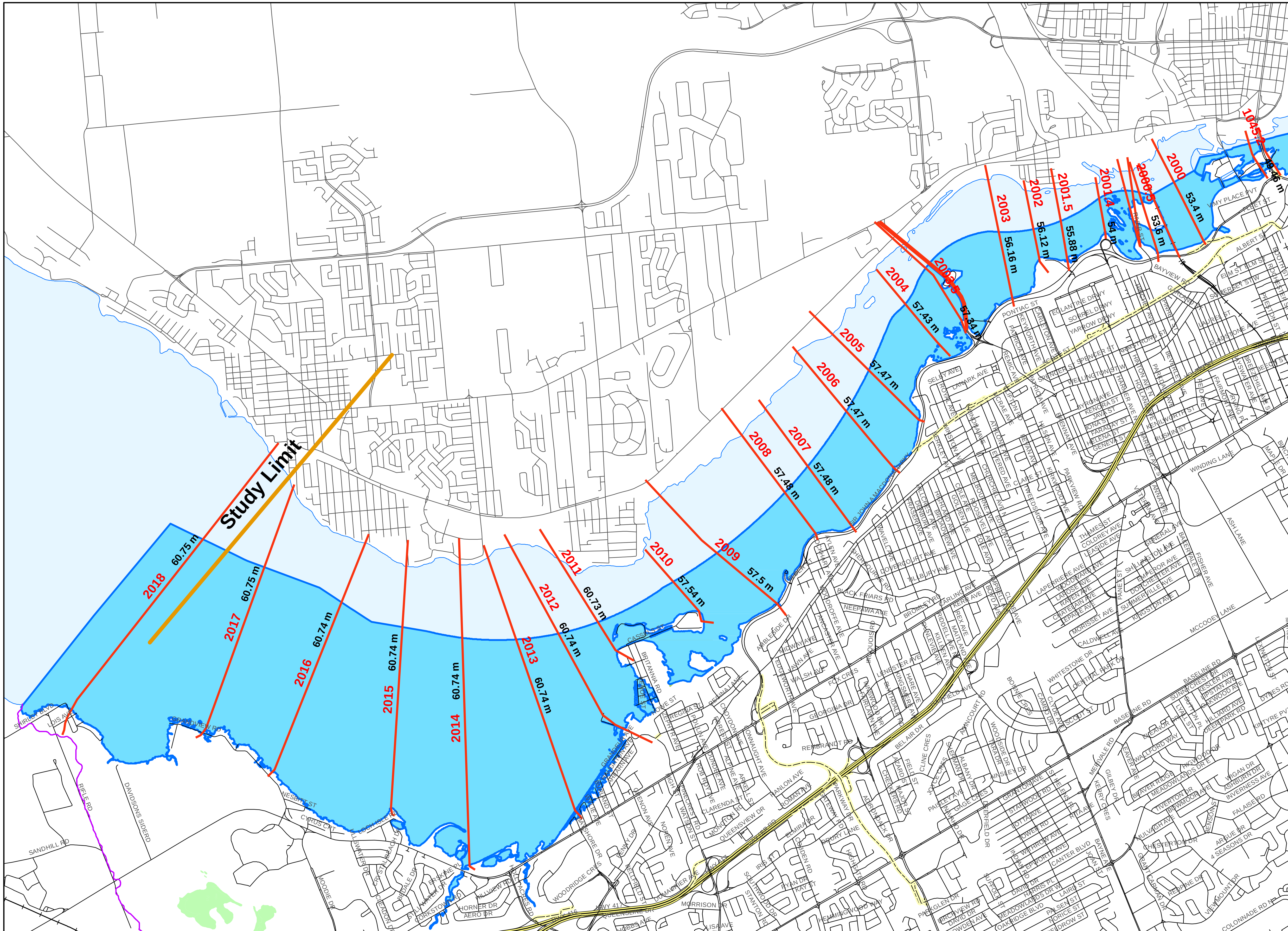
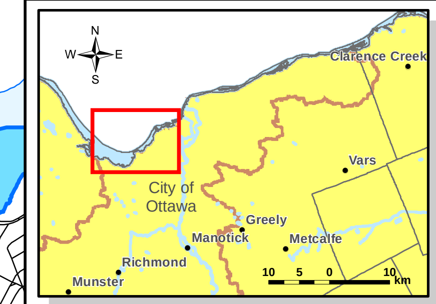


Figure 9 Internal Boundary Condition at Britannia
62
61.5
61
60.5
60
59.5
59
58.5
58
57.5
57
Stage (m)
0
2000
4000
6000
8000
Discharge (cms)
Britannia Internal Boundary
Extrapolated Rating Curve
Current Rating Curve (2010-date)



Ottawa River
Flood Plain Mapping
Figure 10a



Roads

- Freeway
- Road
- Rapid Transit
- Railway
- RVCA Boundary
- Ottawa River Flood Plain
- Ottawa River

Evaluated Wetlands

- Provincially Significant
- Other

Cross-Section	Regulatory Flood Level
2018	60.57 m

RIDEAU VALLEY CONSERVATION AUTHORITY

Map Scale: 1:40,000

Projection note: U.T.M. Zone 18 - NAD 83 Datum

File Location:

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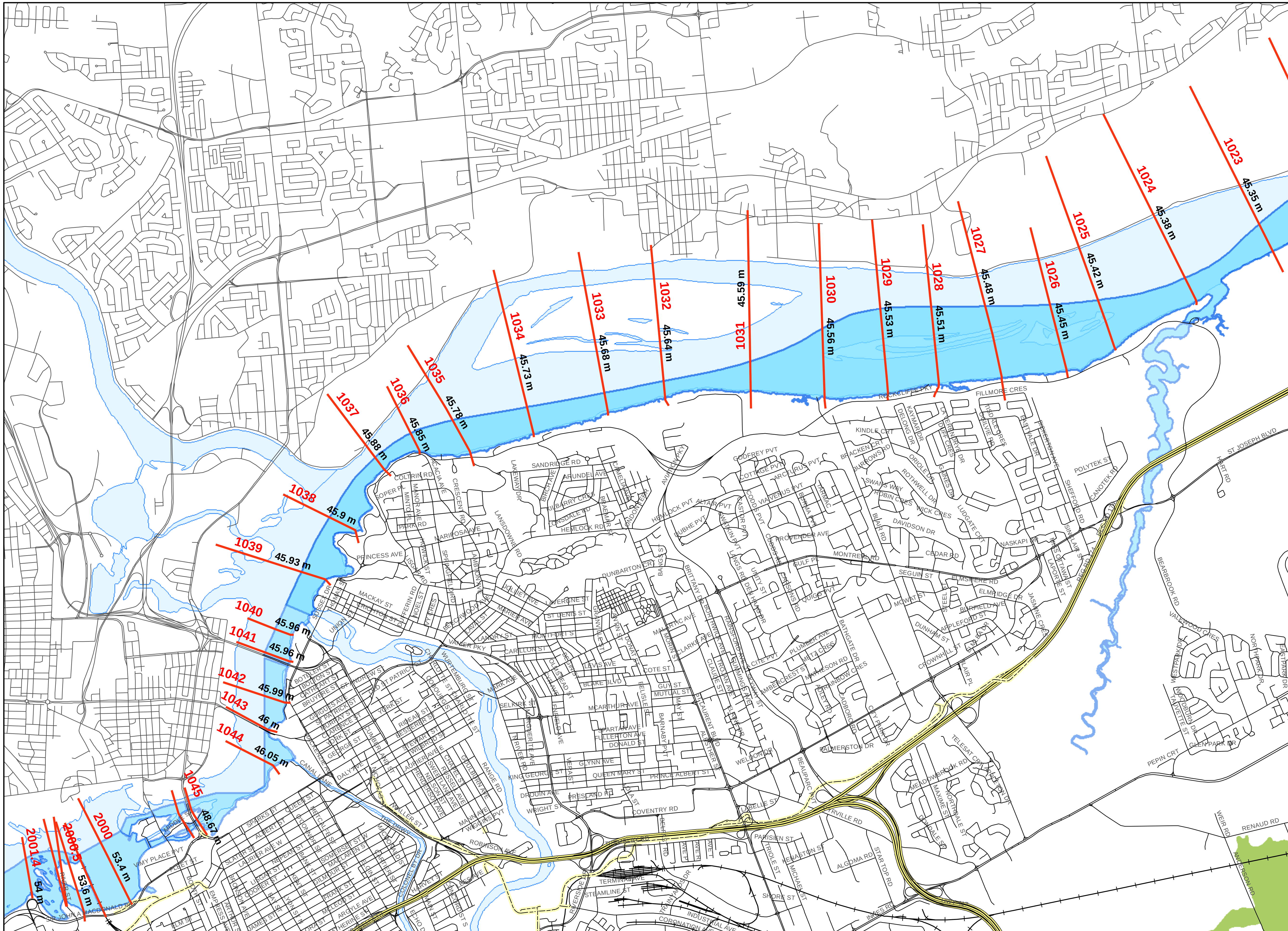
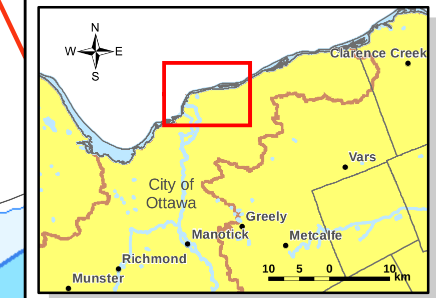
500 250 0 500 1,000 Meters

Ottawa River
Flood Plain Mapping
Figure 10b





Roads

- Freeway
- Road
- Rapid Transit
- Railway
- Ottawa River Flood Plain
- Ottawa River

Evaluated Wetlands

- Provincially Significant
- Other

Cross-Section	Regulatory Flood Level
2018	60.57 m

RIDEAU VALLEY CONSERVATION AUTHORITY

Map Scale: 1:40,000

N W E S

Projection note: U.T.M. Zone 18 - NAD 83 Datum

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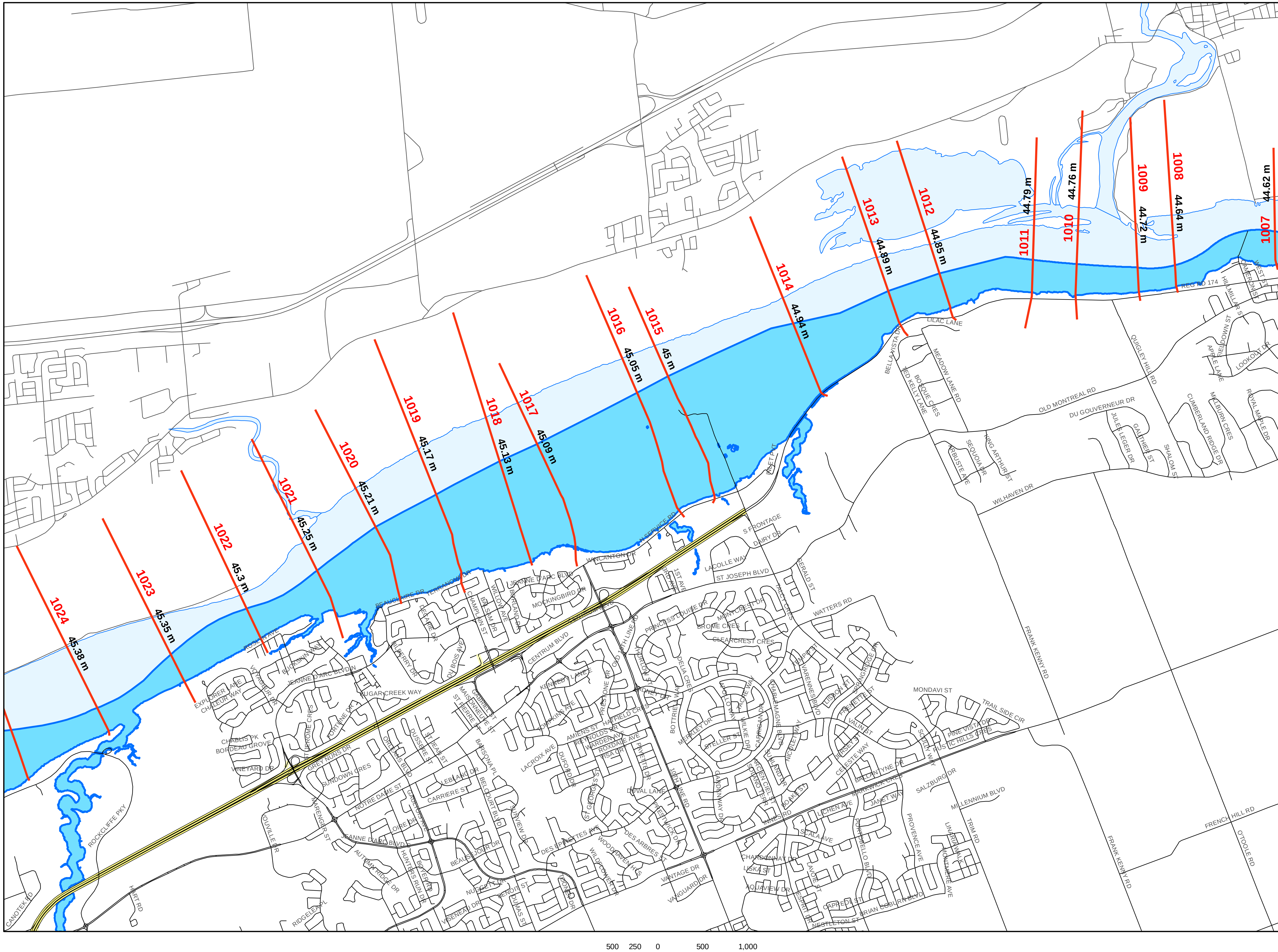
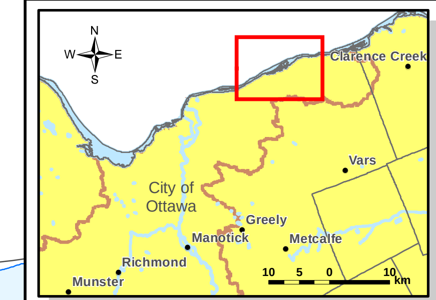
500 250 0 500 1,000
Meters

Ottawa River Flood Plain Mapping
Figure 10c





Roads

- Freeway
- Road
- Rapid Transit
- Railway
- Ottawa River
- Ottawa Flood Plain

Evaluated Wetlands

- Provincially Significant
- Other

Cross-Section	Regulatory Flood Level
2018	60.57 m

RIDEAU VALLEY CONSERVATION AUTHORITY

Map Scale: 1:40,000

Projection note: U.T.M. Zone 18 - NAD 83 Datum

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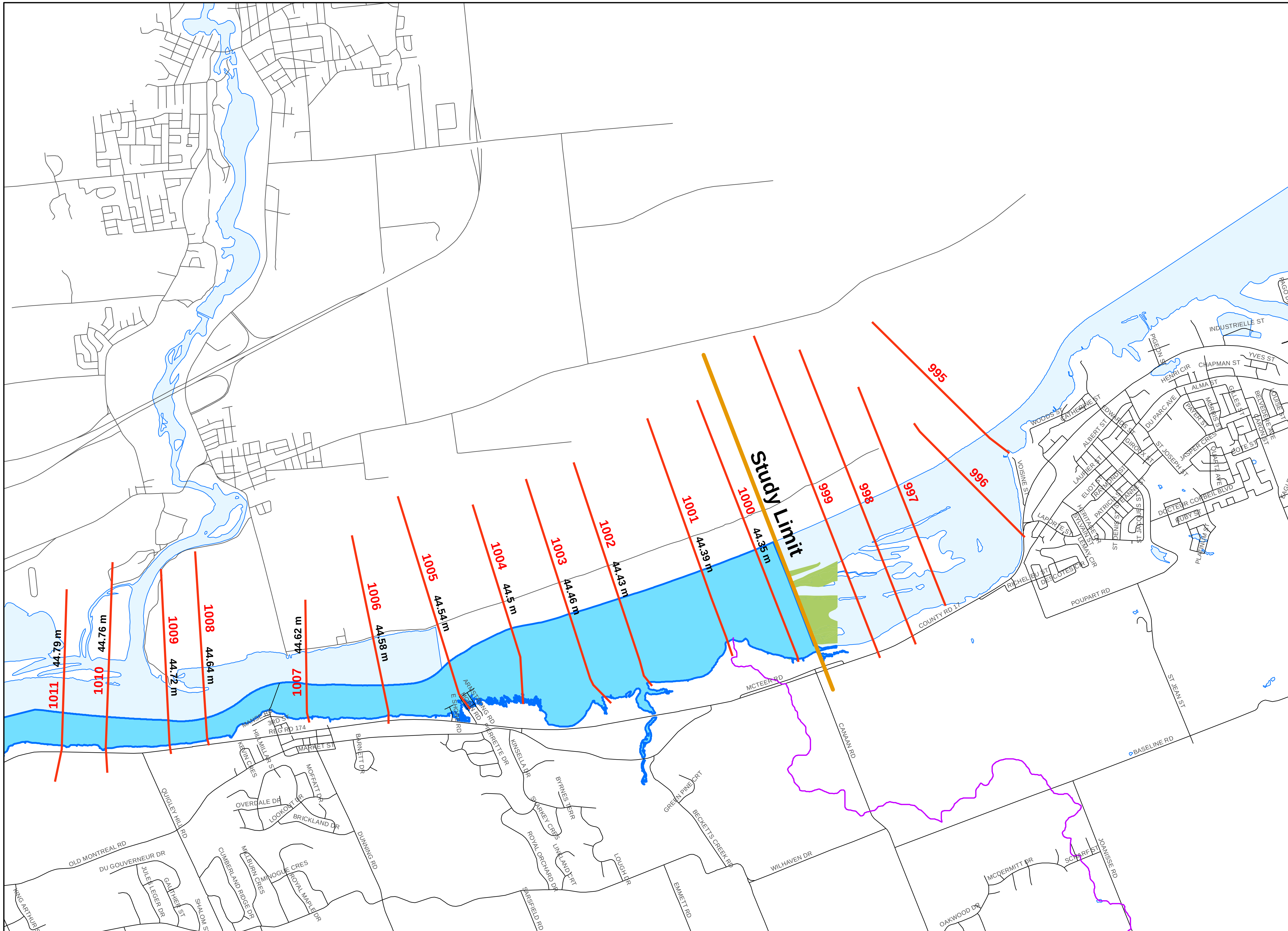
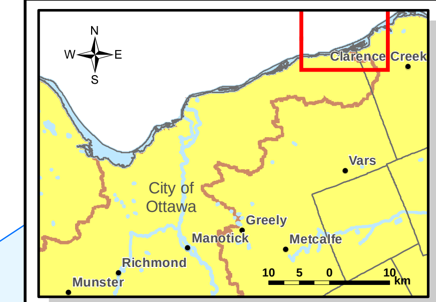
Ottawa River Flood Plain Mapping
Figure 10d





Roads

- Freeway
- Road
- Rapid Transit
- Railway
- RVCA Boundary
- Ottawa River
- Ottawa Flood Plain

Evaluated Wetlands

- Provincially Significant
- Other

Cross-Section 2018

Regulatory Flood Level 60.57 m

RIDEAU VALLEY CONSERVATION AUTHORITY

Map Scale: 1:40,000

Projection note: U.T.M. Zone 18 - NAD 83 Datum

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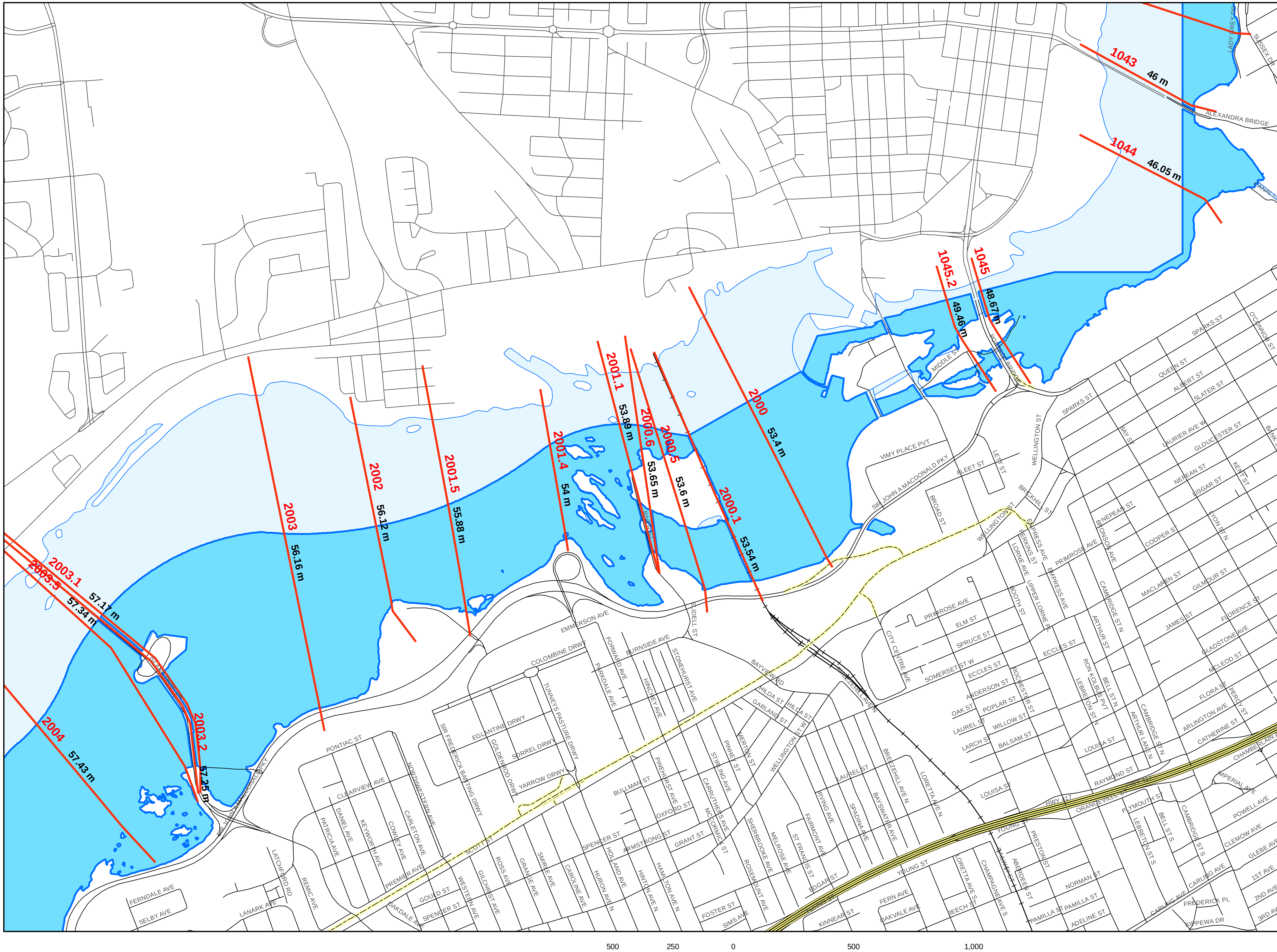
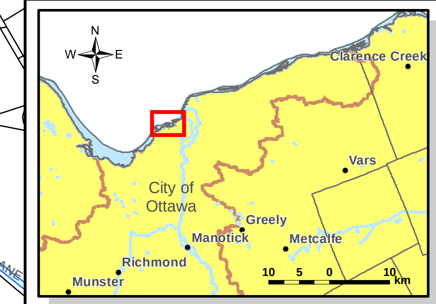
500 250 0 500 1,000 Meters



500 250 0 500 1,000 Meters

Ottawa River Flood Plain Mapping
Figure 10e



Roads
- Freeway
- Road
- Rapid Transit
- Railway
- Ottawa River
- Ottawa River Flood Plain

Evaluated Wetlands
- Provincially Significant
- Other

Cross-Section	Regulatory Flood Level
2018	60.57 m

RIDEAU VALLEY CONSERVATION AUTHORITY

Map Scale: 1:15,000

Projection note: U.T.M. Zone 18 - NAD 83 Datum

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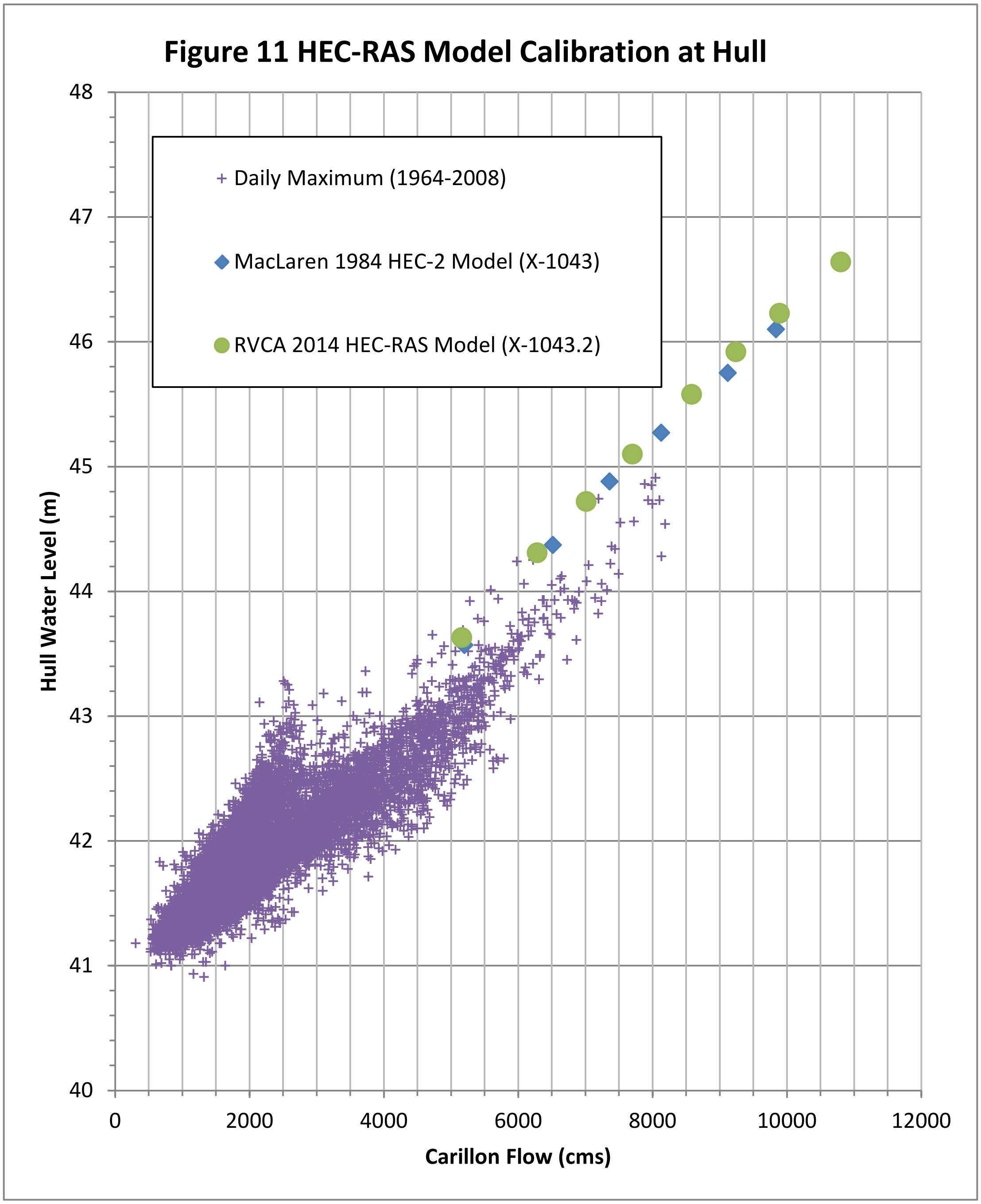


Figure 11 HEC-RAS Model Calibration at Hull
Daily Maximum (1964-2008)
MacLaren 1984 HEC-2 Model (X-1043)
RVCA 2014 HEC-RAS Model (X-1043.2)
Hull Water Level (m)
Carillon Flow (cms)
48
47
46
45
44
43
42
41
40
0
2000
4000
6000
8000
10000
12000

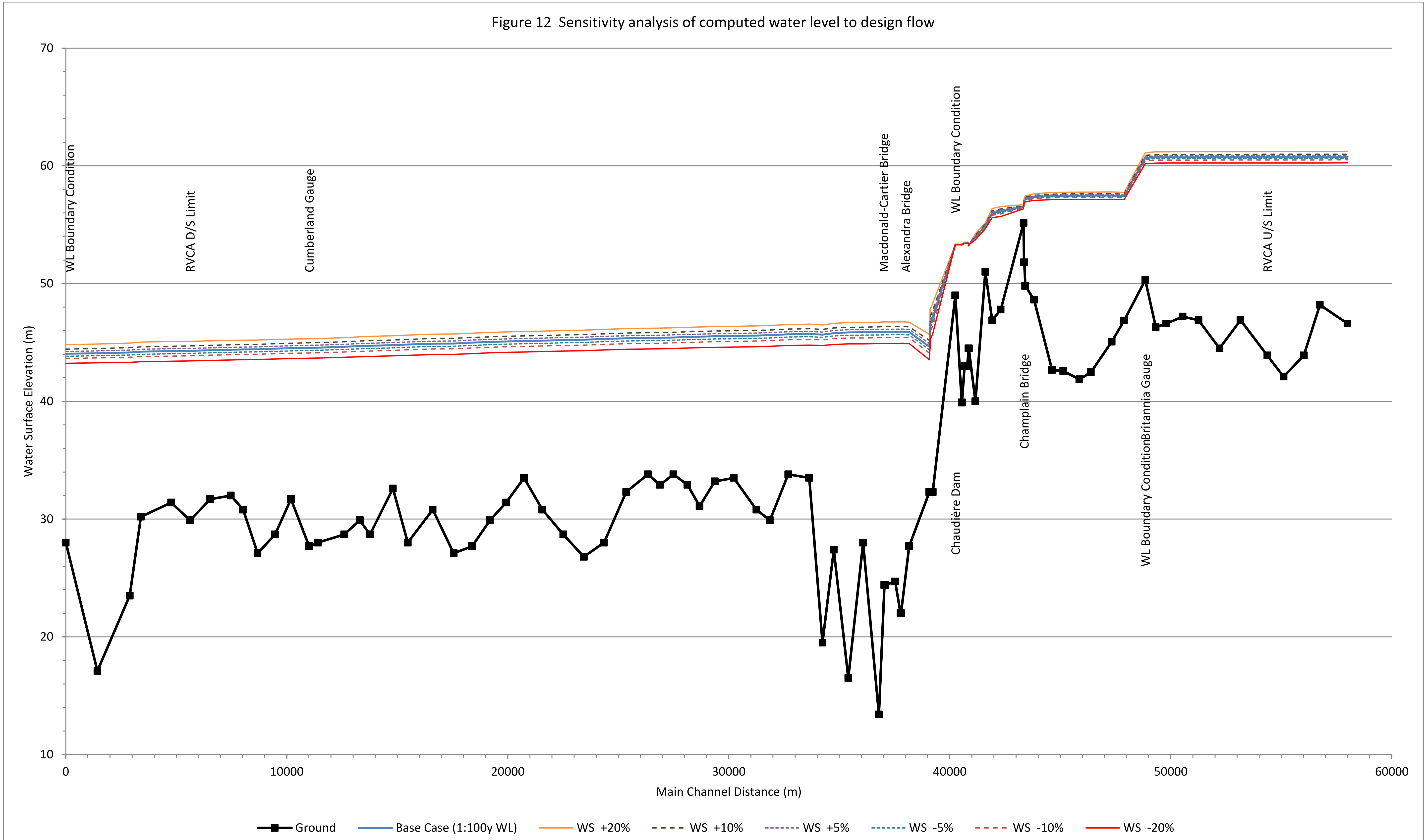


Figure 12 Sensitivity analysis of computed water level to design flow
Water Surface Elevation (m)
Main Channel Distance (m)
70
60
50
40
30
20
10
0
10000
20000
30000
40000
50000
60000
WL Boundary Condition
RVCA D/S Limit
Cumberland Gauge
Macdonald-Cartier Bridge
Alexandra Bridge
WL Boundary Condition
Chaudière Dam
Champlain Bridge
WL Boundary Condition
Britannia Gauge
RVCA U/S Limit
Ground
Base Case (1:100y WL)
WS +20%
WS +10%
WS +5%
WS -5%
WS -10%
WS -20%

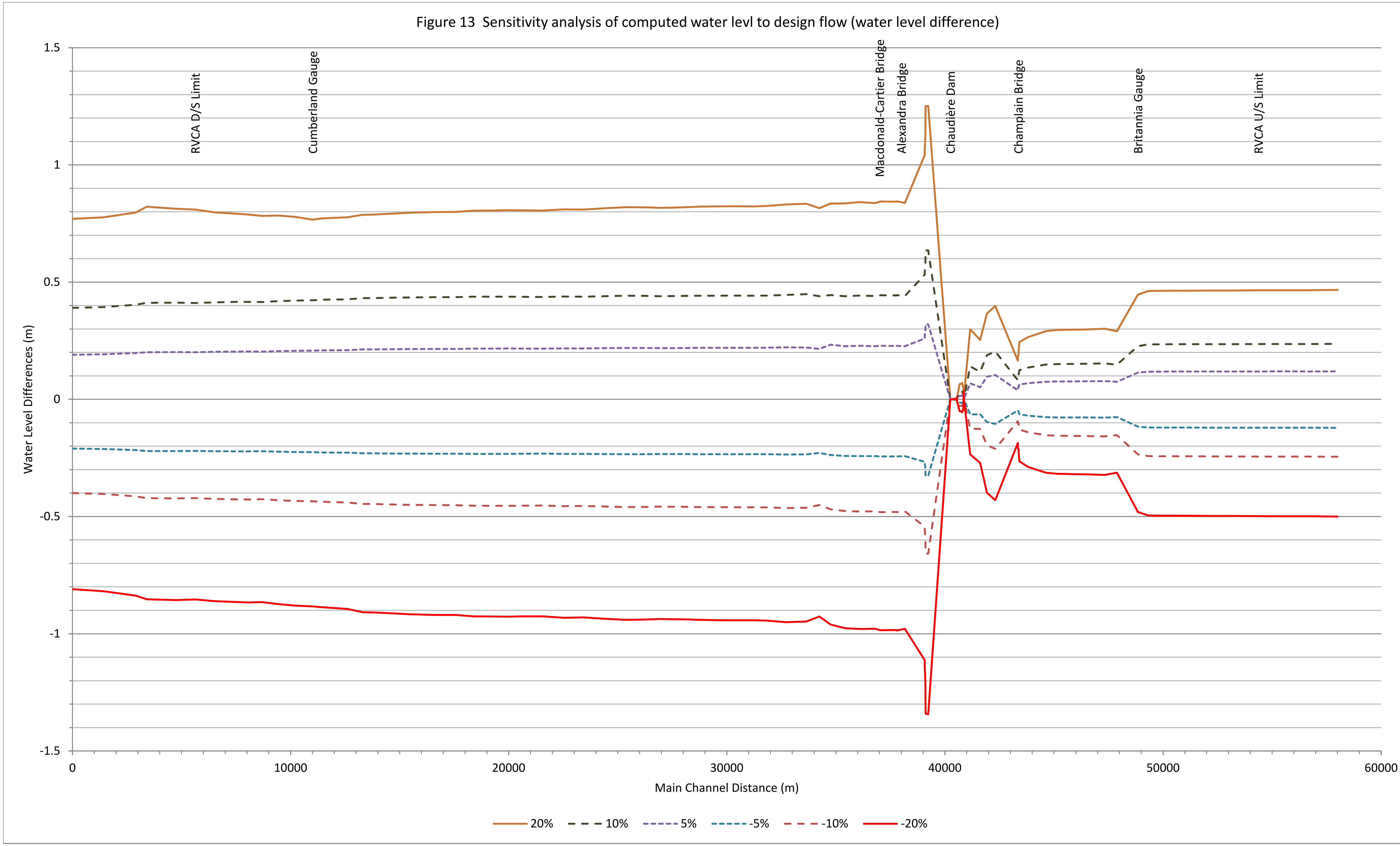
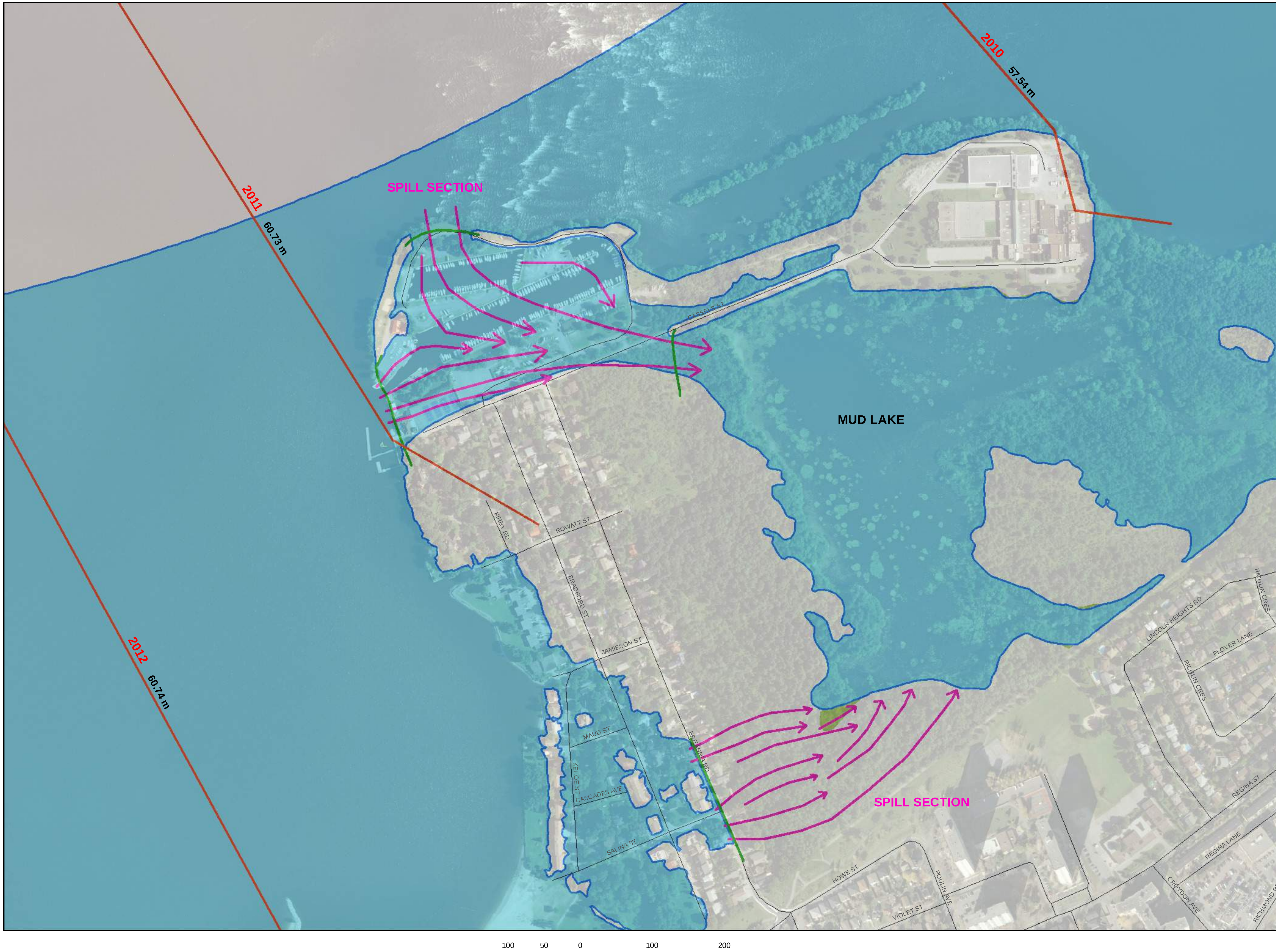
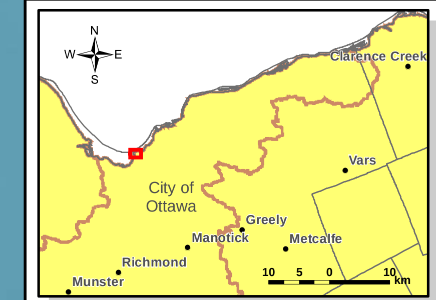


Figure 13 Sensitivity analysis of computed water levl to design flow (water level difference)
Water Level Differences (m)
Main Channel Distance (m)
RVCA D/S Limit
Cumberland Gauge
Macdonald-Cartier Bridge
Alexandra Bridge
Chaudière Dam
Champlain Bridge
Britannia Gauge
RVCA U/S Limit
1.5
1
0.5
0
-0.5
-1
-1.5
0
10000
20000
30000
40000
50000
60000
20%
10%
5%
-5%
-10%
-20%

Ottawa River
Britannia Village
Figure 14





Roads

- Freeway
- Road
- Rapid Transit
- SpillSectionLine
- Railway
- RVCA Boundary
- Ottawa Flood Plain

Evaluated Wetlands

- Provincially Significant
- Other

Cross-Section	Regulatory Flood Level
2018	60.57 m

RIDEAU VALLEY CONSERVATION AUTHORITY

Map Scale: 1:5,000

Projection note: U.T.M. Zone 18 - NAD 83 Datum

File Location: Z:\Mapping\MXDs\FPM\OttawaRiver\OttawaFPM_Fig14

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Appendix A

Statistical Analysis of Flow Data

Introduction

Before working with historical flow rate data obtained from various sources, it is important to analyze the data to determine its statistical suitability for use in estimating long-term processes in the watercourse. The statistical tests used in this study repeat those done in the previous Ottawa River flood plain mapping study (MacLaren, 1984). These tests were repeated for two reasons; first, the software used to complete the tests is no longer available and a new implementation of the functions had to be used and, second, the tests used are common in hydrologic analysis (McCuen, 2003).

To complete the tests a combination of coded and built-in functions were used in R (R Core Team, 2012), a language for statistical computing that is used widely in financial, data analysis and life science companies, as well as universities. The user base of the language is expanding and the base statistical components have been used and improved since around 1999. The R language is based on the older S and S-plus languages, also statistical computing languages.

The MacLaren (1984) study used a software program from Environment Canada called NONPARA that provided the following tests:

1. Spearman Rank Order Serial Correlation Coefficient test for independence,
2. Spearman Rank Order Correlation Coefficient test for trend,
3. Mann-Whitney split sample test for homogeneity,
4. Wald-Wolfowitz split sample test for homogeneity, and
5. Runs above and below the median for general randomness.

These tests and other similar tests are suggested in current literature (Machiwal and Jha, 2012; Maidment, 1992; McCuen, 2003), and additional statistical tests will be discussed below. The remainder of this appendix will cover documentation for the R code written for the functions that were not available followed by a comparison of R results to the 1984 report and results from the current study.

R documentation

Spearman Rank Order Serial Correlation Coefficient

An implementation of the Spearman Rank Order Serial Correlation Coefficient (SROSC) was written based on steps outlined in Appendix B of the 1984 study (MacLaren, 1984). This test is nonparametric and it checks whether the sample is serially independent, i.e., one year's annual maximum does not influence the following year's annual maximum. The SROSC function is written in the file *SROSC.R* and the steps are explained in comments.

Spearman Rank Order Correlation Coefficient

The Spearman Rank Order Correlation Coefficient (SROC) is available as a function in the 'stats' package in R (R Core Team, 2012). SROC is a nonparametric test that tests for positive trend. An alternative test is the Pearson R which is a parametric test for positive or negative trend. However, using a parametric test that assumes an underlying normal distribution may not be a good choice for examining a time series of extreme values. Another implementation of SROC was written in the *SROC.R* file with appropriate commentary. This alternative implementation preserves the sign of the Spearman *rho* statistic.

Mann-Whitney

The Mann-Whitney test is used to examine whether subsamples are homogeneous or whether a long-term record should be split into shorter periods. It is a nonparametric test and is written in *MannWhitney.R* based on McCuen (2003).

Wald-Wolfowitz

The Wald-Wolfowitz test is used to determine if two samples were drawn from the same continuous population. This function is programmed based on a discussion in McCuen (2003). The function is written in *WaldWolfowitz.R* and is explained in comments.

Runs Above/Below the Median

Runs above and below the median (RunAB) is a test for general randomness within a sample. The median is used because the probability of being above or below is

0.5 for any probability distribution (MacLaren, 1984). A function for this test was written in R based on the steps listed in Appendix B of the 1984 study (MacLaren, 1984), and is found in *RunABz.R* with explanations in comments.

Discussion of Statistical Test on MacLaren's 1984 Report Data

The five tests above were performed using R and some were done manually to check deviations from MacLaren's reported values. The reported and replicated values are reported in Table A1, and are discussed below. The input data for the replication tests was the Chats Falls annual maximum daily flow series from 1915 to 1980 (n = 66). All these tests except SROSC were done by MacLaren using an edited data set with some flow rate values increased by 1 to avoid ties in rank (see Appendix A table in 1984 report (MacLaren, 1984). The SROSC test was done using actual data with tied ranks for 9 pairs of records.

Table A1 - Comparison of Results

Test	Reported MacLaren (1984)	Replicated RVCA (2013)	Notes
SROSC	-0.173	-0.17365096	DF=63
SROC	-0.250	-0.02498695	DF=64
Mann-Whitney	-0.180	-0.18028906	N1=36 N2=30
Wald-Wolfowitz	-0.057	-0.05686339	
RunAB	0.000	0.00000000	N1=33 N2=33

Note: DF – degrees of freedom, N1 and N2 are sub-sample sizes

Deviations in all the calculated values can be attributed to carrying more digits through the calculations in the math processing used in current computers. The small deviations do not affect the test statistics computed and the replicated values provide the same results in hypothesis testing as the reported statistics.

Spearman Rank Order Serial Correlation

SROSC test results from R provided a value 0.001 more negative than the reported value. Based on the hypothesis test, at significance level (α) of 0.05, the samples are from the same population:

H_0: The two independent samples are drawn from the same population.

H_A: The two independent samples are not drawn from the same population.

This is done as a one-sided test and the test t produced by the test should be less than t_α to reject H_0 with N-3 degrees of freedom.

Spearman Rank Order Correlation

SROC produced the same result, adjusted for rounding as reported. Based on the hypothesis test, at $\alpha = 0.05$ level, the samples are from the same population:

H_0: The two independent samples are drawn from the same population.

H_A: The two independent samples are not drawn from the same population.

This is a two-sided test and the test t produced by the test must be less than $-t_{\alpha/2}$ or greater than $t_{\alpha/2}$ to reject H_0 with N-2 degrees of freedom.

Mann-Whitney

Mann-Whitney, as coded, produced the same result as the reported values. Based on the hypothesis test, at $\alpha = 0.05$ level, the samples are from the same population:

H_0: The two independent samples are drawn from the same population.

H_A: The two independent samples are not drawn from the same population.

This is a one-sided test and the test Z produced by the test should be less than to Z_α to reject H_0.

Wald-Wolfowitz

The Wald-Wolfowitz implementation as written matched the reported values when rounded to the same number of significant digits. Based on the hypothesis test, at $\alpha = 0.05$ level, the samples are from the same population:

H_0: The two independent samples are drawn from the same population.

H_A: The two independent samples are not drawn from the same population.

This is a one-sided test and the test Z produced must be great than Z_α to reject H_0.

Wald-Wolfowitz is also implemented as part of the ‘adehabitat’ package (Calenge, 2006), but the behaviour of the function with respect to ties in rank did not provide the expected results from the 1984 study or manual calculations.

Runs Above or Below the Median

RunAB produced the same results in R as reported. Based on the hypothesis test, at $\alpha = 0.05$ level, the samples are from the same population:

H_0: The two independent samples are drawn from the same population.

H_A: The two independent samples are not drawn from the same population.

This is a two-sided test and the test Z produced by the test must be less than $-Z_{\alpha/2}$ or greater than $Z_{\alpha/2}$ to reject H_0.

Current Study

Table A2 shows the results of the above tests performed on the full record of data currently available using annual maximum daily flow series at each gauge. It was found that all three records were independent, without trend, homogeneous and random at a 5% significance level, and therefore could be used in flood frequency analysis without further adjustment.

Summary

The functions used in R to reproduce the statistical tests from MacLaren's 1984 study performed well and provided close matches to reported results. The functions were written using guidance from McCuen (2003) and Appendix B of MacLaren (1984), which is a description of the NONPARA software from Environment Canada. The R script files can be used to perform statistical analysis of historical flow rate or level data. Output files for the replication test and current study can be found in Appendix B.

Table A2 Statistical Results for Current Study

Spearman Rank Order Serial Correlation

Sample	S	t value	critical t	DF	Reject H_0
Carillon 1933-2012	-0.0210296	-0.1833724	1.67	76	no
Britannia 1961-2012	0.1711842	1.216242	1.68	49	no
Chats Falls 1915-2012	-0.08492193	-0.8307175	1.661	95	no

Spearman Rank Order Correlation

Sample	S	t value	critical t	DF	Reject H_0
Carillon 1933-2012	0.1103457	0.9742286	±1.99	77	no
Britannia 1961-2012	-0.07165116	-0.5079558	±2.008	50	no
Chats Falls 1915-2012	0.1137336	1.121635	±1.985	96	no

Mann-Whitney split sample (1950 - 1980, 1981 - 2012)

Sample	z-value	critical z	Reject H_0
Carillon 1933-2012	-0.6479516	-1.645	no
Britannia 1961-2012	-0.009404435		no
Chats Falls 1915-2012	-1.051735		no

Wald-Wolfowitz split sample (1950 - 1980, 1981 - 2012)

Sample	z-value	critical z	Reject H_0
Carillon 1933-2012	0.6492188	1.645	no
Britannia 1961-2012	0.03417686		no
Chats Falls 1915-2012	0.7602785		no

Runs above/below Median

Sample	z-value	critical z	Reject H_0
Carillon 1933-2012	0.2340349	±1.96	no
Britannia 1961-2012	0.3845385		no
Chats Falls 1915-2012	0		no

Appendix B

R Output Files

R Output for Replication Run (run 2012-12-06)

```
> # Run tests from 1984 study
>
> # Import data cf84 is edited data (no ties), oldCF is actual data (w/
ties)
> cf84 <- read.csv("chats1984.csv")
> oldCF <- subset(read.csv("chatspeaks.csv"), Year <1981)
>
> # Assign ranks to data
> cf84$rank <- (length(cf84$MaxDaily) +1 - rank(cf84$MaxDaily))
> oldCF$rank <- (length(oldCF$MaxDaily) +1 - rank(oldCF$MaxDaily,
ties.method="average"))
>
> # Split sample at 1950 break point
> cf84.1 <- subset(cf84, Year <1951)
> cf84.2 <- subset(cf84, Year >1950)
>
>
> # Spearman Rank Order Serial Correlation
> SROSC(oldCF$MaxDaily)
N =  66
S = -0.173651
 degrees of freedom = 63
 p-value =  0.1665455
 t_s =[1] -1.399575
>
> # Spearman Rank Order Correlation
> SROC(cf84$MaxDaily)
r_s = -0.02498695
 degrees of freedom = 64
 p-value =  0.8421474
 t_s =[1] -0.1999581
>
> # Mann-Whitney split sample test for homogeneity
> # Using split in sample from above
> MannWhitney(cf84.1$rank,cf84.2$rank)
U =  526
 p-value = 0.8569256
 z =[1] -0.1802891
>
> #Wald-Wolfowitz split sample test for homogeneity
> WaldWolfowitz(cf84.1$MaxDaily,cf84.2$MaxDaily)
33.72727 3.99682
Runs =  34
 p-value = 0.954654
 z = [1] -0.05686339
>
> # Run Above and Below the Median for general randomness
> RunABz(cf84$MaxDaily)
nA = 33
 nB = 33
 Runs =  34
 p-value = 1
 z =[1]
```

R Output for Carillon (1933-2012) (run 2012-12-06)

```
> # Grenville/Carillon for all data
> # Run using R 2.15.2 and RStudio 0.97.248
>
> # Import data
> GC <- subset(read.csv("data\\GrenCari1933-2012.csv"))
>
> # Assign ranks to data
> GC$rank <- (length(GC$MaxDaily) +1 - rank(GC$MaxDaily,
ties.method="average"))
>
> # Scenario 1: Split sample at 1950 break point, all data
> GC.1 <- subset(GC, Year <1951)
> GC.2 <- subset(GC, Year >1950)
>
> # Spearman Rank Order Serial Correlation
> SROSC(GC$MaxDaily)
N =  79
S = -0.0210296
 degrees of freedom = 76
 p-value =  0.8549942
 t_95%= 1.665151
 t_s =[1] -0.1833724
>
> # Spearman Rank Order Correlation
> SROC(GC$MaxDaily)
r_s = 0.1103457
 degrees of freedom = 77
 p-value =  0.3329937
 t_5% = -1.991254
 t_s =[1] 0.9742286
>
> # Mann-Whitney split sample test for homogeneity
> # Using split in Scenario 1
> MannWhitney(GC.1$rank,GC.2$rank)
U =  530
 p-value = 0.8242561
 z =[1] -0.2220742
>
> #Wald-Wolfowitz split sample test for homogeneity
> # Using split in Scenario 1
> WaldWolfowitz(GC.1$MaxDaily,GC.2$MaxDaily)
Runs =  31
 p-value = 0.5816846
 z = [1] 0.5509256
>
> # Run Above and Below the Median for general randomness
> RunABz(GC$MaxDaily)
nA = 39
 nB = 40
 Runs =  34
 p-value = 0.8149579
 z =[1] 0.2340349
>
>
> # Scenario 2: Split sample at 1980 break point using 1950-2012 data
> subGC <- subset(GC, Year > 1949)
> subGC$rank <- (length(subGC$MaxDaily) +1 - rank(subGC$MaxDaily,
ties.method="average"))
>
> GC.3 <- subset(subGC, Year <1981)
```

```
> GC.4 <- subset(subGC, Year >1980)
>
> # Mann-Whitney split sample test for homogeneity
> # Using split in Scenario 2
> MannWhitney(GC.3$rank,GC.4$rank)
U =  434
 p-value = 0.5170163
 z =[1] -0.6479516
>
> #Wald-Wolfowitz split sample test for homogeneity
> # Using split in Scenario 2
> WaldWolfowitz(GC.3$MaxDaily,GC.4$MaxDaily)
Runs =  35
 p-value = 0.5161969
 z = [1] 0.6492188
```

R Output for Britannia (1961-2012) (run 2012-12-06)

```
> # Britannia for all data
> # Run using R 2.15.2 and RStudio 0.97.248
>
> # Import data
> BB <- subset(read.csv("data\\Britannia1961-2012.csv"))
>
> # Assign ranks to data
> BB$rank <- (length(BB$MaxDaily) +1 - rank(BB$MaxDaily,
ties.method="average"))
>
> # Scenario 2: Split sample at 1980 break point using 1950-2012 data
> BB.3 <- subset(BB, Year <1981)
> BB.3 <- subset(BB.3, Year >1949)
> BB.4 <- subset(BB, Year >1980)
>
> # Spearman Rank Order Serial Correlation
> SROSC(BB$MaxDaily)
N =  52
S = 0.1711842
 degrees of freedom = 49
 p-value =  0.2297192
 t_95%= 1.676551
 t_s =[1] 1.216242
>
> # Spearman Rank Order Correlation
> SROC(BB$MaxDaily)
r_s = -0.07165116
 degrees of freedom = 50
 p-value =  0.613718
 t_5% = -2.008559
 t_s =[1] -0.5079558
>
> # Mann-Whitney split sample test for homogeneity
> # Using split in Scenario 2
> MannWhitney(BB.3$rank,BB.4$rank)
U =  319.5
 p-value = 0.9924965
 z =[1] -0.009404435
>
> #Wald-Wolfowitz split sample test for homogeneity
> # Using split in Scenario 2
> WaldWolfowitz(BB.3$MaxDaily,BB.4$MaxDaily)
Runs =  25
 p-value = 0.9727361
```

```
 z = [1] 0.03417686
>
> # Run Above and Below the Median for general randomness
> RunABz(BB$MaxDaily)
nA = 26
 nB = 26
 Runs =  20
 p-value = 0.7005794
 z =[1] 0.3845385
```

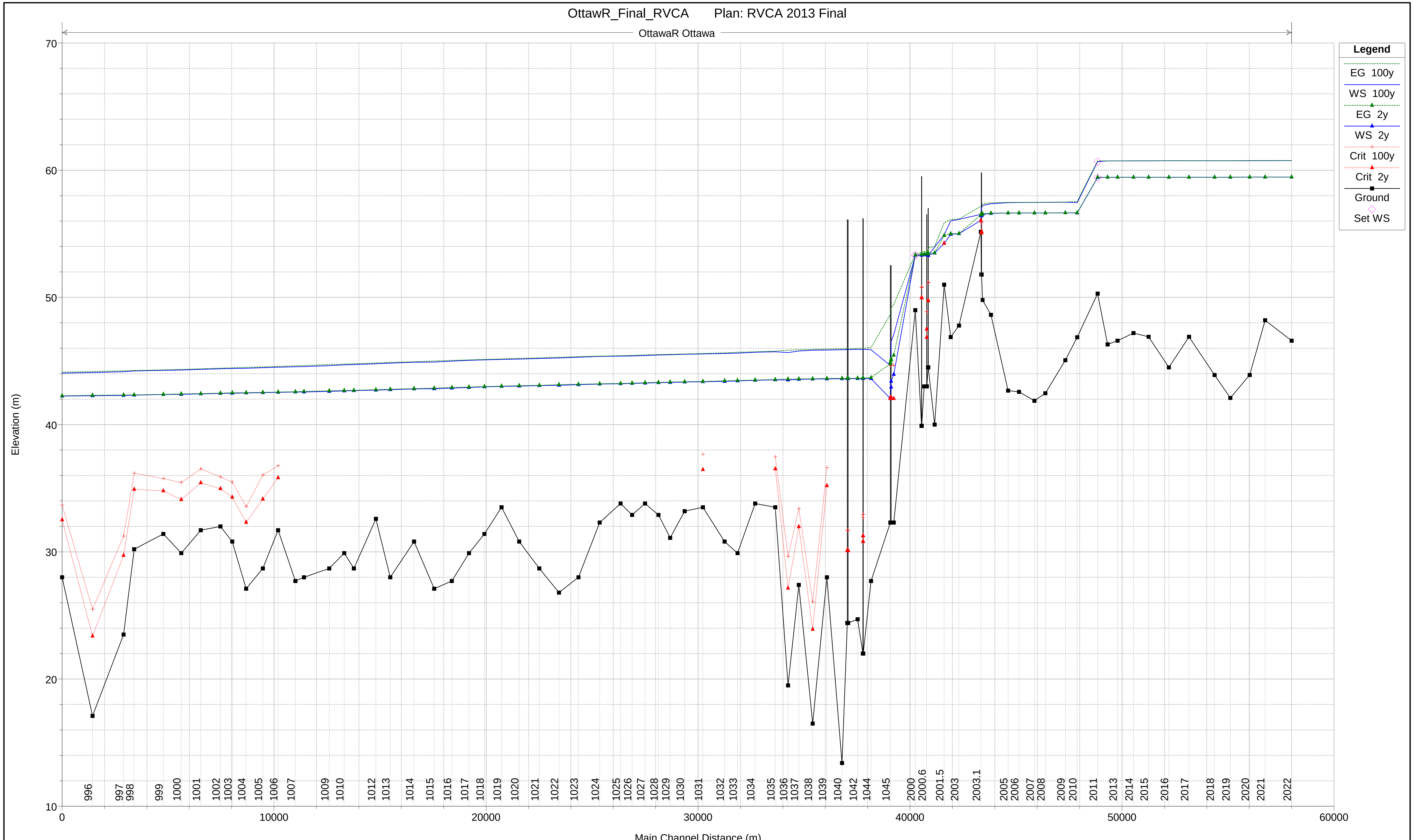
R Output for Chats Falls (1915-2012) (run 2012-12-06)

```
> # Chats Falls all data
> # Run using R 2.15.2 and RStudio 0.97.248
>
> # Import data CF is edited data (no ties), CF is actual data (w/
ties)
> CF <- subset(read.csv("data\\chatspeaks.csv"))
>
> # Assign ranks to data
> CF$rank <- (length(CF$MaxDaily) +1 - rank(CF$MaxDaily,
ties.method="average"))
>
> # Scenario 1: Split sample at 1950 break point, all data
> CF.1 <- subset(CF, Year <1951)
> CF.2 <- subset(CF, Year >1950)
>
> # Spearman Rank Order Serial Correlation
> SROSC(CF$MaxDaily)
N =  98
S = -0.08492193
 degrees of freedom = 95
 p-value =  0.4082162
 t_95%= 1.661052
 t_s =[1] -0.8307175
>
> # Spearman Rank Order Correlation
> SROC(CF$MaxDaily)
r_s = 0.1137336
 degrees of freedom = 96
 p-value =  0.2648154
 t_5% = -1.984984
 t_s =[1] 1.121635
>
> # Mann-Whitney split sample test for homogeneity
> # Using split in Scenario 1
> MannWhitney(CF.1$rank,CF.2$rank)
U =  989.5
 p-value = 0.351225
 z =[1] -0.9322158
>
> #Wald-Wolfowitz split sample test for homogeneity
> # Using split in Scenario 1
> WaldWolfowitz(CF.1$MaxDaily,CF.2$MaxDaily)
Runs =  40
 p-value = 0.1858589
 z = [1] 1.322929
>
> # Run Above and Below the Median for general randomness
> RunABz(CF$MaxDaily)
nA = 49
 nB = 49
```

```
 Runs =  50
 p-value = 1
 z =[1] 0
>
> # Scenario 2: Split sample at 1980 break point using 1950-2012 data
> subCF <- subset(CF, Year > 1949)
> subCF$rank <- (length(subCF$MaxDaily) +1 - rank(subCF$MaxDaily,
ties.method="average"))
>
> CF.3 <- subset(subCF, Year <1981)
> CF.4 <- subset(subCF, Year >1980)
>
> # Mann-Whitney split sample test for homogeneity
> # Using split in Scenario 2
> MannWhitney(CF.3$rank,CF.4$rank)
U =  419.5
 p-value = 0.2929213
 z =[1] -1.051735
>
> #Wald-Wolfowitz split sample test for homogeneity
> # Using split in Scenario 2
> WaldWolfowitz(CF.3$MaxDaily,CF.4$MaxDaily)
Runs =  29
 p-value = 0.4470882
 z = [1] 0.7602785
```

Appendix C

HEC-RAS Profiles and Cross-Sections


OttawR_Final_RVCA Plan: RVCA 2013 Final
OttawaR Ottawa
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Set WS
Elevation (m)
Main Channel Distance (m)
0
10000
20000
30000
40000
50000
60000
10
20
30
40
50
60
70
996
997
998
999
1000
1001
1002
1003
1004
1005
1006
1007
1009
1010
1012
1013
1014
1015
1016
1017
1018
1019
1020
1021
1022
1023
1024
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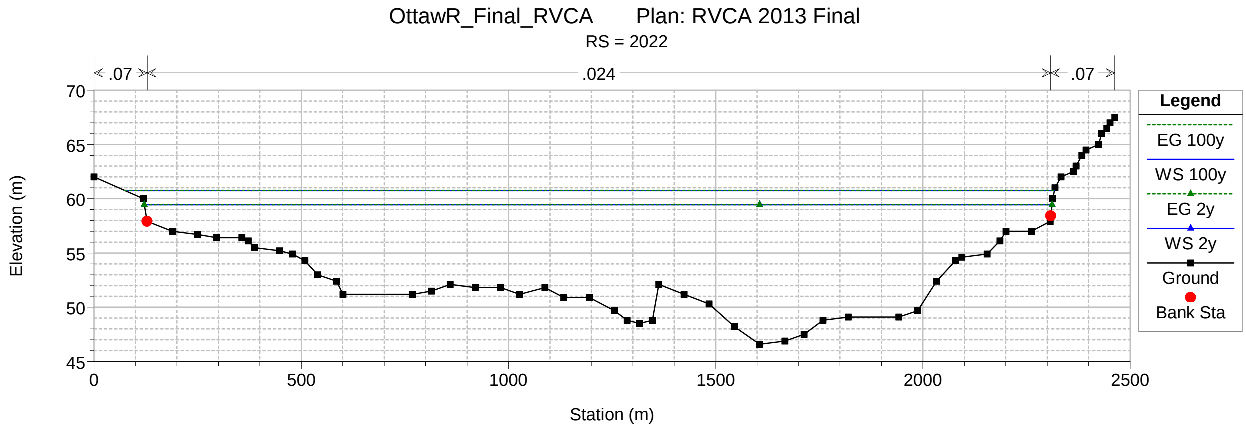
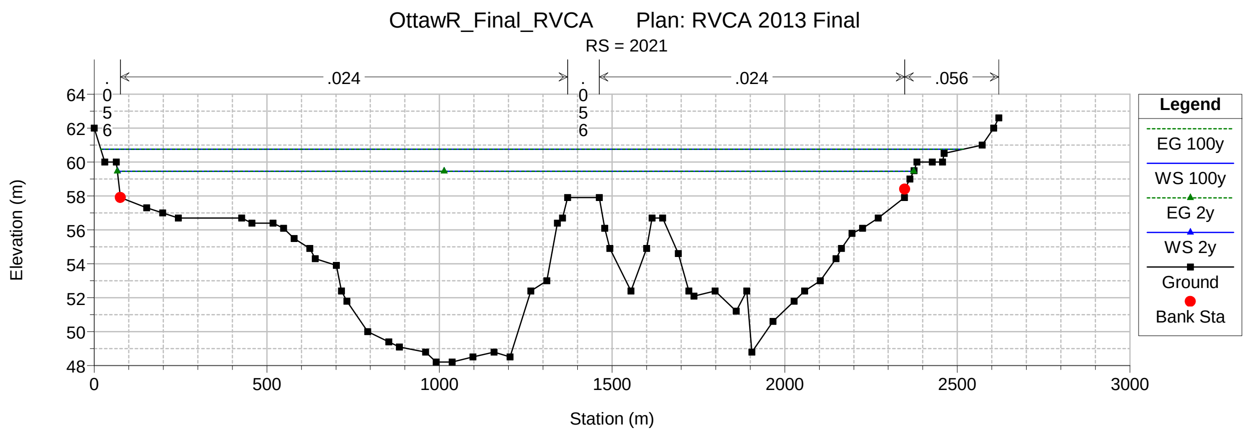
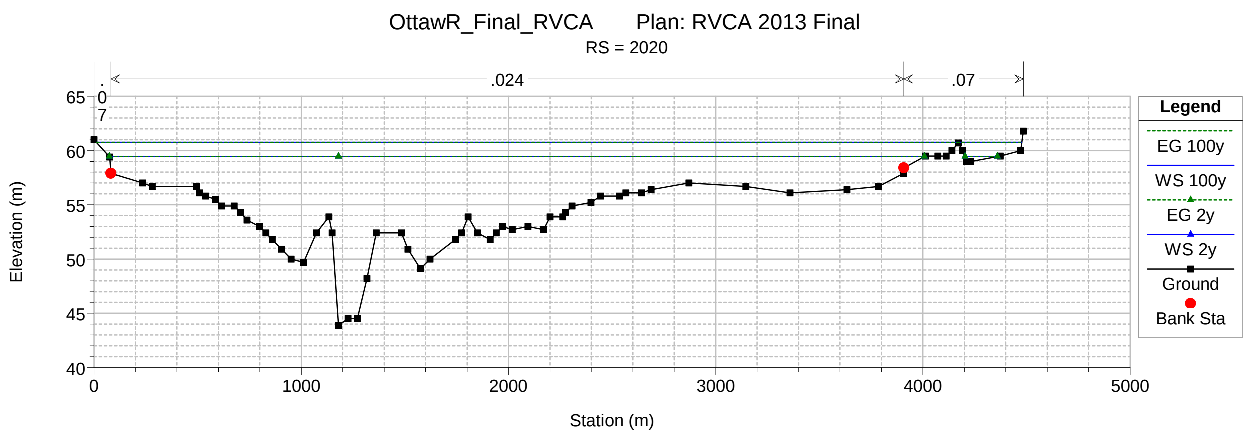
1028
1029
1030
1031
1032
1033
1034
1035
1036
1037
1038
1039
1040
1042
1044
1045
2000
2000.6
2001.5
2003
2003.1
2005
2006
2007
2008
2009
2010
2011
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022



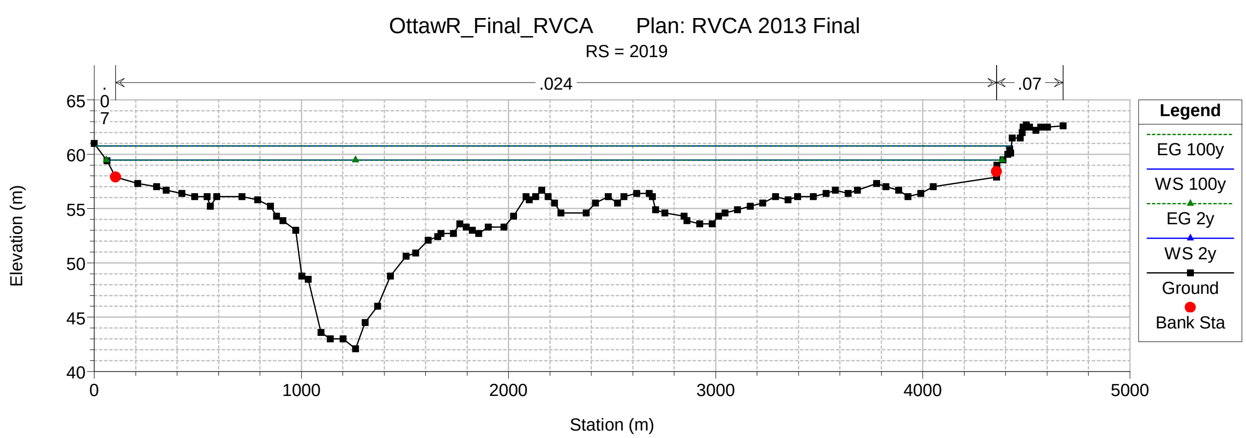
OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2022
.07
.024
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta



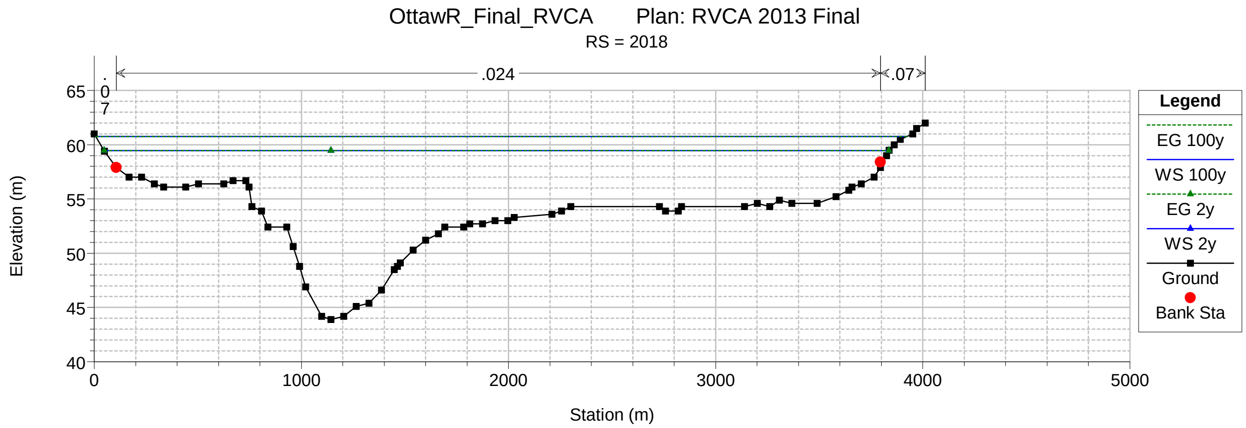
OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2021
.056
.024
.056
.024
.056
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

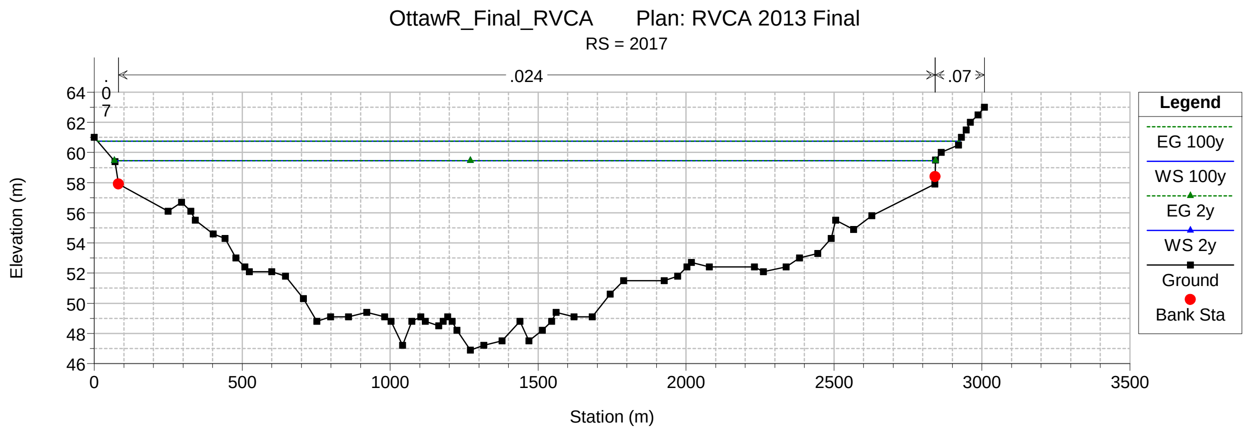


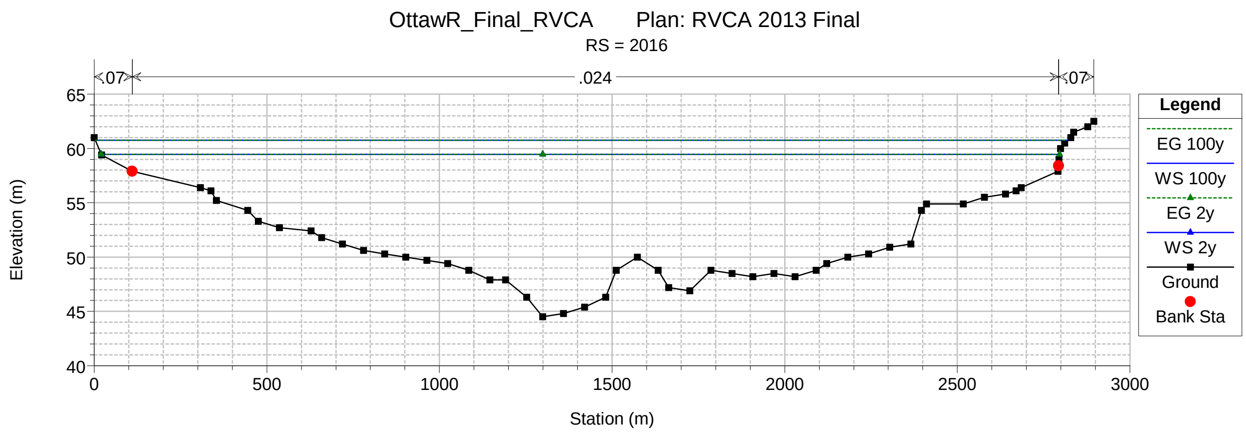
OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2020
.07
.024
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

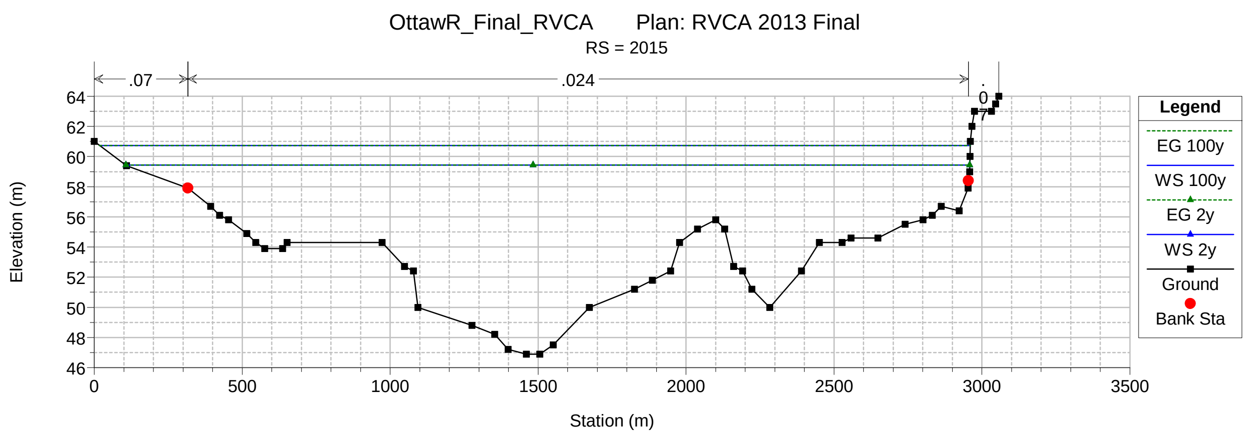


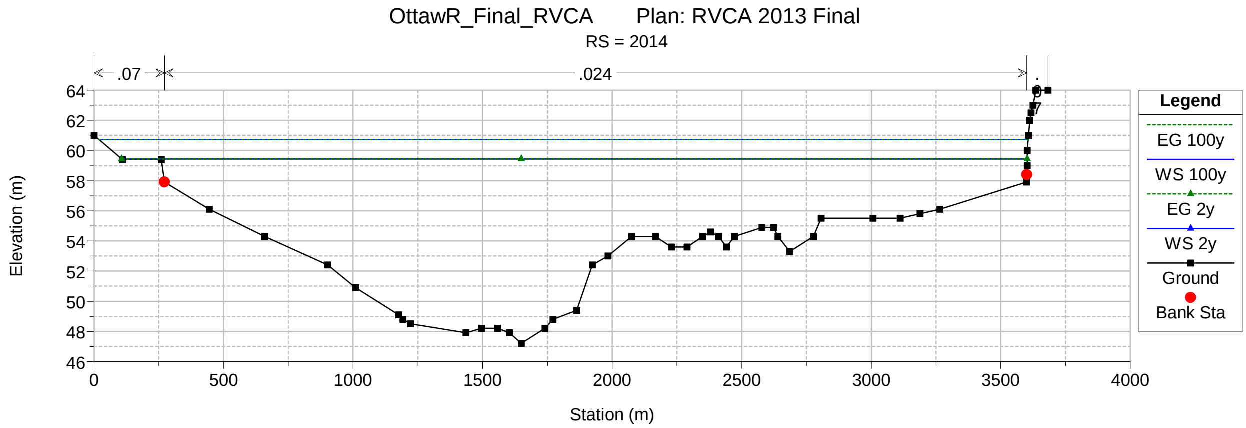
OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2019
.07
.024
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

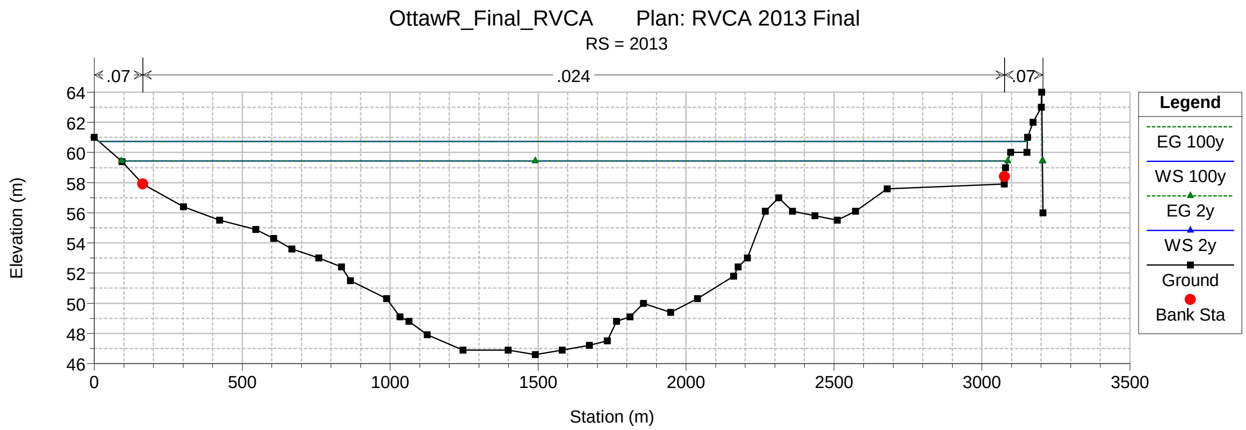

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2018
.024
.07
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

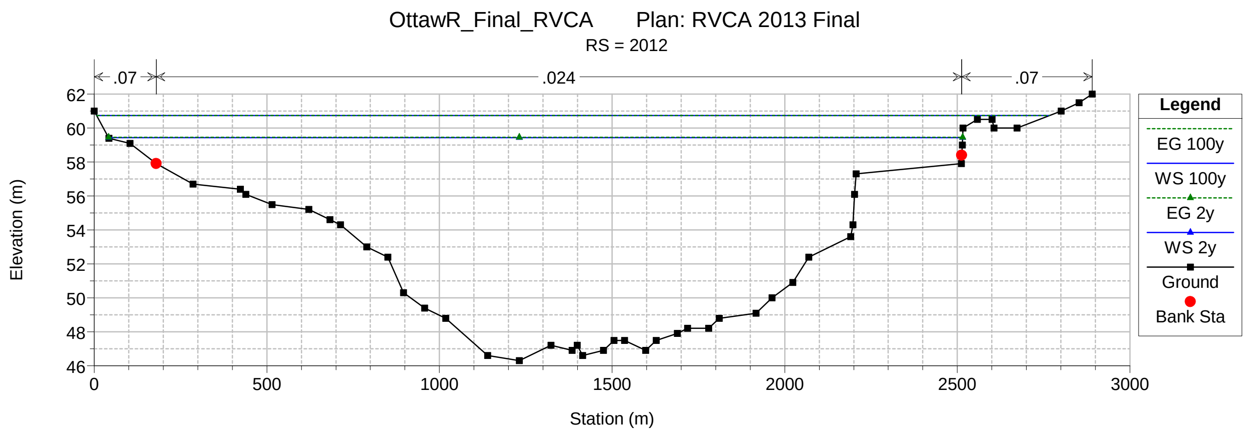

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2017
.024
.07
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

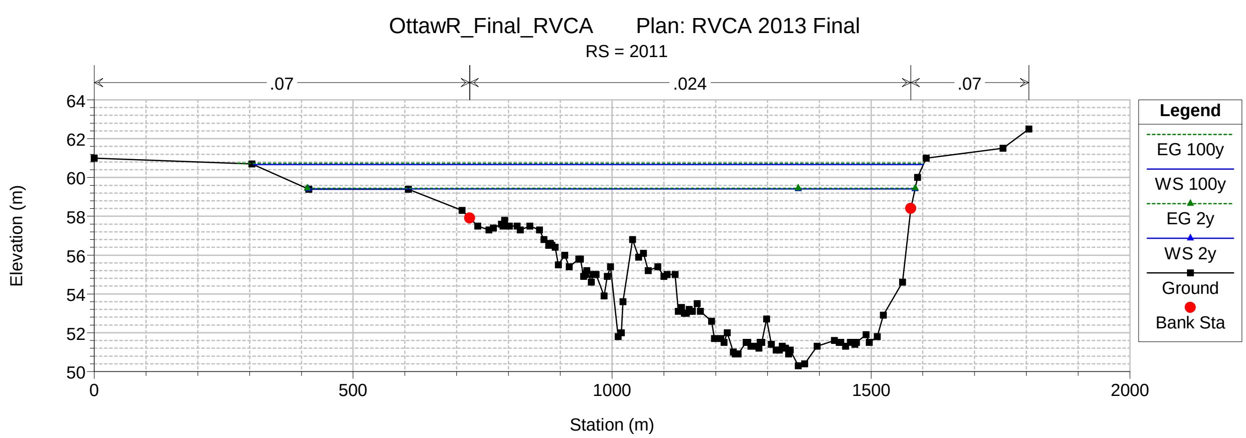

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2016
.07
.024
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

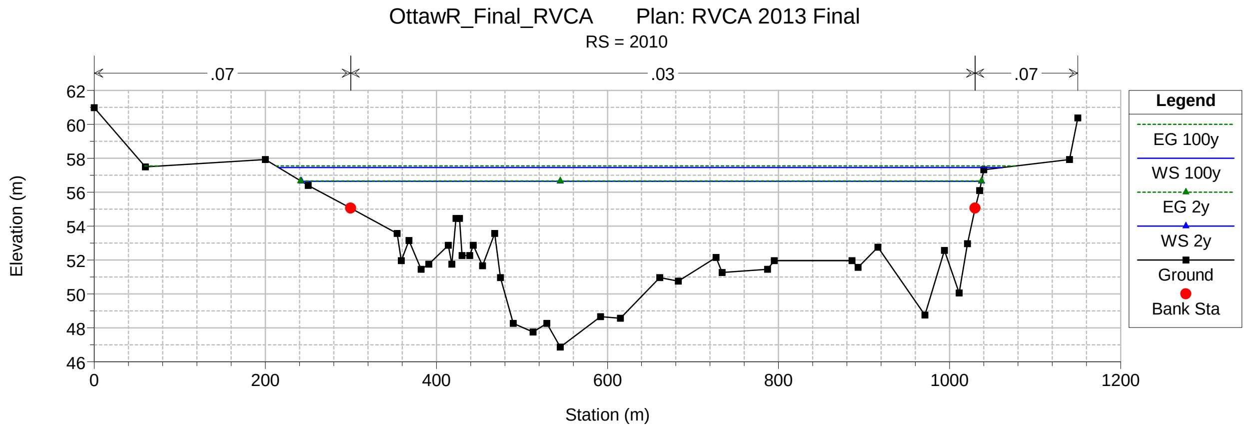

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2015
.07
.024
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

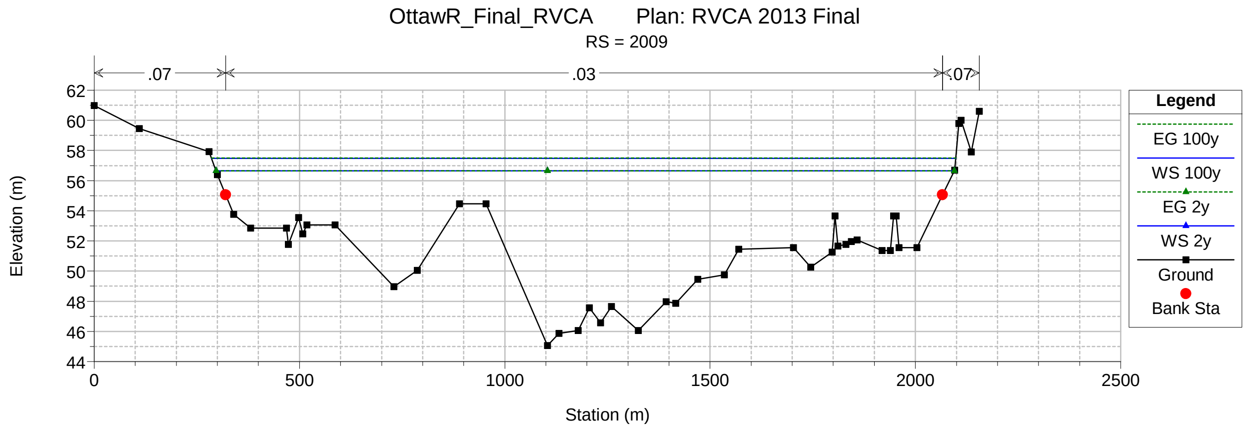

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2014
.07
.024
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

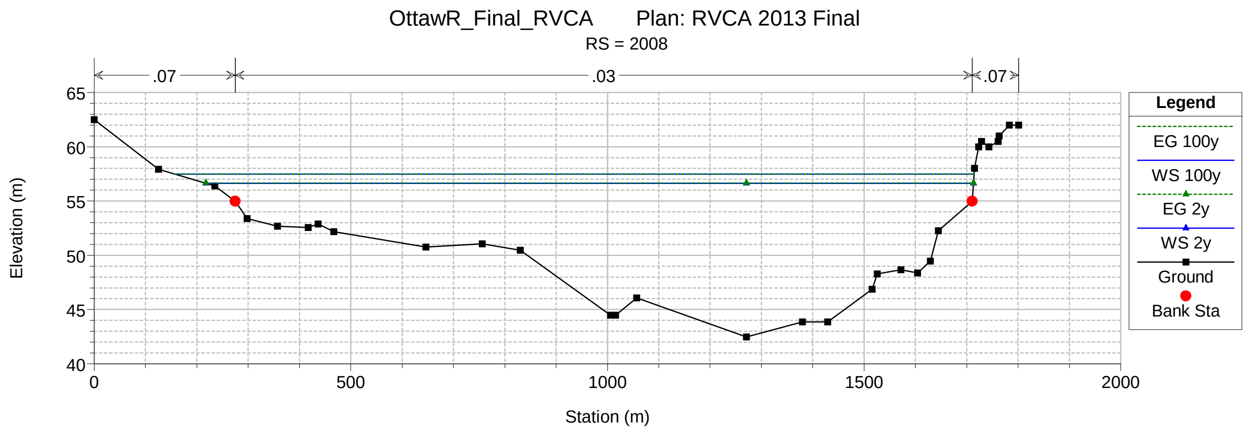

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2013
.07
.024
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

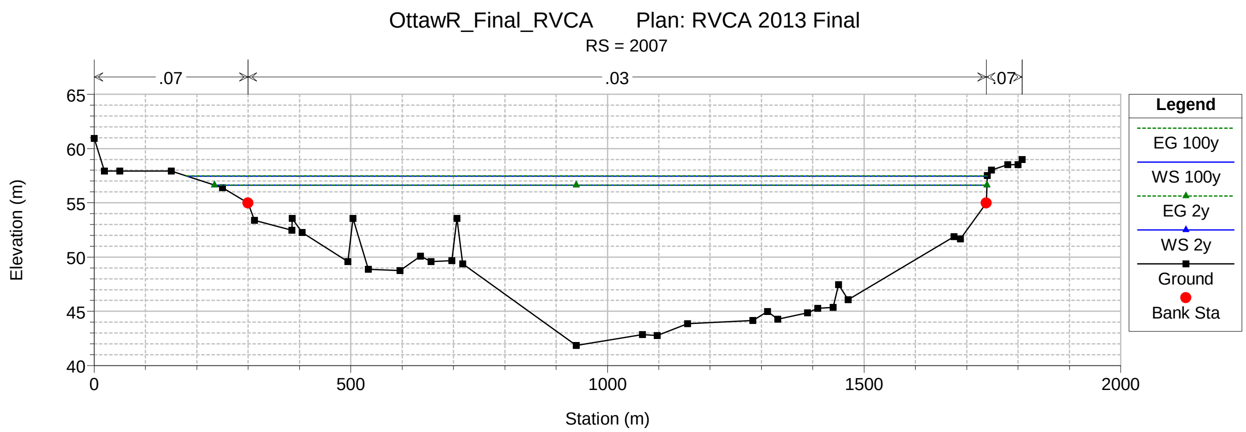

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2012
.07
.024
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

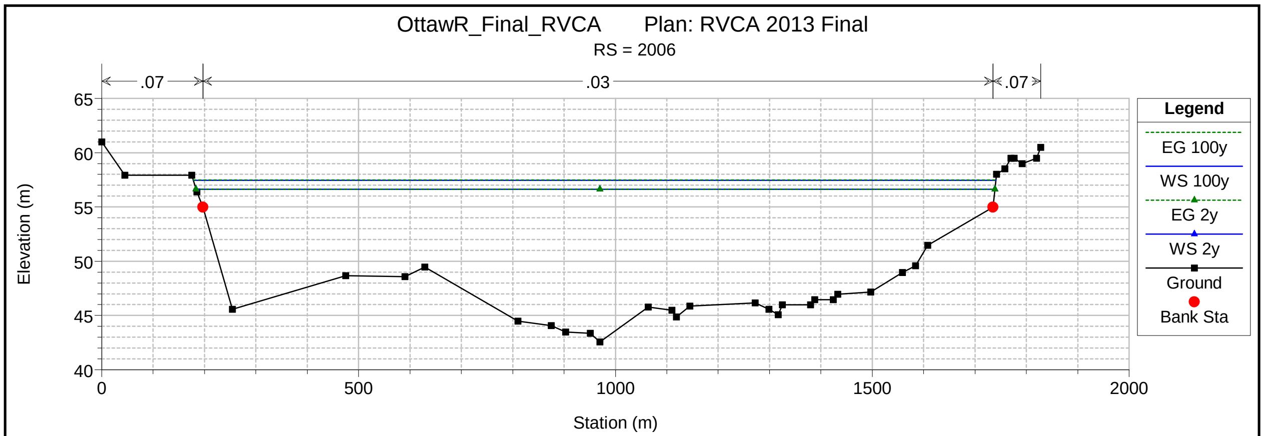

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2011
.07
.024
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

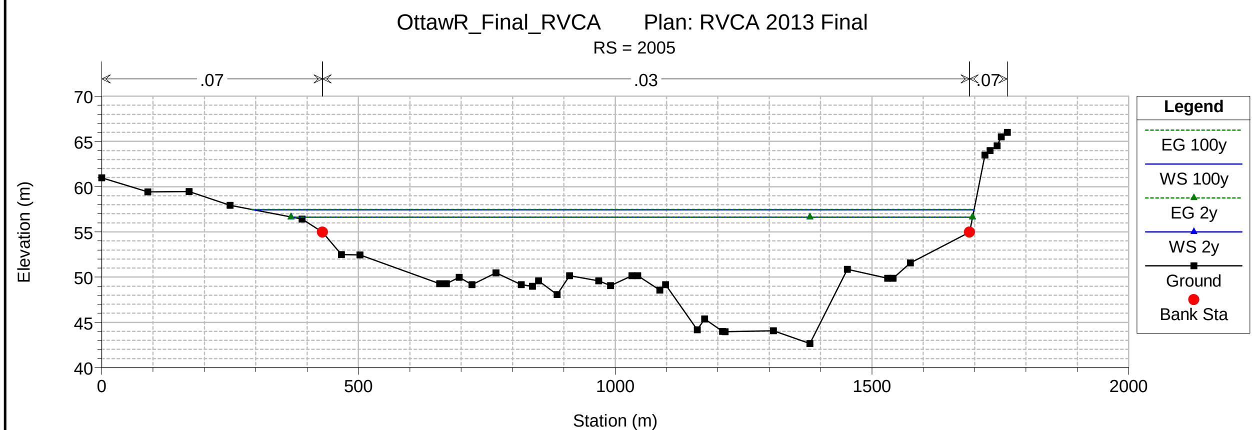

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2010
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

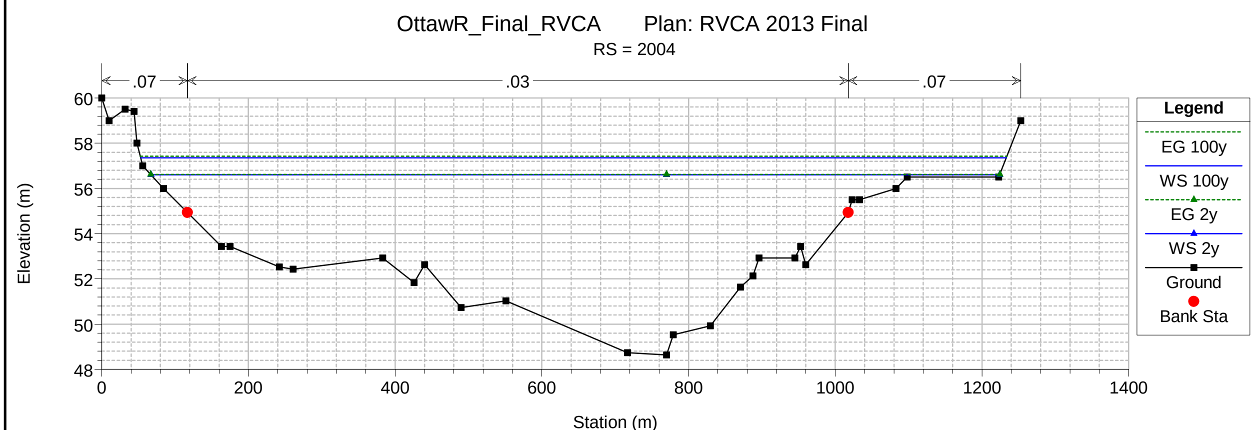

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2009
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

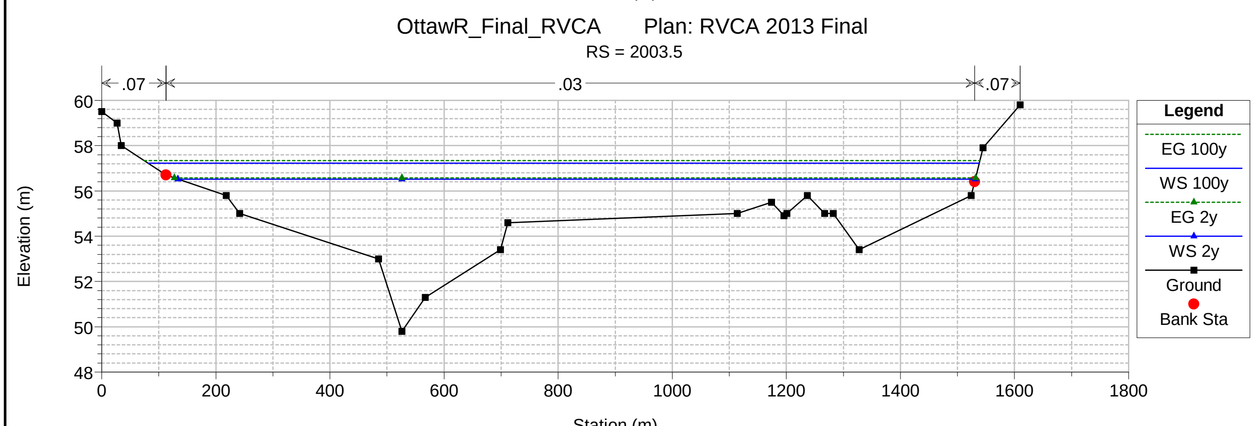

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2008
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

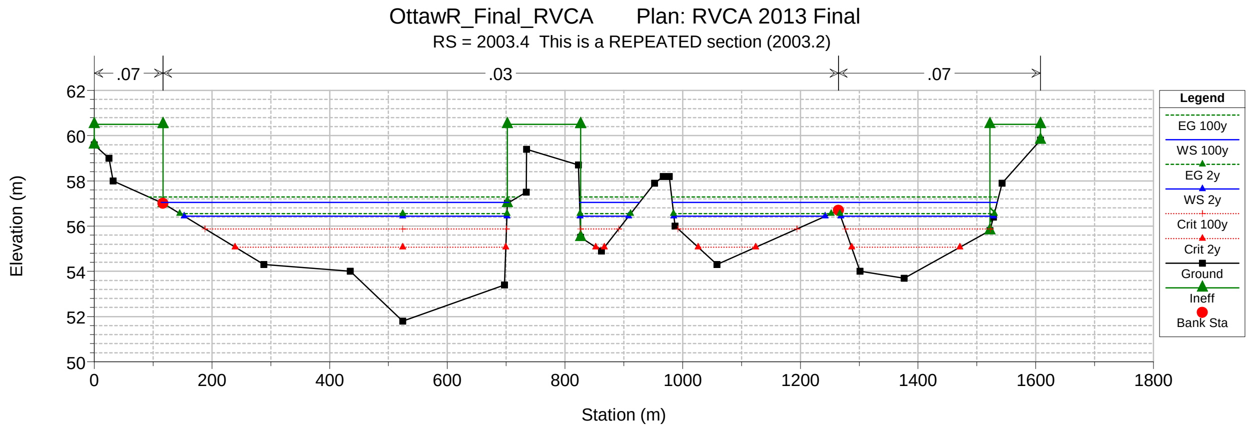

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2007
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

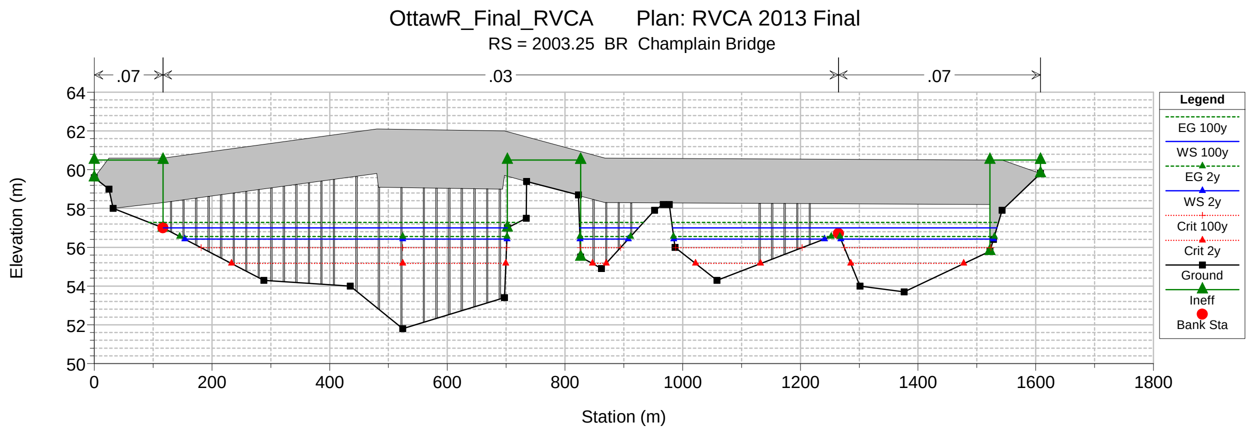

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2006
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

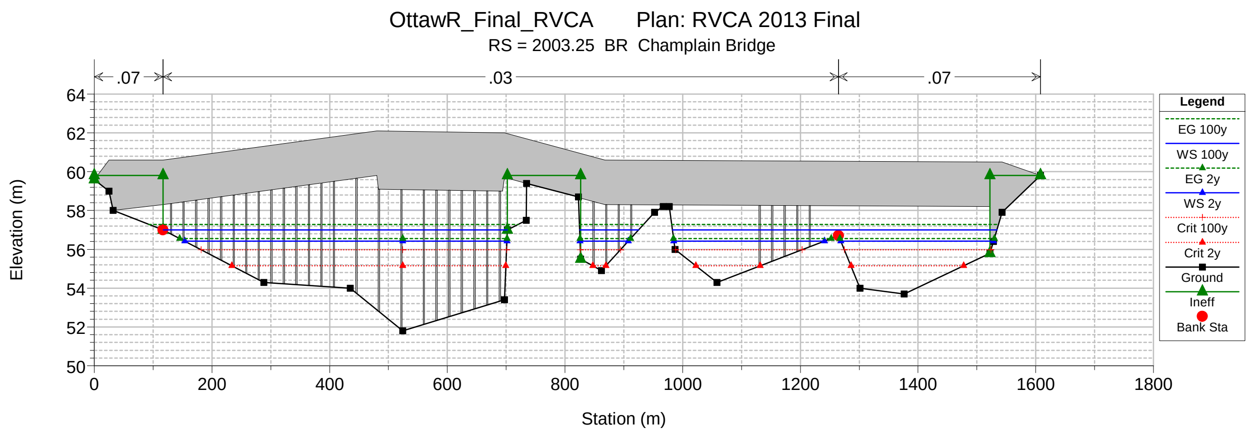

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2005
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

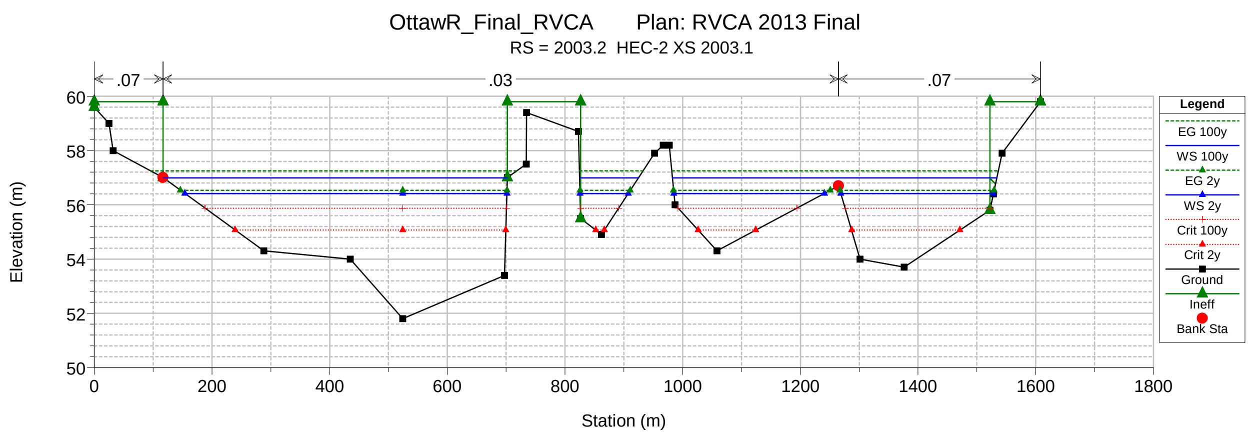

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2004
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

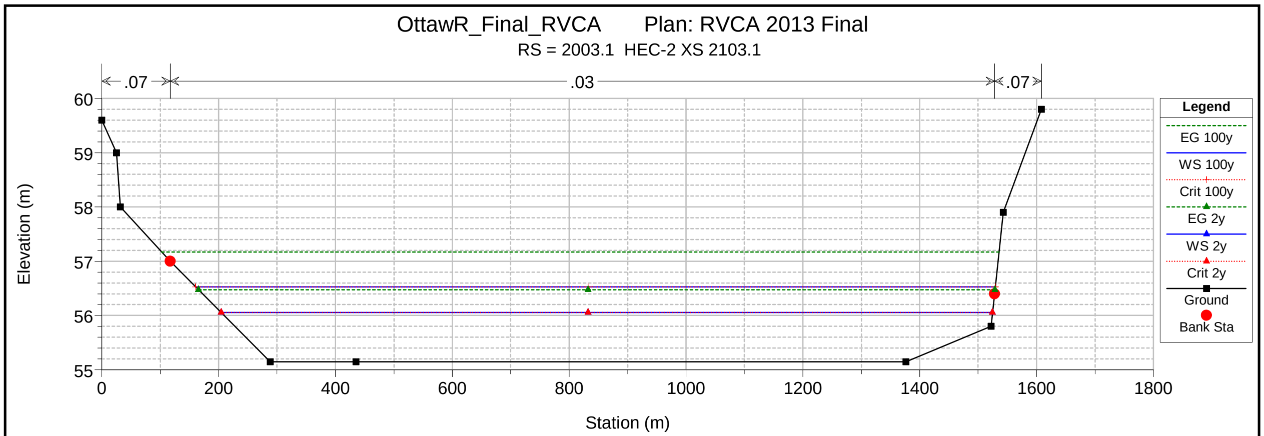

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2003.5
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

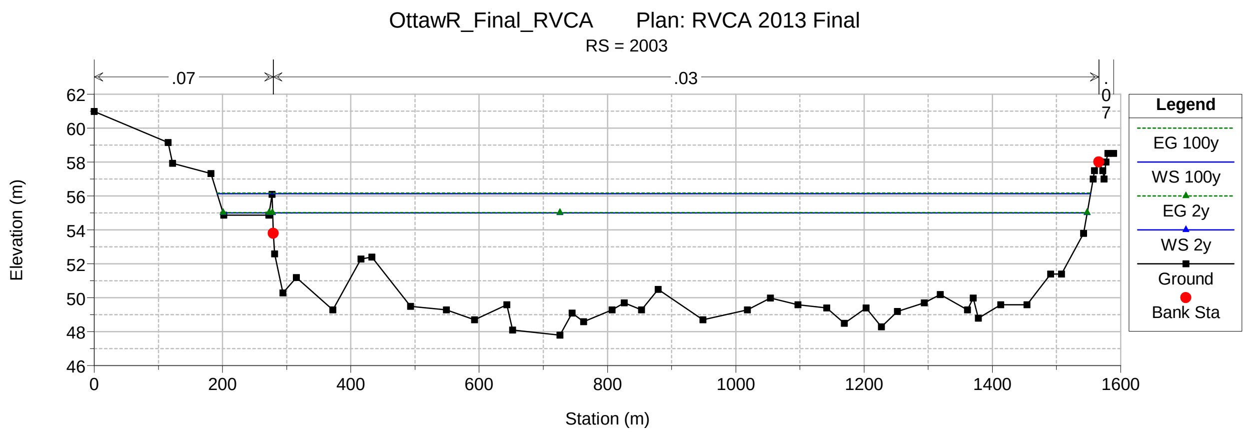

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2003.4 This is a REPEATED section (2003.2)
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

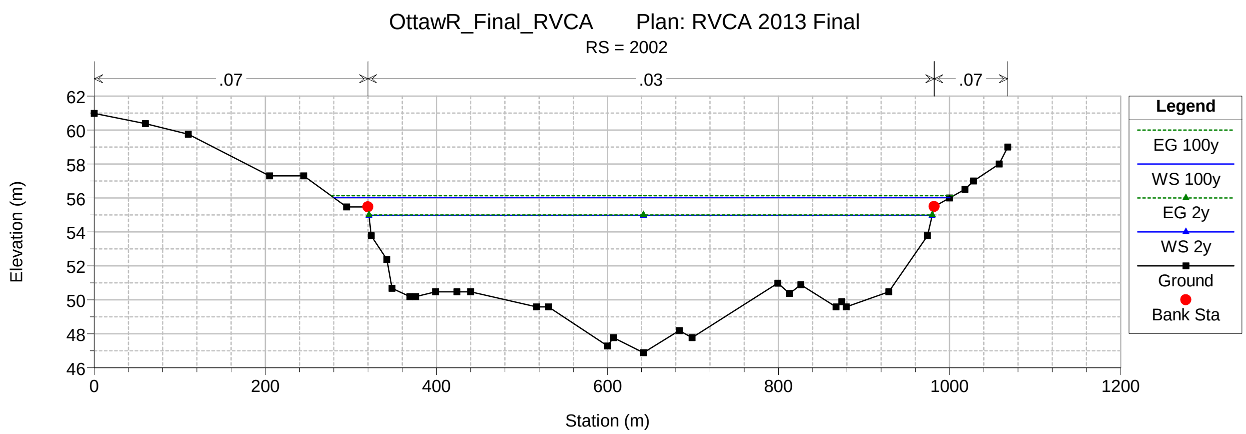

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2003.25 BR Champlain Bridge
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

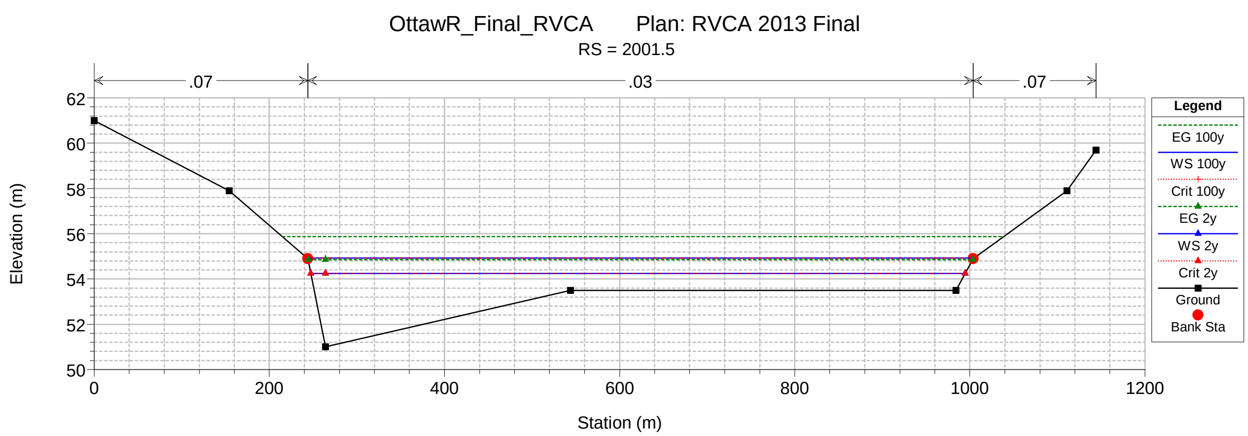

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2003.25 BR Champlain Bridge
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

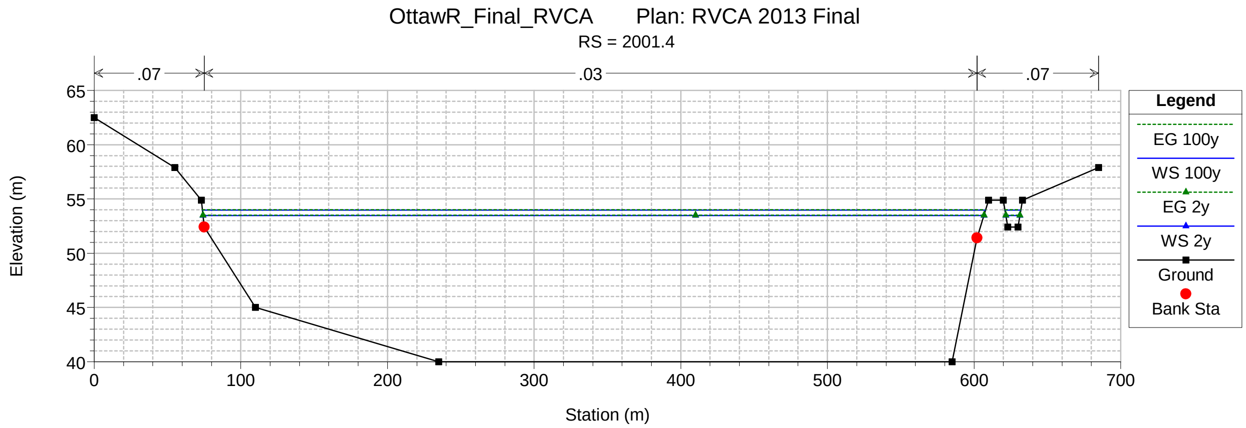

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2003.2 HEC-2 XS 2003.1
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

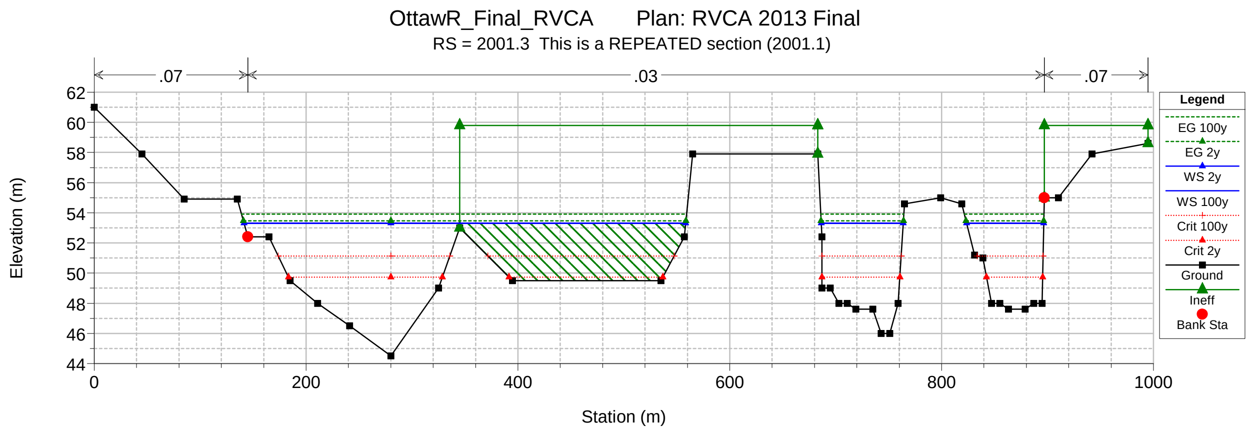

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2003.1 HEC-2 XS 2103.1
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
Crit 100y
EG 2y
WS 2y
Crit 2y
Ground
Bank Sta

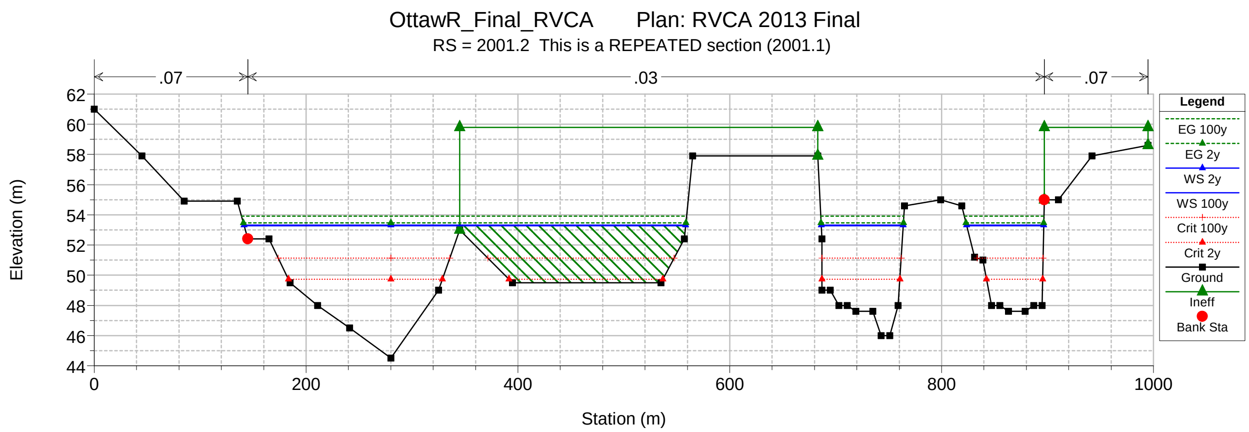

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2003
.07
.03
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

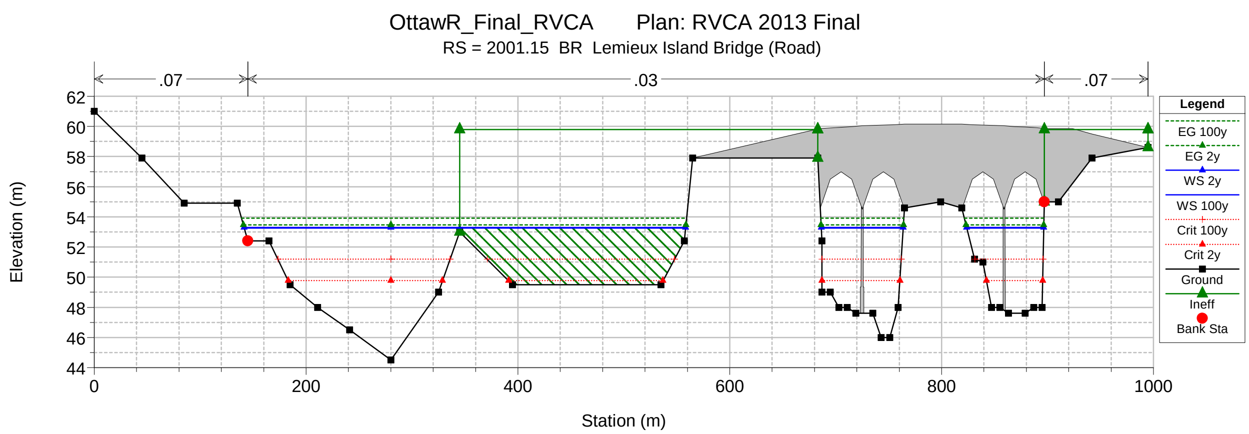

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2002
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

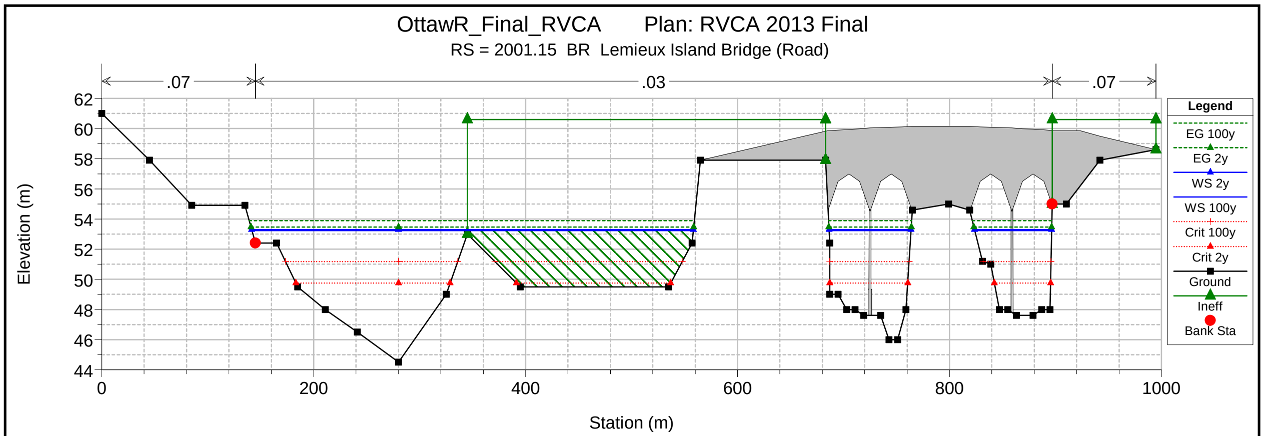

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2001.5
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
Crit 100y
EG 2y
WS 2y
Crit 2y
Ground
Bank Sta


OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2001.4
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

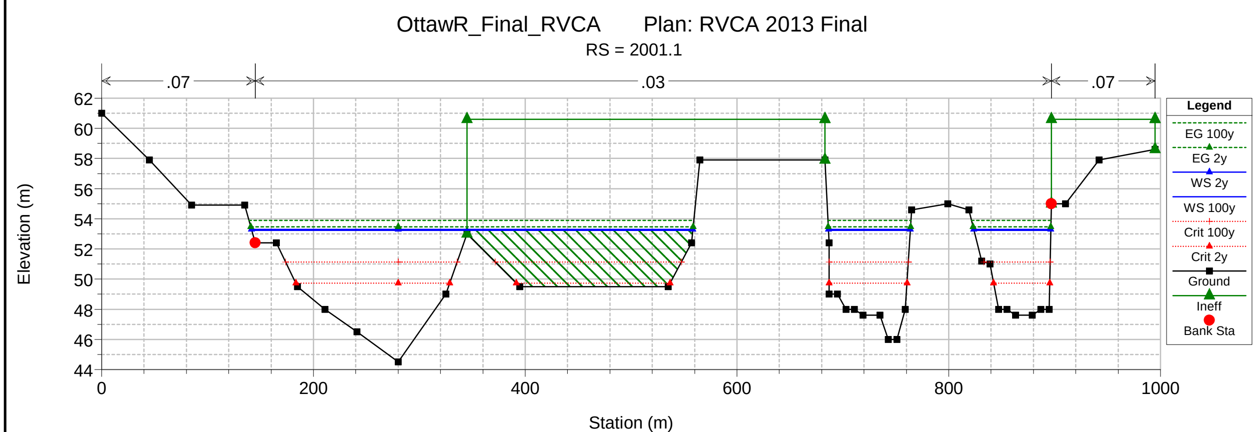

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2001.3 This is a REPEATED section (2001.1)
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
EG 2y
WS 2y
WS 100y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta


OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2001.2 This is a REPEATED section (2001.1)
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
EG 2y
WS 2y
WS 100y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

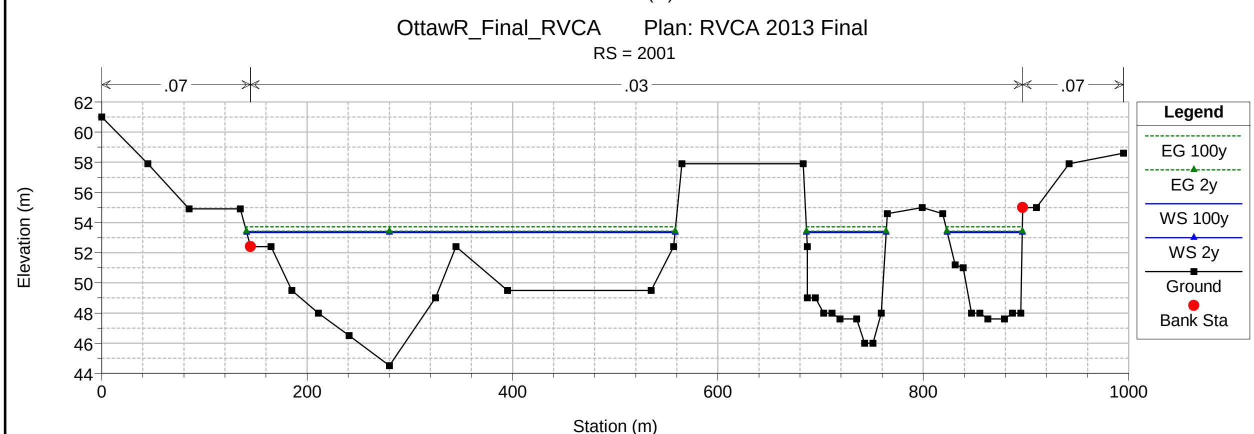

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2001.15 BR Lemieux Island Bridge (Road)
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
EG 2y
WS 2y
WS 100y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta



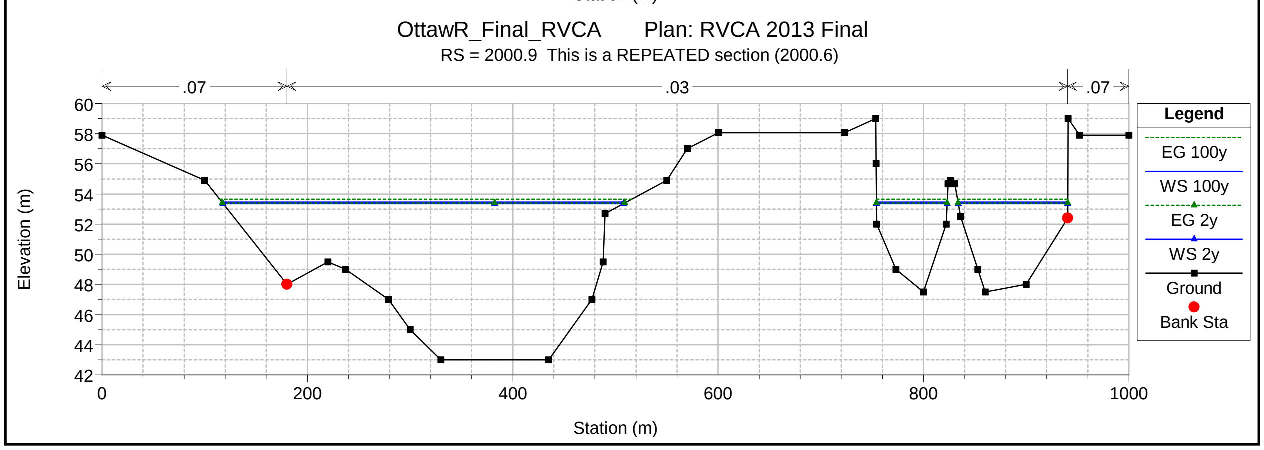
OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2001.15 BR Lemieux Island Bridge (Road)
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
EG 2y
WS 2y
WS 100y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta



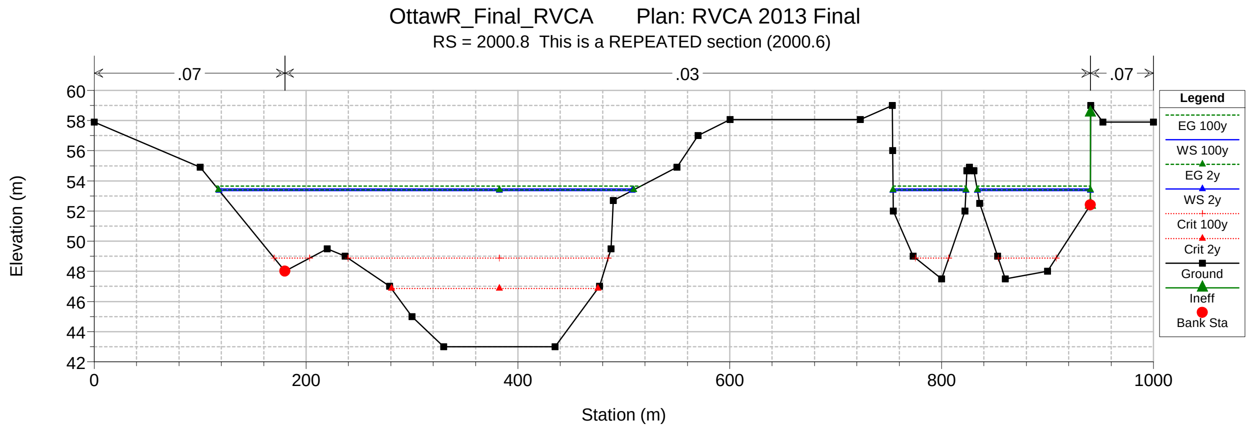
OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2001.1
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
EG 2y
WS 2y
WS 100y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

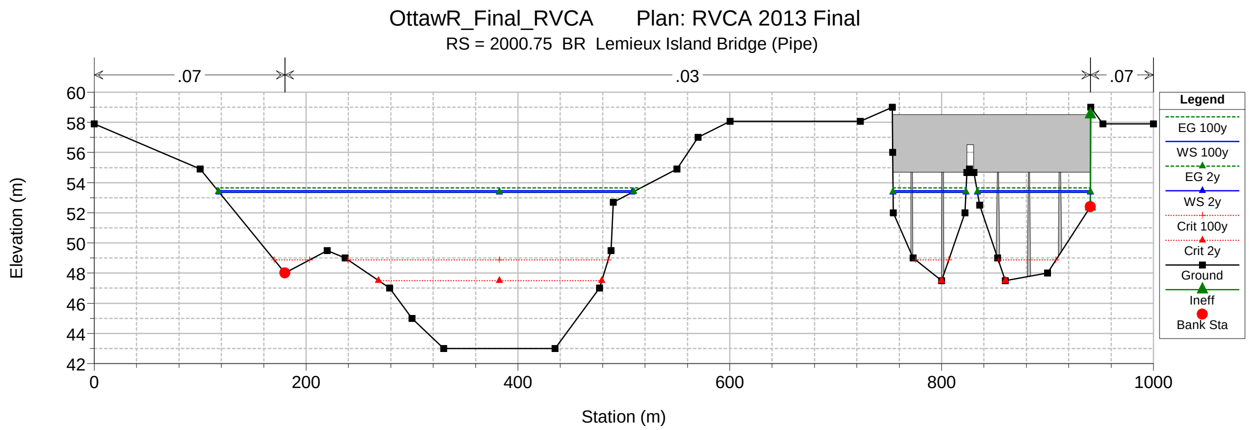


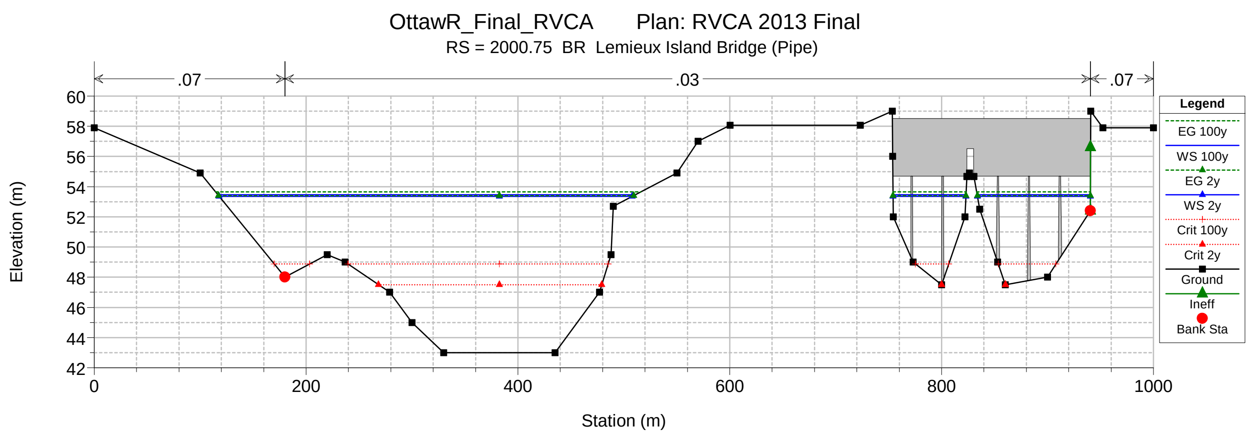
OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2001
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
EG 2y
WS 100y
WS 2y
Ground
Bank Sta

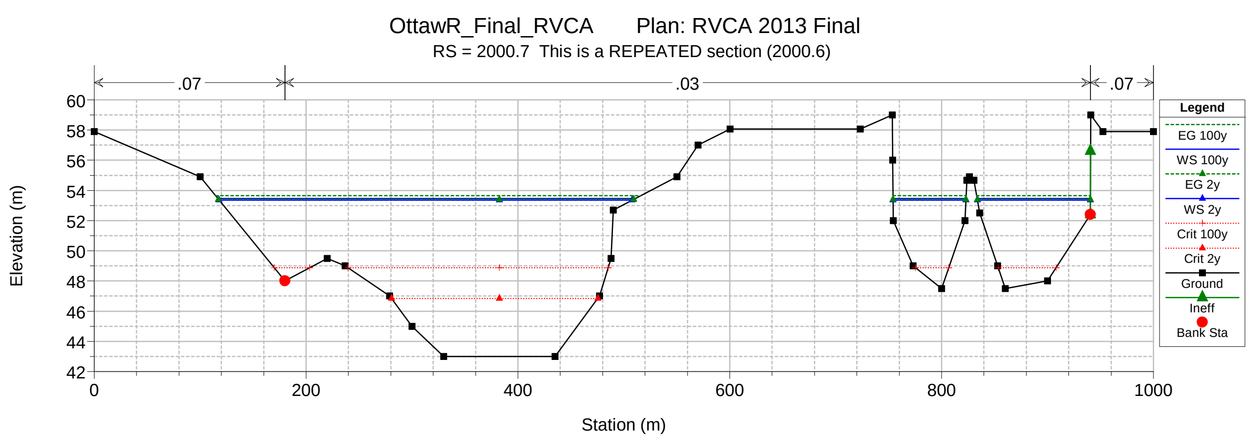


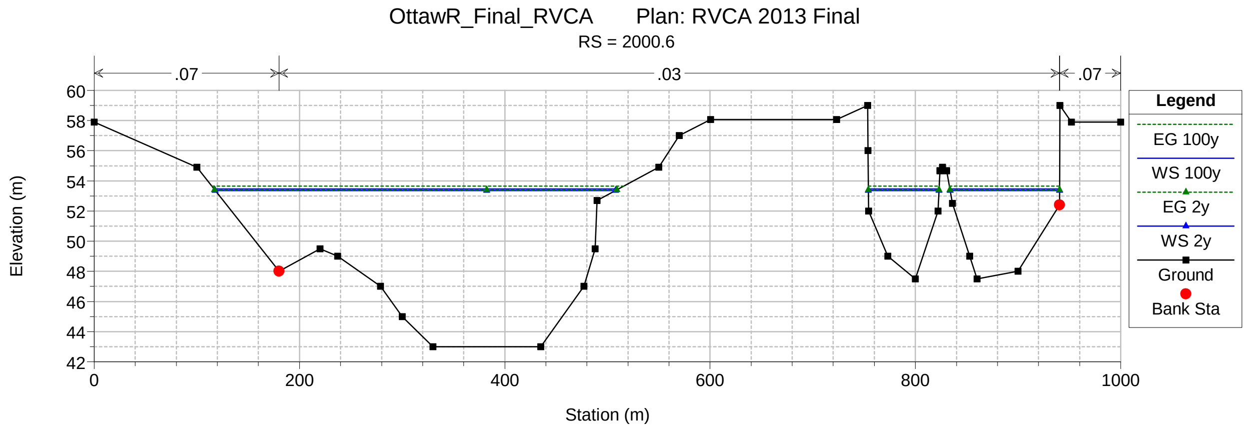
OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2000.9 This is a REPEATED section (2000.6)
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

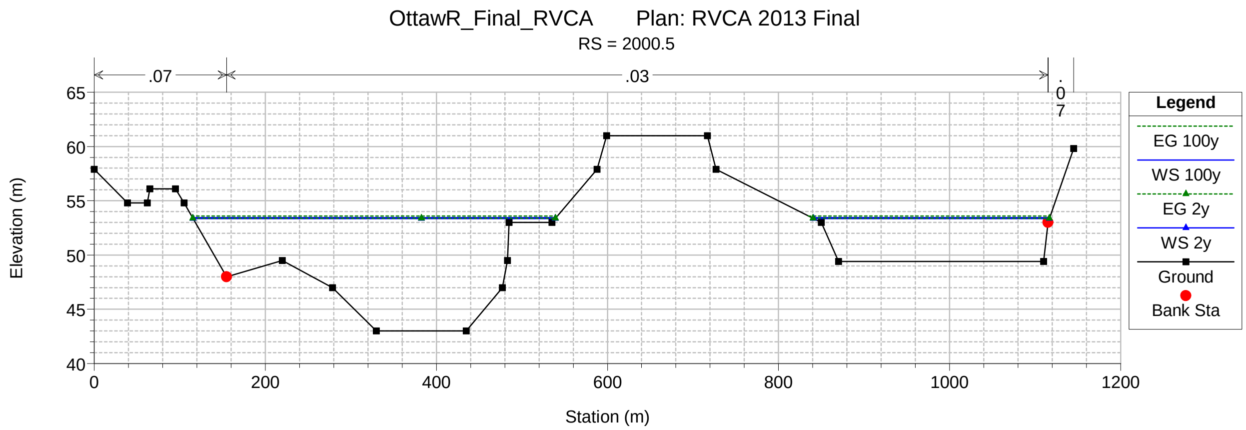

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2000.8 This is a REPEATED section (2000.6)
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

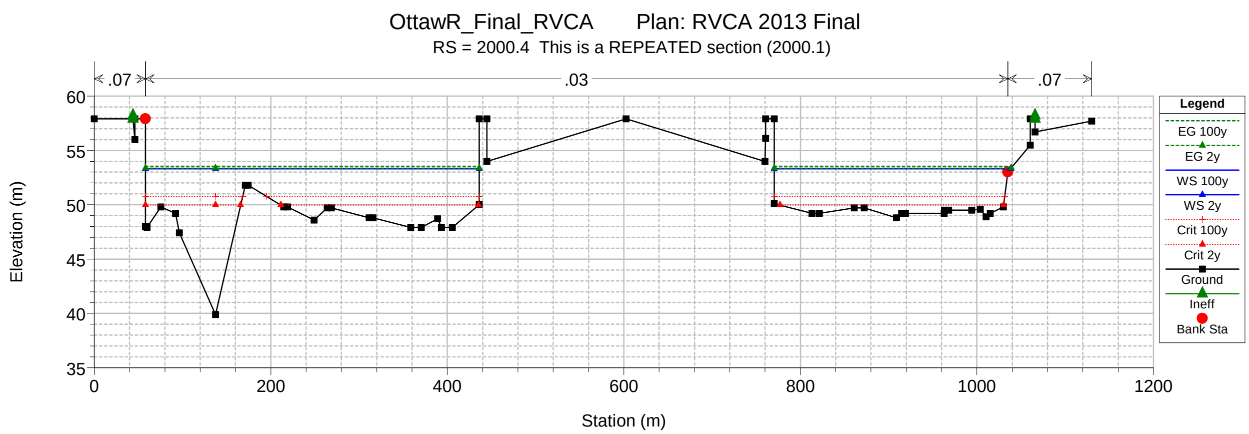

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2000.75 BR Lemieux Island Bridge (Pipe)
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

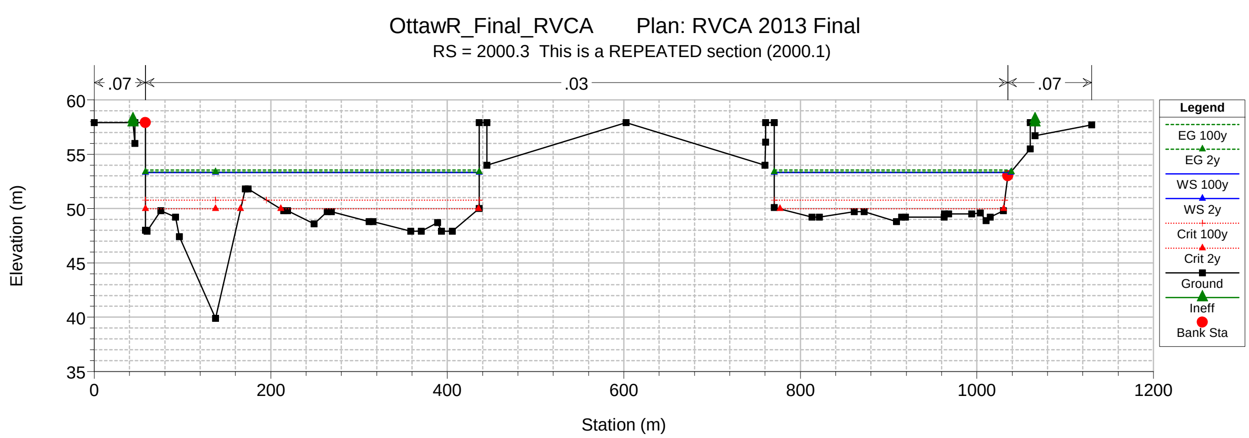

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2000.75 BR Lemieux Island Bridge (Pipe)
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

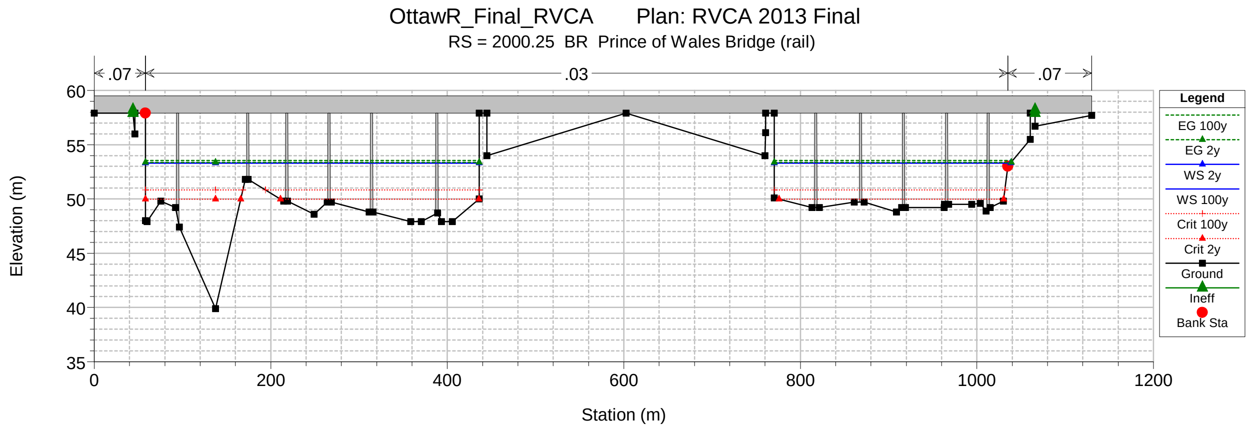

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2000.7 This is a REPEATED section (2000.6)
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

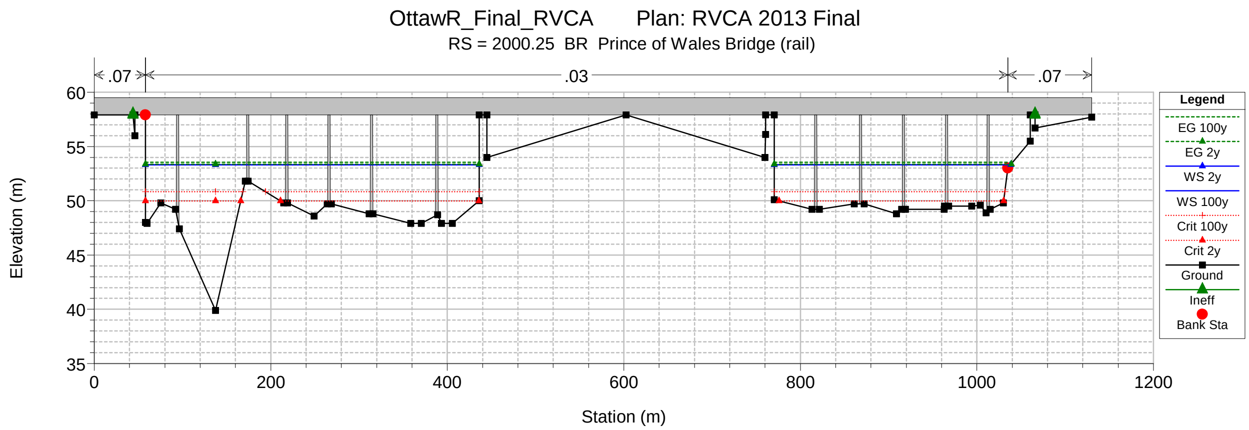

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2000.6
.07
.03
.07
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta
Elevation (m)
Station (m)

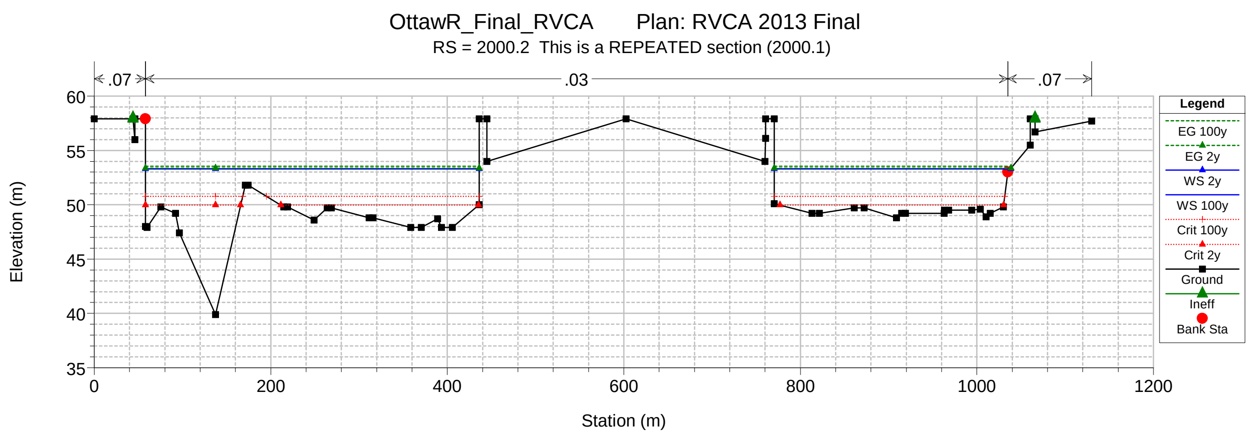

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2000.5
.07
.03
.07
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta
Elevation (m)
Station (m)

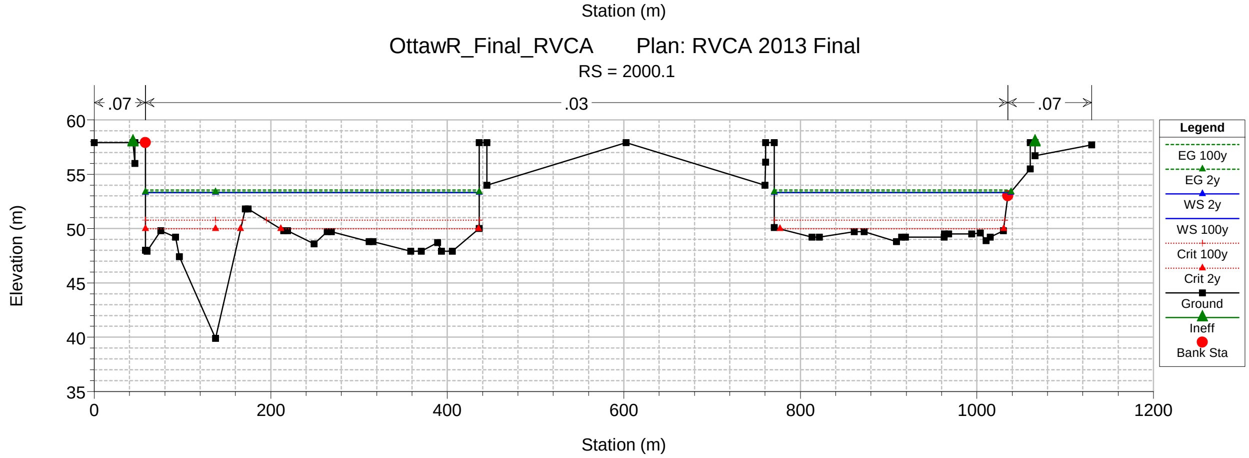

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2000.4 This is a REPEATED section (2000.1)
.07
.03
.07
Legend
EG 100y
EG 2y
WS 100y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)

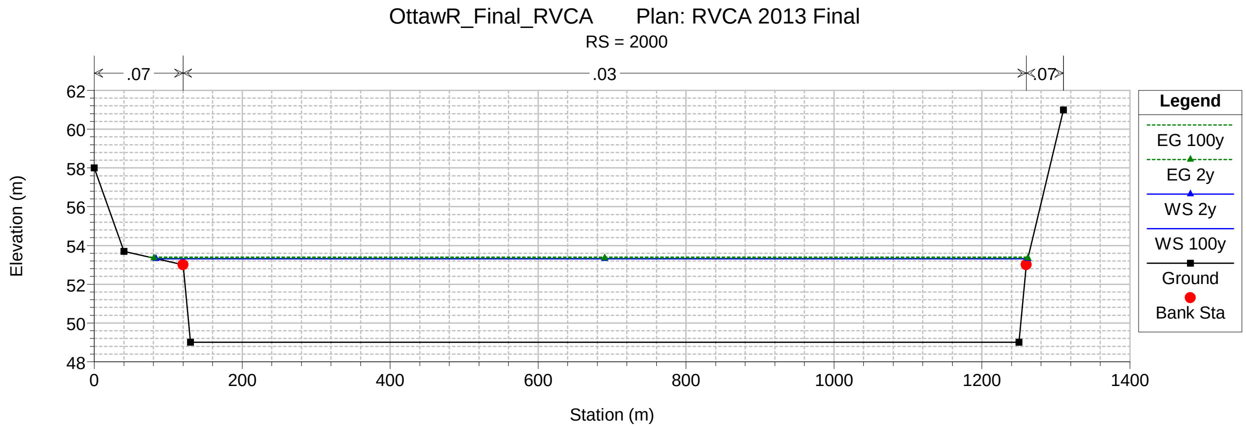

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2000.3 This is a REPEATED section (2000.1)
.07
.03
.07
Legend
EG 100y
EG 2y
WS 100y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)

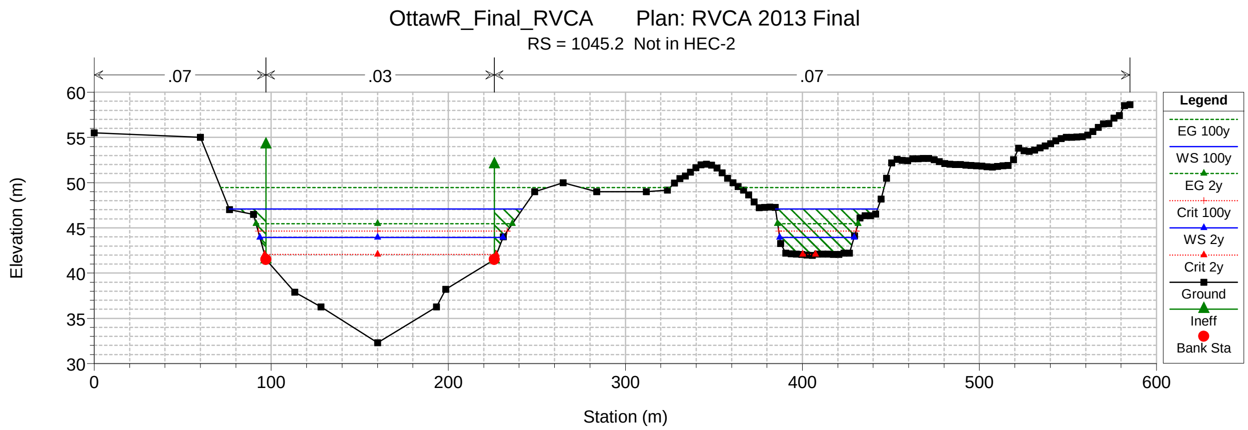

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2000.25 BR Prince of Wales Bridge (rail)
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
EG 2y
WS 2y
WS 100y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

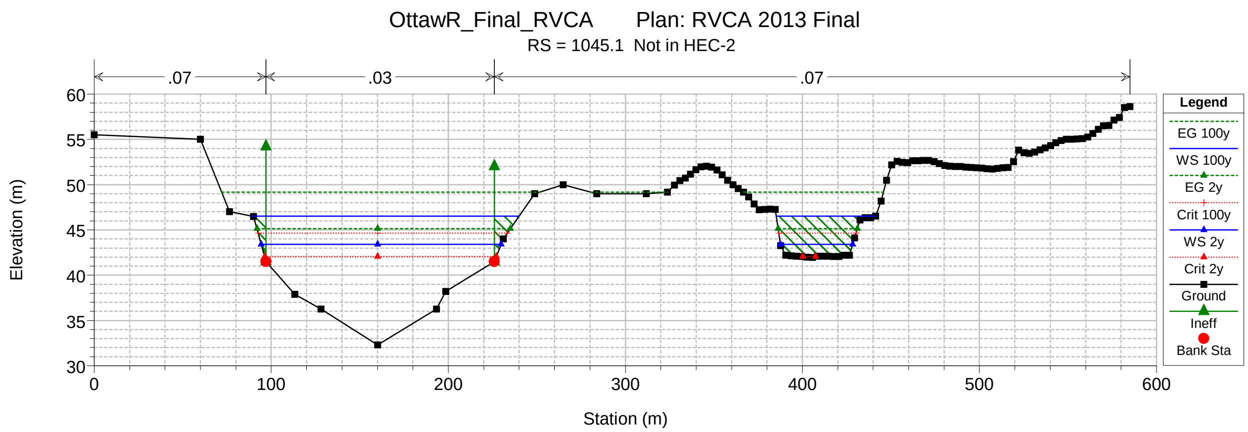

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2000.25 BR Prince of Wales Bridge (rail)
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
EG 2y
WS 2y
WS 100y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

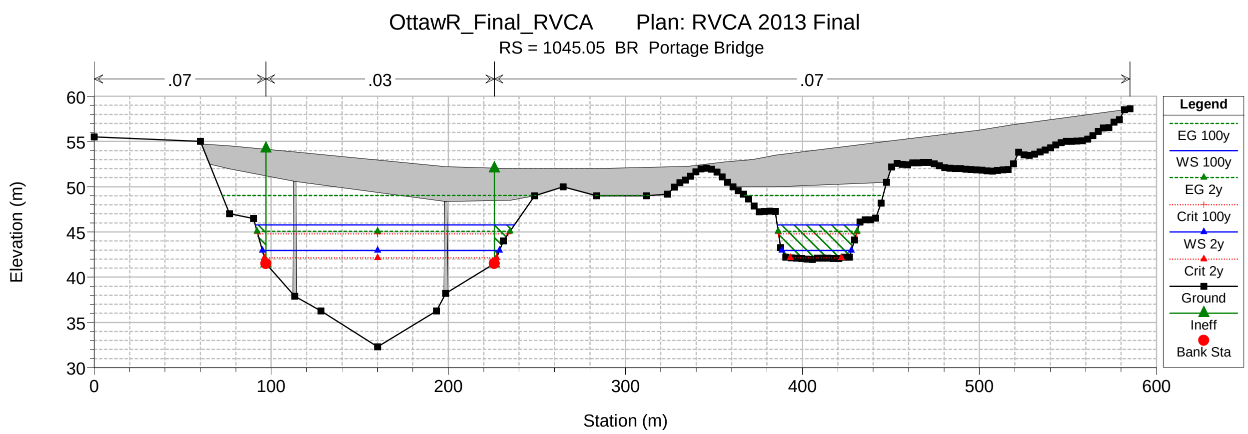

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2000.2 This is a REPEATED section (2000.1)
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
EG 2y
WS 2y
WS 100y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

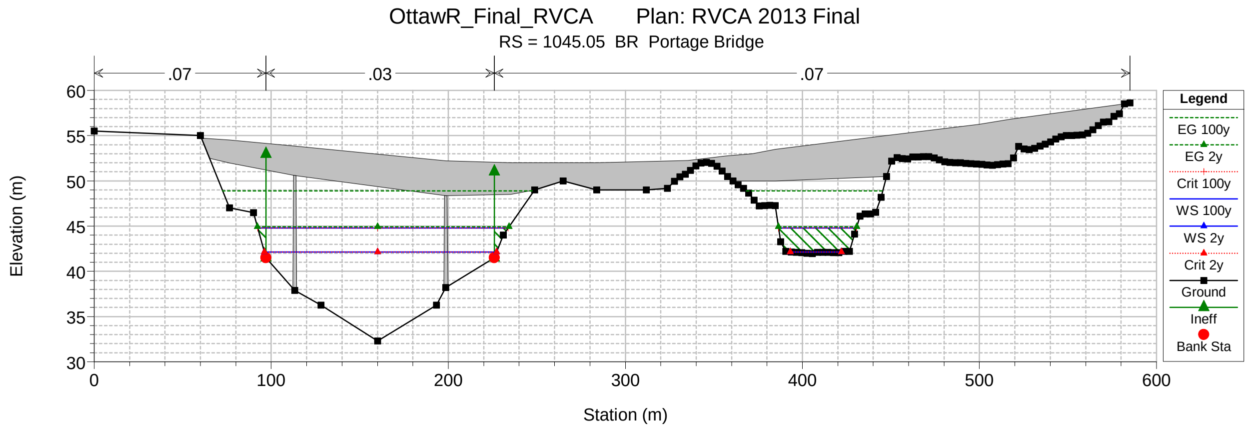

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2000.1
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
EG 2y
WS 2y
WS 100y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

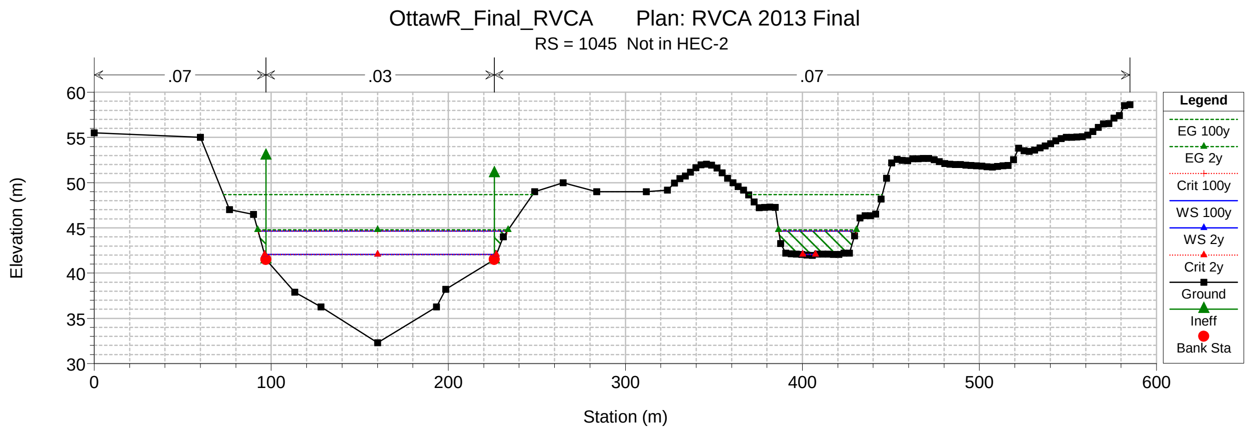

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 2000
.07
.03
.07
Elevation (m)
Station (m)
62
60
58
56
54
52
50
48
0
200
400
600
800
1000
1200
1400
Legend
EG 100y
EG 2y
WS 2y
WS 100y
Ground
Bank Sta

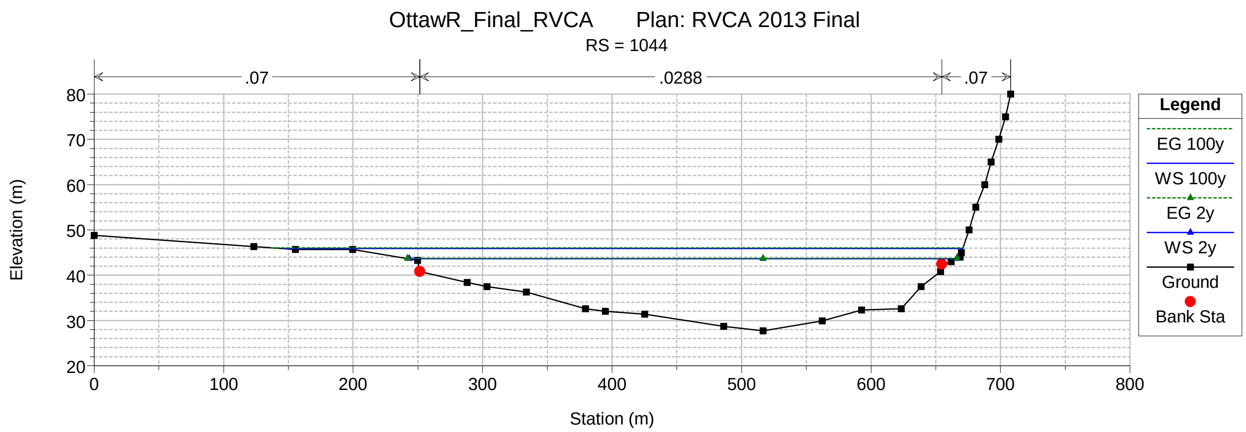

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1045.2 Not in HEC-2
.07
.03
.07
Elevation (m)
Station (m)
60
55
50
45
40
35
30
0
100
200
300
400
500
600
Legend
EG 100y
WS 100y
EG 2y
Crit 100y
WS 2y
Crit 2y
Ground
Ineff
Bank Sta

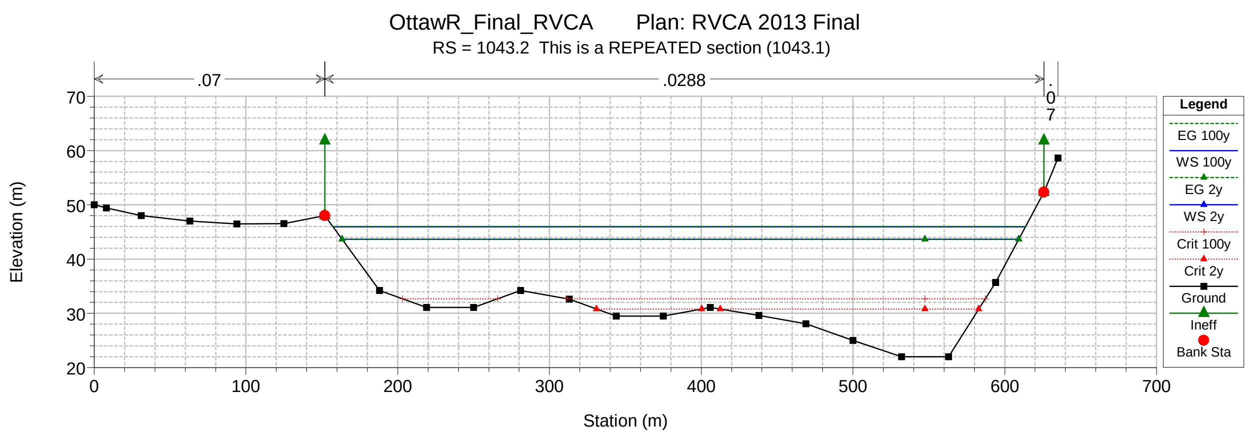

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1045.1 Not in HEC-2
.07
.03
.07
Elevation (m)
Station (m)
60
55
50
45
40
35
30
0
100
200
300
400
500
600
Legend
EG 100y
WS 100y
EG 2y
Crit 100y
WS 2y
Crit 2y
Ground
Ineff
Bank Sta

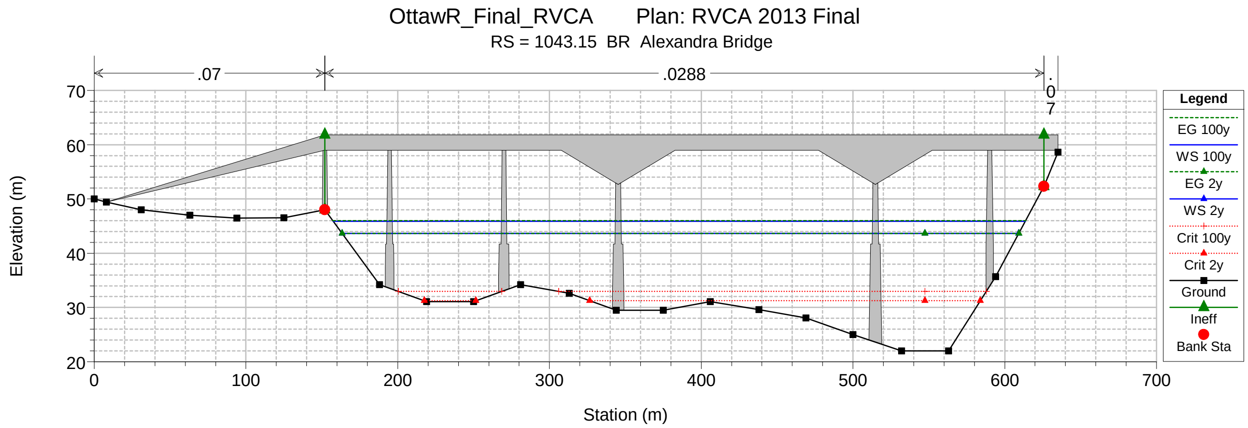

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1045.05 BR Portage Bridge
.07
.03
.07
Elevation (m)
Station (m)
60
55
50
45
40
35
30
0
100
200
300
400
500
600
Legend
EG 100y
WS 100y
EG 2y
Crit 100y
WS 2y
Crit 2y
Ground
Ineff
Bank Sta


OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1045.05 BR Portage Bridge
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
EG 2y
Crit 100y
WS 100y
WS 2y
Crit 2y
Ground
Ineff
Bank Sta

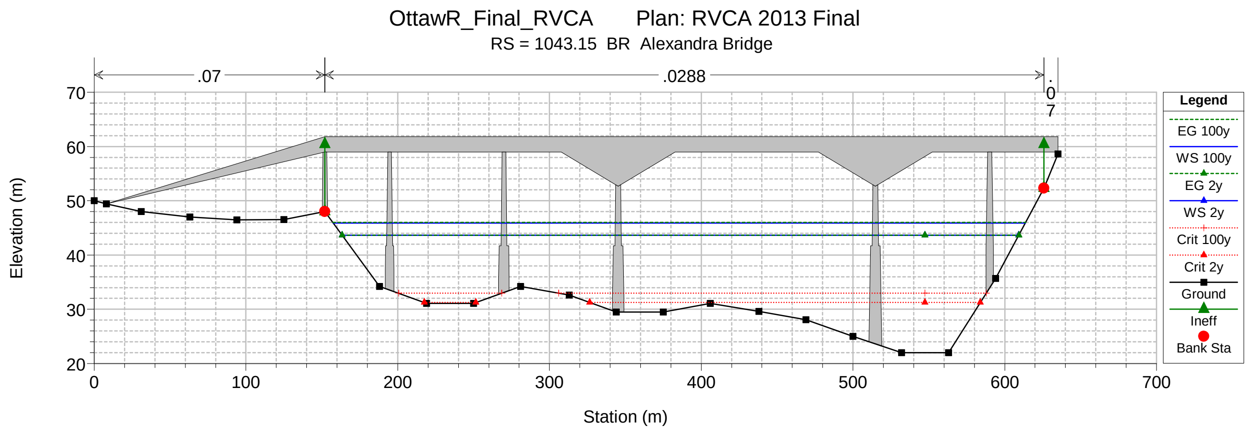

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1045 Not in HEC-2
.07
.03
.07
Elevation (m)
Station (m)
Legend
EG 100y
EG 2y
Crit 100y
WS 100y
WS 2y
Crit 2y
Ground
Ineff
Bank Sta


OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1044
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

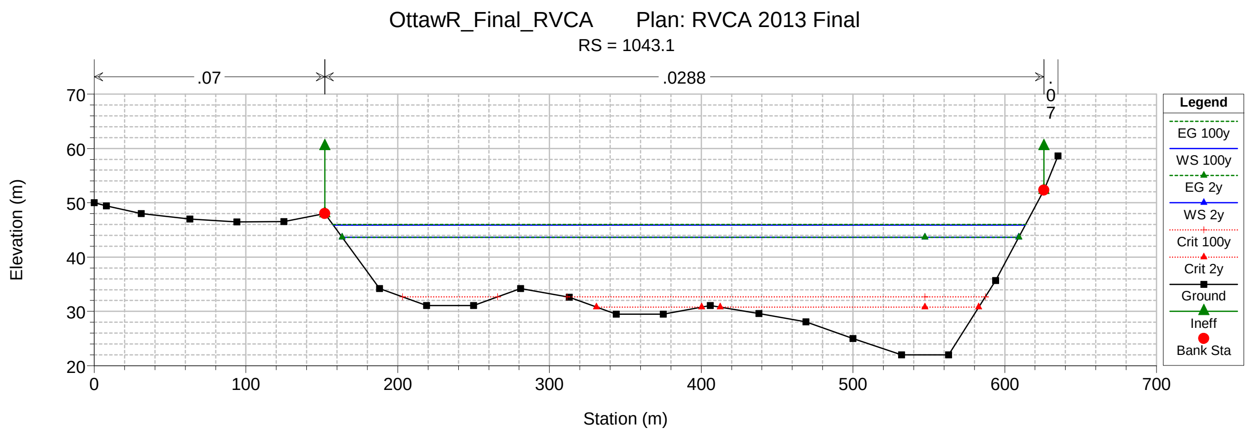

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1043.2 This is a REPEATED section (1043.1)
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta



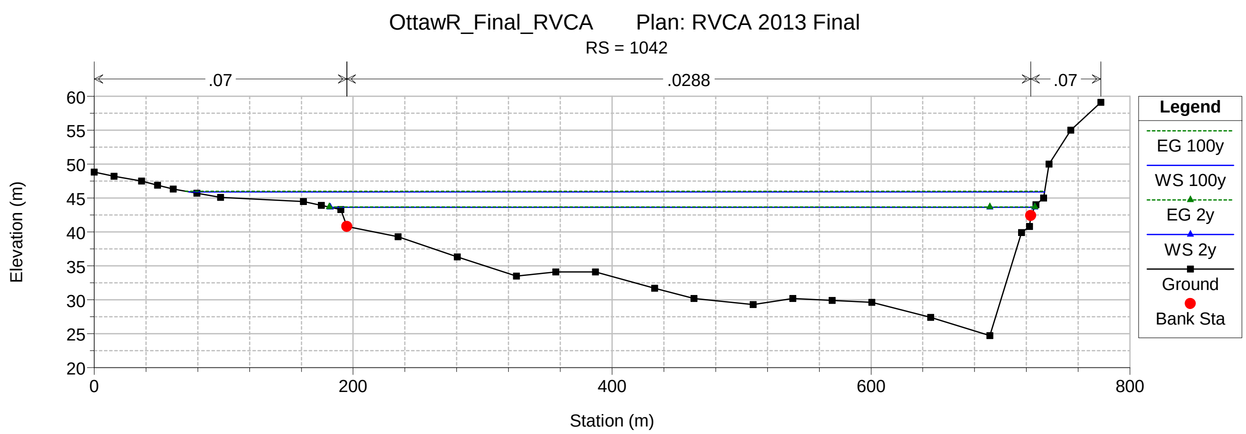
OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1043.15 BR Alexandra Bridge
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta



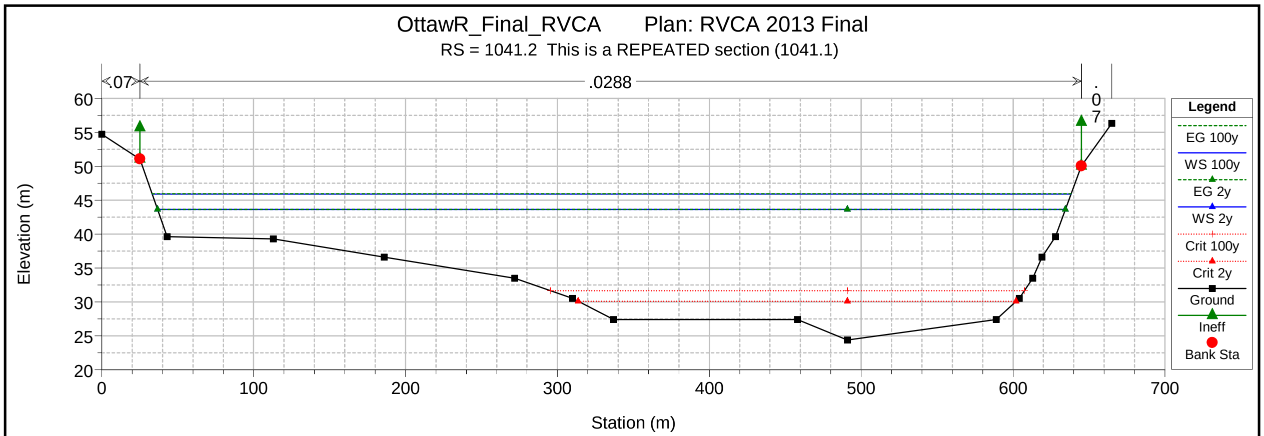
OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1043.15 BR Alexandra Bridge
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

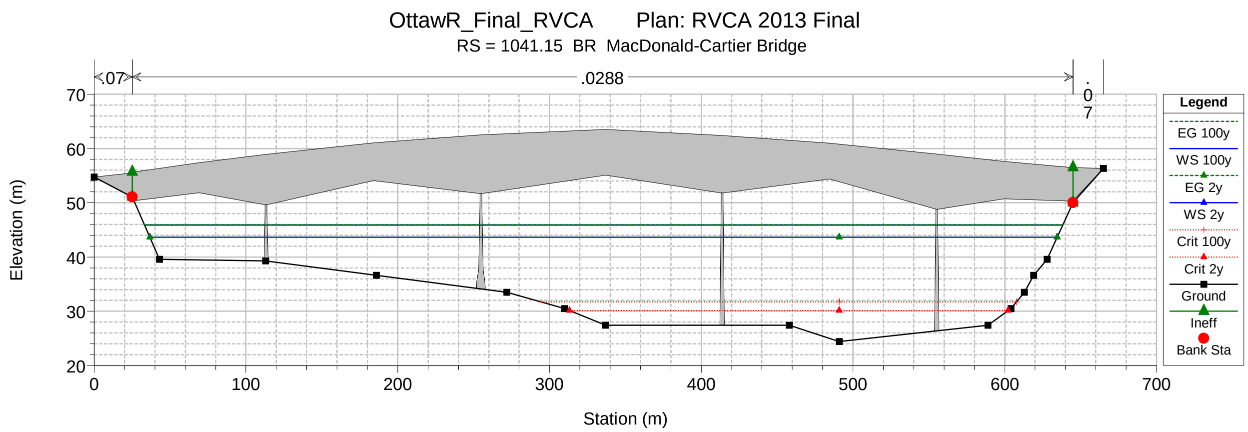


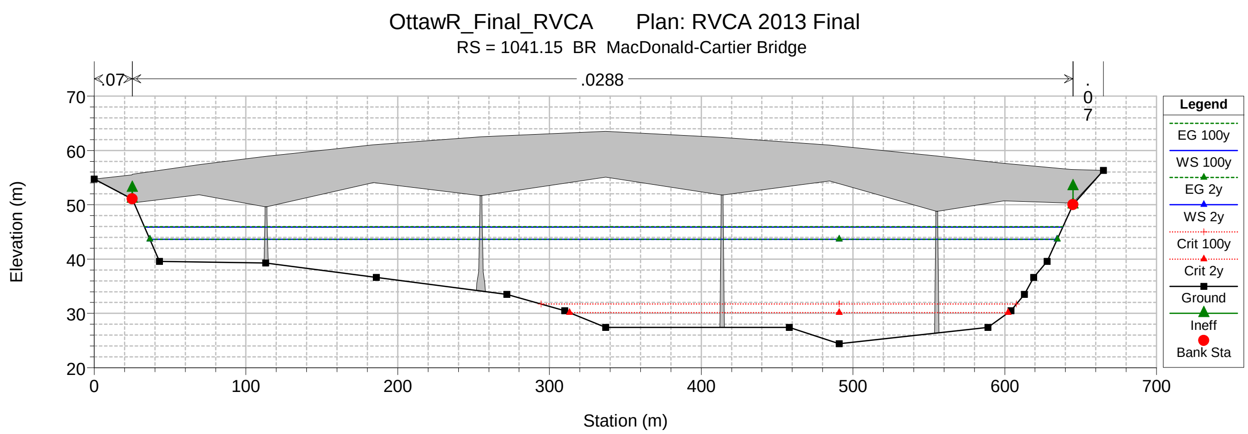
OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1043.1
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

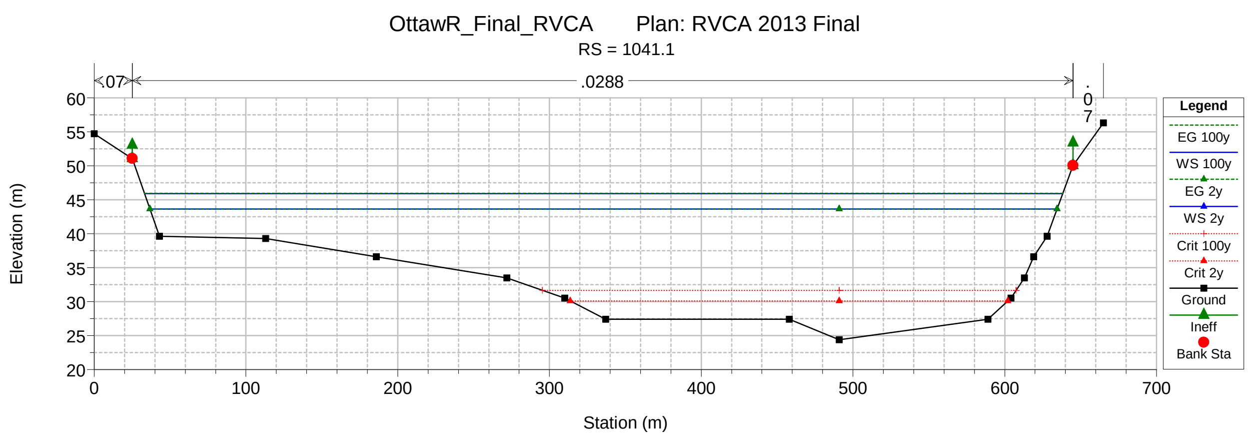


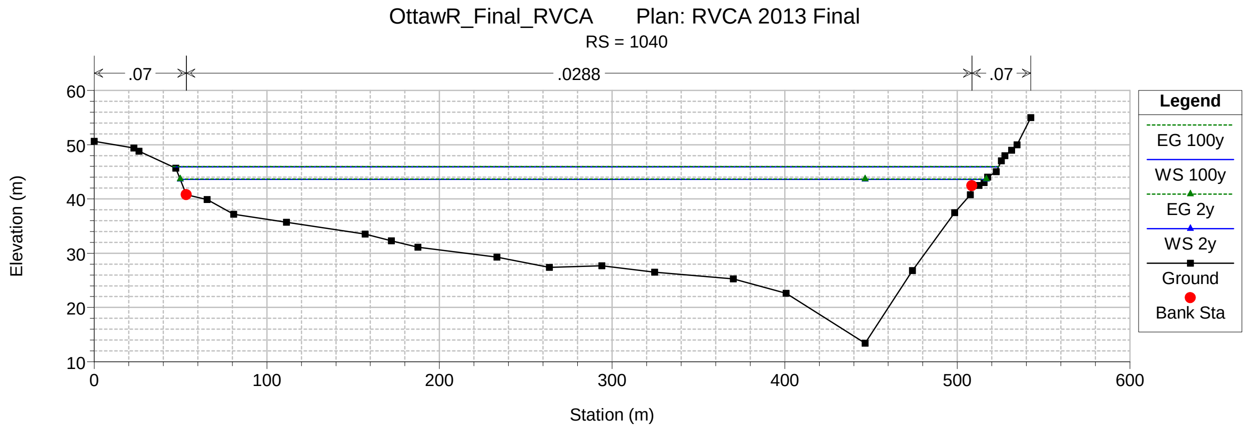
OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1042
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

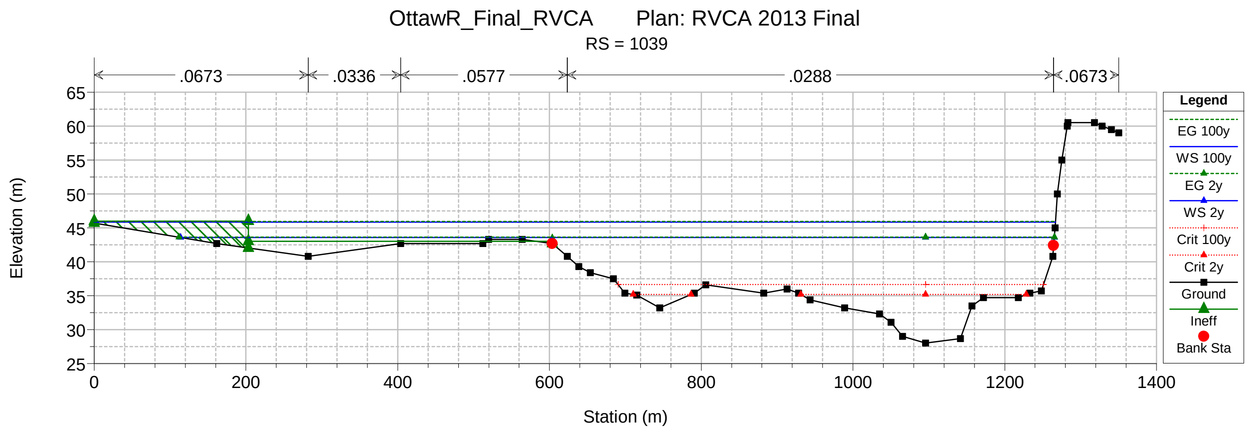

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1041.2 This is a REPEATED section (1041.1)
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

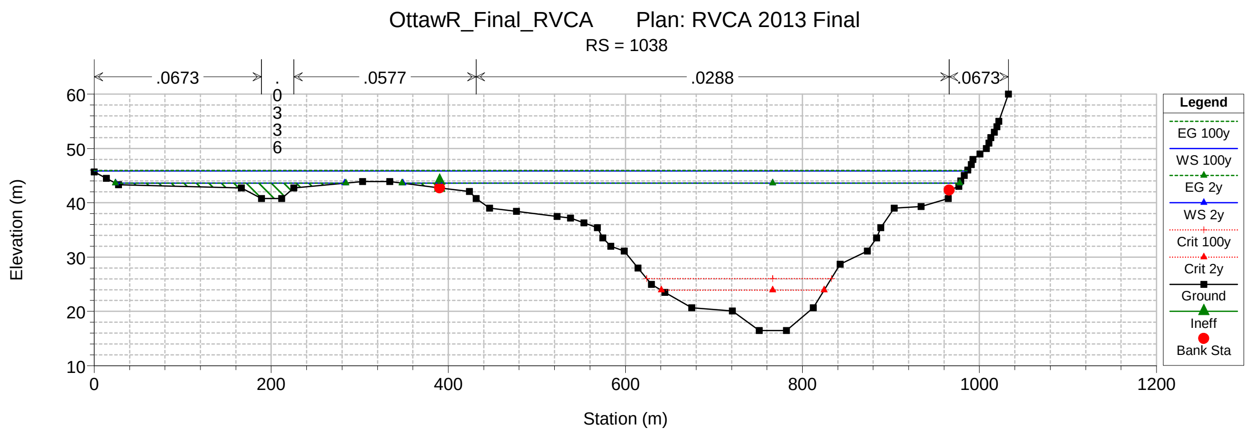

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1041.15 BR MacDonald-Cartier Bridge
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

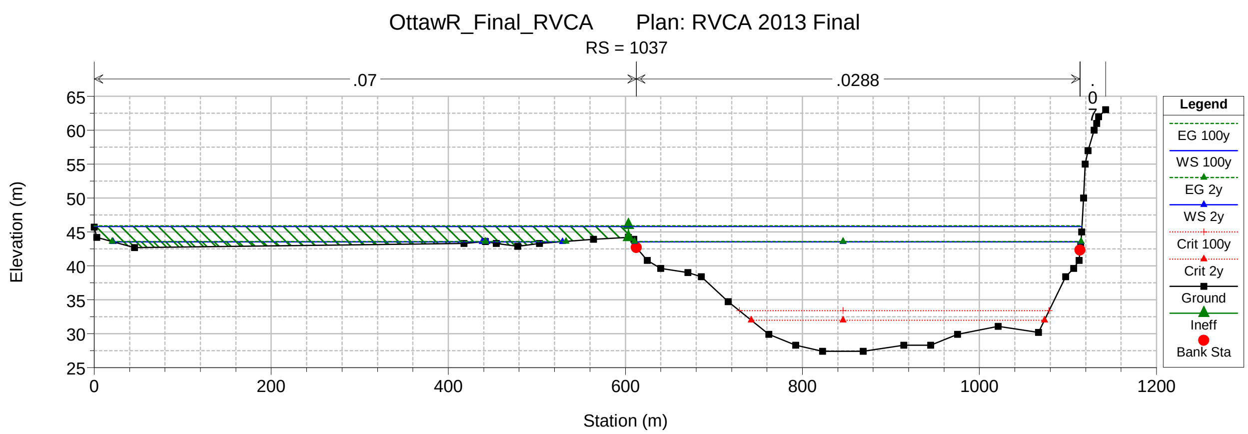

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1041.15 BR MacDonald-Cartier Bridge
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

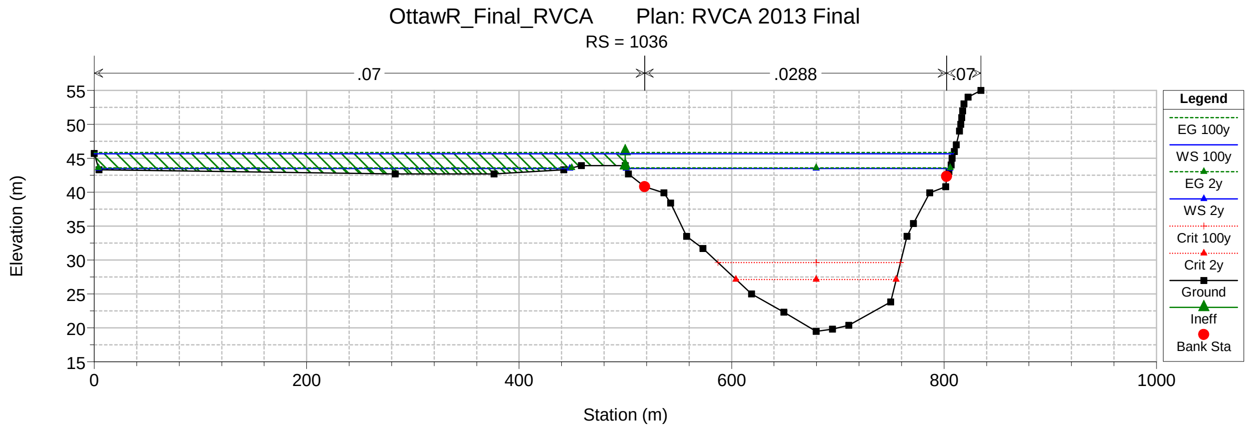

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1041.1
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

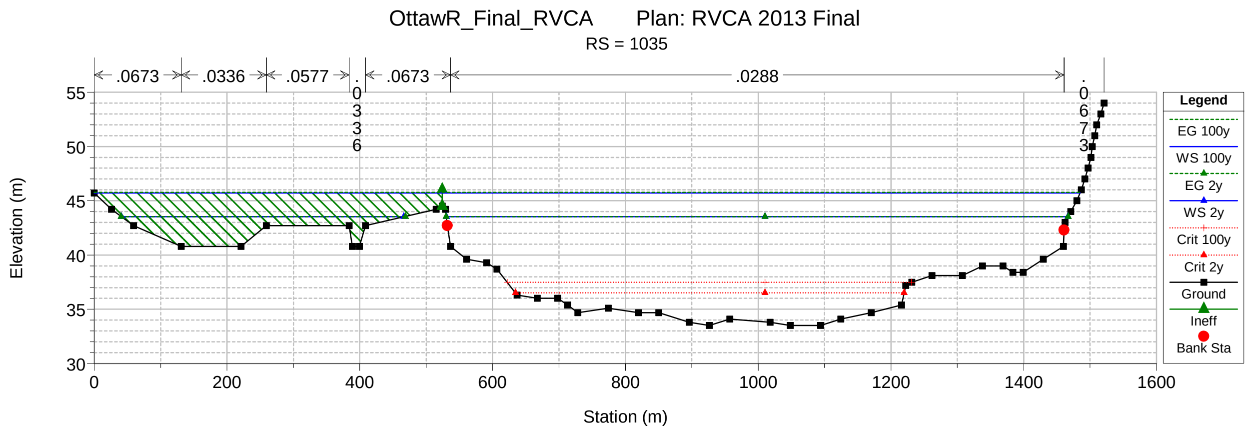

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1040
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

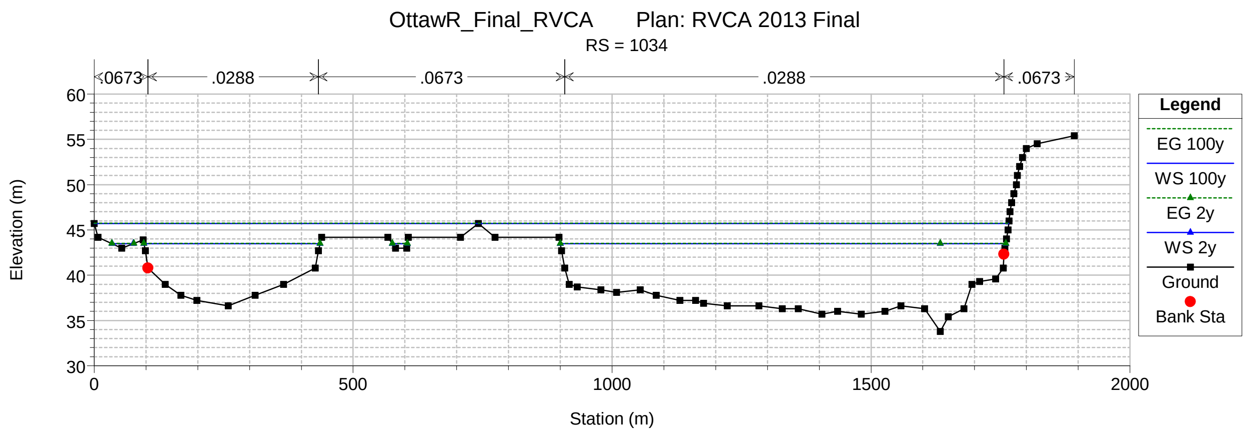

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1039
.0673
.0336
.0577
.0288
.0673
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

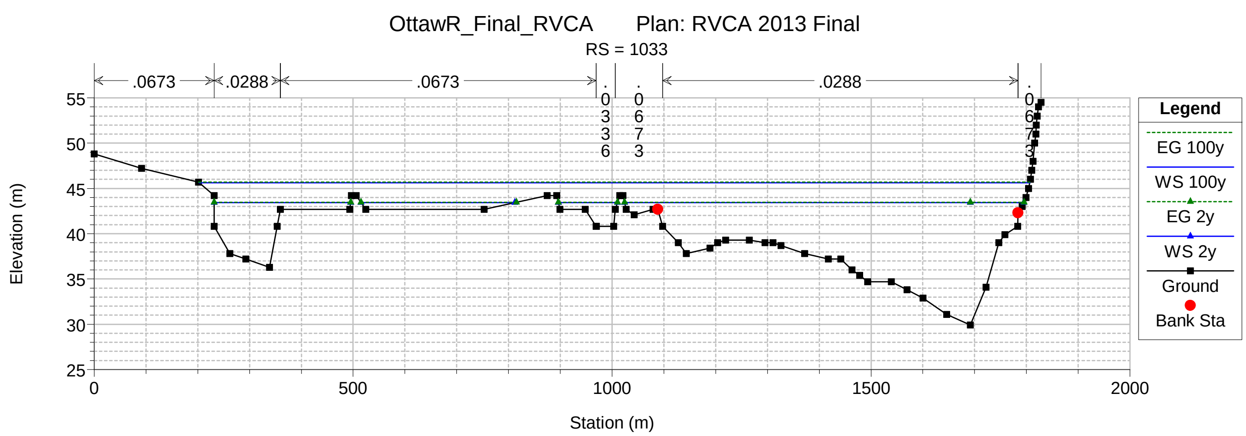

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1038
.0673
.0336
.0577
.0288
.0673
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

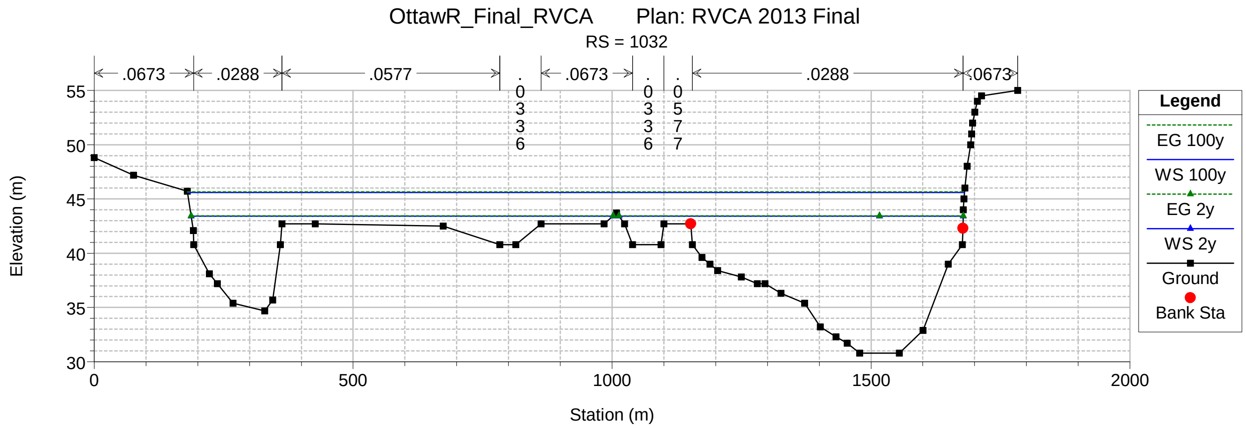

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1037
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

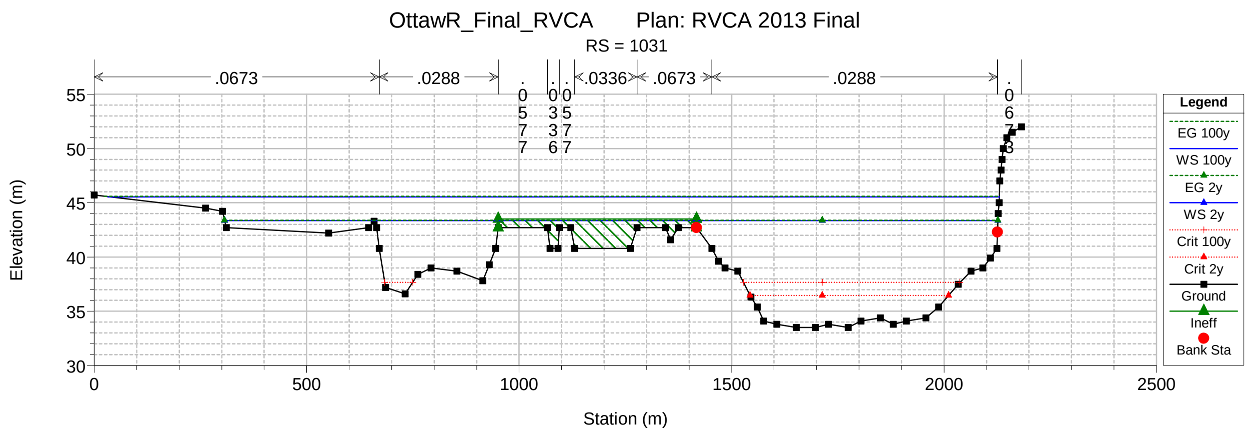

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1036
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

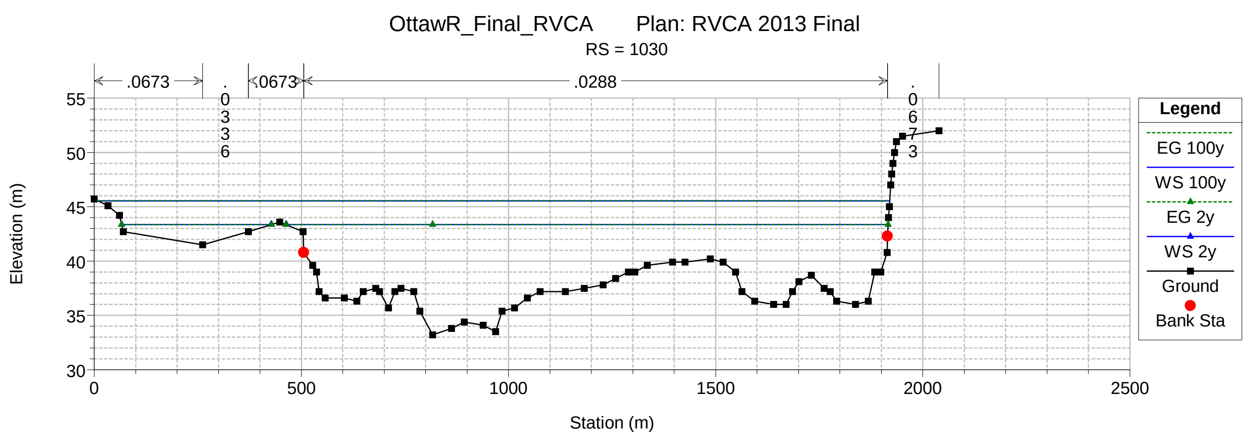

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1035
.0673
.0336
.0577
.0336
.0673
.0288
.0673
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

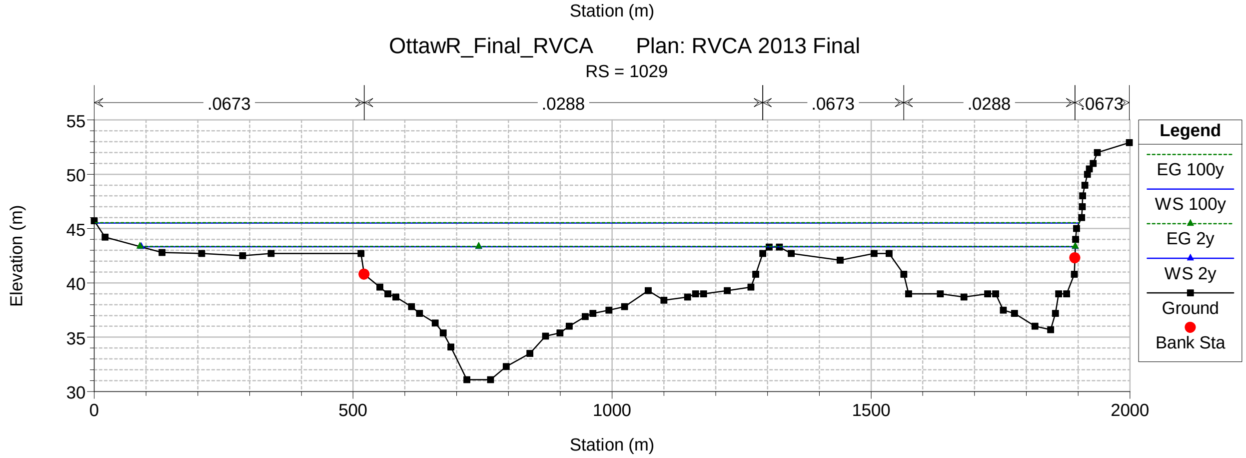

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1034
.0673
.0288
.0673
.0288
.0673
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

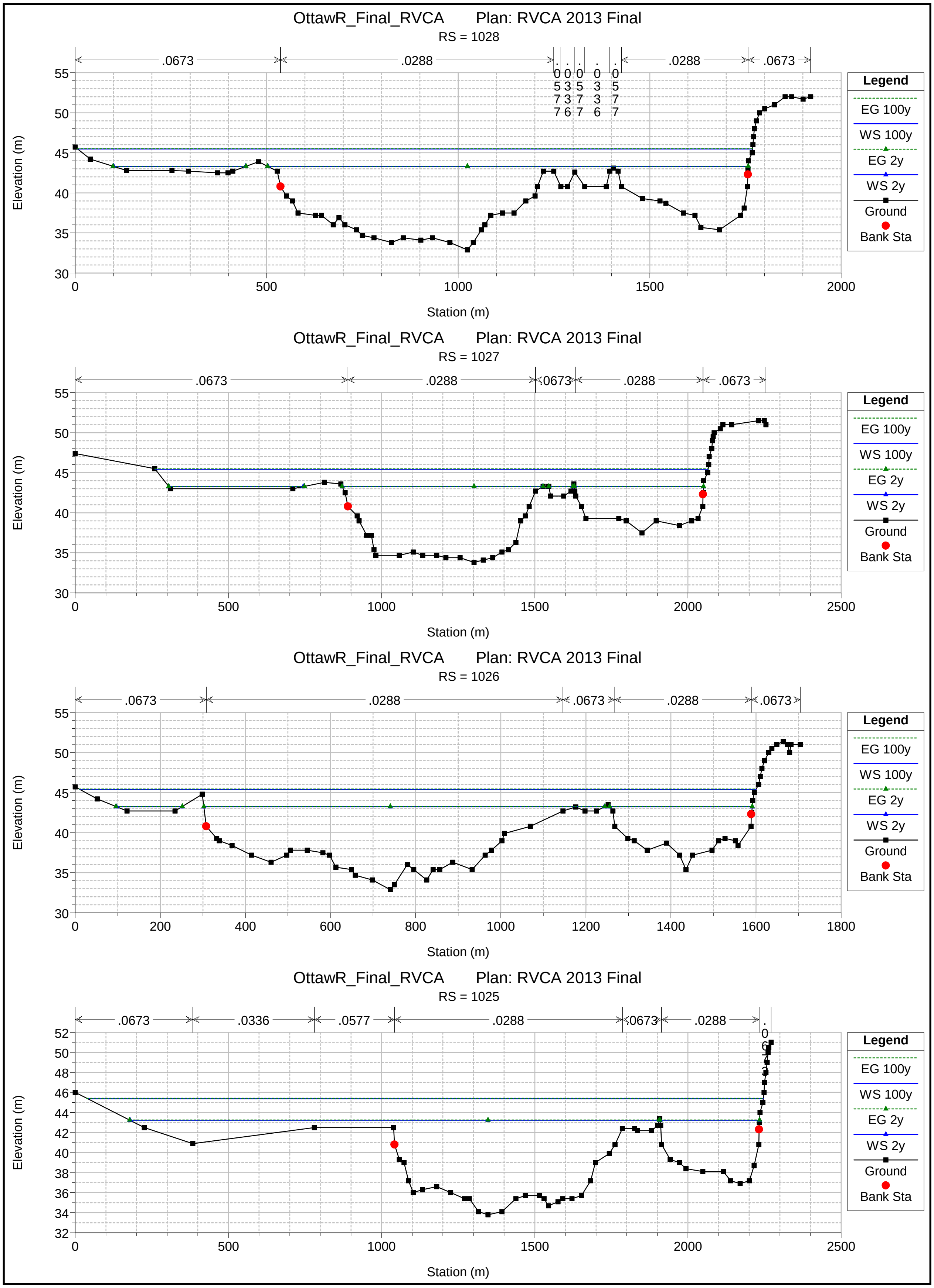

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1033
.0673
.0288
.0673
.0336
.0673
.0288
.0673
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

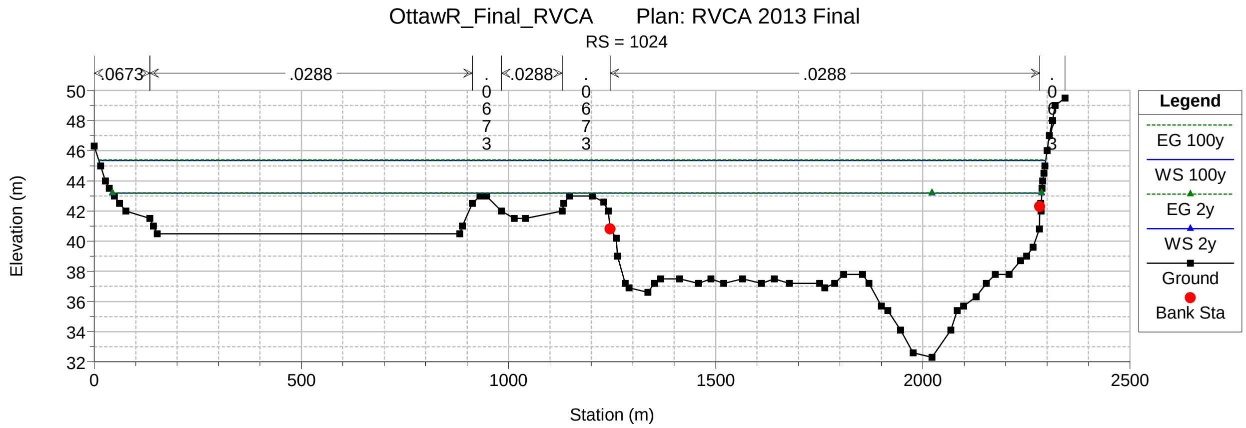

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1032
.0673
.0288
.0577
.0336
.0673
.0336
.0577
.0288
.0673
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

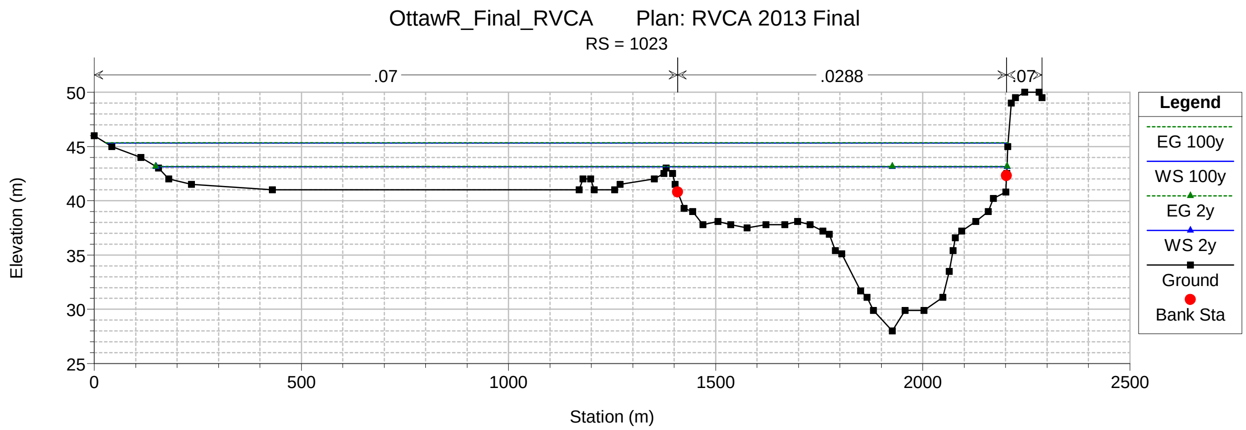

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1031
.0673
.0288
.0577
.0336
.0577
.0336
.0673
.0288
.0673
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

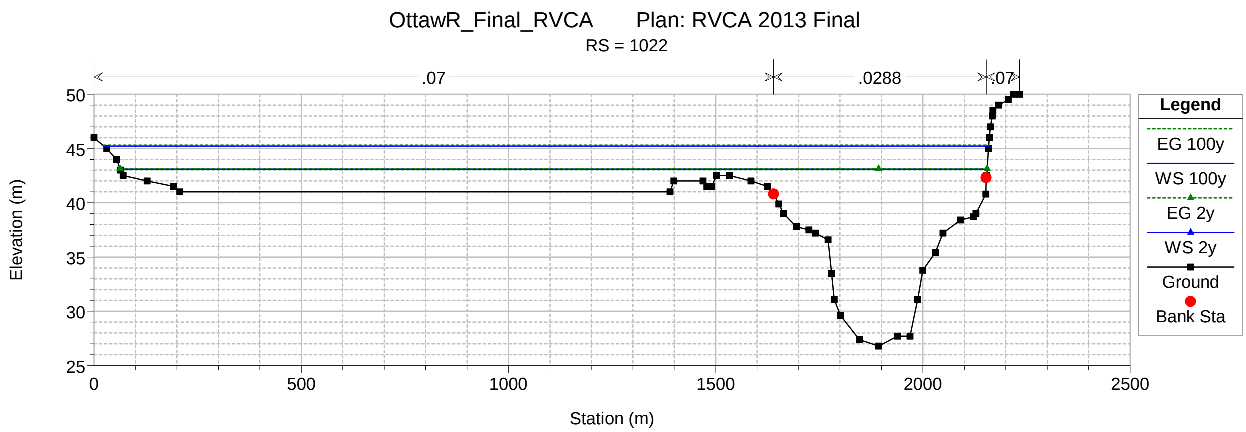

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1030
.0673
.0336
.0673
.0288
.0673
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

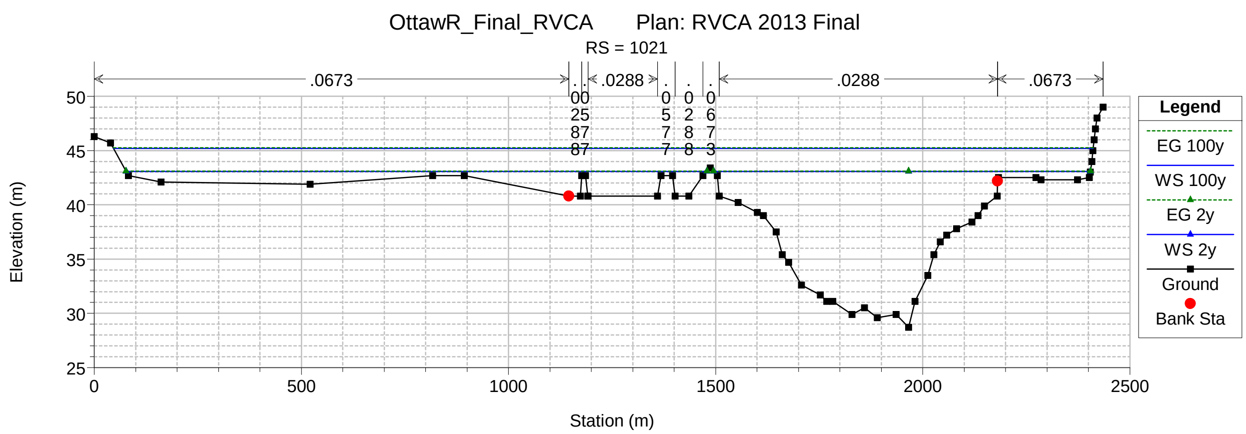

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1029
.0673
.0288
.0673
.0288
.0673
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

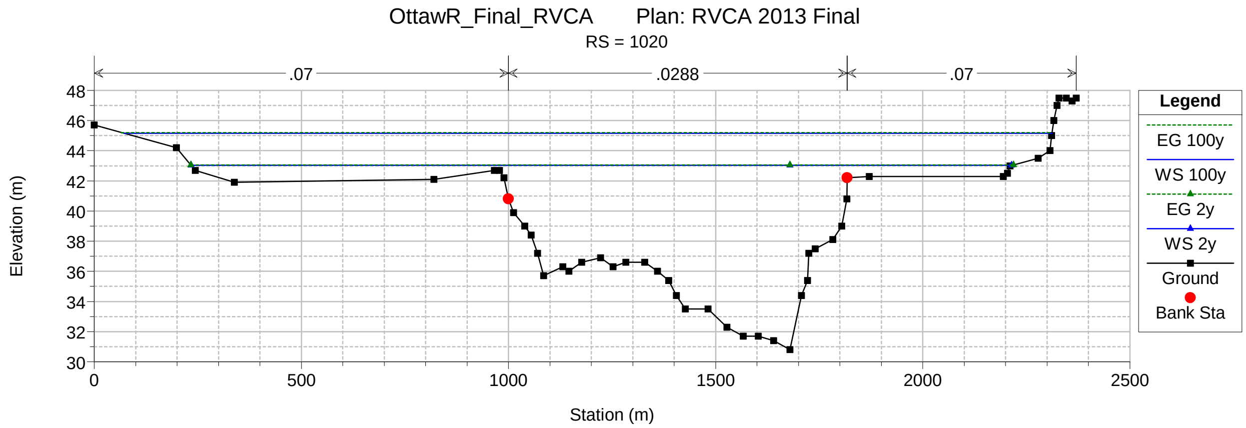

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1028
.0673
.0288
.0288
.0673
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta
OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1027
.0673
.0288
.0673
.0288
.0673
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta
OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1026
.0673
.0288
.0673
.0288
.0673
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta
OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1025
.0673
.0336
.0577
.0288
.0673
.0288
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

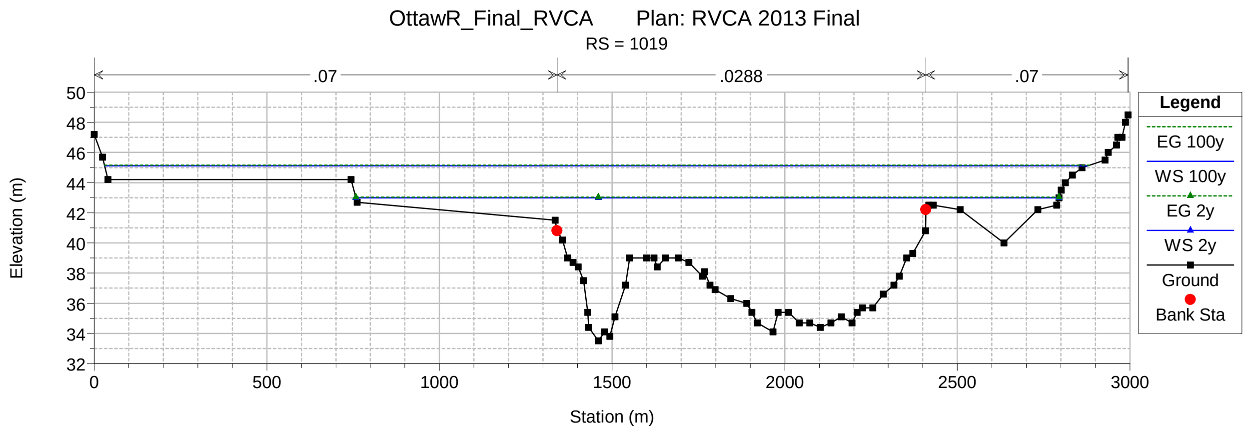

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1024
.0673
.0288
.0673
.0288
.0673
.0288
.063
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

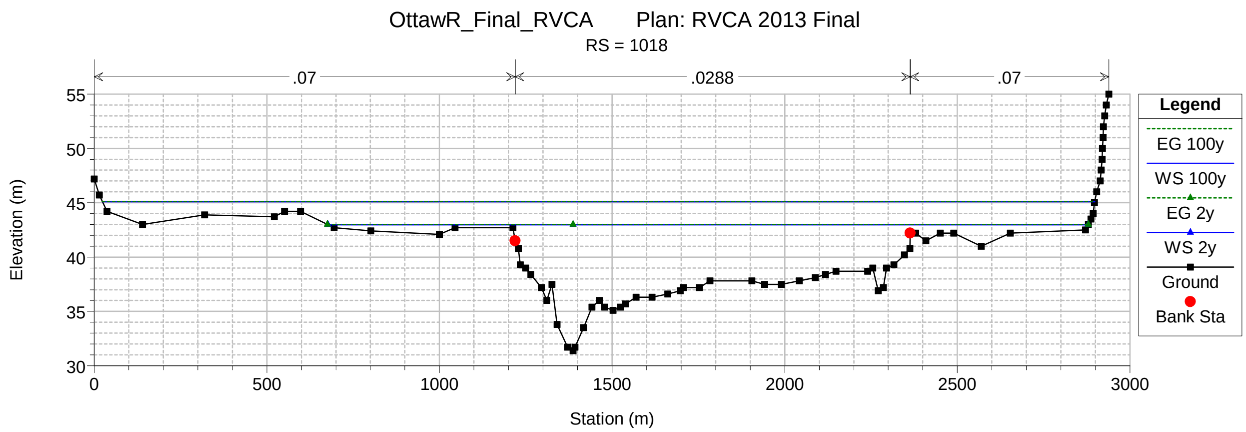

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1023
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

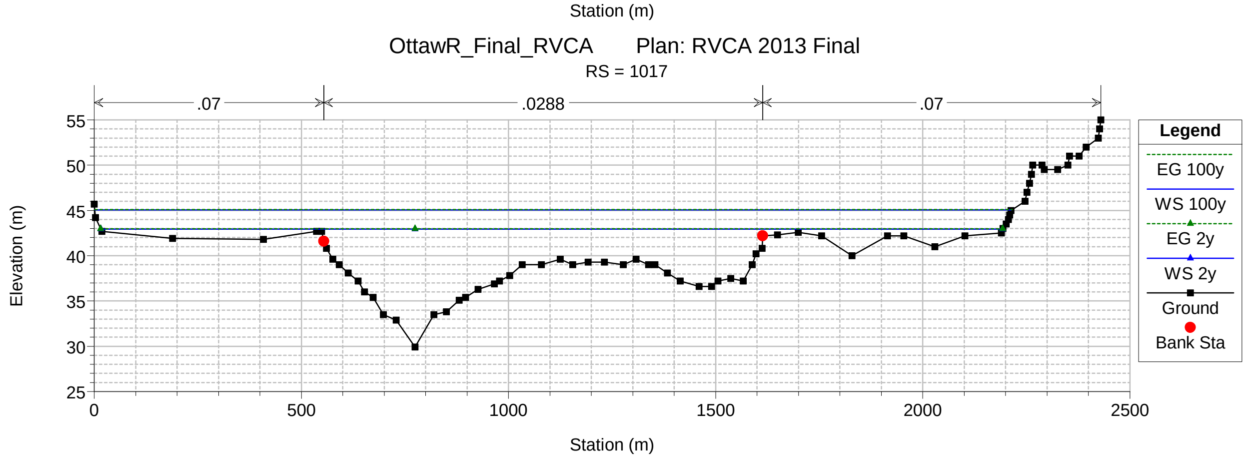

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1022
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

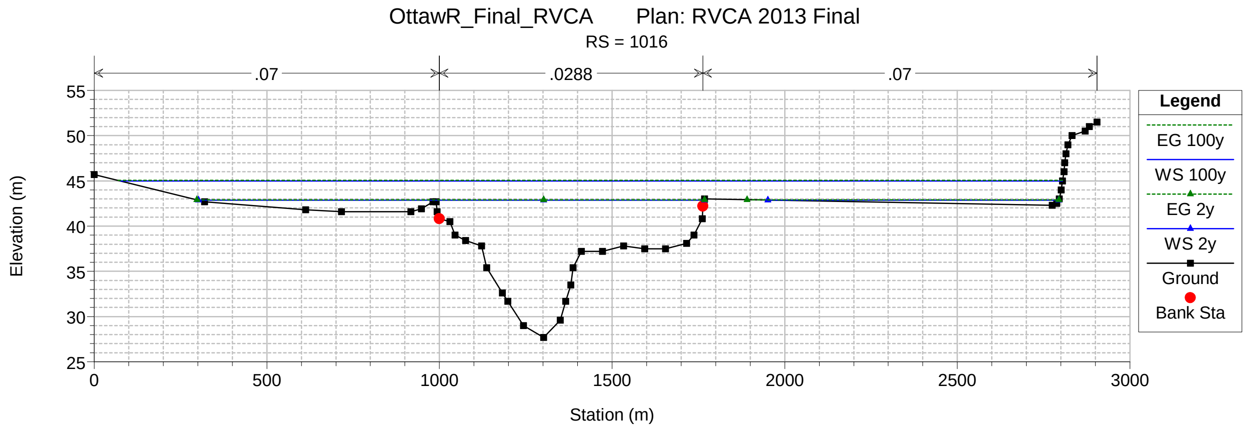

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1021
.0673
.002587
.0288
.0577
.0288
.0673
.0288
.0673
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

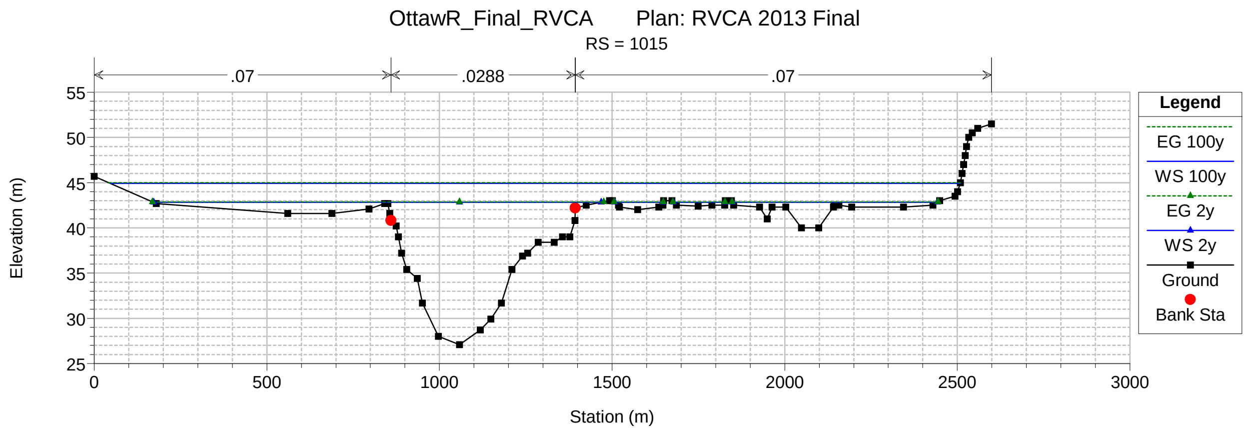

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1020
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

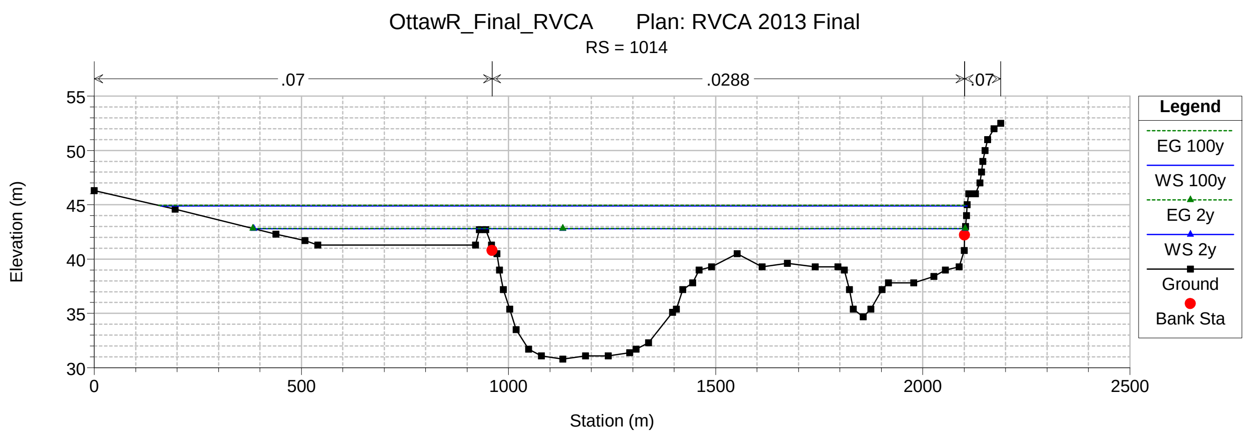

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1019
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

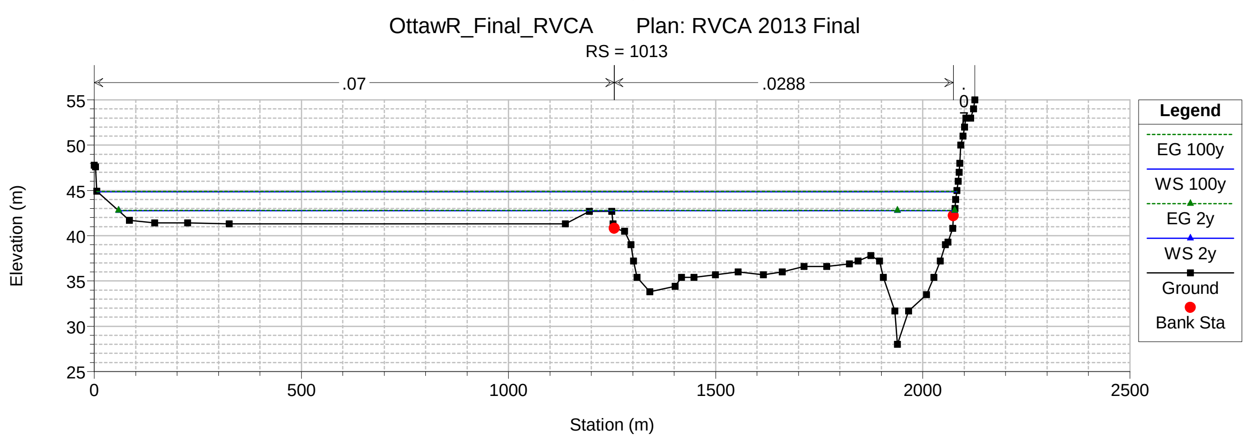

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1018
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

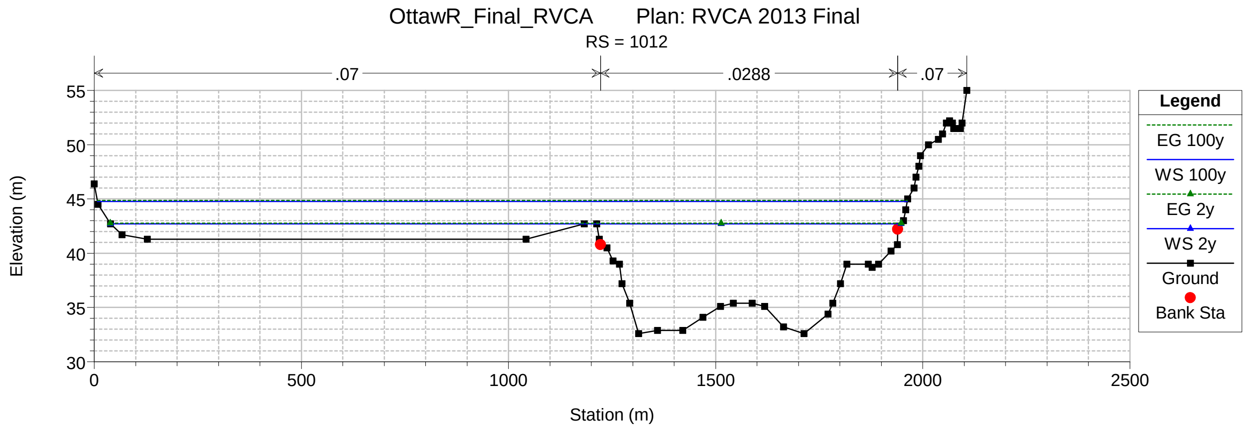

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1017
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

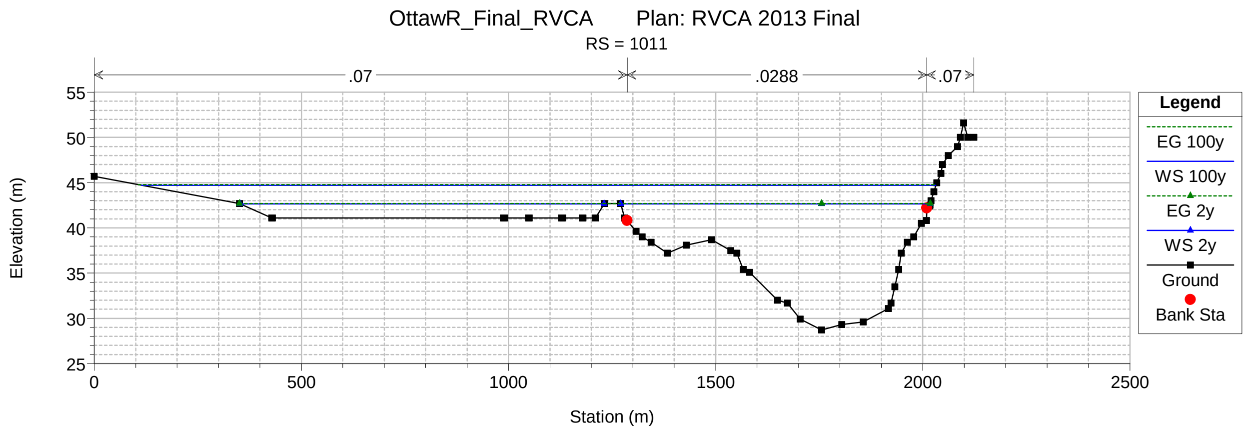

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1016
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

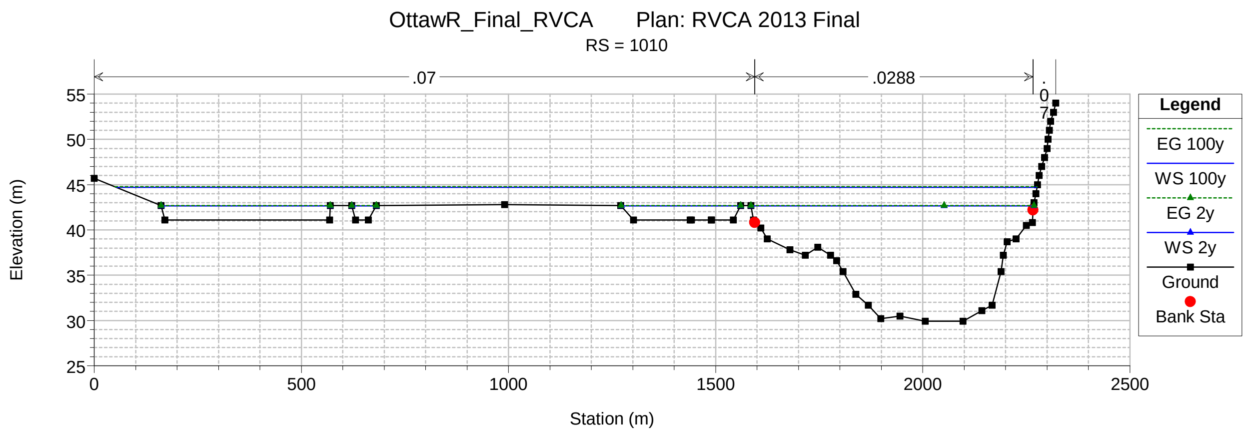

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1015
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

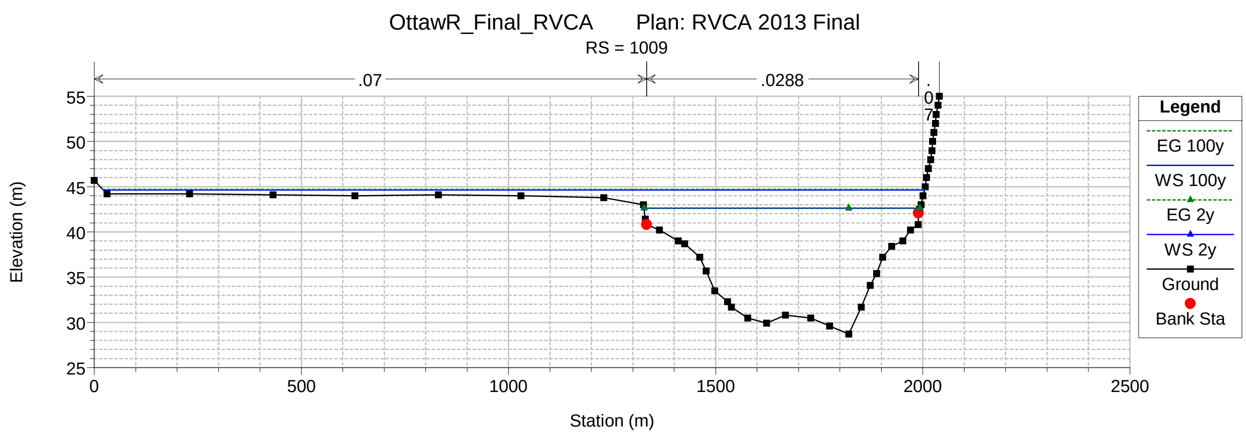

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1014
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

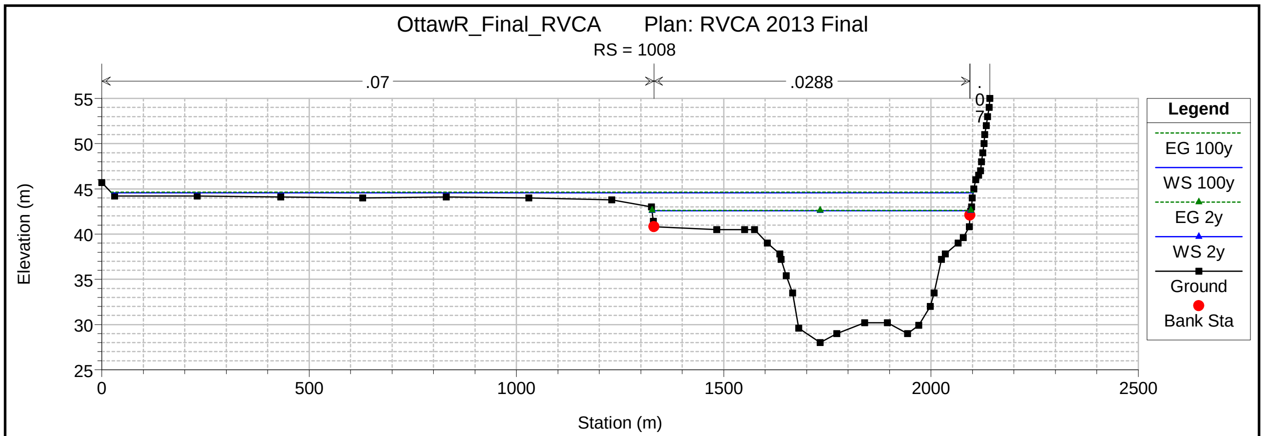

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1013
.07
.0288
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

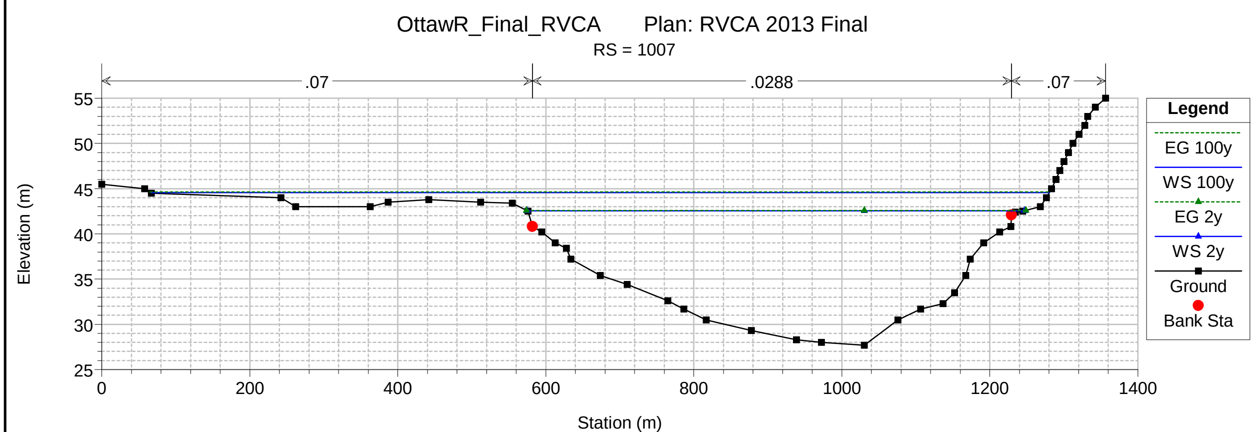

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1012
.07
.0288
.07
Elevation (m)
30
35
40
45
50
55
Station (m)
0
500
1000
1500
2000
2500
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

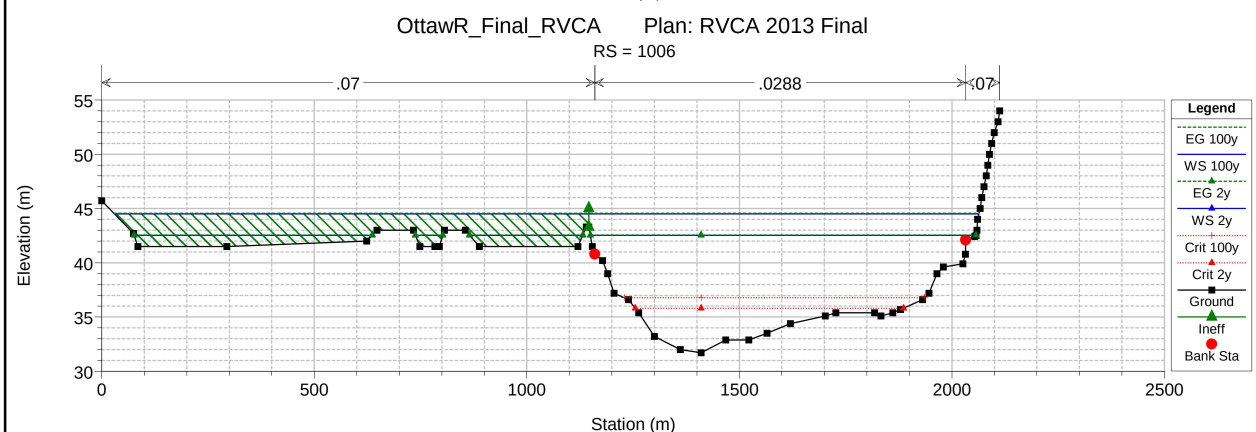

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1011
.07
.0288
.07
Elevation (m)
25
30
35
40
45
50
55
Station (m)
0
500
1000
1500
2000
2500
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

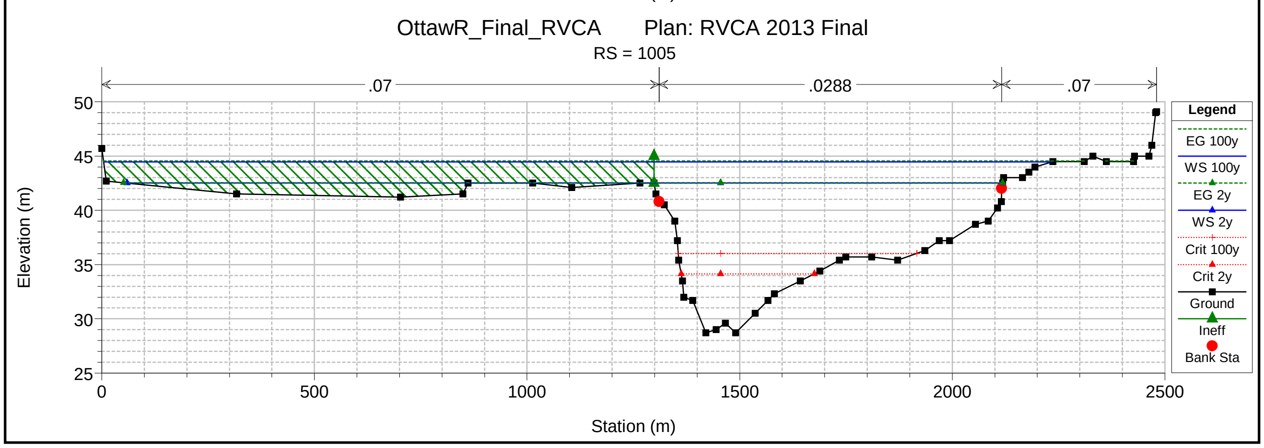

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1010
.07
.0288
.
0
7
Elevation (m)
25
30
35
40
45
50
55
Station (m)
0
500
1000
1500
2000
2500
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

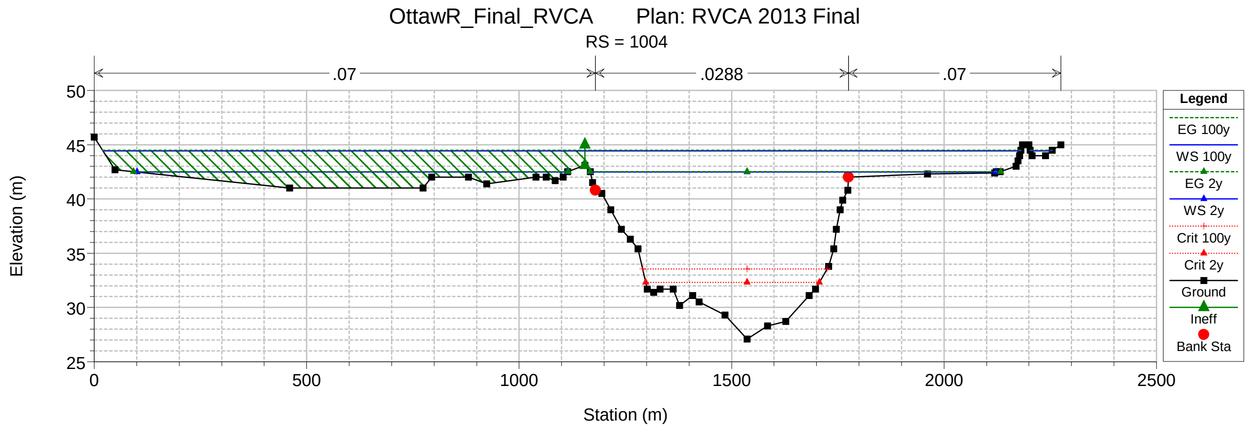

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1009
.07
.0288
.
0
7
Elevation (m)
25
30
35
40
45
50
55
Station (m)
0
500
1000
1500
2000
2500
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

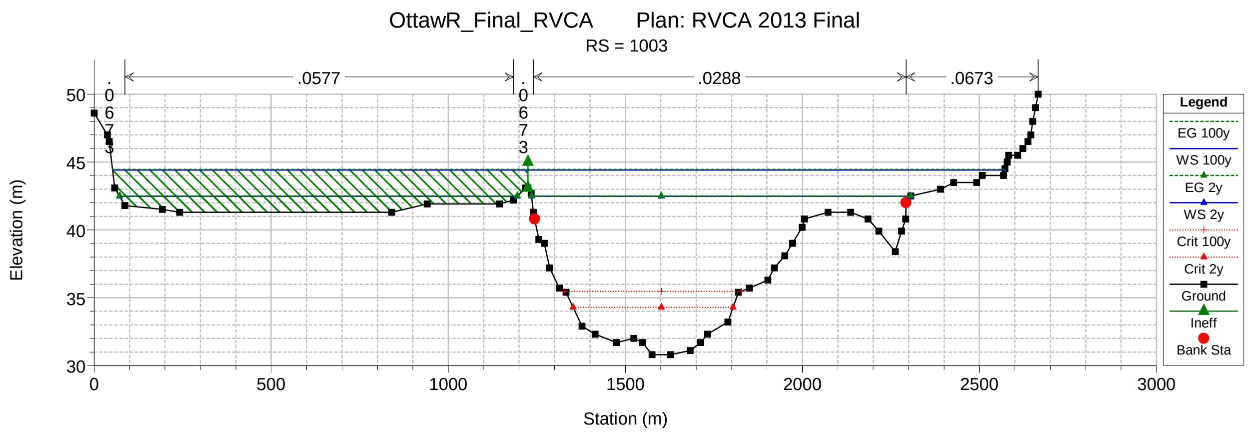

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1008
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

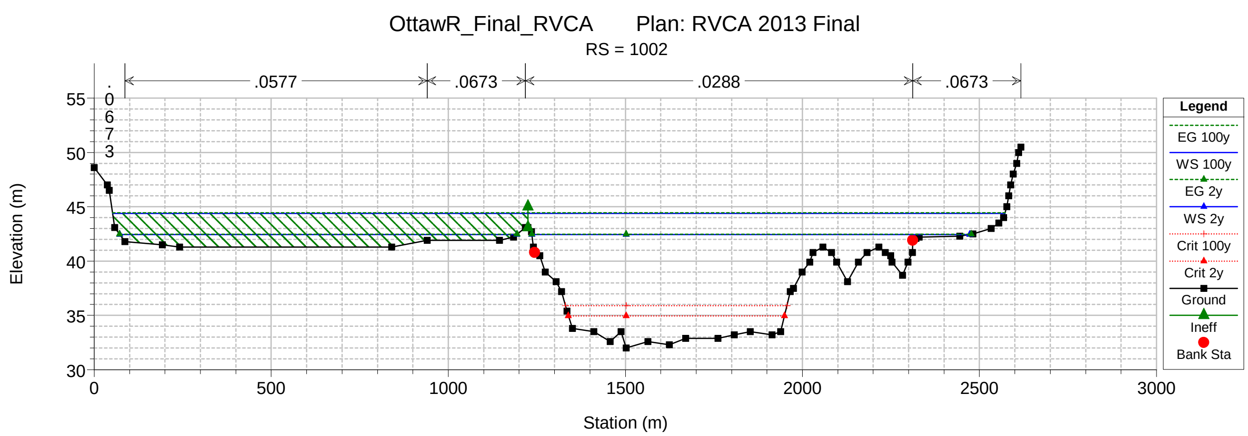

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1007
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Ground
Bank Sta

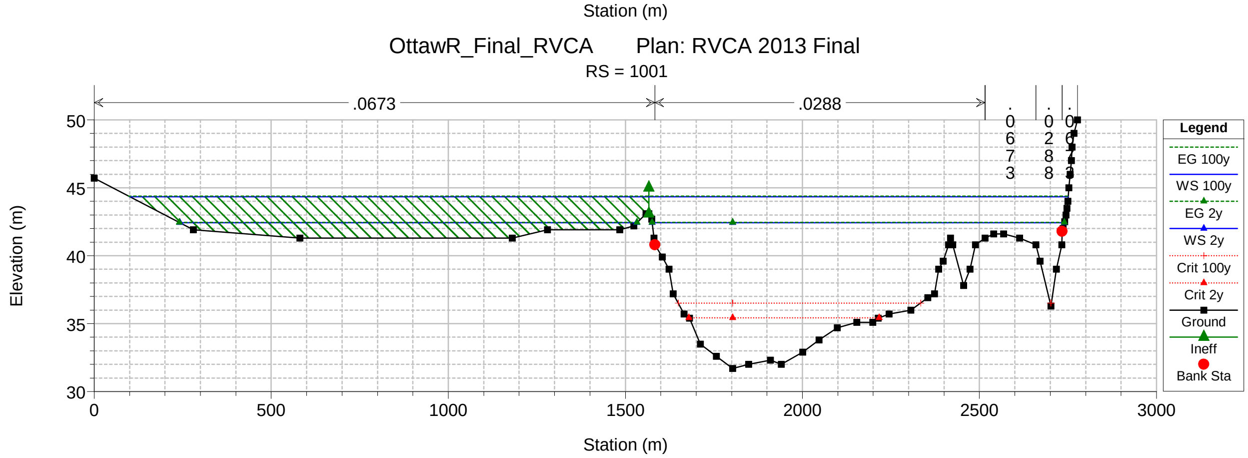

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1006
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

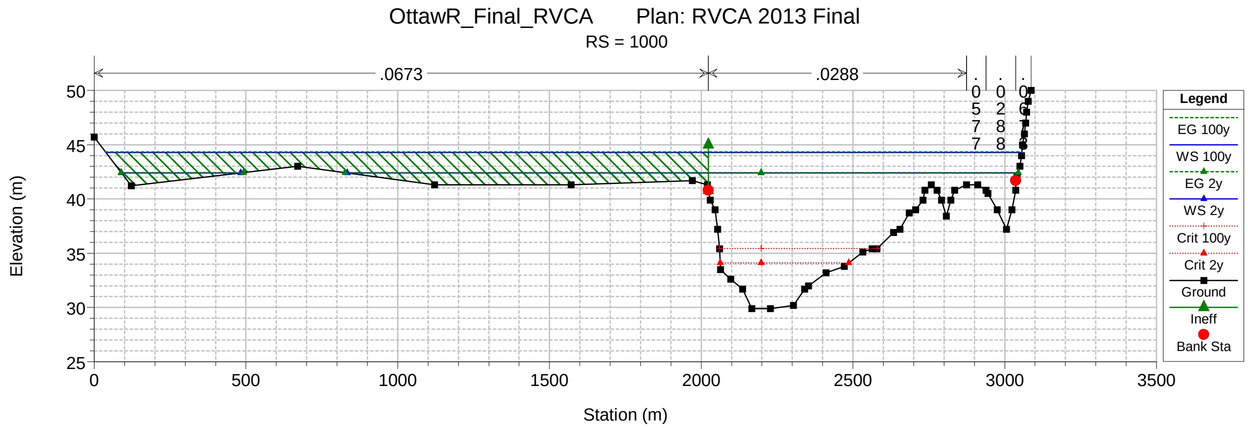

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1005
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

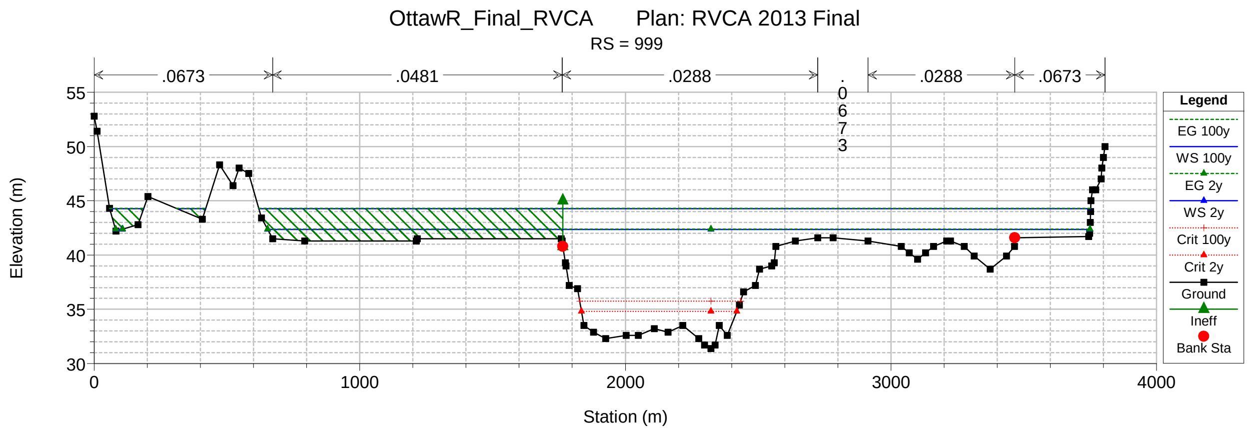

OttawR_Final_RVCA   Plan: RVCA 2013 Final
RS = 1004
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

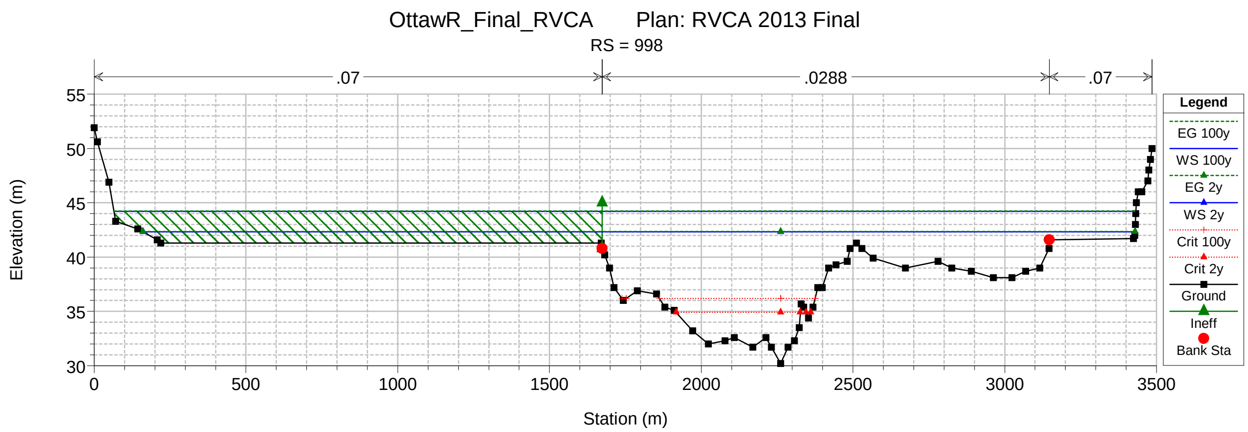

OttawR_Final_RVCA   Plan: RVCA 2013 Final
RS = 1003
.0673
.0577
.0673
.0288
.0673
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

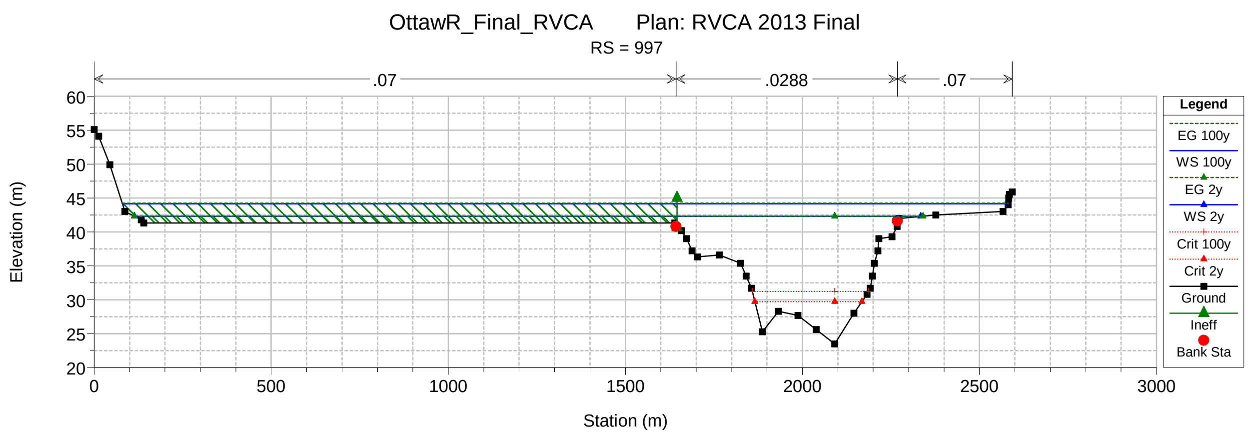

OttawR_Final_RVCA   Plan: RVCA 2013 Final
RS = 1002
.0673
.0577
.0673
.0288
.0673
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

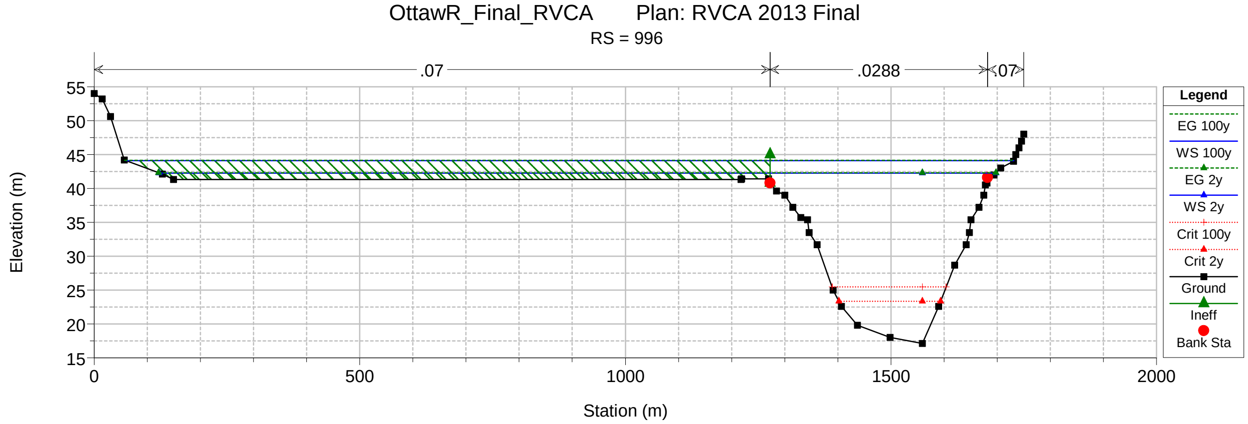

OttawR_Final_RVCA   Plan: RVCA 2013 Final
RS = 1001
.0673
.0288
.0673
.0288
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta

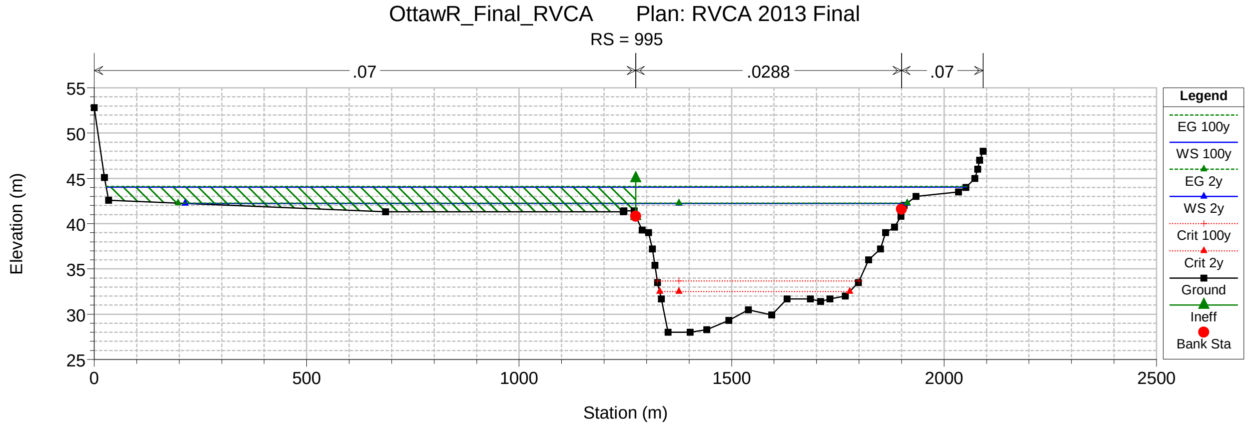

OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 1000
.0673
.0288
.0577
.0288
.06
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta


OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 999
.0673
.0481
.0288
.0673
.0288
.0673
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta


OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 998
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta


OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 997
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta


OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 996
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta


OttawR_Final_RVCA Plan: RVCA 2013 Final
RS = 995
.07
.0288
.07
Elevation (m)
Station (m)
Legend
EG 100y
WS 100y
EG 2y
WS 2y
Crit 100y
Crit 2y
Ground
Ineff
Bank Sta