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Technical Memorandum

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Subject: **Rideau River Flood Risk Mapping from Hogs Back to Kars**

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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 Rideau River from Hogs Back to Kars. The project has been completed 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 (as per Ontario Regulation 174/06) and in municipal land use planning and development approval processes under the Planning Act.

Contents

1. 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 mapping will be created for the first time.

Historically, the Rideau River from Poonamalie Dam to the Rideau Falls has been segmented in to five reaches for flood mapping studies:

1) Rideau River (Hogs Back to Rideau Falls)
2) Rideau River (Hogs Back to Kars) *[this study]*
3) Rideau River (Kars to Burritts Rapids)
4) Rideau River (Burritts Rapids to Smiths Falls)
5) Rideau River (Smiths Falls to Poonamalie Dam)

The first three reaches are within the City of Ottawa and were therefore identified for updating during this program. Updating of the first reach (Hogs Back to Rideau Falls) has already been completed (RVCA, 2016). This report deals with the second reach (Hogs Back to Kars); the third reach is also being studied concurrently (RVCA, 2017b).

The middle three reaches are in need of updating and it was decided that a single, comprehensive hydrological analysis done for the entire Rideau River will be a logical approach. This single hydrological study has now been completed (RVCA, 2017a), which should be read along with the present report. The flood quantiles derived from the hydrology report have been used here (and will be used elsewhere) for flood mapping purposes along the Rideau River.

This report deals with the flood risk mapping of the second reach of the Rideau River (Hogs Back to Kars).

The last mapping study (Dillon, 1989) of this reach is now 28 years old. Changes in the landscape have taken place along the shoreline and floodplain, such that the plotted flood limits in some locations may no longer accurately depict areas that are presently flood prone under regulatory flood conditions. It has been deemed desirable and necessary by the City of Ottawa to produce updated flood line mapping, to facilitate the implementation of the natural hazards policies of its Official Plan and the associated zoning by-laws. A funding contribution from the City has enabled the RVCA to prioritize this project within its ongoing, watershed-wide program of flood risk assessment and flood plain delineation.

This report provides a summary of the analytical methods used and underlying assumptions applied in the preparation of flood plain mapping for the Rideau River from Hogs Back to Kars (Figure 1). 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. It also conforms to the 'generic regulation' guidelines of Conservation Ontario (2005). The 1:100 year flood lines delineated here are suitable for use in the RVCA's regulation limits mapping (as per Ontario Regulation 174/06) and in municipal land use planning and development approval processes under the Planning Act.

The Dillon (1989) mapping has been used by RVCA for regulatory purposes since 1989. The present mapping, when endorsed by RVCA's Board of Directors, will supersede the 1989 Dillon mapping.

2. Study Area

The following stream reaches have been mapped during this study:

- Rideau River from Hogs Back to Manotick;
- Rideau River East Branch around Manotick Island;
- Rideau River West Branch around Manotick Island; and
- Rideau River from Manotick to Kars.

The study reach of the Rideau River extends from the upstream side of Hogs Back Dam to the downstream side of Regional Road 6 or Roger Stevens Drive at Kars (Figure 1). The area mapped is located entirely within the City of Ottawa. The 16 km downstream reach from Hogs Back to Manotick passes through dense urban areas, while the upstream 9 km reach from Manotick to Kars goes through sparsely populated rural areas. There are a few flood vulnerable areas such as those near Winding Way, Carleton Golf and Yacht Club and Hurst Marina.

3. Previous Studies

Two flood plain mapping studies that included the reach from Hogs Back to Kars have been carried out in the past (Dillon, 1972, 1989).

The first study covered a 38 km reach from the Ottawa River to Kars Bridge and used unpublished and published data spanning from 1916 to 1972. Using 56 years of streamflow data of the Rideau River at Ottawa (02LA004; located at Hurdman Bridge from 1911 to 1945 and then moved to Carleton University), a 'best fit' frequency curve was derived. The 1:100 year flow at this location was estimated at 26000 cfs (736.2 cms). Flows at other locations were also estimated, but the details were not documented. It was also mentioned that a 1:100 year rainfall generated much smaller flows than snowmelt-driven spring flows, but again the details were missing. The flood levels were computed using the 'standard step method' and about 200 cross-sections. No information about water control structures or their operation was included in this report. Flood risk lines were then plotted on contour maps obtained from National Capital Commission (NCC). The role of ice in flooding was recognized; however, ice-induced flooding was not investigated as ice cutting/blasting was considered successful in managing ice-induced flooding.

The second study by Dillon (1989) appears to be first study within RVCA jurisdiction to be done under the Canada-Ontario Flood Damage Reduction Program (FDRP) initiated in 1978. This covered the 29 km reach from Hogs Back to Kars. Adjustments at the Carleton gauge were made for instantaneous flows (6% increase) and for Poonamalie Dam operation (5% increase of post-1976 peak flows) using Robinson's (1984) approach[1], but with additional data. During the flood frequency analysis, the effect of discarding low outliers was investigated, and after discussions with Environment Canada staff, it was decided not to discard outliers since such procedures have a tendency to make the data set an unrepresentative sample. Four distributions from the CFA program were fitted to 40 years (1947-1986) of data at the Carleton gauge, yielding estimates of the 1:100 year flood in the range from 597 to 678 cms, with an average of 629 cms which was only 4% lower than Robinson's (1984) estimate of 654 cms. Considering all, it was decided to continue using Robinson's (1984) estimate of 654 cms.

[1] The accompanying hydrology report (RVCA, 2017a) provides more details on Robinson's (1984) methodology and other aspects of hydrological analysis over the last four decades.

Similar adjustments and frequency analysis were done on the Below Manotick gauge data (1948-1986). The same flow (654 cms) was used from Hogs Back to the confluence of the Jock River. The flow distribution along the East and West Branches at Manotick was determined from the hydraulic (HEC-2) computation. The flows at Kars were determined using area prorating using Carleton and Below Manotick gauges (thus making it an extrapolation rather than interpolation); and then the flows between Manotick and Kars were estimated based on linear distance along the river. Once the flows were estimated, the HEC-2 model was setup and run to calculate water surface profiles, and the floodplain lines were plotted on 1:2000 scale topographic maps (made from 1:8000 scale aerial photography) with 1.0 m contour lines and 0.5 m interpolated auxiliary contour lines.

4. Topographical Mapping

LIDAR: High quality topography is the key to high quality flood risk mapping. Digital elevation models were derived from LIDAR data procured by the City of Ottawa. The LIDAR was flown in April 2007 and August 2012. This data set has a density of about 7 to 8 points per square meter, and an estimated vertical accuracy of 0.10 m (Airborne Imagery, 2013). The City also provided 0.25 m contour lines that were derived from LIDAR data. However, we only used the LIDAR points directly for this study, and the contour lines were never used.

In some places, the LIDAR data was missing along the water line or were obscured by trees and shrubs. RVCA staff carried out ground surveys during 2014 and 2015 to collect data to augment the LIDAR data for the purposes of flood line delineation.

The accuracy of the LIDAR data was checked in the field by RVCA staff in April-May 2015. 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, to determine that any differences between mapped and true elevations were within the accuracy prescribed by the FDRP standards.

In total, 330 spot heights were verified (see Table B.1 and Figure B.1 in Appendix B). 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 of the field measurement. As shown in Table B.1, this criterion has been adequately met[2]. On average, the spot heights are within 6.3 cm (Figure B.2).

At the few locations where these criteria are not met, changes to the landscape since the date of air photo have been identified as the probable cause of the discrepancy. Data at these locations were disregarded in the DTM verification.

Drape Imagery: The Drape imagery was collected in April-June 2014 with a horizontal accuracy of ±0.5 metre. This high quality colored photo clearly shows the

[2] FDRP (1986) Manual also specifies criteria for checking contour crossings. However, in this study we used only LIDAR spot heights, not contour lines. Therefore, we did not check the accuracy of contour lines supplied by the City of Ottawa.

rivers, creeks, land use, houses, buildings, roads, infrastructure, vegetation and other details.

2011 Aerial photo: The 2011 aerial photo 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 for the area inside the urban boundary. It enables us to accurately draw flood lines around buildings. This data layer contained information collected over a number of years.

5. Hydrological Analysis

The hydrological analyses to support this study have been documented in an accompanying report (RVCA, 2017a), and are not repeated here. Suffice it to say that the methodology was based on a thorough review of past studies.

Our current methodology for estimating flood quantiles along the Rideau River consists of the following components:

- Estimating and using instantaneous flows
- Converting 'regulated flows' to 'naturalized flows' by using the Robinson (1984) methodology
- Testing streamflow data for suitability for flood frequency analysis (homogeneity, independence, randomness, and trend)
- Using standard flood frequency analysis where long enough streamflow record is available (gauge locations) to estimate flood quantiles
- Using area pro-rating to transpose flood quantiles from gauge locations to other locations
- Using the hydraulic model (HEC-RAS) to determine the flow split where multiple branches are present

Once we settled on this approach, the available streamflow data and watershed characteristics determined to a large extent the eventual outcome of this analysis, i.e., the flood quantiles. Table 1, taken from RVCA (2017a), shows the flood quantiles that were computed for flood mapping purposes along the Rideau River. Table 2 lists the exponents which were determined from streamflow data and were used in computing flows at ungauged locations. Table 3 shows the flows that were used for hydraulic computation (HEC-RAS modeling). Figures 2 and 3 illustrate the spatial distribution of flood quantiles and their relative magnitude.

6. Hydraulic Computations

6.1 HEC-RAS Model

Following standard procedures (MNR, 1986; USACE, 1990, 2010), a steady-state hydraulic model of the Rideau River was built. The steady-state hydraulic model developed using HEC-2 by Dillon (1989) was converted to HEC-RAS and updated to present conditions. The HEC-RAS software (version 4.1.0) developed by the US Army Corps of Engineers (USACE, 2010) was used. It uses the same back water calculation procedure as HEC-2 (USACE, 1990), which has been the industry standard since the 1970s, but with improved data processing and graphical capabilities.

The following streams were included in the model (Figure 4):

- Rideau River from Hogs Back to Manotick (16 km)
- East Branch (5 km)
- West Branch (5 km)
- Rideau River from Manotick to Kars (9 km)

Cross-Sections: The cross-sections used in the modeling were imported from Dillon's (1989) HEC-2 files. These cross-sections (178 in total) were based on the original 1970 bathymetry generated by sounding technique by Canadian Hydrometric Service (CHS). The above-water part of the cross-sections was extracted from 1:2000 scale topographical mapping generated from aerial photography collected on 26th April 1985. This data was supplemented by field data collected by Dillon (1989) and RVCA staff at that time. These cross-sections were deemed to be suitable for the current study. There was some thought about verifying the channel bottom, but the necessary survey work to verify the representativeness of the below-water portion of the cross-sections in the model was considered to be beyond the scope of the project.

In total, 178 cross-sections were used in our HEC-RAS model. Figure 4 shows a schematic of the HEC-RAS model. Figures 9(a-e) show the cross-sections in greater detail, along with the computed Regulatory Flood Levels (RFLs) and flood risk limits. The spacing between and the alignment of river cross-sections within the model were reviewed and adjusted as necessary.

Channel Roughness: These values were directly taken from Dillon's (1989) calibrated HEC-2 model. The Manning's roughness coefficient was generally between

0.030 and 0.035 in the main channel, and was 0.08 for most of the overbank areas (a tabular listing is included in Appendix A). These values were consistent with standard values, such as those recommended by Chow (1959). As will be seen later in this report, these values were found satisfactory and no further adjustment was necessary.

Rating Curve: Rating curve at the Rideau River Below Manotick gauge location was obtained from Water Survey of Canada (WSC) and was used in the verification process (Figure 5).

Bridges/Structures: Within the study area there are seven bridges and four dams (Tables 4 and 5). As-built drawings for all the bridges within the reach were obtained from the City of Ottawa and VIA Rail. The bridges and associated cross-sections were updated to match the as-built information. As-built information for the dams was obtained from Park Canada's Rideau Canal Office, Smith Falls and from Acres (1994) report. Tables 6 and 7 lists the cross-sections, bridges and dams that were modified from Dillon (1989) during the course of this study, and the reason for doing so.

The design flows from the hydrologic analysis (discussed above), with return periods ranging from 2 to 500 years (Table 1), were used in the HEC-RAS model. Table 3 shows the flows that were input to the HEC-RAS model, including the flow split among the East and West Branches around Manotick Island. Flows at this split were automatically computed by the HEC-RAS model. After calibration, the final optimized split is 49% in the East Branch and 51% in the West Branch for the 1:100 year flows. The split varies as flows decreased with larger flows in the west channel, where the 1:2 year flow split was 47% in the east and 53% in the west.

At the downstream end of the HEC-RAS model, the model was extended about 75 m. The boundary conditions, i.e., water levels at the downstream end (cross-section 4.7), were taken from the recent HEC-RAS model for the downstream reach (from Hogs Back to Rideau Falls; RVCA, 2016). Table 8 lists the boundary conditions for various flood events.

All dams were assumed to be fully open during flood conditions. This is the current policy of Parks Canada, the owner and operator of the dams[3].

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.

6.2 Model Verification

If possible, hydraulic models are generally calibrated and validated before being accepted as representative of the river system being modeled. In this case, our HEC-RAS model is based on Dillon's (1989) HEC-2 model, which was calibrated and found satisfactory at that time. Therefore, we first tested the new HEC-RAS model, without significant changes, to see if it works. We found that it works well, and conforms to available data (collected both during Dillon study and since then). By virtue of being a slightly modified version of the well calibrated Dillon's (1989) HEC-2 model[4], the current HEC-RAS model needed almost no adjustment to be considered calibrated. The verification was done in the following ways:

- By comparing water levels during 4 April 2015 flood event
- By comparing water levels during 11 April 2014 flood event
- By comparing water levels during 6 April 1999 flood event
- By comparing water levels during 5 April 1982 flood event
- By comparing water levels during 24 February 1981 flood event
- By comparing the rating curve at Below Manotick gauge

[3] In a meeting between RVCA and Parks Canada staff on 12 March 2015, the current operating policies for the dams along the Rideau Canal were clarified and confirmed by Parks Canada staff. During flood events, Parks Canada fully opens the dams and allows 'free flowing' condition at all structures.

[4] Dillon (1989) calibrated the HEC-2 model by comparing the computed water level to available measured water level during two events (2 October 1986; 27 March 1988) and then corroborated the model by comparing it to air photos and water level data during two other events (29 March 1976; and 26 March to 6 April 1988). The model predicted the water level within 0-26 cm. It appears that all events were used for calibration, and none for validation. These four events used by Dillon (1989) were not considered in this study because pertinent dam setting information was not available.

At Below Manotick gauge (Figure 5), computed water level matches the rating curve very well over a range of flows, with a very slight degree of conservatism (i.e., HEC-RAS overestimates the water levels by about 2-3 cm). This confirms that our intention of calibrating the model to match data as closely as possible, but with a slight degree of conservatism, has been achieved.

The HEC-RAS model is able to match observed water level data very well for the other three events listed above, for which the data was collected by Parks Canada over the years. Tables 9c, 9d and 9e indicate that the matching was within 2-4 cm. The 6 April 1999 and 24 February 1981 floods had a return period between 2 to 5 years, while the 5 April 1982 flood was somewhat smaller.

During the April 2015 flood (a small freshet with a flow of 134 cms at Manotick), high water levels were collected by RVCA staff using photographs and survey grade Trimble. The model was able to compute water levels within 1-10 cm where good measurements were available (Table 9a). In other places, where measurement was done under challenging conditions (waves, steep bank, dam drawdown, etc.) and therefore was prone to greater error and uncertainly, the model underestimated the water level by 16-86 cm; however, the greater uncertainty in the measurement precluded any conclusive proof of model deficiency.

The flow on 11 April 2014 had a return period of about 5 years. The water level recorded at the Below Manotick gauge could be reproduced within 4 cm by the HEC-RAS model (Figure 9b).

The dam setting information during the verification events was supplied by Parks Canada[5] and was used in the verification runs of the model.

Figure 6 shows the summary of all five verification events. Our model was able to simulate water levels within 1-10 cm where good measurements were available. This establishes that the model is good for flood mapping purposes.

It has traditionally and widely been accepted that the calibration process is not meant to force the model to fit all observations, but to match the computed water surface profile to observed water levels within a certain limit. A rule of thumb used by the USACE (US Army Core of Engineers) specifies good calibration when the model

[5] Email communication from Parks Canada staff dated 21 January 2015 and 23 July 2015.

predicts elevations within 30 cm of observation (Heastead Methods, 2003; Bentley Systems 2007); whereas FEMA (US Federal Emergency Management Agency) suggests a 15 cm tolerance (FEMA, 2009). Our model satisfies both criteria. Our approach of slight conservatism (a combination of hydrologic and hydraulic computations) is also congruent with the current notion of the Precautionary Principle, which applies when there exist considerable scientific uncertainties about causality, magnitude, probability, and consequences of different course of action (UNESCO, 2005). The Precautionary Principle is also a key policy of Environment Canada[6].

Based on the above reasoning, the model is considered well calibrated and suitable for flood hazard mapping[7].

6.3 Computed Water Surface Profiles

Once calibrated, the model was run with the design floods. The 1:100 year computed water surface elevations and other parameters are shown in Table 10. A few typical water surface profiles and all cross-sections are included in Appendix A.

Computed water surface elevations for various flood events with return periods ranging from 2 to 500 years are presented in Tables 11 and 12. It should be pointed out that the model has been built and calibrated based on observed flood events in the 130-320 cms range (at Below Manotick gauge) occurring during spring freshet. Caution should be used when applying this model to simulate water surface profiles for flows outside this range, or for flows that occur during other seasons of the year. Such water surface profiles – simulated using the same parameters, especially the Manning's roughness coefficient – would be only approximate, and should be used with caution.

[6] Canada's environmental policy is also guided by the precautionary principle and is reflected in the Federal Sustainable Development Act which states that the Minister of Environment must "develop a Federal Sustainable Development Strategy based on the precautionary principle". The precautionary principle states that: "Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation". In other words, the absence of complete scientific evidence to take precautions does not mean that precautions should not be taken – especially when there is a possibility of irreversible damage (Environment Canada, 2010).

[7] 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.

This is because the river roughness can vary with flow magnitude (with higher resistance associated with lower flows) and with the time of the year (as related to the presence of instream vegetation).

It is also acknowledged that the 1:100 year flood is much larger than the flow range used for calibration. However, use of the same calibration parameter (Manning's roughness calibrated for 130-320 cms flow range) for the 1:100 year flow will result in a very slightly higher (conservative) flood level. This approach is reasonable and is widely accepted as a standard practice.

In cold climate areas like Ontario, floods may occur with or without ice jam. Here we have only analyzed the ice-free or open water condition. Ice-induced flooding has not been looked at because we are unaware of any ice-related flooding that caused significant concern in this area (Hogs Back to Kars). Downstream of Hogs Back, ice jams have historically occurred and have been managed by ice cutting/blasting for at least the last one hundred years.

6.4 Sensitivity Analysis

Flood quantiles have the highest degree of uncertainty in our computation and is most likely to affect the water surface profile. Due to the presence of dams and step-like bed profile of the river, bed roughness is unlikely to exert a major influence on water surface profile computation. Therefore, we decided to test the sensitivity of water surface profile to flow variation.

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

Figures 7(a-b) and 8(a-b) show the computed water surface profiles and the differences in computed water levels for each condition. These figures indicate that the computed water surface elevations are more sensitive to the discharge value in the steeper portions of the reach. The sensitivity analysis indicates that the computed water level can vary by about 0.15 to 0.25 m for a 10% variation in flow along most of the river reach, which is typical in the hydrologic estimation of design flow. For a 20% increase in flow, the water level can go up by 0.2 to 0.5 m.

The sensitivity analysis provides an indication of the potential effect of changes in the expected flood flows that might result from anthropologic intervention in the watershed or from natural variability such as climate change.

7. 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[8]. 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 numerical modeling.

When the stream velocity is relatively low and varies only gradually over relatively long river reaches, the water surface 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 flow velocity and depth 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. Setting RFL equal to the energy grade resolves this problem.

[8] Review of historical water level indicates that it never exceeded the estimated 1:100 year flood level. In a recent study on the lower most reach from Hags Back to Rideau Falls (RVCA, 2016), it was found that the highest recorded water level at Carleton University gauge (60.35 m on 28 March 1976) was lower than the estimated 1:100 year flood level of 60.75 m. Furthermore, during subsequent studies on the upstream reaches (Hogs Back to Kars, and Kars to Burritts Rapids) (RVCA, 2017a, 2017b), the same was found at Manotick gauge (81.01 m recorded vs. 81.80 m estimated flood level) and at Becketts Landing (86.76 m recorded vs. 87.31 m estimated flood level). Therefore, the 1:100 year flood is the appropriate mapping standard for the Rideau River.

In all cases, the RFL is always between the computed water level and energy grade line. Hence, for the sake of simplicity and consistency, 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 10, along with the computed water surface elevations and energy grades at each cross-section in the model.

8. Flood Line Delineation

8.1 General

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 LIDAR spot heights, the inundated area below the RFLs can be easily delineated manually or by using automated computer programs. In the present case, it was done manually with a focus on areas with complex topography, infrastructure, and overbank flow paths. The raw LIDAR spot heights were extensively used in the plotting the flood risk limit.

Field surveys were conducted by RVCA staff in 2015 to verify hydraulic connectivity through culvert openings and flood prone areas. This information (Table 13) was used in plotting the flood risk limit near culverts.

The record of site-specific information associated with RVCA's regulatory approval process was compiled since 2006 (Table 14). At five locations, the site-specific information warranted adjustment of the flood lines; but for the vast majority of locations, no change was required. Available as-built drawings, building layer, and aerial photographs were used to determine the flood risk limit.

Special attention was paid near the outfalls of smaller tributaries to the Rideau River within the study area, since such areas are subjected to flood risk from two sources (backwater from a high Rideau 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 Rideau River – that is, assuming a horizontal water surface profile up along the tributary and an insignificant flow in the tributary itself. 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 – by taking into consideration the potential effect of high flows originating in the tributary watershed, possibly in combination with high water levels on the Rideau River in an appropriate manner.

8.2 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. Recently, RVCA has consolidated a few rules for drawing flood lines in the vicinity of buildings (Appendix C), which have been followed in this study. 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 arise for more 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.

8.3 Islands in the floodplain

Presence of small islands, especially those associated with septic beds, within the floodplain also requires special attention. Recently, RVCA has decided to show small islands with an area less than 1000 m^2 as flood risk area (Appendix C) This guidance was followed during this study.

8.4 Flood mapping data in GIS

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).

Figures 9(a-e) shows the flood risk limits as delineated in this study. At all cross-section locations, the RFL is indicated. The general surrounding and land marks are also included for easy referencing.

9. 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 Rideau 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, 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.

10. 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 (as per Ontario Regulation 174/06) and in municipal land use planning and development approval processes under the Planning Act. The water surface profiles generated in the study will also be useful in the flood forecasting and warning services provided by the RVCA.

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Table 1 Estimated Flood Quantiles to be Used for Flood Mapping.

		Rideau River at Ottawa (02LA004)	Rideau River Below Manotick (02LA012)	Rideau River Below Merrickville (02LA011)	Rideau River Above Smith Falls (02LA005)	Jock River Near Richmond (02LA007)	Kemptville Creek Near Kemptville (02LA006)
Return Period (year)	Annual Probability of Exceedence (%)	Discharge (m^3/s)	Discharge (m^3/s)	Discharge (m^3/s)	Discharge (m^3/s)	Discharge (m^3/s)	Discharge (m^3/s)
2	50	369.00	230.00	120.00	53.00	84.70	48.20
5	20	475.00	292.00	148.00	100.00	125.00	67.20
10	10	529.00	330.00	162.00	117.00	140.00	75.50
20	5	572.00	364.00	174.00	128.00	147.00	80.70
50	2	617.00	406.00	186.00	135.00	151.00	84.80
100	1	644.00	435.00	194.00	140.00	153.00	86.60
200	0.5	667.00	463.00	200.00	145.00	153.00	87.80
350††	0.3	680.00	480.00	204.00	148.00	154.00	88.00
500	0.2	691.00	497.00	207.00	150.00	154.00	88.60
Drainage Area (km^2)		3809	3138	1967	1250	526	411
Data Span		1947-2012	1981-2014	1980-2014	1970-2010	1970-2014	1970-2014
Frequency		GEV	GEV	GEV	Manual Fit	WAKEBY	WAKEBY

Note:

GEV - Generalized Extreme Value

3PLN - 3 Parameter Lognormal

LP3 - Log Pearson Type III

WKY - Wakeby

† Source: RVCA (2015) Rideau River Flood Risk Mapping from Hogs Back to Rideau Falls

†† 350 year flood quantile was estimated by graphical interpolation.

Table 2 Calculated "k" Exponents That Are Used In the Flow Transposition Equation in Order to Determine the Flows at Different Locations.

Return Period (Years)	Rideau River at Ottawa (02LA004) and Rideau River Below Manotick (02LA012)	Rideau River Below Manotick (02LA012) and Rideau River Below Merrickville (02LA011)	Rideau River Below Merrickville (02LA011) and Rideau River Above Smith Falls (02LA005)	Rideau River at Ottawa (02LA004) and Jock River Near Richmond (02LA007)	Rideau River at Ottawa (02LA004) and Kemptville Creek Near Kemptville (02LA006)
2	2.44	1.39	1.80	0.74	0.91
5	2.51	1.45	0.86	0.67	0.88
10	2.44	1.52	0.72	0.67	0.87
20	2.33	1.58	0.68	0.69	0.88
50	2.16	1.67	0.71	0.71	0.89
100	2.03	1.73	0.72	0.73	0.90
200	1.88	1.80	0.71	0.74	0.91
350	1.80	1.83	0.71	0.75	0.92
500	1.70	1.87	0.71	0.76	0.92

Table 3 Estimated Flood Quantiles for HEC-RAS Modelling.

River	Reach	Cross-Section ID	Return Period (Year)								
			500 Yr	350 Yr	200 Yr	100 Yr	50 Yr	20 Yr	10 Yr	5 Yr	2 Yr
Rideau River	USManotick	29000	460.45	445.42	430.18	405.32	379.23	341.25	310.13	275.21	217.30
Rideau River	USManotick	28727	460.84	445.80	430.53	405.64	379.52	341.50	310.35	275.39	217.44
Rideau River	USManotick	27870	462.68	447.54	432.18	407.14	380.87	342.64	311.35	276.24	218.09
Rideau River	USManotick	26830	466.75	451.39	435.84	410.45	383.86	345.19	313.58	278.12	219.51
Rideau River	USManotick	26060	466.86	451.49	435.94	410.53	383.94	345.26	313.64	278.17	219.55
Rideau River	USManotick	25110	467.26	451.88	436.30	410.87	384.24	345.51	313.86	278.36	219.69
Rideau River	USManotick	24165	469.44	453.94	438.26	412.64	385.83	346.87	315.05	279.37	220.45
Rideau River	USManotick	23130	470.37	454.81	439.09	413.39	386.51	347.45	315.55	279.79	220.77
Rideau River	USManotick	21765	473.44	457.72	441.85	415.89	388.76	349.36	317.22	281.21	221.84
Rideau River	USManotick	20890	473.63	457.90	442.02	416.04	388.91	349.48	317.33	281.29	221.91
Rideau River	East Branch†	19890	233.71	225.29	216.94	203.34	189.16	168.27	150.38	133.01	104.42
Rideau River	West Branch†	20090	239.92	232.61	225.08	212.70	199.75	181.21	166.95	148.28	117.49
Rideau River	DS Manotick	15350	497.00	480.00	463.00	435.00	406.00	364.00	330.00	292.00	230.00
Rideau River	DS Manotick	13730	657.69	640.69	622.65	594.65	563.56	517.39	476.08	422.43	318.38
Rideau River	DS Manotick	6615	682.85	671.51	658.30	634.94	607.76	562.77	520.06	466.75	362.77
Rideau River	DS Manotick	0	691.00	680.00	667.00	644.00	617.00	572.00	529.00	475.00	369.00

Note:

† Automatically optimized by HEC-RAS model.

Table 4 Bridge Information.

River/Reach	Bridge	Chainage (m)	Bounding Cross Sections	Top of Deck (m)	Low Chord (m)	Deck Width (m)	Coefficient of Contraction	Coefficient of Expansion	Date of Drawing	Source
Rideau River/DSManotick	Via Rail Bridge	3635	3630 & 3640	89.40	85.70	10.00	0.3	0.5	1979	VIA Rail
Rideau River/DSManotick	Hunt Club Road	5087	5075 & 5100	96.60	92.70	25.00	0.3	0.5	1983	City of Ottawa
Rideau River/DSManotick	Strandherd Drive	12646	12610 & 12685	87.50	86.30	58.70	0.3	0.5	2010	City of Ottawa
Rideau River/West Branch	Barnsdale Road	15856	15850 & 15862	86.50	85.00	12.00	0.3	0.5	1959	City of Ottawa
Rideau River/West Branch	Bridge Street - West Branch	18627	18620 & 18634	88.50	87.80	14.00	0.3	0.5	1957	City of Ottawa
Rideau River/East Branch	Bridge Street - East Branch	18191	18185 & 18196	93.00	92.20	11.00	0.3	0.5	1999	City of Ottawa
Rideau River/USManotick	Roger Stevens Drive	28719	28715 & 28727	94.50	92.60	12.00	0.3	0.5	2011	City of Ottawa

Table 5 Dam Information.

River/Reach	Bridge	Chainage (m)	Bounding Cross Sections	Top of Deck (m)	Sill (m)	Deck Width (m)	Coefficient of Contraction	Coefficient of Expansion	Date of Drawing	Source
Rideau River/DSManotick	Hogs Back Dam	-23	-33 & -12	77.00	71.16, 70.25, 69.64	8.00	0.3	0.5	2008	Parks Canada
Rideau River/DSManotick	Black Rapids Dam	6646	6615 & 6680	79.55	77.24, 74.65, 73.90	7.00	0.3	0.5	2011	Parks Canada
Rideau River/West Branch	Manotick Mill Dam	18792	18759 & 18825	87.43	82.59, 82.21	6.00	0.3	0.5	2008	Parks Canada
Rideau River/East Branch	Long Island Dam	15440	15425 & 15452	86.56	82.30	20.00	0.3	0.5	2007	Parks Canada

Table 6 List of Modified Cross Sections.

Cross-Section	Reason for Change
DS Manotick - (-33)	Added cross section 11550 from the 2014 Rideau River (Rideau Falls to Hogs Back) Study so that the Hogs Back to Kars model stabilises before study area.
DS Manotick - (-74.7)	Added cross section 11507 from the 2014 Rideau River (Rideau Falls to Hogs Back) Study so that the Hogs Back to Kars model stabilises before study area.
DS Manotick - 6680	Added new cross section while updating the Black Rapids Dam. Bathymetry information taken from the next upstream cross section due to the close proximity of the new cross section.
DS Manotick -12610	Added new cross section while modelling the new Strandherd Dr bridge. Bathymetry information taken from the next upstream cross section due to the close proximity of the new cross section.
DS Manotick - 12685	Adjusted cross section while modelling the new Strandherd Dr bridge.
West Branch - 18825	Added new cross sections while upating the Manotick Mill Dam. Limited bathymetry available, therefore trapezoidal channel assumed. Bathymetry data came from the Canadian Hydrographic Service's Nautical Navigation Charts.
West Branch - 18759	
East Branch - 15425	Updated cross section to better reflect channel geometry downstream of Long Island Dam. Limited bathymetry available, therefore trapezoidal channel assumed. Bathymetry data came from the Canadian Hydrographic Service's Nautical Navigation Charts.
East Branch - 15452	Added new cross section while upating the Long Island Dam. Limited bathymetry available, therefore trapezoidal channel assumed. Bathymetry data came from the Canadian Hydrographic Service's Nautical Navigation Charts.

Table 7 List of Modified Bridges and Dams.

Dam or Bridge Section Number	Reason for Change
DS Manotick -23	All dams were remodelled as inline structures instead of cross sections in order to better model the behaviour of the flow over the structures. Dam drawings and information were received from Parks Canada in the form of dam safety inspection sheets.
DS Manotick - 6646	
East Branch - 15440	
West Branch - 18792	
DS Manotick - 12646	Strandherd Dr Bridge was added to the model from planned drawings and later verified with as-built drawings.

Table 8 Downstream Boundary Conditions (Cross Sections -74.7).

Return Period (Years)	Water Level at Cross Section -74.7 (m)
	Taken from Cross Section 11507 of the 2014 Rideau River (Rideau Falls to Hogs Back) HEC-RAS Model
2	70.30
5	70.69
10	70.88
20	71.03
50	71.18
100	71.26
200	71.34
350	71.38
500	71.42

Note:
Taken from Cross Section 11507 of the RVCA (2015) Rideau Falls to Hogs Back HEC-RAS Model.

Table 9A Comparison of the Observed and Computed Water Levels on April 4, 2015.

	Nearest Cross-Section	April 4, 2015 Observed Water Level (m) Q_{Ottawa} = 171.75 m^3/s $Q_{Manotick}$ = 133.61 m^3/s $Q_{Merrickville}$ = 45.62 m^3/s	HEC-RAS Modelled Water Level (m)	WL Difference (Modeled vs Observed) (cm)
Upstream of Hogs Back	105	72.90	72.93	3.00
Hunt Club Bridge	5075	74.82	74.81	-1.00
Lowersill Black Rapids Dam	6615	74.88	74.86	-2.00
Uppersill Black Rapids Dam	6680	77.62	77.46	
Manotick Stream Gauge	15350	80.08	80.00	-8.00
Bridge St East	East Branch - 18196	85.02	85.12	10.00
Whitehorse Park Piers	East Branch - 17920	84.71	84.68	-3.00
Bridge St West	West Branch - 18634	82.60	81.74	
		Average Water Level Difference		-0.17

Notes on Highlighted Cells:

1. Conditions not very conducive to accurate measurements due to waves, steep slopes, dam drawdown and accessibility of site.

2. Due to the measurement conditions the measured value has relatively low accuracy and low confidence.

Table 9B Comparison of the Observed and Computed Water Levels on April 11, 2014.

	Nearest Cross-Section	April 11, 2014 Observed Water Level (m) QOttawa = 430.67 m^3/s QManotick = 315.67 m^3/s QMerrickville = 140.22 m^3/s	HEC-RAS Modelled Water Level (m)	WL Difference (Modeled vs Observed) (cm)
Manotick Stream Gauge	15350	80.96	81.00	4.00
		Average Water Level Difference		4.00

Table 9C Comparison of the Observed and Computed Water Levels on April 6, 1999.

	Nearest Cross-Section	April 6, 1999 Observed Water Level (m) Q_{Ottawa} = 397.00 m³/s $Q_{Manotick}$ = 276.00 m³/s $Q_{Merrickville}$ = 136.00 m³/s	HEC-RAS Modelled Water Level (m)	WL Difference (Modeled vs Observed) (cm)
Manotick Stream Gauge	15350	80.79	80.81	2.00
Kelly's Landing	23780	86.09	86.10	1.00
Doyle Creek	27870	86.28	86.34	6.00
		Average Water Level Difference		3.00

Table 9D Comparison of the Observed and Computed Water Levels on April 5, 1982.

	Nearest Cross-Section	April 5, 1982 Observed Water Level (m) Q_{Ottawa} = 332.00 m^3/s $Q_{Manotick}$ = 262.00 m^3/s $Q_{Merrickville}$ = 89.60 m^3/s	HEC-RAS Modelled Water Level (m)	WL Difference (Modeled vs Observed) (cm)
Lowersill Black Rapids Dam	6615	75.76	75.77	1.00
Uppersill Black Rapids Dam	6680	77.92	77.94	2.00
Manotick Stream Gauge	15350	80.73	80.74	1.00
Bridge St West	West Branch - 18634	83.10	83.16	
		Average Water Level Difference		1.33

Notes on Highlighted Cells:

1. Conditions not very conducive to accurate measurements due to waves, steep slopes, dam drawdown and accessibility of site.
2. Due to the measurement conditions the measured value has relatively low accuracy and low confidence.

Table 9E Comparison of the Observed and Computed Water Levels on February 24, 1981.

	Nearest Cross-Section	February 24, 1981 Observed Water Level (m) Q_{Ottawa} = 435.00 m^3/s $Q_{Manotick}$ = 298.00 m^3/s $Q_{Merrickville}$ = 127.00 m^3/s	HEC-RAS Modelled Water Level (m)	WL Difference (Modeled vs Observed) (cm)
Manotick Stream Gauge	15350	80.88	80.92	4.00
Uppersill Long Island Dam	East Branch - 15452	84.09	84.03	-6.00
Whitehorse Park Piers	East Branch - 17925	85.12	85.19	7.00
Bridge St West	West Branch - 18634	83.50	83.38	
		Average Water Level Difference		1.67

Notes on Highlighted Cells:

1. Conditions not very conducive to accurate measurements due to waves, steep slopes, dam drawdown and accessibility of site.
2. Due to the measurement conditions the measured value has relatively low accuracy and low confidence.

Table 10 Regulatory Flood Levels for the 1:100 Year Flood Event.

River	Reach	Xsec ID #	Q Total (m^3/s)	Computed WSEL (m)	EGL (m)	RFL (m)
Rideau River	USManotick	29000	405.32	87.22	87.23	-
	USManotick	28727	405.64	87.20	87.22	-
	USManotick	28719	Roger Stevens Drive			
	USManotick	28715	405.64	87.20	87.22	87.22
	USManotick	28435	405.64	87.20	87.21	87.21
	USManotick	28245	405.64	87.19	87.20	87.20
	USManotick	28075	405.64	87.19	87.20	87.20
	USManotick	27870	407.14	87.18	87.19	87.19
	USManotick	27540	407.14	87.16	87.18	87.18
	USManotick	27160	407.14	87.15	87.16	87.16
	USManotick	26830	410.45	87.14	87.15	87.15
	USManotick	26545	410.45	87.12	87.14	87.14
	USManotick	26230	410.45	87.11	87.13	87.13
	USManotick	26060	410.53	87.11	87.12	87.12
	USManotick	25810	410.53	87.10	87.11	87.11
	USManotick	25500	410.53	87.09	87.10	87.10
	USManotick	25300	410.53	87.09	87.10	87.10
	USManotick	25110	410.87	87.08	87.09	87.09
	USManotick	24680	410.87	87.03	87.07	87.07
	USManotick	24560	410.87	87.03	87.05	87.05
	USManotick	24350	410.87	86.99	87.03	87.03
	USManotick	24165	412.64	86.98	87.01	87.01
	USManotick	24000	412.64	86.91	86.97	86.97
	USManotick	23780	412.64	86.84	86.91	86.91
	USManotick	23615	412.64	86.81	86.86	86.86
	USManotick	23400	412.64	86.67	86.78	86.78
	USManotick	23130	413.39	86.70	86.71	86.71
	USManotick	22840	413.39	86.68	86.70	86.70
	USManotick	22350	413.39	86.55	86.63	86.63
	USManotick	22015	413.39	86.29	86.44	86.44
	USManotick	21765	415.89	86.36	86.36	86.36
	USManotick	21505	415.89	86.35	86.36	86.36
	USManotick	21275	415.89	86.31	86.34	86.34
	USManotick	21115	415.89	86.30	86.32	86.32
	USManotick	20890	416.04	86.28	86.30	86.30
	USManotick	20515	416.04	86.20	86.25	86.25
	USManotick	20200	416.04	86.15	86.18	86.18
	East Branch	19890	203.34	86.15	86.16	86.16
	East Branch	19715	203.34	86.13	86.15	86.15
	East Branch	19490	203.34	86.08	86.12	86.12
	East Branch	19180	203.34	86.08	86.09	86.09
	East Branch	18870	203.34	86.05	86.07	86.07
	East Branch	18695	203.34	86.04	86.06	86.06
	East Branch	18325	203.34	86.01	86.03	86.03

River	Reach	Xsec ID #	Q Total (m^3/s)	Computed WSEL (m)	EGL (m)	RFL (m)
Rideau River	East Branch	18196	203.34	85.97	86.01	86.01
	East Branch	18191	Bridge Street (East)			
	East Branch	18185	203.34	85.97	86.01	86.01
	East Branch	18135	203.34	85.96	85.99	85.99
	East Branch	17925	203.34	85.52	85.82	85.82
	East Branch	17920	203.34	85.20	85.72	85.72
	East Branch	17720	203.34	85.13	85.14	85.14
	East Branch	17460	203.34	85.05	85.10	85.10
	East Branch	17170	203.34	84.92	84.99	84.99
	East Branch	16820	203.34	84.77	84.82	84.82
	East Branch	16515	203.34	84.71	84.74	84.74
	East Branch	16430	203.34	84.71	84.73	84.73
	East Branch	16130	203.34	84.70	84.70	84.70
	East Branch	16030	203.34	84.70	84.70	84.70
	East Branch	15770	203.34	84.69	84.70	84.70
	East Branch	15570	203.34	84.69	84.70	84.70
	East Branch	15452	203.34	84.55	84.66	84.66
	East Branch	15440	Long Island Dam			
	East Branch	15425	203.34	81.81	81.95	81.95
	West Branch	20090	212.70	86.09	86.16	86.16
	West Branch	19945	212.70	85.88	86.02	86.02
	West Branch	19815	212.70	85.61	85.82	85.82
	West Branch	19690	212.70	85.50	85.63	85.63
	West Branch	19530	212.70	85.52	85.54	85.54
	West Branch	19360	212.70	85.48	85.51	85.51
	West Branch	19025	212.70	85.09	85.30	85.30
	West Branch	18885	212.70	84.39	84.79	84.79
	West Branch	18825	212.70	84.37	84.52	84.52
	West Branch	18792	Manotick Mill Dam			
	West Branch	18759	212.70	84.07	84.15	84.15
	West Branch	18716	212.70	84.02	84.12	84.12
	West Branch	18709	212.70	84.02	84.12	84.12
	West Branch	18634	212.70	84.01	84.07	84.07
	West Branch	18627	Bridge Street (West)			
	West Branch	18620	212.70	84.00	84.06	84.06
	West Branch	18490	212.70	83.88	83.99	83.99
	West Branch	18270	212.70	83.55	83.77	83.77
	West Branch	17975	212.70	83.24	83.43	83.43
	West Branch	17785	212.70	83.25	83.29	83.29
	West Branch	17595	212.70	83.22	83.26	83.26
	West Branch	17375	212.70	83.18	83.22	83.22
	West Branch	17040	212.70	83.11	83.16	83.16
	West Branch	16860	212.70	83.08	83.13	83.13
	West Branch	16510	212.70	82.96	83.04	83.04
	West Branch	16177	212.70	82.70	82.84	82.84

River	Reach	Xsec ID #	Q Total (m^3/s)	Computed WSEL (m)	EGL (m)	RFL (m)
Rideau River	West Branch	15862	212.70	82.42	82.53	82.53
	West Branch	15856	Barnsdale Road			
	West Branch	15850	212.70	82.40	82.52	82.52
	West Branch	15740	212.70	82.10	82.35	82.35
	West Branch	15600	212.70	81.97	82.14	82.14
	West Branch	15420	212.70	81.81	81.96	81.96
	DSManotick	15350	435.00	81.47	81.80	81.80
	DSManotick	15260	435.00	80.43	81.31	81.31
	DSManotick	15190	435.00	80.45	80.74	80.74
	DSManotick	15080	435.00	80.50	80.56	80.56
	DSManotick	14875	435.00	80.47	80.51	80.51
	DSManotick	14625	435.00	80.32	80.44	80.44
	DSManotick	14400	435.00	80.26	80.36	80.36
	DSManotick	14305	435.00	80.28	80.31	80.31
	DSManotick	14210	435.00	80.23	80.29	80.29
	DSManotick	14060	435.00	80.08	80.22	80.22
	DSManotick	13920	435.00	80.13	80.14	80.14
	DSManotick	13730	594.65	80.11	80.13	80.13
	DSManotick	13465	594.65	80.06	80.10	80.10
	DSManotick	13255	594.65	80.03	80.08	80.08
	DSManotick	13045	594.65	79.82	79.99	79.99
	DSManotick	12855	594.65	79.82	79.88	79.88
	DSManotick	12685	594.65	79.65	79.80	79.80
	DSManotick	12646	Strandherd Drive			
	DSManotick	12610	594.65	79.36	79.50	79.50
	DSManotick	12510	594.65	79.33	79.44	79.44
	DSManotick	12315	594.65	79.33	79.36	79.36
	DSManotick	12100	594.65	79.30	79.32	79.32
	DSManotick	11795	594.65	79.27	79.30	79.30
	DSManotick	11480	594.65	79.23	79.27	79.27
	DSManotick	11215	594.65	79.21	79.24	79.24
	DSManotick	10895	594.65	79.18	79.21	79.21
	DSManotick	10575	594.65	79.15	79.19	79.19
	DSManotick	10365	594.65	79.14	79.17	79.17
	DSManotick	10105	594.65	79.12	79.14	79.14
	DSManotick	10055	594.65	79.10	79.14	79.14
	DSManotick	9955	594.65	79.09	79.12	79.12
	DSManotick	9860	594.65	79.08	79.11	79.11
	DSManotick	9665	594.65	79.08	79.10	79.10
	DSManotick	9410	594.65	79.03	79.07	79.07
	DSManotick	9200	594.65	79.01	79.05	79.05
	DSManotick	8960	594.65	78.98	79.03	79.03
	DSManotick	8840	594.65	78.95	79.00	79.00
	DSManotick	8590	594.65	78.92	78.95	78.95
	DSManotick	8400	594.65	78.93	78.93	78.93

River	Reach	Xsec ID #	Q Total (m^3/s)	Computed WSEL (m)	EGL (m)	RFL (m)
Rideau River	DSManotick	8325	594.65	78.92	78.93	78.93
	DSManotick	8245	594.65	78.91	78.92	78.92
	DSManotick	8060	594.65	78.89	78.91	78.91
	DSManotick	7915	594.65	78.86	78.89	78.89
	DSManotick	7725	594.65	78.85	78.87	78.87
	DSManotick	7500	594.65	78.77	78.83	78.83
	DSManotick	7260	594.65	78.65	78.75	78.75
	DSManotick	6955	594.65	78.60	78.65	78.65
	DSManotick	6755	594.65	78.57	78.61	78.61
	DSManotick	6680	594.65	78.56	78.60	78.60
	DSManotick	6646	Black Rapids Dam			
	DSManotick	6615	634.94	77.14	77.19	77.19
	DSManotick	6560	634.94	77.14	77.17	77.17
	DSManotick	6430	634.94	77.15	77.16	77.16
	DSManotick	6210	634.94	77.13	77.15	77.15
	DSManotick	5940	634.94	77.08	77.13	77.13
	DSManotick	5560	634.94	77.03	77.09	77.09
	DSManotick	5205	634.94	77.00	77.05	77.05
	DSManotick	5100	634.94	76.99	77.04	77.04
	DSManotick	5087	Hunt Club Road			
	DSManotick	5075	634.94	76.99	77.04	77.04
	DSManotick	4980	634.94	76.98	77.04	77.04
	DSManotick	4810	634.94	76.94	77.01	77.01
	DSManotick	4555	634.94	76.94	76.98	76.98
	DSManotick	4320	634.94	76.94	76.95	76.95
	DSManotick	4015	634.94	76.88	76.93	76.93
	DSManotick	3750	634.94	76.63	76.83	76.83
	DSManotick	3640	634.94	76.59	76.75	76.75
	DSManotick	3635	VIA Rail Bridge			
	DSManotick	3630	634.94	76.58	76.74	76.74
	DSManotick	3535	634.94	76.52	76.69	76.69
	DSManotick	3335	634.94	76.47	76.58	76.58
	DSManotick	3065	634.94	76.44	76.50	76.50
	DSManotick	2780	634.94	76.33	76.43	76.43
	DSManotick	2440	634.94	76.29	76.34	76.34
	DSManotick	2290	634.94	76.21	76.30	76.30
	DSManotick	2085	634.94	76.02	76.19	76.19
	DSManotick	1950	634.94	75.79	76.05	76.05
	DSManotick	1815	634.94	75.50	75.84	75.84
	DSManotick	1690	634.94	75.22	75.60	75.60
	DSManotick	1545	634.94	75.10	75.35	75.35
	DSManotick	1415	634.94	75.14	75.22	75.22
	DSManotick	1285	634.94	75.16	75.18	75.18
	DSManotick	1150	634.94	75.16	75.17	75.17
	DSManotick	825	634.94	75.16	75.17	75.17

River	Reach	Xsec ID #	Q Total (m^3/s)	Computed WSEL (m)	EGL (m)	RFL (m)
Rideau River	DSManotick	510	634.94	75.15	75.16	75.16
	DSManotick	380	634.94	75.13	75.16	75.16
	DSManotick	200	634.94	75.14	75.15	75.15
	DSManotick	105	634.94	74.95	75.10	75.10
	DSManotick	50	634.94	73.70	74.77	74.77
	DSManotick	0	644.00	73.51	74.19	74.19
	DSManotick	-12	644.00	73.47	74.17	-
	DSManotick	-23	Hogs Back Dam			
	DSManotick	-33	644.00	73.21	73.54	-
	DSManotick	-74.7	644.00	71.26	72.73	-

Note:

RFL - Regulatory Flood Level

EGL - Energy Grade Elevation

WSEL - Computed Water Surface Elevation

Table 11 Flows and Computed Water Levels for the 100, 200, 350 and 500 Year Flood Events.

River	Reach	Xsec ID #	Flow (m³/s) and Computed WSEL (m) for Different Flood Events							
			Q500	WL500	Q350	WL350	Q200	WL200	Q100	WL100
Rideau River	USManotick	29000	460.45	87.50	445.42	87.43	430.18	87.35	405.32	87.22
	USManotick	28727	460.84	87.49	445.80	87.41	430.53	87.33	405.64	87.20
	USManotick	28719	Roger Stevens Drive							
	USManotick	28715	460.84	87.49	445.80	87.41	430.53	87.33	405.64	87.20
	USManotick	28435	460.84	87.48	445.80	87.40	430.53	87.33	405.64	87.20
	USManotick	28245	460.84	87.47	445.80	87.40	430.53	87.32	405.64	87.19
	USManotick	28075	460.84	87.47	445.80	87.39	430.53	87.32	405.64	87.19
	USManotick	27870	462.68	87.46	447.54	87.39	432.18	87.31	407.14	87.18
	USManotick	27540	462.68	87.44	447.54	87.36	432.18	87.29	407.14	87.16
	USManotick	27160	462.68	87.42	447.54	87.35	432.18	87.27	407.14	87.15
	USManotick	26830	466.75	87.41	451.39	87.34	435.84	87.26	410.45	87.14
	USManotick	26545	466.75	87.40	451.39	87.32	435.84	87.25	410.45	87.12
	USManotick	26230	466.75	87.38	451.39	87.31	435.84	87.23	410.45	87.11
	USManotick	26060	466.86	87.38	451.49	87.30	435.94	87.23	410.53	87.11
	USManotick	25810	466.86	87.37	451.49	87.30	435.94	87.22	410.53	87.10
	USManotick	25500	466.86	87.36	451.49	87.29	435.94	87.21	410.53	87.09
	USManotick	25300	466.86	87.35	451.49	87.28	435.94	87.21	410.53	87.09
	USManotick	25110	467.26	87.35	451.88	87.28	436.30	87.20	410.87	87.08
	USManotick	24680	467.26	87.30	451.88	87.23	436.30	87.16	410.87	87.03
	USManotick	24560	467.26	87.30	451.88	87.22	436.30	87.15	410.87	87.03
	USManotick	24350	467.26	87.25	451.88	87.18	436.30	87.11	410.87	86.99
	USManotick	24165	469.44	87.23	453.94	87.16	438.26	87.09	412.64	86.98
	USManotick	24000	469.44	87.16	453.94	87.09	438.26	87.02	412.64	86.91
	USManotick	23780	469.44	87.08	453.94	87.02	438.26	86.95	412.64	86.84
	USManotick	23615	469.44	87.05	453.94	86.99	438.26	86.92	412.64	86.81
	USManotick	23400	469.44	86.91	453.94	86.84	438.26	86.78	412.64	86.67
	USManotick	23130	470.37	86.94	454.81	86.88	439.09	86.81	413.39	86.70
	USManotick	22840	470.37	86.92	454.81	86.85	439.09	86.79	413.39	86.68
	USManotick	22350	470.37	86.76	454.81	86.71	439.09	86.65	413.39	86.55
	USManotick	22015	470.37	86.49	454.81	86.44	439.09	86.38	413.39	86.29
	USManotick	21765	473.44	86.57	457.72	86.51	441.85	86.45	415.89	86.36
	USManotick	21505	473.44	86.56	457.72	86.50	441.85	86.45	415.89	86.35
	USManotick	21275	473.44	86.51	457.72	86.45	441.85	86.40	415.89	86.31
	USManotick	21115	473.44	86.49	457.72	86.44	441.85	86.39	415.89	86.30
	USManotick	20890	473.63	86.48	457.90	86.42	442.02	86.37	416.04	86.28
	USManotick	20515	473.63	86.39	457.90	86.34	442.02	86.28	416.04	86.20
	USManotick	20200	473.63	86.33	457.90	86.28	442.02	86.23	416.04	86.15
	East Branch	19890	233.71	86.33	225.29	86.28	216.94	86.23	203.34	86.15
	East Branch	19715	233.71	86.32	225.29	86.27	216.94	86.22	203.34	86.13
	East Branch	19490	233.71	86.26	225.29	86.21	216.94	86.17	203.34	86.08
	East Branch	19180	233.71	86.26	225.29	86.21	216.94	86.16	203.34	86.08
	East Branch	18870	233.71	86.23	225.29	86.18	216.94	86.13	203.34	86.05

River	Reach	Xsec ID #	Flow (m³/s) and Computed WSEL (m) for Different Flood Events							
			Q500	WL500	Q350	WL350	Q200	WL200	Q100	WL100
Rideau River	East Branch	18695	233.71	86.21	225.29	86.17	216.94	86.12	203.34	86.04
	East Branch	18325	233.71	86.18	225.29	86.14	216.94	86.09	203.34	86.01
	East Branch	18196	233.71	86.13	225.29	86.08	216.94	86.04	203.34	85.97
	East Branch	18191	Bridge Street (East)							
	East Branch	18185	233.71	86.13	225.29	86.08	216.94	86.04	203.34	85.97
	East Branch	18135	233.71	86.12	225.29	86.08	216.94	86.03	203.34	85.96
	East Branch	17925	233.71	85.64	225.29	85.61	216.94	85.58	203.34	85.52
	East Branch	17920	233.71	85.31	225.29	85.28	216.94	85.25	203.34	85.20
	East Branch	17720	233.71	85.35	225.29	85.29	216.94	85.23	203.34	85.13
	East Branch	17460	233.71	85.28	225.29	85.22	216.94	85.16	203.34	85.05
	East Branch	17170	233.71	85.15	225.29	85.09	216.94	85.03	203.34	84.92
	East Branch	16820	233.71	85.00	225.29	84.94	216.94	84.88	203.34	84.77
	East Branch	16515	233.71	84.95	225.29	84.89	216.94	84.82	203.34	84.71
	East Branch	16430	233.71	84.94	225.29	84.88	216.94	84.81	203.34	84.71
	East Branch	16130	233.71	84.93	225.29	84.87	216.94	84.80	203.34	84.70
	East Branch	16030	233.71	84.93	225.29	84.87	216.94	84.80	203.34	84.70
	East Branch	15770	233.71	84.93	225.29	84.87	216.94	84.80	203.34	84.69
	East Branch	15570	233.71	84.93	225.29	84.86	216.94	84.80	203.34	84.69
	East Branch	15452	233.71	84.76	225.29	84.71	216.94	84.65	203.34	84.55
	East Branch	15440	Long Island Dam							
	East Branch	15425	233.71	82.06	225.29	81.99	216.94	81.93	203.34	81.81
	West Branch	20090	239.92	86.28	232.61	86.23	225.08	86.18	212.70	86.09
	West Branch	19945	239.92	86.06	232.61	86.02	225.08	85.97	212.70	85.88
	West Branch	19815	239.92	85.79	232.61	85.74	225.08	85.69	212.70	85.61
	West Branch	19690	239.92	85.67	232.61	85.62	225.08	85.58	212.70	85.50
	West Branch	19530	239.92	85.70	232.61	85.65	225.08	85.60	212.70	85.52
	West Branch	19360	239.92	85.65	232.61	85.61	225.08	85.56	212.70	85.48
	West Branch	19025	239.92	85.24	232.61	85.20	225.08	85.16	212.70	85.09
	West Branch	18885	239.92	84.55	232.61	84.51	225.08	84.46	212.70	84.39
	West Branch	18825	239.92	84.54	232.61	84.49	225.08	84.45	212.70	84.37
	West Branch	18792	Manotick Mill Dam							
	West Branch	18759	239.92	84.33	232.61	84.26	225.08	84.19	212.70	84.07
	West Branch	18716	239.92	84.27	232.61	84.21	225.08	84.14	212.70	84.02
	West Branch	18709	239.92	84.27	232.61	84.20	225.08	84.14	212.70	84.02
	West Branch	18634	239.92	84.26	232.61	84.19	225.08	84.12	212.70	84.01
	West Branch	18627	Bridge Street (West)							
	West Branch	18620	239.92	84.25	232.61	84.19	225.08	84.12	212.70	84.00
	West Branch	18490	239.92	84.13	232.61	84.07	225.08	84.00	212.70	83.88
	West Branch	18270	239.92	83.80	232.61	83.73	225.08	83.66	212.70	83.55
	West Branch	17975	239.92	83.50	232.61	83.43	225.08	83.36	212.70	83.24
	West Branch	17785	239.92	83.50	232.61	83.44	225.08	83.37	212.70	83.25
	West Branch	17595	239.92	83.48	232.61	83.41	225.08	83.34	212.70	83.22
	West Branch	17375	239.92	83.43	232.61	83.37	225.08	83.30	212.70	83.18

River	Reach	Xsec ID #	Flow (m³/s) and Computed WSEL (m) for Different Flood Events							
			Q500	WL500	Q350	WL350	Q200	WL200	Q100	WL100
Rideau River	West Branch	17040	239.92	83.36	232.61	83.30	225.08	83.23	212.70	83.11
	West Branch	16860	239.92	83.33	232.61	83.27	225.08	83.20	212.70	83.08
	West Branch	16510	239.92	83.21	232.61	83.14	225.08	83.08	212.70	82.96
	West Branch	16177	239.92	82.94	232.61	82.88	225.08	82.81	212.70	82.70
	West Branch	15862	239.92	82.67	232.61	82.60	225.08	82.53	212.70	82.42
	West Branch	15856	Barnsdale Road							
	West Branch	15850	239.92	82.66	232.61	82.59	225.08	82.52	212.70	82.40
	West Branch	15740	239.92	82.34	232.61	82.27	225.08	82.21	212.70	82.10
	West Branch	15600	239.92	82.22	232.61	82.15	225.08	82.08	212.70	81.97
	West Branch	15420	239.92	82.07	232.61	82.00	225.08	81.93	212.70	81.81
	DSManotick	15350	497.00	81.70	480.00	81.64	463.00	81.57	435.00	81.47
	DSManotick	15260	497.00	80.67	480.00	80.60	463.00	80.54	435.00	80.43
	DSManotick	15190	497.00	80.72	480.00	80.65	463.00	80.58	435.00	80.45
	DSManotick	15080	497.00	80.77	480.00	80.70	463.00	80.62	435.00	80.50
	DSManotick	14875	497.00	80.74	480.00	80.66	463.00	80.59	435.00	80.47
	DSManotick	14625	497.00	80.57	480.00	80.50	463.00	80.43	435.00	80.32
	DSManotick	14400	497.00	80.50	480.00	80.44	463.00	80.37	435.00	80.26
	DSManotick	14305	497.00	80.53	480.00	80.46	463.00	80.39	435.00	80.28
	DSManotick	14210	497.00	80.47	480.00	80.41	463.00	80.34	435.00	80.23
	DSManotick	14060	497.00	80.30	480.00	80.24	463.00	80.18	435.00	80.08
	DSManotick	13920	497.00	80.37	480.00	80.31	463.00	80.24	435.00	80.13
	DSManotick	13730	657.69	80.34	640.69	80.28	622.65	80.22	594.65	80.11
	DSManotick	13465	657.69	80.29	640.69	80.23	622.65	80.16	594.65	80.06
	DSManotick	13255	657.69	80.26	640.69	80.20	622.65	80.14	594.65	80.03
	DSManotick	13045	657.69	80.03	640.69	79.98	622.65	79.92	594.65	79.82
	DSManotick	12855	657.69	80.03	640.69	79.98	622.65	79.92	594.65	79.82
	DSManotick	12685	657.69	79.86	640.69	79.80	622.65	79.75	594.65	79.65
	DSManotick	12646	Strandherd Drive							
	DSManotick	12610	657.69	79.55	640.69	79.50	622.65	79.45	594.65	79.36
	DSManotick	12510	657.69	79.52	640.69	79.47	622.65	79.42	594.65	79.33
	DSManotick	12315	657.69	79.52	640.69	79.47	622.65	79.41	594.65	79.33
	DSManotick	12100	657.69	79.49	640.69	79.44	622.65	79.39	594.65	79.30
	DSManotick	11795	657.69	79.46	640.69	79.41	622.65	79.36	594.65	79.27
	DSManotick	11480	657.69	79.42	640.69	79.37	622.65	79.32	594.65	79.23
	DSManotick	11215	657.69	79.39	640.69	79.35	622.65	79.29	594.65	79.21
	DSManotick	10895	657.69	79.36	640.69	79.31	622.65	79.26	594.65	79.18
	DSManotick	10575	657.69	79.33	640.69	79.29	622.65	79.24	594.65	79.15
	DSManotick	10365	657.69	79.32	640.69	79.27	622.65	79.22	594.65	79.14
	DSManotick	10105	657.69	79.30	640.69	79.25	622.65	79.20	594.65	79.12
	DSManotick	10055	657.69	79.28	640.69	79.23	622.65	79.18	594.65	79.10
	DSManotick	9955	657.69	79.26	640.69	79.22	622.65	79.17	594.65	79.09
	DSManotick	9860	657.69	79.26	640.69	79.21	622.65	79.16	594.65	79.08
	DSManotick	9665	657.69	79.25	640.69	79.20	622.65	79.15	594.65	79.08

River	Reach	Xsec ID #	Flow (m³/s) and Computed WSEL (m) for Different Flood Events							
			Q500	WL500	Q350	WL350	Q200	WL200	Q100	WL100
Rideau River	DSManotick	9410	657.69	79.20	640.69	79.15	622.65	79.11	594.65	79.03
	DSManotick	9200	657.69	79.17	640.69	79.13	622.65	79.08	594.65	79.01
	DSManotick	8960	657.69	79.14	640.69	79.10	622.65	79.06	594.65	78.98
	DSManotick	8840	657.69	79.11	640.69	79.07	622.65	79.02	594.65	78.95
	DSManotick	8590	657.69	79.08	640.69	79.04	622.65	79.00	594.65	78.92
	DSManotick	8400	657.69	79.09	640.69	79.04	622.65	79.00	594.65	78.93
	DSManotick	8325	657.69	79.08	640.69	79.03	622.65	78.99	594.65	78.92
	DSManotick	8245	657.69	79.06	640.69	79.02	622.65	78.98	594.65	78.91
	DSManotick	8060	657.69	79.04	640.69	79.00	622.65	78.96	594.65	78.89
	DSManotick	7915	657.69	79.02	640.69	78.98	622.65	78.93	594.65	78.86
	DSManotick	7725	657.69	79.00	640.69	78.96	622.65	78.92	594.65	78.85
	DSManotick	7500	657.69	78.91	640.69	78.88	622.65	78.84	594.65	78.77
	DSManotick	7260	657.69	78.78	640.69	78.75	622.65	78.71	594.65	78.65
	DSManotick	6955	657.69	78.72	640.69	78.69	622.65	78.65	594.65	78.60
	DSManotick	6755	657.69	78.70	640.69	78.66	622.65	78.63	594.65	78.57
	DSManotick	6680	657.69	78.69	640.69	78.65	622.65	78.62	594.65	78.56
	DSManotick	6646	Black Rapids Dam							
	DSManotick	6615	682.85	77.32	671.51	77.28	658.30	77.23	634.94	77.14
	DSManotick	6560	682.85	77.33	671.51	77.28	658.30	77.23	634.94	77.14
	DSManotick	6430	682.85	77.34	671.51	77.29	658.30	77.24	634.94	77.15
	DSManotick	6210	682.85	77.32	671.51	77.28	658.30	77.23	634.94	77.13
	DSManotick	5940	682.85	77.27	671.51	77.23	658.30	77.18	634.94	77.08
	DSManotick	5560	682.85	77.21	671.51	77.17	658.30	77.12	634.94	77.03
	DSManotick	5205	682.85	77.18	671.51	77.14	658.30	77.09	634.94	77.00
	DSManotick	5100	682.85	77.17	671.51	77.13	658.30	77.08	634.94	76.99
	DSManotick	5087	Hunt Club Road							
	DSManotick	5075	682.85	77.17	671.51	77.13	658.30	77.08	634.94	76.99
	DSManotick	4980	682.85	77.16	671.51	77.12	658.30	77.07	634.94	76.98
	DSManotick	4810	682.85	77.12	671.51	77.08	658.30	77.03	634.94	76.94
	DSManotick	4555	682.85	77.11	671.51	77.07	658.30	77.02	634.94	76.94
	DSManotick	4320	682.85	77.11	671.51	77.07	658.30	77.02	634.94	76.94
	DSManotick	4015	682.85	77.05	671.51	77.01	658.30	76.96	634.94	76.88
	DSManotick	3750	682.85	76.79	671.51	76.75	658.30	76.71	634.94	76.63
	DSManotick	3640	682.85	76.75	671.51	76.71	658.30	76.67	634.94	76.59
	DSManotick	3635	VIA Rail Bridge							
	DSManotick	3630	682.85	76.74	671.51	76.70	658.30	76.66	634.94	76.58
	DSManotick	3535	682.85	76.67	671.51	76.64	658.30	76.60	634.94	76.52
	DSManotick	3335	682.85	76.63	671.51	76.59	658.30	76.55	634.94	76.47
	DSManotick	3065	682.85	76.59	671.51	76.56	658.30	76.51	634.94	76.44
	DSManotick	2780	682.85	76.48	671.51	76.44	658.30	76.40	634.94	76.33
	DSManotick	2440	682.85	76.45	671.51	76.41	658.30	76.37	634.94	76.29
	DSManotick	2290	682.85	76.36	671.51	76.32	658.30	76.28	634.94	76.21
	DSManotick	2085	682.85	76.16	671.51	76.13	658.30	76.09	634.94	76.02

River	Reach	Xsec ID #	Flow (m^3/s) and Computed WSEL (m) for Different Flood Events							
			Q500	WL500	Q350	WL350	Q200	WL200	Q100	WL100
Rideau River	DSManotick	1950	682.85	75.93	671.51	75.90	658.30	75.86	634.94	75.79
	DSManotick	1815	682.85	75.65	671.51	75.62	658.30	75.58	634.94	75.50
	DSManotick	1690	682.85	75.38	671.51	75.34	658.30	75.30	634.94	75.22
	DSManotick	1545	682.85	75.26	671.51	75.23	658.30	75.18	634.94	75.10
	DSManotick	1415	682.85	75.31	671.51	75.27	658.30	75.23	634.94	75.14
	DSManotick	1285	682.85	75.33	671.51	75.29	658.30	75.25	634.94	75.16
	DSManotick	1150	682.85	75.33	671.51	75.29	658.30	75.25	634.94	75.16
	DSManotick	825	682.85	75.33	671.51	75.29	658.30	75.24	634.94	75.16
	DSManotick	510	682.85	75.32	671.51	75.28	658.30	75.23	634.94	75.15
	DSManotick	380	682.85	75.30	671.51	75.26	658.30	75.21	634.94	75.13
	DSManotick	200	682.85	75.30	671.51	75.26	658.30	75.22	634.94	75.14
	DSManotick	105	682.85	75.10	671.51	75.07	658.30	75.03	634.94	74.95
	DSManotick	50	682.85	73.83	671.51	73.80	658.30	73.76	634.94	73.70
	DSManotick	0	691.00	73.65	680.00	73.62	667.00	73.58	644.00	73.51
	DSManotick	-12	691.00	73.62	680.00	73.58	667.00	73.54	644.00	73.47
	DSManotick	-23	Hogs Back Dam							
	DSManotick	-33	691.00	73.40	680.00	73.36	667.00	73.30	644.00	73.21
	DSManotick	-74.7	691.00	71.42	680.00	71.38	667.00	71.34	644.00	71.26

Note:

WSEL - Water Surface Elevation

Q500 - Flow Rate for a 500 year flood event

WL500 - Water Surface Elevation for a 500 year flood event

Q350 - Flow Rate for a 350 year flood event

WL350 - Water Surface Elevation for a 350 year flood event

Q200 - Flow Rate for a 200 year flood event

WL200 - Water Surface Elevation for a 200 year flood event

Q100 - Flow Rate for a 100 year flood event

WL100 - Water Surface Elevation for a 100 year flood event

Table 12 Flows and Computed Water Levels for the 2, 5, 10, 20 and 50 Year Flood Events.

River	Reach	Xsec ID #	Flow (m^3/s) and Computed WSEL (m) for Different Flood Events									
			Q50	WL50	Q20	WL20	Q10	WL10	Q5	WL5	Q2	WL2
Rideau River	USManotick	29000	379.23	87.08	341.25	86.86	310.13	86.68	275.21	86.46	217.30	86.07
	USManotick	28727	379.52	87.06	341.50	86.85	310.35	86.67	275.39	86.46	217.44	86.06
	USManotick	28719	Roger Stevens Drive									
	USManotick	28715	379.52	87.06	341.50	86.85	310.35	86.67	275.39	86.45	217.44	86.06
	USManotick	28435	379.52	87.06	341.50	86.85	310.35	86.67	275.39	86.45	217.44	86.06
	USManotick	28245	379.52	87.05	341.50	86.84	310.35	86.66	275.39	86.45	217.44	86.05
	USManotick	28075	379.52	87.05	341.50	86.84	310.35	86.66	275.39	86.44	217.44	86.05
	USManotick	27870	380.87	87.04	342.64	86.83	311.35	86.66	276.24	86.44	218.09	86.05
	USManotick	27540	380.87	87.02	342.64	86.82	311.35	86.64	276.24	86.43	218.09	86.04
	USManotick	27160	380.87	87.01	342.64	86.80	311.35	86.63	276.24	86.42	218.09	86.03
	USManotick	26830	383.86	87.00	345.19	86.79	313.58	86.62	278.12	86.41	219.51	86.02
	USManotick	26545	383.86	86.99	345.19	86.78	313.58	86.61	278.12	86.40	219.51	86.02
	USManotick	26230	383.86	86.98	345.19	86.77	313.58	86.60	278.12	86.39	219.51	86.01
	USManotick	26060	383.94	86.97	345.26	86.77	313.64	86.60	278.17	86.39	219.55	86.01
	USManotick	25810	383.94	86.97	345.26	86.76	313.64	86.59	278.17	86.38	219.55	86.00
	USManotick	25500	383.94	86.96	345.26	86.76	313.64	86.59	278.17	86.38	219.55	86.00
	USManotick	25300	383.94	86.95	345.26	86.75	313.64	86.58	278.17	86.37	219.55	86.00
	USManotick	25110	384.24	86.95	345.51	86.75	313.86	86.58	278.36	86.37	219.69	85.99
	USManotick	24680	384.24	86.90	345.51	86.71	313.86	86.54	278.36	86.33	219.69	85.96
	USManotick	24560	384.24	86.90	345.51	86.70	313.86	86.54	278.36	86.33	219.69	85.96
	USManotick	24350	384.24	86.86	345.51	86.67	313.86	86.51	278.36	86.30	219.69	85.94
	USManotick	24165	385.83	86.85	346.87	86.66	315.05	86.49	279.37	86.29	220.45	85.93
	USManotick	24000	385.83	86.79	346.87	86.60	315.05	86.44	279.37	86.25	220.45	85.89
	USManotick	23780	385.83	86.72	346.87	86.53	315.05	86.38	279.37	86.19	220.45	85.84
	USManotick	23615	385.83	86.69	346.87	86.51	315.05	86.36	279.37	86.17	220.45	85.82
	USManotick	23400	385.83	86.55	346.87	86.38	315.05	86.23	279.37	86.05	220.45	85.72
	USManotick	23130	386.51	86.59	347.45	86.41	315.55	86.26	279.79	86.07	220.77	85.73
	USManotick	22840	386.51	86.56	347.45	86.39	315.55	86.24	279.79	86.06	220.77	85.72
	USManotick	22350	386.51	86.44	347.45	86.28	315.55	86.14	279.79	85.97	220.77	85.65
	USManotick	22015	386.51	86.19	347.45	86.04	315.55	85.92	279.79	85.76	220.77	85.47
	USManotick	21765	388.76	86.26	349.36	86.10	317.22	85.97	281.21	85.81	221.84	85.51
	USManotick	21505	388.76	86.25	349.36	86.10	317.22	85.97	281.21	85.81	221.84	85.51
	USManotick	21275	388.76	86.21	349.36	86.06	317.22	85.94	281.21	85.78	221.84	85.48
	USManotick	21115	388.76	86.20	349.36	86.05	317.22	85.93	281.21	85.77	221.84	85.48
	USManotick	20890	388.91	86.18	349.48	86.04	317.33	85.92	281.29	85.76	221.91	85.47
	USManotick	20515	388.91	86.10	349.48	85.96	317.33	85.85	281.29	85.70	221.91	85.42
	USManotick	20200	388.91	86.05	349.48	85.92	317.33	85.81	281.29	85.66	221.91	85.38
	East Branch	19890	189.16	86.05	168.27	85.92	150.38	85.81	133.01	85.65	104.42	85.38
	East Branch	19715	189.16	86.04	168.27	85.91	150.38	85.79	133.01	85.64	104.42	85.37
	East Branch	19490	189.16	86.00	168.27	85.86	150.38	85.76	133.01	85.61	104.42	85.34
	East Branch	19180	189.16	85.99	168.27	85.86	150.38	85.75	133.01	85.61	104.42	85.34
	East Branch	18870	189.16	85.96	168.27	85.84	150.38	85.73	133.01	85.59	104.42	85.32
	East Branch	18695	189.16	85.95	168.27	85.83	150.38	85.72	133.01	85.58	104.42	85.31
	East Branch	18325	189.16	85.93	168.27	85.80	150.38	85.70	133.01	85.56	104.42	85.29

River	Reach	Xsec ID #	Flow (m^3/s) and Computed WSEL (m) for Different Flood Events									
			Q50	WL50	Q20	WL20	Q10	WL10	Q5	WL5	Q2	WL2
Rideau River	East Branch	18196	189.16	85.89	168.27	85.77	150.38	85.67	133.01	85.53	104.42	85.28
	East Branch	18191	Bridge Street (East)									
	East Branch	18185	189.16	85.88	168.27	85.76	150.38	85.67	133.01	85.53	104.42	85.28
	East Branch	18135	189.16	85.88	168.27	85.76	150.38	85.67	133.01	85.53	104.42	85.27
	East Branch	17925	189.16	85.46	168.27	85.38	150.38	85.33	133.01	85.17	104.42	84.89
	East Branch	17920	189.16	85.16	168.27	85.08	150.38	84.86	133.01	84.77	104.42	84.62
	East Branch	17720	189.16	85.01	168.27	84.84	150.38	84.68	133.01	84.53	104.42	84.25
	East Branch	17460	189.16	84.94	168.27	84.77	150.38	84.62	133.01	84.47	104.42	84.20
	East Branch	17170	189.16	84.81	168.27	84.64	150.38	84.49	133.01	84.34	104.42	84.08
	East Branch	16820	189.16	84.65	168.27	84.48	150.38	84.32	133.01	84.17	104.42	83.89
	East Branch	16515	189.16	84.60	168.27	84.43	150.38	84.27	133.01	84.11	104.42	83.84
	East Branch	16430	189.16	84.59	168.27	84.42	150.38	84.26	133.01	84.11	104.42	83.84
	East Branch	16130	189.16	84.58	168.27	84.41	150.38	84.26	133.01	84.10	104.42	83.83
	East Branch	16030	189.16	84.58	168.27	84.41	150.38	84.26	133.01	84.10	104.42	83.83
	East Branch	15770	189.16	84.58	168.27	84.41	150.38	84.25	133.01	84.10	104.42	83.83
	East Branch	15570	189.16	84.58	168.27	84.41	150.38	84.25	133.01	84.10	104.42	83.83
	East Branch	15452	189.16	84.45	168.27	84.29	150.38	84.16	133.01	84.01	104.42	83.77
	East Branch	15440	Long Island Dam									
	East Branch	15425	189.16	81.69	168.27	81.51	150.38	81.36	133.01	81.18	104.42	80.84
	West Branch	20090	199.75	86.00	181.21	85.86	166.95	85.75	148.28	85.60	117.49	85.33
	West Branch	19945	199.75	85.79	181.21	85.66	166.95	85.55	148.28	85.40	117.49	85.12
	West Branch	19815	199.75	85.53	181.21	85.39	166.95	85.29	148.28	85.15	117.49	84.86
	West Branch	19690	199.75	85.41	181.21	85.27	166.95	85.17	148.28	85.02	117.49	84.72
	West Branch	19530	199.75	85.43	181.21	85.29	166.95	85.18	148.28	85.03	117.49	84.73
	West Branch	19360	199.75	85.39	181.21	85.25	166.95	85.14	148.28	85.00	117.49	84.70
	West Branch	19025	199.75	85.01	181.21	84.89	166.95	84.79	148.28	84.67	117.49	84.45
	West Branch	18885	199.75	84.32	181.21	84.21	166.95	84.13	148.28	84.02	117.49	83.82
	West Branch	18825	199.75	84.29	181.21	84.18	166.95	84.10	148.28	83.98	117.49	83.78
	West Branch	18792	Manotick Mill Dam									
	West Branch	18759	199.75	83.95	181.21	83.76	166.95	83.62	148.28	83.42	117.49	83.07
	West Branch	18716	199.75	83.90	181.21	83.72	166.95	83.58	148.28	83.38	117.49	83.04
	West Branch	18709	199.75	83.90	181.21	83.72	166.95	83.57	148.28	83.38	117.49	83.03
	West Branch	18634	199.75	83.88	181.21	83.70	166.95	83.56	148.28	83.36	117.49	83.02
	West Branch	18627	Bridge Street (West)									
	West Branch	18620	199.75	83.88	181.21	83.70	166.95	83.55	148.28	83.36	117.49	83.01
	West Branch	18490	199.75	83.76	181.21	83.58	166.95	83.43	148.28	83.24	117.49	82.89
	West Branch	18270	199.75	83.43	181.21	83.25	166.95	83.11	148.28	82.92	117.49	82.58
	West Branch	17975	199.75	83.12	181.21	82.94	166.95	82.79	148.28	82.59	117.49	82.24
	West Branch	17785	199.75	83.12	181.21	82.93	166.95	82.78	148.28	82.58	117.49	82.22
	West Branch	17595	199.75	83.09	181.21	82.91	166.95	82.76	148.28	82.56	117.49	82.20
	West Branch	17375	199.75	83.06	181.21	82.87	166.95	82.72	148.28	82.53	117.49	82.17
	West Branch	17040	199.75	82.99	181.21	82.80	166.95	82.66	148.28	82.46	117.49	82.11
	West Branch	16860	199.75	82.96	181.21	82.78	166.95	82.63	148.28	82.44	117.49	82.09
	West Branch	16510	199.75	82.84	181.21	82.67	166.95	82.53	148.28	82.34	117.49	82.01
	West Branch	16177	199.75	82.58	181.21	82.41	166.95	82.27	148.28	82.08	117.49	81.76

River	Reach	Xsec ID #	Flow (m^3/s) and Computed WSEL (m) for Different Flood Events									
			Q50	WL50	Q20	WL20	Q10	WL10	Q5	WL5	Q2	WL2
Rideau River	West Branch	15862	199.75	82.30	181.21	82.12	166.95	81.97	148.28	81.79	117.49	81.46
	West Branch	15856	Barnsdale Road									
	West Branch	15850	199.75	82.28	181.21	82.10	166.95	81.96	148.28	81.77	117.49	81.45
	West Branch	15740	199.75	81.98	181.21	81.81	166.95	81.67	148.28	81.49	117.49	81.19
	West Branch	15600	199.75	81.85	181.21	81.67	166.95	81.52	148.28	81.34	117.49	81.02
	West Branch	15420	199.75	81.69	181.21	81.50	166.95	81.35	148.28	81.16	117.49	80.83
	DSManotick	15350	406.00	81.36	364.00	81.19	330.00	81.06	292.00	80.89	230.00	80.58
	DSManotick	15260	406.00	80.31	364.00	80.14	330.00	79.99	292.00	79.86	230.00	79.65
	DSManotick	15190	406.00	80.32	364.00	80.10	330.00	79.91	292.00	79.65	230.00	79.07
	DSManotick	15080	406.00	80.36	364.00	80.15	330.00	79.95	292.00	79.70	230.00	79.17
	DSManotick	14875	406.00	80.33	364.00	80.12	330.00	79.92	292.00	79.67	230.00	79.14
	DSManotick	14625	406.00	80.20	364.00	80.00	330.00	79.81	292.00	79.57	230.00	79.05
	DSManotick	14400	406.00	80.14	364.00	79.94	330.00	79.76	292.00	79.52	230.00	79.00
	DSManotick	14305	406.00	80.15	364.00	79.96	330.00	79.77	292.00	79.53	230.00	79.01
	DSManotick	14210	406.00	80.11	364.00	79.92	330.00	79.74	292.00	79.50	230.00	78.97
	DSManotick	14060	406.00	79.96	364.00	79.78	330.00	79.60	292.00	79.37	230.00	78.86
	DSManotick	13920	406.00	80.01	364.00	79.83	330.00	79.65	292.00	79.41	230.00	78.89
	DSManotick	13730	563.56	79.99	517.39	79.81	476.08	79.63	422.43	79.39	318.38	78.88
	DSManotick	13465	563.56	79.94	517.39	79.76	476.08	79.58	422.43	79.35	318.38	78.84
	DSManotick	13255	563.56	79.92	517.39	79.74	476.08	79.56	422.43	79.33	318.38	78.82
	DSManotick	13045	563.56	79.71	517.39	79.54	476.08	79.38	422.43	79.17	318.38	78.69
	DSManotick	12855	563.56	79.71	517.39	79.54	476.08	79.37	422.43	79.16	318.38	78.68
	DSManotick	12685	563.56	79.55	517.39	79.39	476.08	79.23	422.43	79.03	318.38	78.57
	DSManotick	12646	Strandherd Drive									
	DSManotick	12610	563.56	79.26	517.39	79.11	476.08	78.98	422.43	78.79	318.38	78.37
	DSManotick	12510	563.56	79.23	517.39	79.09	476.08	78.95	422.43	78.76	318.38	78.35
	DSManotick	12315	563.56	79.23	517.39	79.08	476.08	78.94	422.43	78.75	318.38	78.34
	DSManotick	12100	563.56	79.20	517.39	79.05	476.08	78.91	422.43	78.72	318.38	78.32
	DSManotick	11795	563.56	79.17	517.39	79.03	476.08	78.89	422.43	78.70	318.38	78.31
	DSManotick	11480	563.56	79.14	517.39	78.99	476.08	78.86	422.43	78.67	318.38	78.29
	DSManotick	11215	563.56	79.11	517.39	78.97	476.08	78.84	422.43	78.66	318.38	78.28
	DSManotick	10895	563.56	79.09	517.39	78.95	476.08	78.81	422.43	78.64	318.38	78.26
	DSManotick	10575	563.56	79.06	517.39	78.92	476.08	78.79	422.43	78.62	318.38	78.25
	DSManotick	10365	563.56	79.05	517.39	78.91	476.08	78.78	422.43	78.60	318.38	78.24
	DSManotick	10105	563.56	79.03	517.39	78.89	476.08	78.76	422.43	78.59	318.38	78.23
	DSManotick	10055	563.56	79.01	517.39	78.87	476.08	78.75	422.43	78.58	318.38	78.21
	DSManotick	9955	563.56	79.00	517.39	78.87	476.08	78.74	422.43	78.57	318.38	78.21
	DSManotick	9860	563.56	78.99	517.39	78.86	476.08	78.73	422.43	78.56	318.38	78.20
	DSManotick	9665	563.56	78.99	517.39	78.85	476.08	78.73	422.43	78.56	318.38	78.20
	DSManotick	9410	563.56	78.94	517.39	78.82	476.08	78.70	422.43	78.53	318.38	78.18
	DSManotick	9200	563.56	78.92	517.39	78.80	476.08	78.68	422.43	78.52	318.38	78.17
	DSManotick	8960	563.56	78.90	517.39	78.77	476.08	78.66	422.43	78.50	318.38	78.16
	DSManotick	8840	563.56	78.87	517.39	78.74	476.08	78.63	422.43	78.47	318.38	78.14
	DSManotick	8590	563.56	78.84	517.39	78.72	476.08	78.60	422.43	78.45	318.38	78.11
	DSManotick	8400	563.56	78.84	517.39	78.72	476.08	78.61	422.43	78.45	318.38	78.12

River	Reach	Xsec ID #	Flow (m³/s) and Computed WSEL (m) for Different Flood Events									
			Q50	WL50	Q20	WL20	Q10	WL10	Q5	WL5	Q2	WL2
Rideau River	DSManotick	8325	563.56	78.83	517.39	78.71	476.08	78.60	422.43	78.44	318.38	78.11
	DSManotick	8245	563.56	78.82	517.39	78.70	476.08	78.59	422.43	78.43	318.38	78.11
	DSManotick	8060	563.56	78.81	517.39	78.68	476.08	78.57	422.43	78.42	318.38	78.09
	DSManotick	7915	563.56	78.78	517.39	78.66	476.08	78.55	422.43	78.40	318.38	78.08
	DSManotick	7725	563.56	78.77	517.39	78.65	476.08	78.54	422.43	78.39	318.38	78.08
	DSManotick	7500	563.56	78.70	517.39	78.58	476.08	78.48	422.43	78.34	318.38	78.04
	DSManotick	7260	563.56	78.58	517.39	78.48	476.08	78.39	422.43	78.26	318.38	77.98
	DSManotick	6955	563.56	78.53	517.39	78.43	476.08	78.34	422.43	78.22	318.38	77.95
	DSManotick	6755	563.56	78.51	517.39	78.41	476.08	78.32	422.43	78.20	318.38	77.94
	DSManotick	6680	563.56	78.50	517.39	78.40	476.08	78.31	422.43	78.19	318.38	77.93
	DSManotick	6646	Black Rapids Dam									
	DSManotick	6615	607.76	77.03	562.77	76.84	520.06	76.66	466.75	76.43	362.77	75.93
	DSManotick	6560	607.76	77.03	562.77	76.84	520.06	76.66	466.75	76.43	362.77	75.93
	DSManotick	6430	607.76	77.04	562.77	76.85	520.06	76.67	466.75	76.43	362.77	75.94
	DSManotick	6210	607.76	77.03	562.77	76.84	520.06	76.66	466.75	76.42	362.77	75.93
	DSManotick	5940	607.76	76.98	562.77	76.79	520.06	76.62	466.75	76.39	362.77	75.90
	DSManotick	5560	607.76	76.92	562.77	76.75	520.06	76.57	466.75	76.34	362.77	75.87
	DSManotick	5205	607.76	76.89	562.77	76.72	520.06	76.54	466.75	76.32	362.77	75.85
	DSManotick	5100	607.76	76.89	562.77	76.71	520.06	76.54	466.75	76.31	362.77	75.84
	DSManotick	5087	Hunt Club Road									
	DSManotick	5075	607.76	76.89	562.77	76.71	520.06	76.54	466.75	76.31	362.77	75.84
	DSManotick	4980	607.76	76.88	562.77	76.70	520.06	76.53	466.75	76.31	362.77	75.84
	DSManotick	4810	607.76	76.84	562.77	76.66	520.06	76.49	466.75	76.27	362.77	75.81
	DSManotick	4555	607.76	76.83	562.77	76.66	520.06	76.49	466.75	76.27	362.77	75.81
	DSManotick	4320	607.76	76.83	562.77	76.66	520.06	76.49	466.75	76.27	362.77	75.80
	DSManotick	4015	607.76	76.77	562.77	76.60	520.06	76.44	466.75	76.22	362.77	75.77
	DSManotick	3750	607.76	76.54	562.77	76.38	520.06	76.23	466.75	76.03	362.77	75.62
	DSManotick	3640	607.76	76.50	562.77	76.34	520.06	76.19	466.75	75.99	362.77	75.58
	DSManotick	3635	Via Rail Bridge									
	DSManotick	3630	607.76	76.49	562.77	76.33	520.06	76.18	466.75	75.98	362.77	75.57
	DSManotick	3535	607.76	76.43	562.77	76.27	520.06	76.12	466.75	75.93	362.77	75.53
	DSManotick	3335	607.76	76.38	562.77	76.23	520.06	76.08	466.75	75.88	362.77	75.48
	DSManotick	3065	607.76	76.35	562.77	76.19	520.06	76.04	466.75	75.85	362.77	75.45
	DSManotick	2780	607.76	76.24	562.77	76.09	520.06	75.94	466.75	75.75	362.77	75.36
	DSManotick	2440	607.76	76.20	562.77	76.05	520.06	75.91	466.75	75.72	362.77	75.33
	DSManotick	2290	607.76	76.12	562.77	75.98	520.06	75.84	466.75	75.65	362.77	75.28
	DSManotick	2085	607.76	75.93	562.77	75.79	520.06	75.65	466.75	75.48	362.77	75.12
	DSManotick	1950	607.76	75.71	562.77	75.57	520.06	75.44	466.75	75.27	362.77	74.93
	DSManotick	1815	607.76	75.42	562.77	75.27	520.06	75.13	466.75	74.95	362.77	74.59
	DSManotick	1690	607.76	75.13	562.77	74.97	520.06	74.81	466.75	74.59	362.77	74.16
	DSManotick	1545	607.76	75.01	562.77	74.84	520.06	74.68	466.75	74.46	362.77	74.00
	DSManotick	1415	607.76	75.05	562.77	74.88	520.06	74.71	466.75	74.49	362.77	74.03
	DSManotick	1285	607.76	75.07	562.77	74.90	520.06	74.72	466.75	74.50	362.77	74.04
	DSManotick	1150	607.76	75.07	562.77	74.90	520.06	74.72	466.75	74.50	362.77	74.04
	DSManotick	825	607.76	75.06	562.77	74.89	520.06	74.72	466.75	74.50	362.77	74.03

River	Reach	Xsec ID #	Flow (m^3/s) and Computed WSEL (m) for Different Flood Events									
			Q50	WL50	Q20	WL20	Q10	WL10	Q5	WL5	Q2	WL2
Rideau River	DSManotick	510	607.76	75.05	562.77	74.88	520.06	74.72	466.75	74.49	362.77	74.03
	DSManotick	380	607.76	75.04	562.77	74.87	520.06	74.70	466.75	74.48	362.77	74.02
	DSManotick	200	607.76	75.04	562.77	74.87	520.06	74.70	466.75	74.48	362.77	74.02
	DSManotick	105	607.76	74.86	562.77	74.71	520.06	74.55	466.75	74.35	362.77	73.91
	DSManotick	50	607.76	73.62	562.77	73.51	520.06	73.40	466.75	73.26	362.77	72.94
	DSManotick	0	617.00	73.43	572.00	73.29	529.00	73.15	475.00	72.98	369.00	72.61
	DSManotick	-12	617.00	73.39	572.00	73.25	529.00	73.11	475.00	72.93	369.00	72.55
	DSManotick	-23	Hogs Back Dam									
	DSManotick	-33	617.00	73.10	572.00	72.91	529.00	72.73	475.00	72.50	369.00	72.00
	DSManotick	-74.7	617.00	71.18	572.00	71.03	529.00	70.88	475.00	70.69	369.00	70.30

Note:
WSEL - Water Surface Elevation
Q50 - Flow Rate for a 50 year flood event
WL50 - Water Surface Elevation for a 50 year flood event
Q20 - Flow Rate for a 20 year flood event
WL20 - Water Surface Elevation for a 20 year flood event
Q10 - Flow Rate for a 10 year flood event
WL10 - Water Surface Elevation for a 10 year flood event
Q5 - Flow Rate for a 5 year flood event
WL5 - Water Surface Elevation for a 5 year flood event
Q2 - Flow Rate for a 2 year flood event
WL2 - Water Surface Elevation for a 2 year flood event

Table 13 Culvert Data from Field Checks and Drawings.

Culvert	Downstream Invert (m)	Upstream Invert (m)	Upstream RFL (m)	Location	City of Ottawa Culvert ID	Source of Information
1	84.24	84.21	86.54	Rideau Valley Dr, south of Eastman Ave	877110	Surveyed on April 29, 2015
2	85.02	85.07	86.44	Boucher Rd	878240	Surveyed on April 29, 2015
3	85.04	85.54	86.44	Rideau Valley Dr just south of Boucher Rd	878210	Surveyed on April 29, 2015
4	85.57	85.65	87.13	Rideau Valley Dr, south of Phelan Rd	878180	Surveyed on April 29, 2015
5	85.78	86.82	87.13	Rideau Valley Dr, north of Upton Rd	A871430	Surveyed on April 29, 2015
6	84.47	84.61	87.19	River Rd, north of Roger Stevens Dr (Culvert 1 of 2)	887030	Surveyed on April 29, 2015
7	84.96	85.16	87.19	River Rd, north of Roger Stevens Dr (Culvert 2 of 2)	887030	Surveyed on April 29, 2015
8	85.16	84.68	86.91	River Rd, just north of St.Brigid Cemetery	888040	Surveyed on April 29, 2015
9	84.80	85.31	86.86	River Rd, south of Kilby Lane	888290	Surveyed on April 29, 2015
10	84.29	84.38	86.7	River Rd just south of Kilby Lane	888010	Surveyed on April 29, 2015
11	77.27	77.38	79.19	River Rd just north of Mulligan St	220200	Surveyed on April 29, 2015
12	77.08	77.34	78.93	River Rd, south of Balmoral Dr	220290	Surveyed on April 29, 2015
13	76.13	77.16	78.93	River Rd, south of Balmoral Dr	220210	Surveyed on April 29, 2015
14	73.78	74.08	76.5	Prince of Wales Dr, south of Fisher Ave	117640	Surveyed on April 29, 2015
15	85.04	85.34	87.22	Rideau Valley Drive, south of Upton Rd	878110	Drawings
16	84.50	84.50	86.06	River Rd, south of Mitch Owens Rd	888270	Drawings
17	85.11	85.26	86.06	Mitch Owens Rd, east of River Rd	228270	Drawings
18	76.20	76.20	79.19	Leitrim Rd just east of River Rd	227010	Drawings
19	76.83	76.95	79.19	Mulligan St just west of River Rd	220190	Drawings
20	76.00	76.00	79.19	River Rd just south of Mulligan St	227020	Drawings

21	80.77	80.77	83.29	Rideau Valley Dr, north of Bankfield Rd	117810	Drawings
22	85.60	85.66		Rideau Narrows Rd	L876310	Surveyed on June 5, 2015
23	86.02	86.17	87.22	Phelan Rd	878490	Surveyed on June 5, 2015
24	86.78	86.70	87.13	Clingin Lane	L873850	Surveyed on June 5, 2015
25	86.72	N/A	87.13	Aston Rd at Clingin Lane	L873890	Surveyed on June 5, 2015
26	85.64	85.77	87.14	Aston Rd near Upton Rd	L873870	Surveyed on June 5, 2015
27	86.13	86.26	87.15	Upton Rd	L874220	Surveyed on June 5, 2015
28	86.52	86.65	87.22	Marina Rd	874030	Surveyed on June 5, 2015
29	85.59	85.83	87.22	Roger Stevens east of Rideau Valley Dr	A872360	Surveyed on June 5, 2015
30	86.45	86.40	87.19	Nixon Rd just south of Snake Island Rd	A881100	Surveyed on June 5, 2015
31	86.17	86.12	87.19	Nixon Rd	881098	Surveyed on June 5, 2015
32	86.32	86.28	87.19	Nixon Rd north of Cabin Rd	A881096	Surveyed on June 5, 2015
33	86.06	86.18	87.19	Nixon Rd just south of Cabin Rd	A881095	Surveyed on June 5, 2015
34	86.01	85.99	87.19	Cabin Rd east of Nixon, (culvert west)	880050	Surveyed on June 5, 2015
35	86.01	85.87	87.19	Cabin Rd east of Nixon (culvert east)	880050	Surveyed on June 5, 2015
36	85.92	85.60	87.09	River Rd south of Flagstation Rd	888060	Surveyed on June 10, 2015
37	86.53	86.54	87.12	Summerside Dr	L881035	Surveyed on June 10, 2015
38	86.11	86.08	87.14	Cedar Dr	L884800	Surveyed on June 10, 2015
39	86.25	86.15	87.27	Osgoode Trail north of Cabin Rd	888305	Surveyed on June 10, 2015
40	86.53	86.48	87.27	Cabin Rd east of Osgoode Trail	887550	Surveyed on June 10, 2015
41	84.49	84.61	87.27	Snake Island Rd East of Nixon Rd (Culvert 1 of 2)	887540	Surveyed on June 10, 2015
42	84.25	84.44	87.27	Snake Island Rd East of Nixon Rd (Culvert 2 of 2)	887540	Surveyed on June 10, 2015

43	86.12	86.05	87.27	Snake Island Rd west of Osgoode Trail	888530	Surveyed on June 10, 2015
44	85.23	85.31	87.27	Osgoode Trail south of Snake Island Rd (Culvert 1 of 2)	885020	Surveyed on June 10, 2015
45	85.37	85.37	87.27	Osgoode Trail south of Snake Island Rd (Culvert 2 of 2)	885020	Surveyed on June 10, 2015
46	86.58	86.69	87.27	Snake Island Rd east of Osgoode Trail (Culvert 1 of 2)	888515	Surveyed on June 10, 2015
47	86.90	86.72	87.27	Snake Island Rd east of Osgoode Trail (Culvert 2 of 2)	888515	Surveyed on June 10, 2015
48	76.99	77.16	79.3	Winding Way	118900	Surveyed on June 10, 2015
49	78.13	87.22	79.3	Waterbridge Dr	L112370	Surveyed on June 10, 2015
50	77.51	78.90	79.14	Prince of Wales north of Crewstway Dr	117600	Surveyed on June 10, 2015

Note:

Culverts that are highlighted orange had poor site access and/or poor measuring coditions; therefore the invert values are only approximations.

Table 14 List of RVCA Regulation Permit Files

RVCA File #	Location	Year	Flood Line Change Required?	Brief Description	Closest HEC-RAS cross-section	Drawing Number
RV3-0912	2446 RIVER RD	2012	No	FILL FOR REPLACEMENT SEPTIC SYSTEM		
RV3-2412	2314 SUMMERSIDE DR	2012	No	REMOVE OLD SEPTIC BED & INSTALL A 54 METRES SQ AREA BED AND A CLEARSTREAM TREATMENT UNIT		
RV3-3612	6619 MARINA DR	2012	No	REMOVE FILL FROM FLOODPLAIN AND CONSTRUCT STONE WALL		
RV3-4311	87 WINDING WAY	2011	Yes	PROPOSED RIP-RAP PROTECTION STRIP FOR EROSION PROTECTION AND INSTALLATION OF A FLOATING DOCK	10575	Paterson Group 87 Winding Way Shoreline Stabilization Plan, PH1575-2 06/2011
RV3-6212	880 RIVER RD	2012	No	INSTALLATION OF GAS MAIN		
RV3-0914	2196 RIVER RD	2014	No	SHORELINE EROSION PROTECTION		
RV3-1413	2678 RIVER RD	2013	No	CONSTRUCT INGROUND POOL		
RV3-2413	6475 MARINA DR	2013	Yes	TO INSTALL A REPLACEMENT CLASS 4 SEWAGE SYSTEM	26545	Paterson Group 6475 Marna Drive Sewage System Layout Plan, PH2245-1/PH2245-2 04/2013
RV3-2414	2096 WATERFRONT CRT	2014	No	TO BUILD A SWIMMING POOL 36' BY 18'		
RV3-3413	48 RYEBURN	2013	No	VIOLATION-FOUNDATION ESCAVATION, SLOPE WORK, SHORELINE WORK		
RV3-3514	1318 RIVER RD	2014	No	RIP-RAP BANK PROTECTION		
RV3-4713	5614 SOUTH RIVER DR	2013	No	TO INSTALL A REPLACEMENT SEPTIC SYSTEM		
RV3-5214	5446 EDGEWATER DRIVE	2014	No	INSTALL AN INGROUND SWIMMING POOL 10 X 20		
RV3-5513	6571 LEWIS WAY	2013	Yes	REPLACE SEPTIC SYSTEM	28435	Kollaard Associates 6575 Lewis Way Proposed Septic Design, 130426 Jul 23, 2013
RV3-6114	5042 MOWATVIEW CRT	2014	No	STAMPED PLAN FOR SEPTIC SYSTEM REPLACEMENT		
RV3-6913	16 LODGE RD	2013	Yes	REPLACE SEPTIC SYSTEM	13730	Green Valley Environmental 16 Lodge Road On-site Sewage Treatment Plan, SP33-13/PG 22/10/13
RV3-7213	5563 SOUTH ISLAND PARK DR	2013	No	FILL FOR SEPTIC		
RV3-7313	87 WINDING WAY	2013	No	PROPOSED RIP RAP PROTECTION STRIP TO BE INSTALLED ALONG THE SHORELINE		
RV3-7314	5627 SOUTH ISLAND PARK DR	2014	No	INSTALL RIP-RAP AND REPLACE UPLAND RAILROAD TIE RETAINING WALL WITH ARMOUR STONE WALL		
RV3-0609	2384 PINE AVE	2009	No	TEAR DOWN EXISTING COTTAGE AND REBUILD NEW HOUSE - REVISION RECEIVED		
RV3-0808	25 WINDING WAY	2008	Yes	TO BUILD AN INGROUND POOL WITHIN THE FLOODPLAIN	10365	Kollaard Associates 25 Wind Way As-Built Grading Plan, 100988-1 Nov 9, 2010
RV3-0907	6071 JAMES BELL DR	2007	No	CONSTRUCT NEW DWELLING		
RV3-0908	1760 A RIVER RD	2008	No	FILL FOR TERTIARY SEPTIC SYSTEM - FILL REQUIRED: 174.6 METRES CUBED		
RV3-1008	15 WINDING WAY	2008	No	TO INSTALL A SEWAGE DISPOSAL SYSTEM (CLASS 4)		
RV3-1107	6066 JAMES BELL DR	2007	No	REMOVE AND REPAIR ROAD SURFACE AND REPLACE WITH PROPER GRAVEL AND STONE DUST		
RV3-1306	12 RYEBURN DR	2006	No	FILL FOR SEPTIC SYSTEM		
RV3-2207	2174 KELWING LN	2007	No	ALTER THE EXISTING COTTAGE TO A PERMANENT RESIDENCE		
RV3-2707	2490 G RIVER RD	2007	No	DIG FOR LAP POOL WITH LANDSCAPING		

Note: Files highlighted yellow were used in the adjustment of floodlines.

Figure 1: Study Area

RIDEAU VALLEY CONSERVATION AUTHORITY

Map Scale: 1:100,000	N W E S
Projection Note: NAD 1983 UTM Zone 18N	

File Path:
\\RVCASTORAGE1\rvcahydrology\M800_City\Rideau_HBtoKars_M800_200_020_204\Rideau23 Report\Maps\Figure 1 Study Area.mxd

Created by: SNolan	Date Modified: 5/29/2015 3:53:07

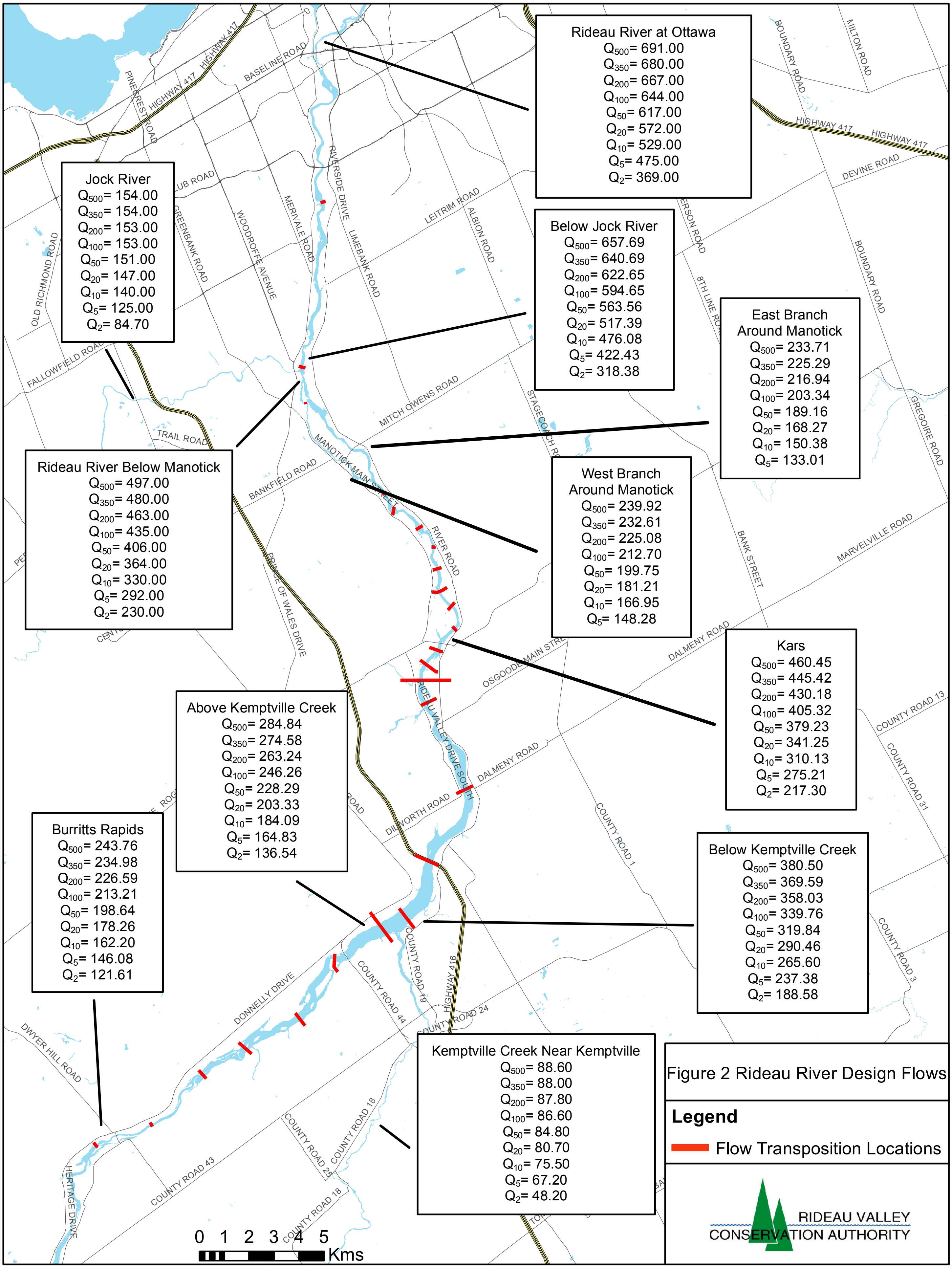
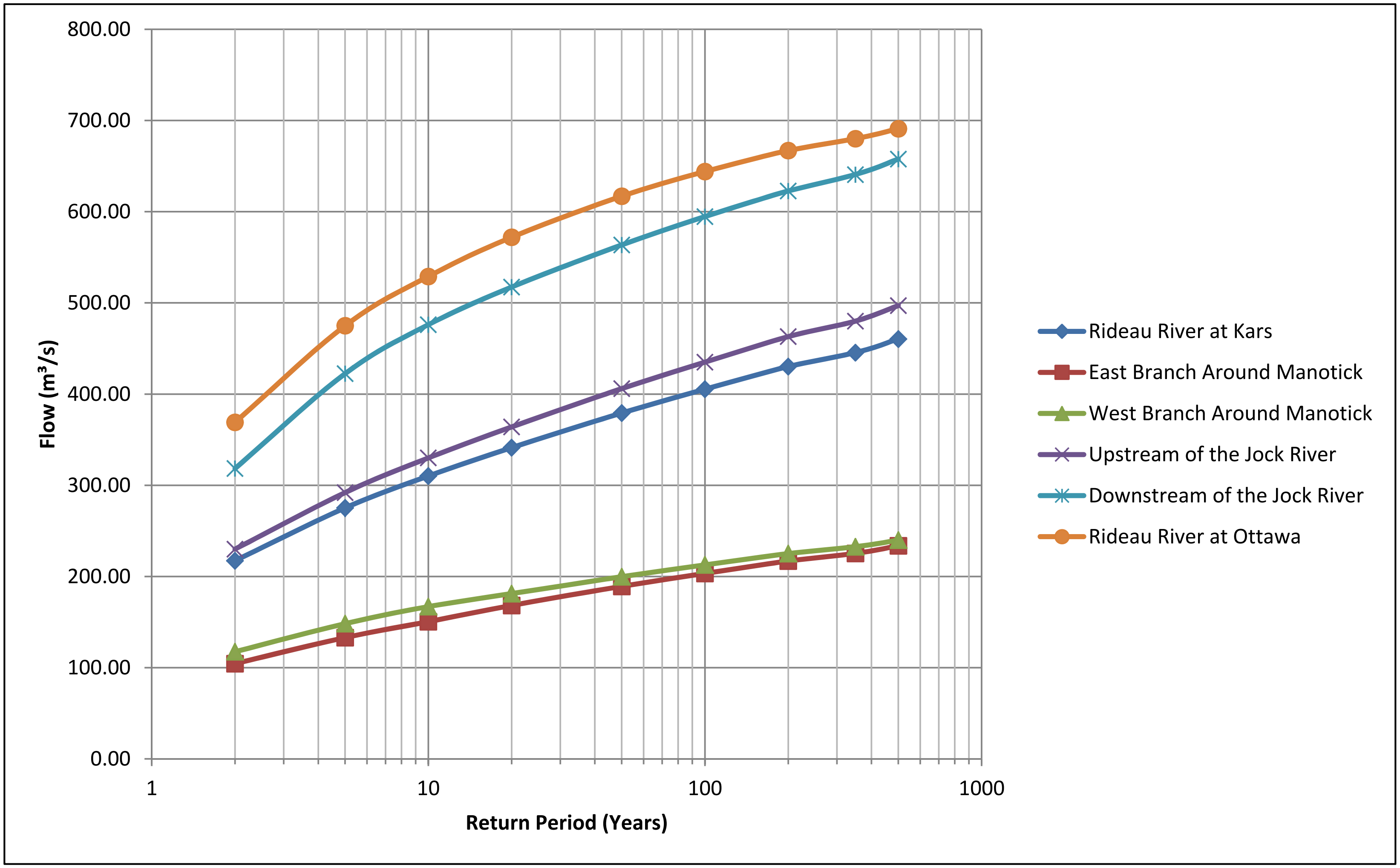


Figure 2 Rideau River Design Flows

Figure 3 Estimated Rideau River Design Flows



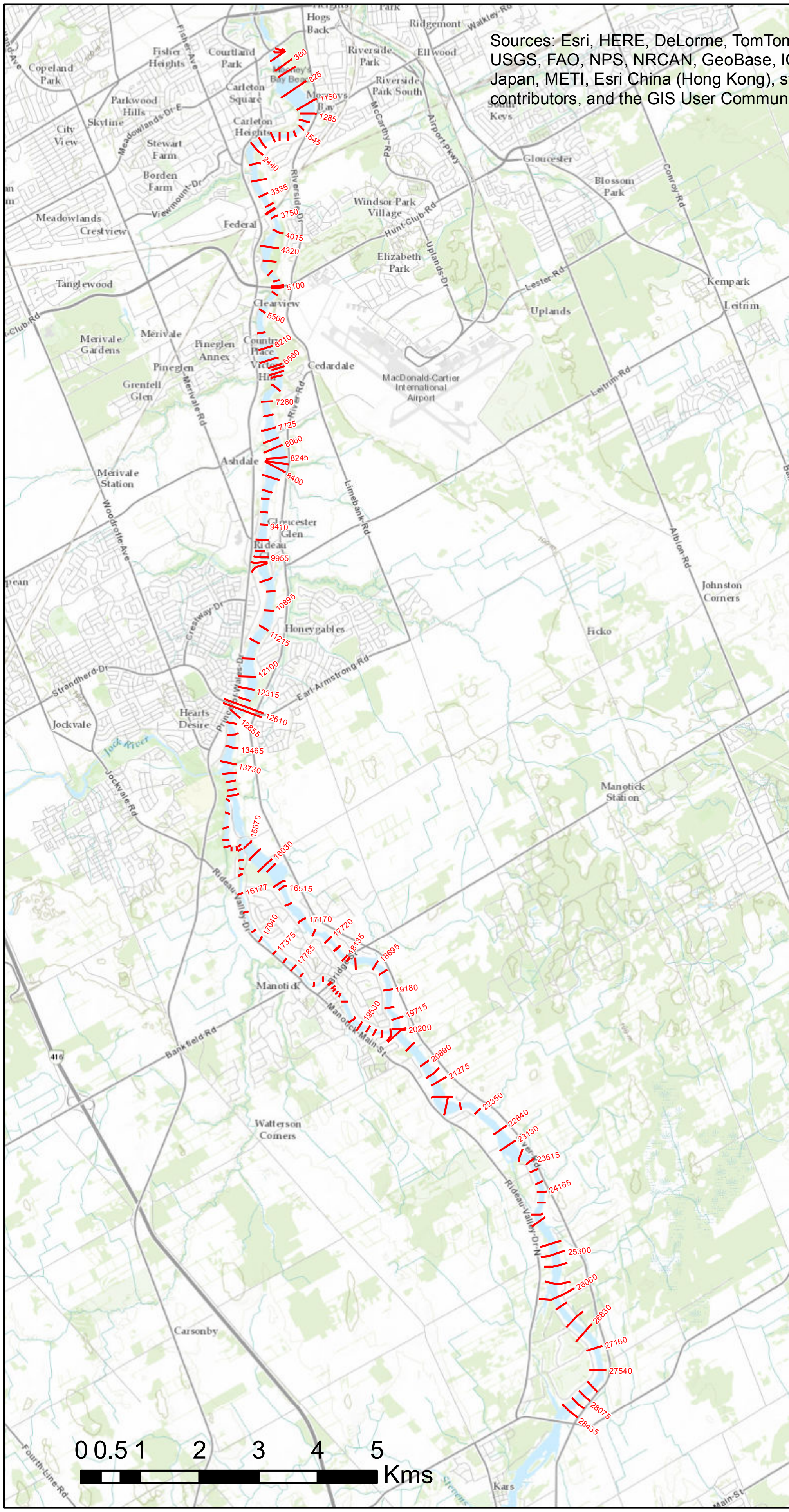


Figure 4: HEC-RAS Schematic

Legend

HEC-RAS Cross-Section

RIDEAU VALLEY CONSERVATION AUTHORITY

1:100,000

Projection Note: NAD 1983 UTM Zone 18N

N W E S

File Path:

Created by: SNolan

Date Modified: 10/30/2015 8:57:24

Figure 5 Calibration of the HEC-RAS Model to the Rideau River Below Manotick (02LA012) Stream Gauge Rating Curve.

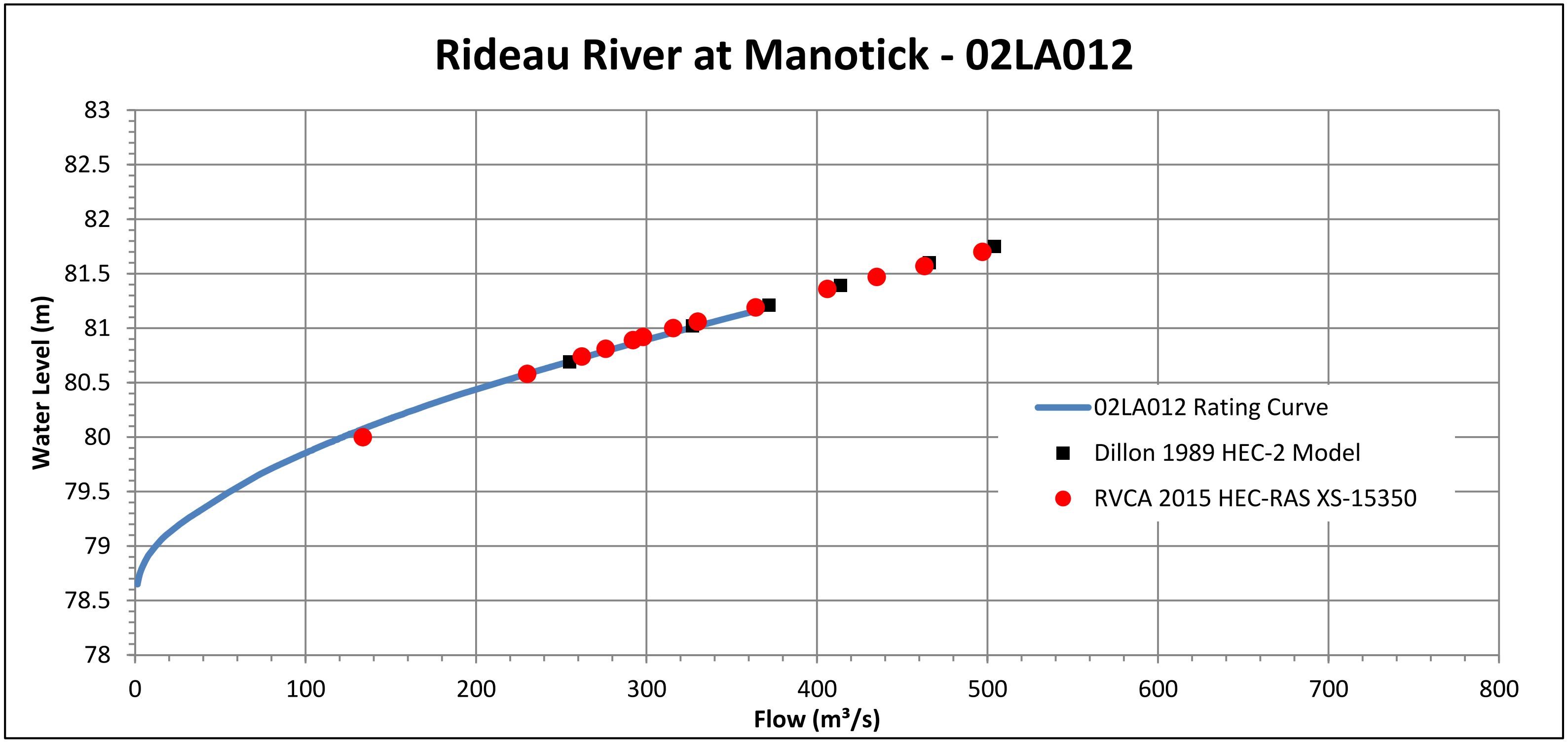


Figure 6 Difference Between Observed and Computed Water Levels for the Hogs Back to Kars to Reach.

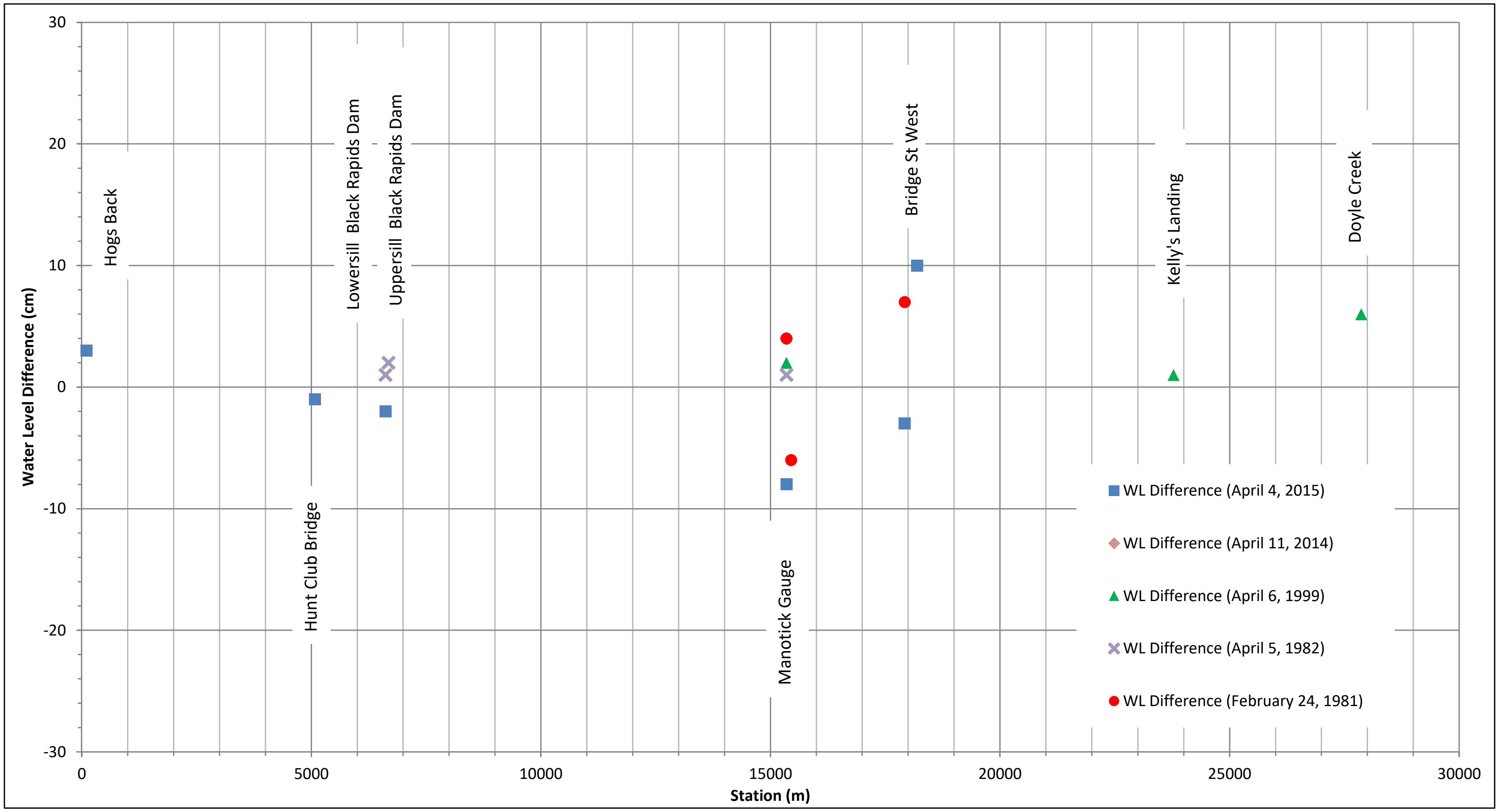


Figure 7A Sensitivity Analysis of Computed Water Level to Design Flow for the Hogs Back to Kars Reach Excluding the East Branch Around Long Island.

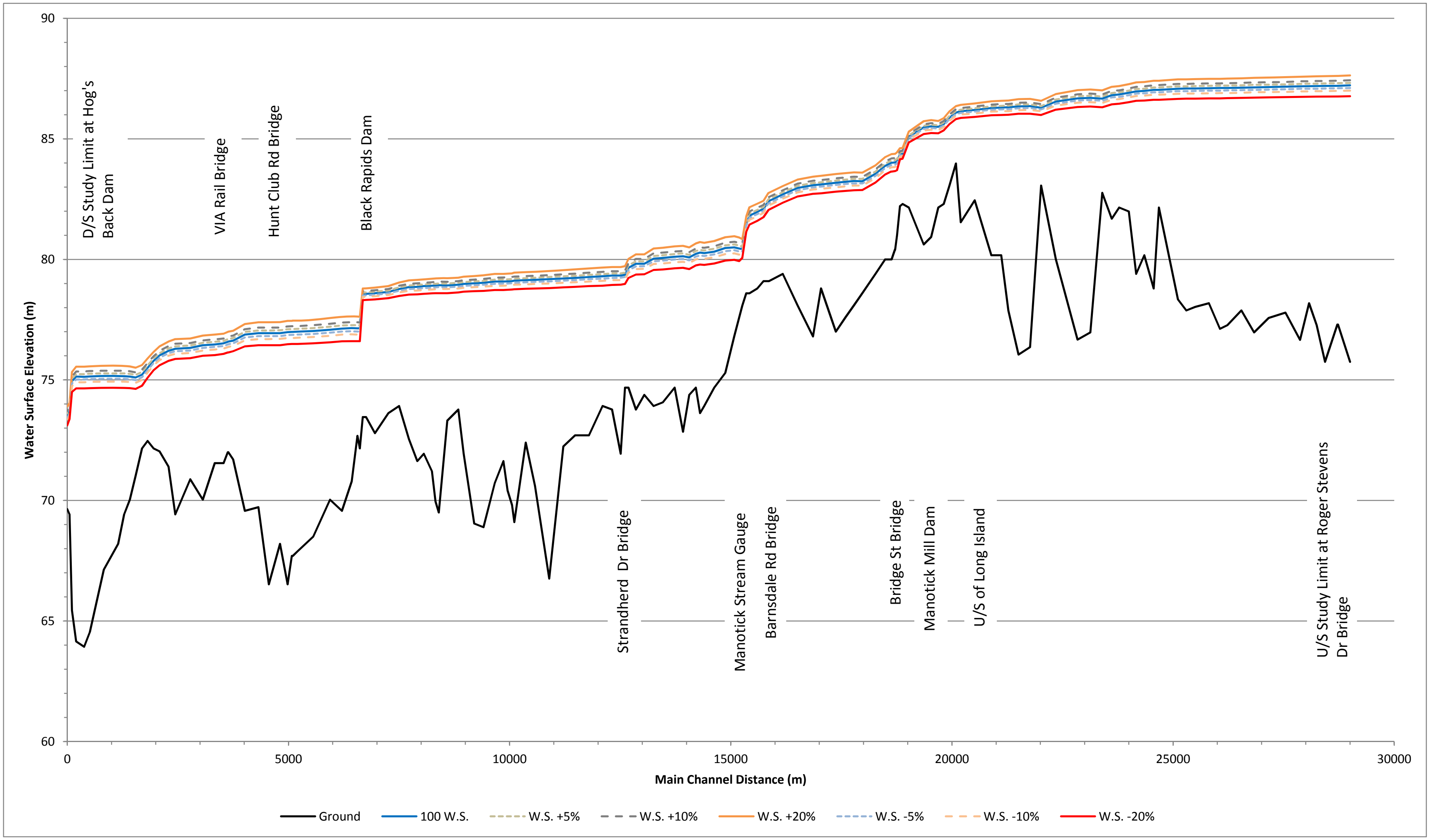


Figure 7B Sensitivity Analysis of Computed Water Level to Design Flow for the Hogs Back to Kars Reach Excluding the West Branch Around Long Island.

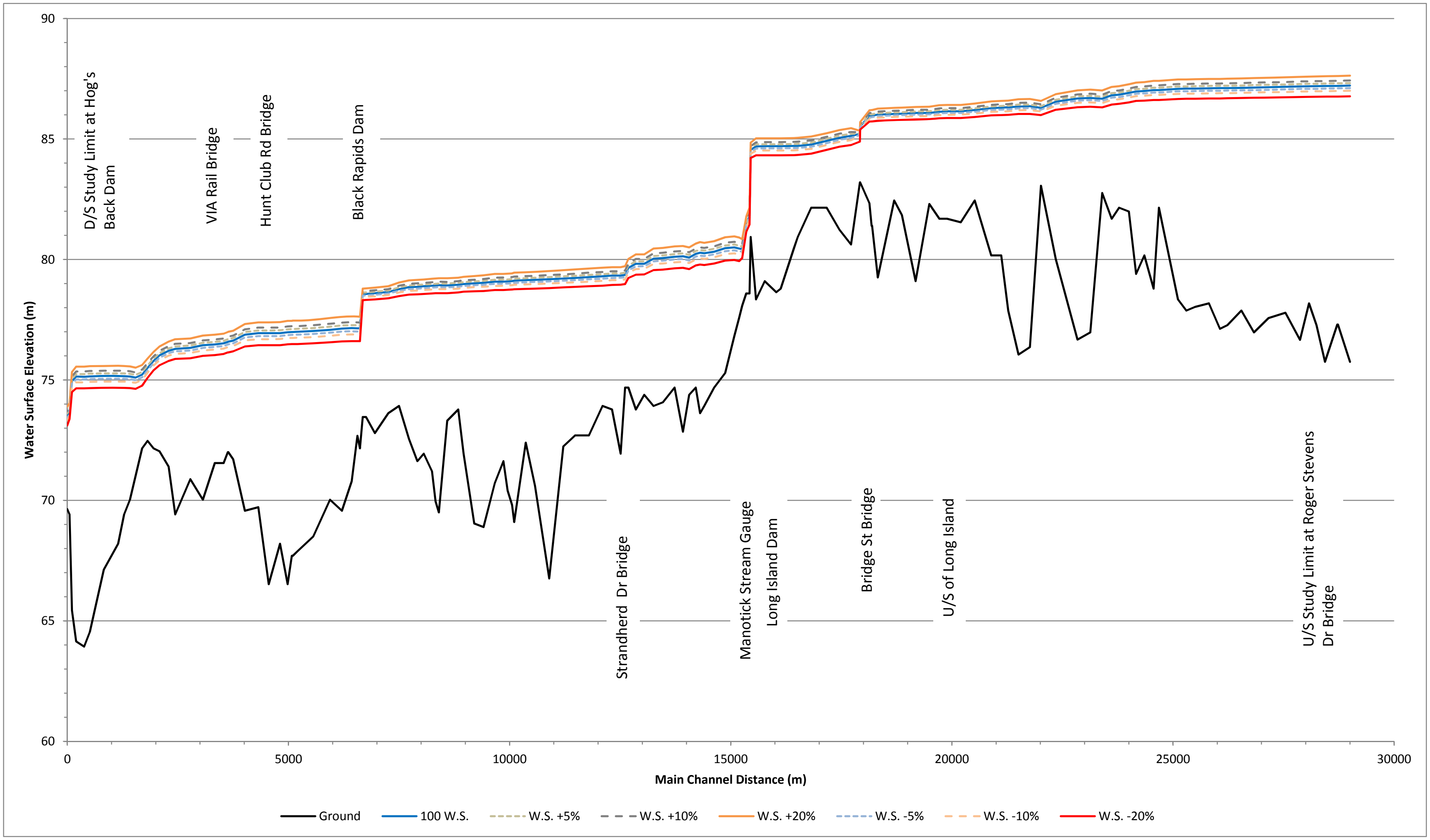


Figure 8A Sensitivity Analysis of Computed Water Level to Design Flow (Water Level Difference) for the Hogs Back to Kars Reach Excluding the East Branch Around Long Island.

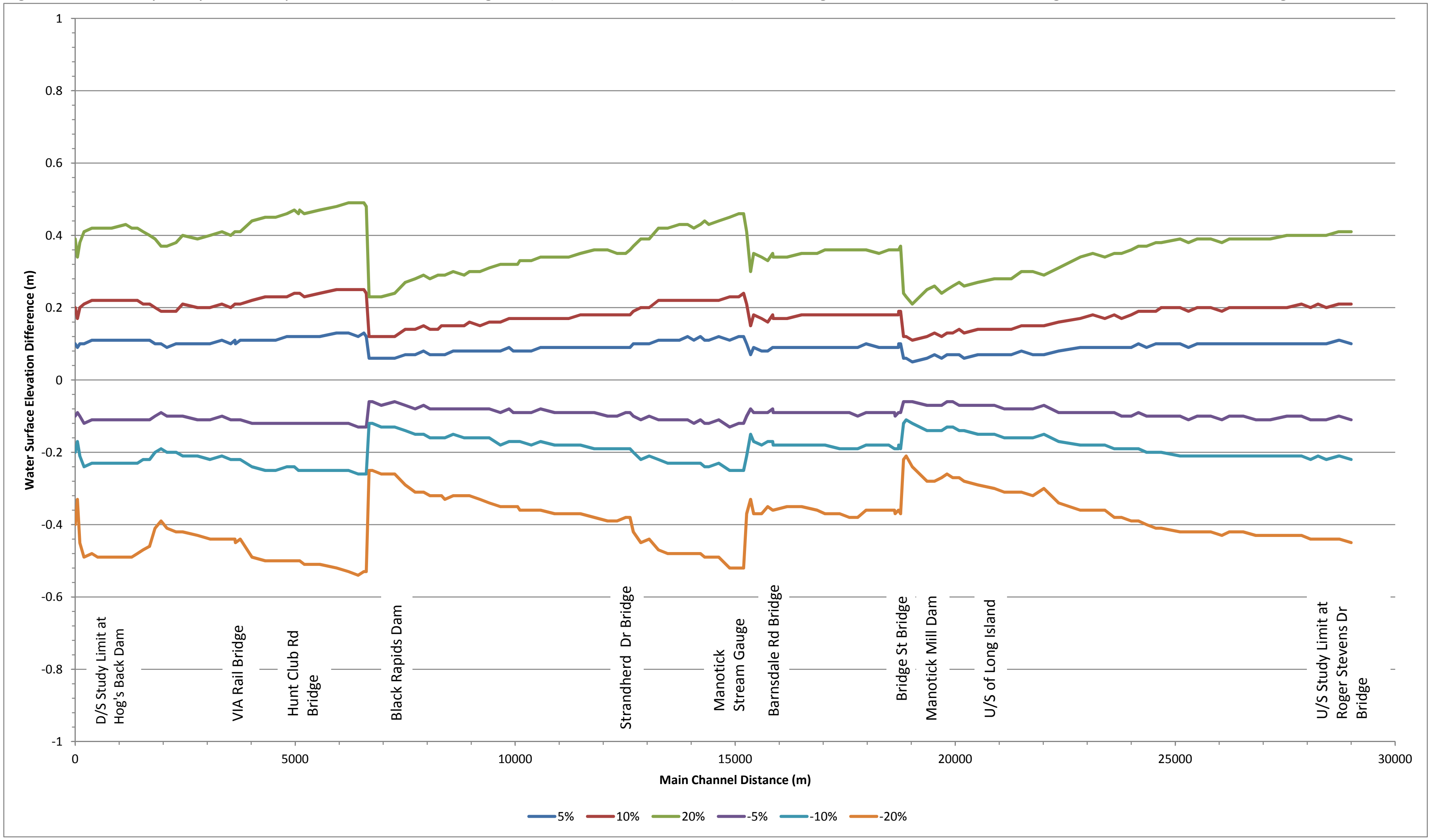
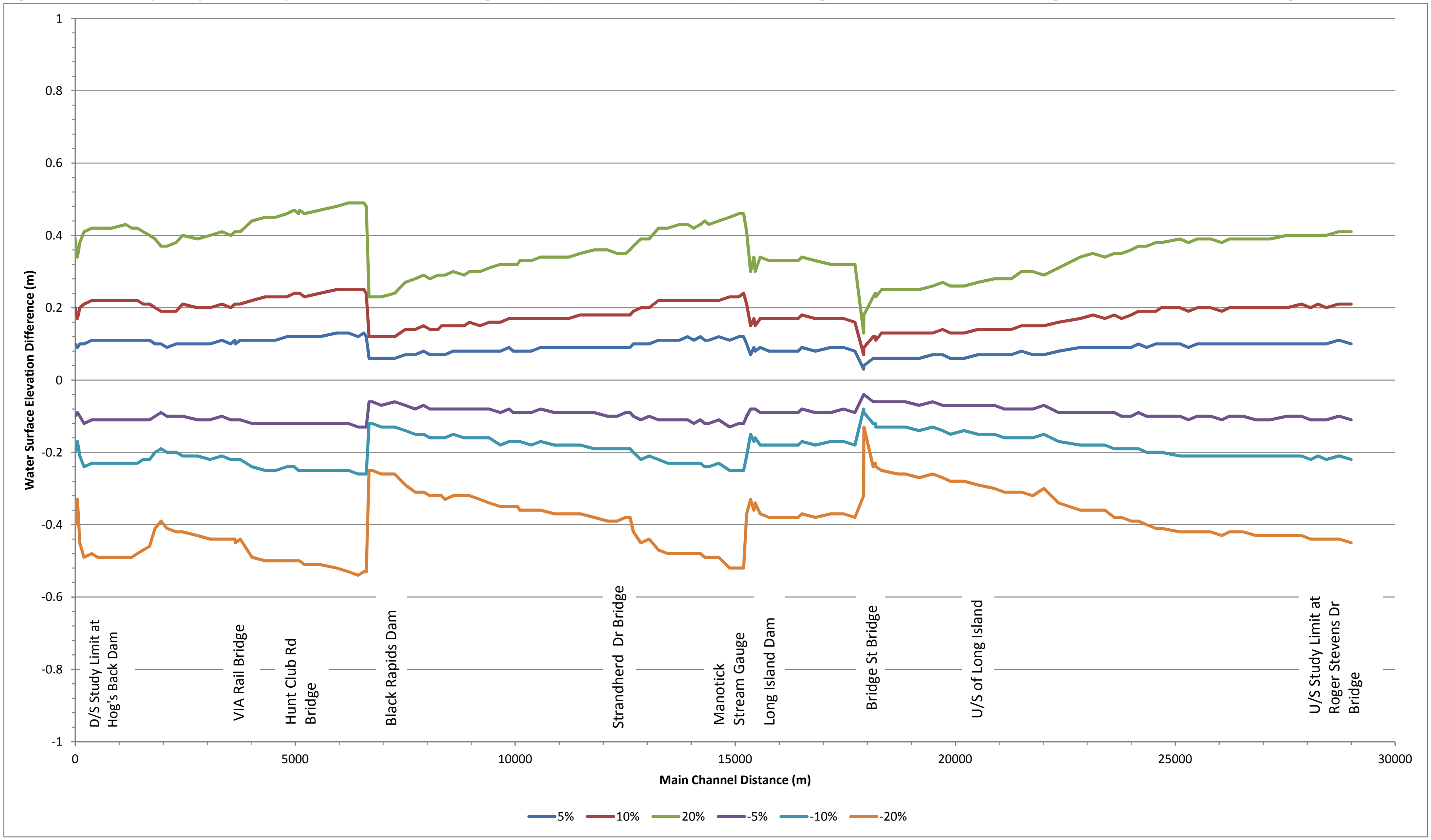
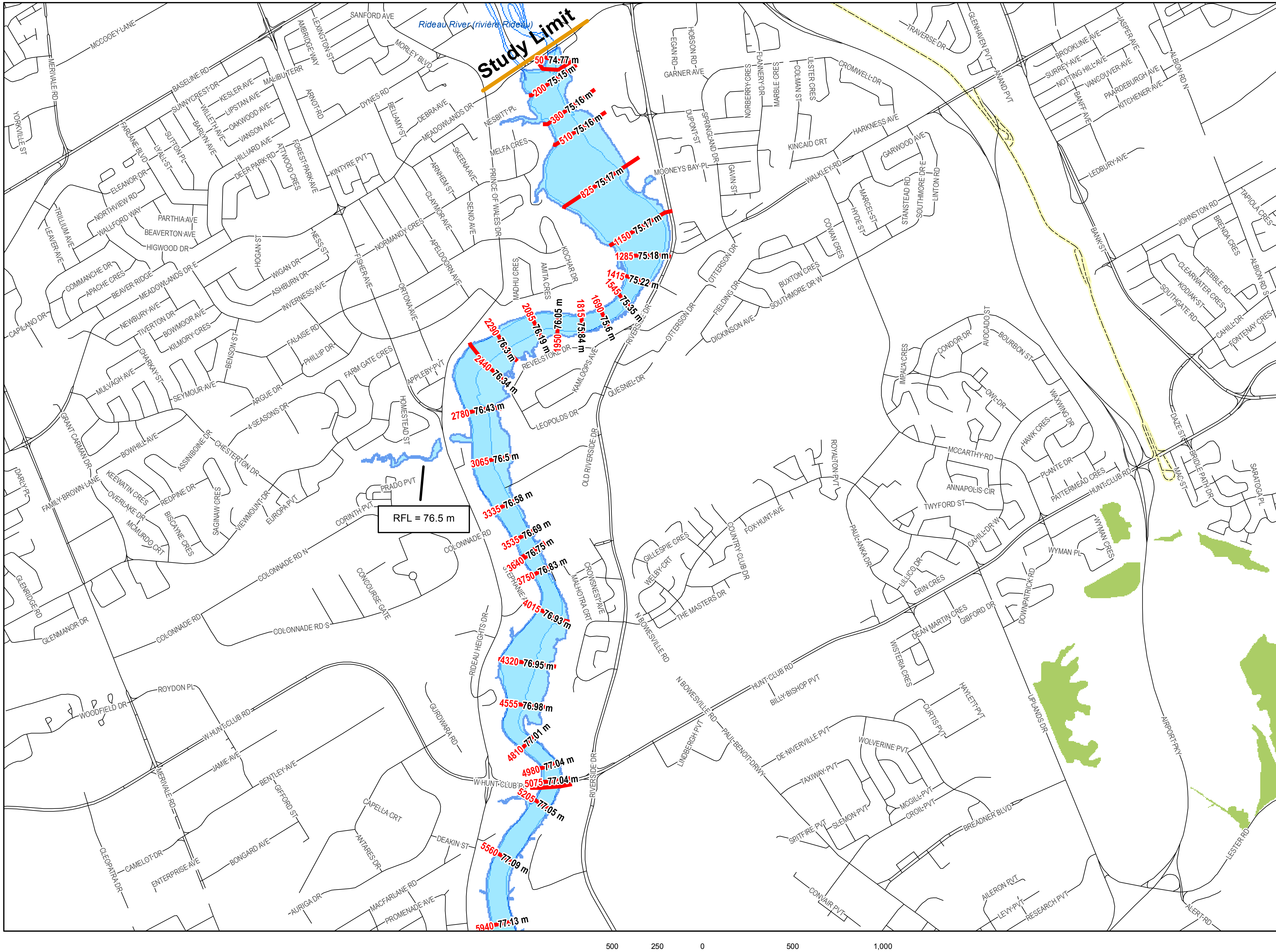


Figure 8B Sensitivity Analysis of Computed Water Level to Design Flow (Water Level Difference) for the Hogs Back to Kars Reach Excluding the West Branch Around Long Island.



Rideau River Flood Plain Mapping
Hog's Back to Kars
Index:1



- Rideau River Floodplain
- Waterbody

Roads

- Freeway
- Road
- Rapid Transit
- RVCA Boundary

Evaluated Wetlands

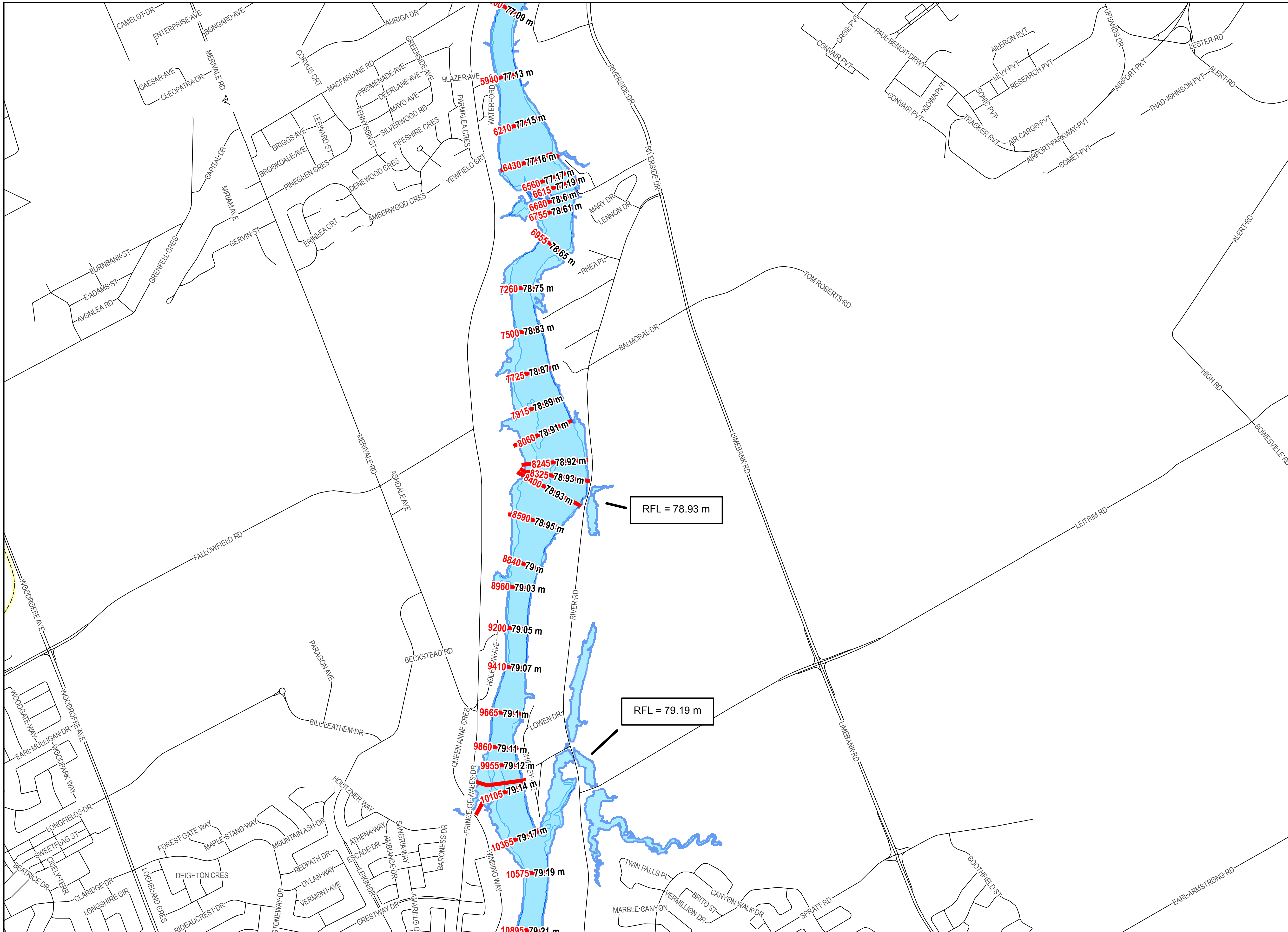
- Provincially Significant
- Other

Cross-Section 2018 — Regulatory Flood Level 60.57 m

Figure 9a

RIDEAU VALLEY CONSERVATION AUTHORITY

Map Scale: 1:20,000	
Projection note: U.T.M. Zone 18 - NAD 83 Datum	
File Location: Z:\GIS_Data\CA_Data\FPM\RVCA\RV3\MapSheets\Report\Rideau_Hogs_Kars_1to20000	
Created by: P.G.	
Modified by: P.G.	Date Modified: 27/07/2017
Published by:	Date Published: 27/07/2017



500 250 0 500 1,000
Meters

Rideau River Flood Plain Mapping
Hog's Back to Kars
Index:2

- Rideau River Floodplain
- Waterbody

Roads

- Freeway
- Road
- Rapid Transit
- RVCA Boundary

Evaluated Wetlands

- Provincially Significant
- Other

Cross-Section 2018	Regulatory Flood Level 60.57 m

Figure 9b

RIDEAU VALLEY CONSERVATION AUTHORITY

Map Scale: 1:20,000

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

File Location:

Created by: P.G.

Modified by: P.G. | Date Modified: 27/07/2017

Published by: | Date Published: 27/07/2017

Rideau River
Flood Plain Mapping
Hog's Back to Kars
Index:3

- Rideau River Floodplain
- Waterbody

Roads
- Freeway
- Road
- Rapid Transit
- RVCA Boundary

Evaluated Wetlands
- Provincially Significant
- Other

Cross-Section 2018 — Regulatory Flood Level 60.57 m

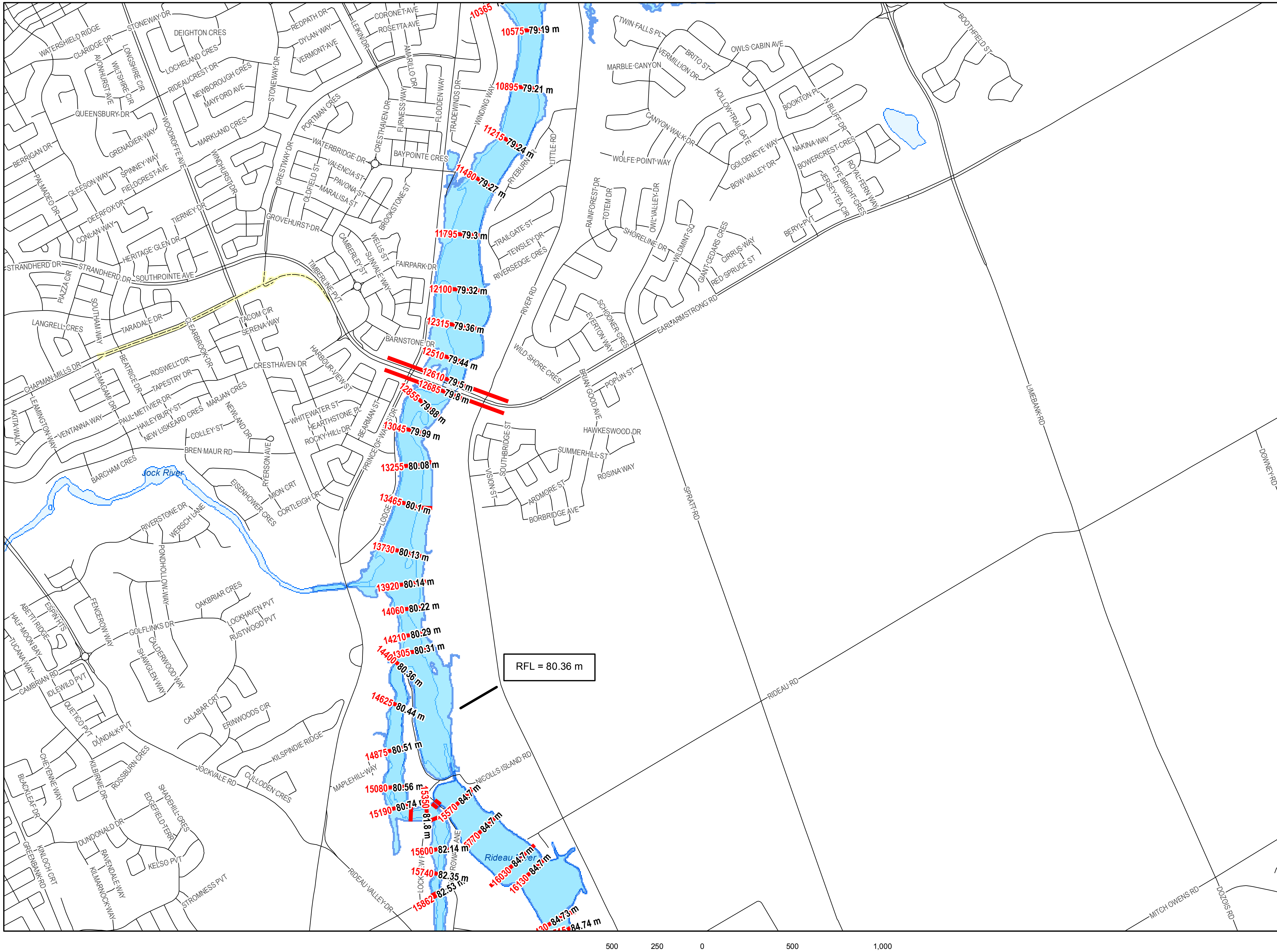


Figure 9c

RIDEAU VALLEY CONSERVATION AUTHORITY

Map Scale: 1:20,000

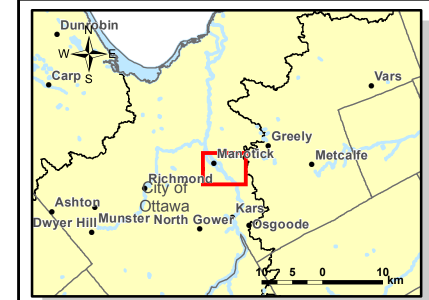
Projection note: U.T.M. Zone 18 - NAD 83 Datum

File Location: Z:\GIS_Data\CA_Data\FPM\RVCA\RV3\MapSheets\Report\Rideau_Hogs_Kars_1to20000

Created by: P.G.	
Modified by: P.G.	Date Modified: 27/07/2017
Published by:	Date Published: 27/07/2017

500 250 0 500 1,000 Meters

Rideau River Flood Plain Mapping
Hog's Back to Kars
Index:4



Rideau River Floodplain
Waterbody

Roads
Freeway
Road
Rapid Transit
RVCA Boundary

Evaluated Wetlands
Provincially Significant
Other

Cross-Section 2018 — Regulatory Flood Level 60.57 m

Figure 9d

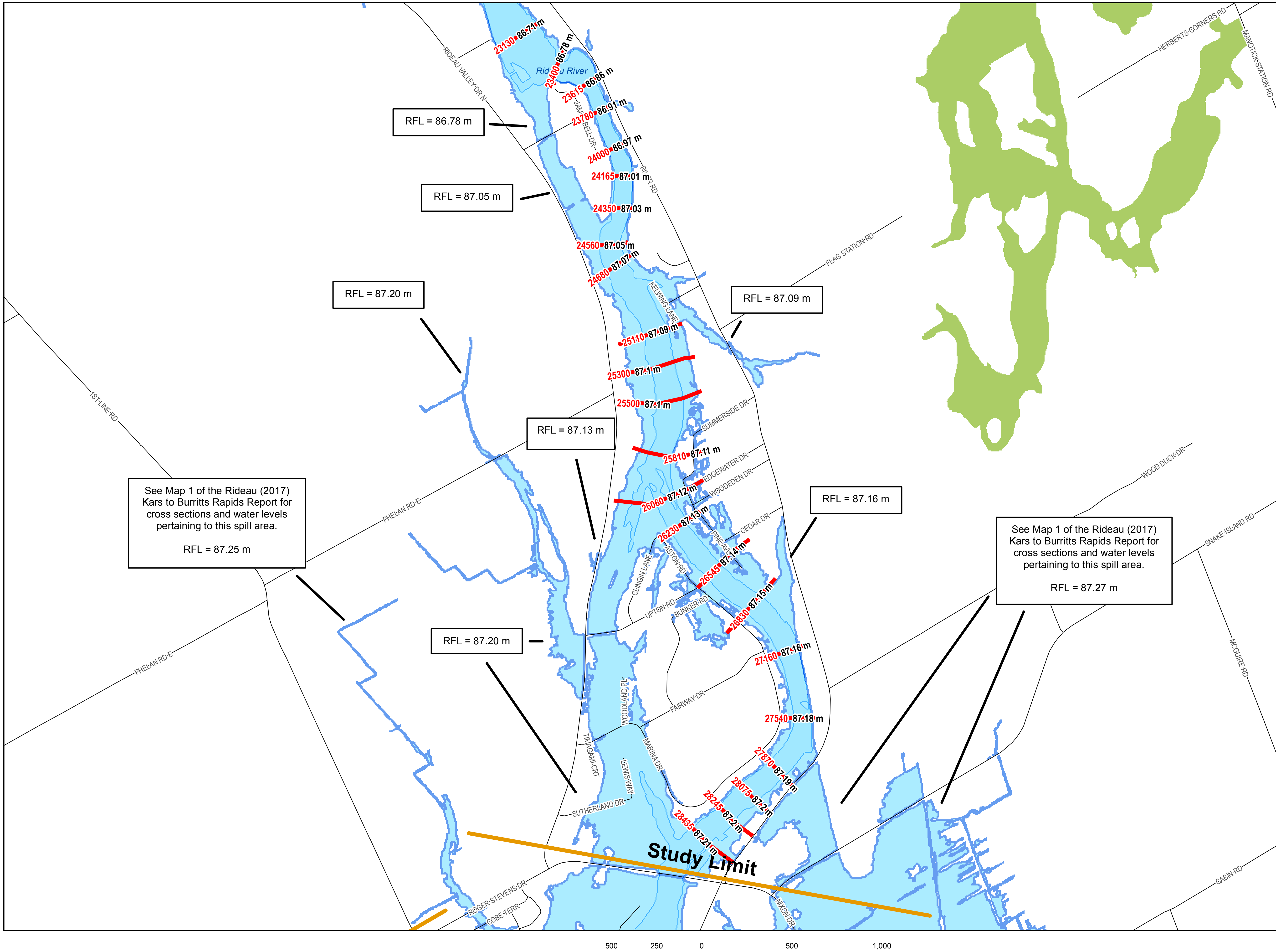
RIDEAU VALLEY CONSERVATION AUTHORITY

Map Scale: 1:20,000

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

File Location: Z:\GIS_Data\CA_Data\FPM\RVCA\RV3\MapSheets\Report\Rideau_Hogs_Kars_1to20000

Created by: P.G.	
Modified by: P.G.	Date Modified: 27/07/2017
Published by:	Date Published: 27/07/2017



Rideau River
Flood Plain Mapping
Hog's Back to Kars
Index:5

- Rideau River Floodplain
- Waterbody

Roads
- Freeway
- Road
- Rapid Transit
- RVCA Boundary

Evaluated Wetlands
- Provincially Significant
- Other

Cross-Section 2018 — Regulatory Flood Level 60.57 m

Figure 9e

RIDEAU VALLEY CONSERVATION AUTHORITY

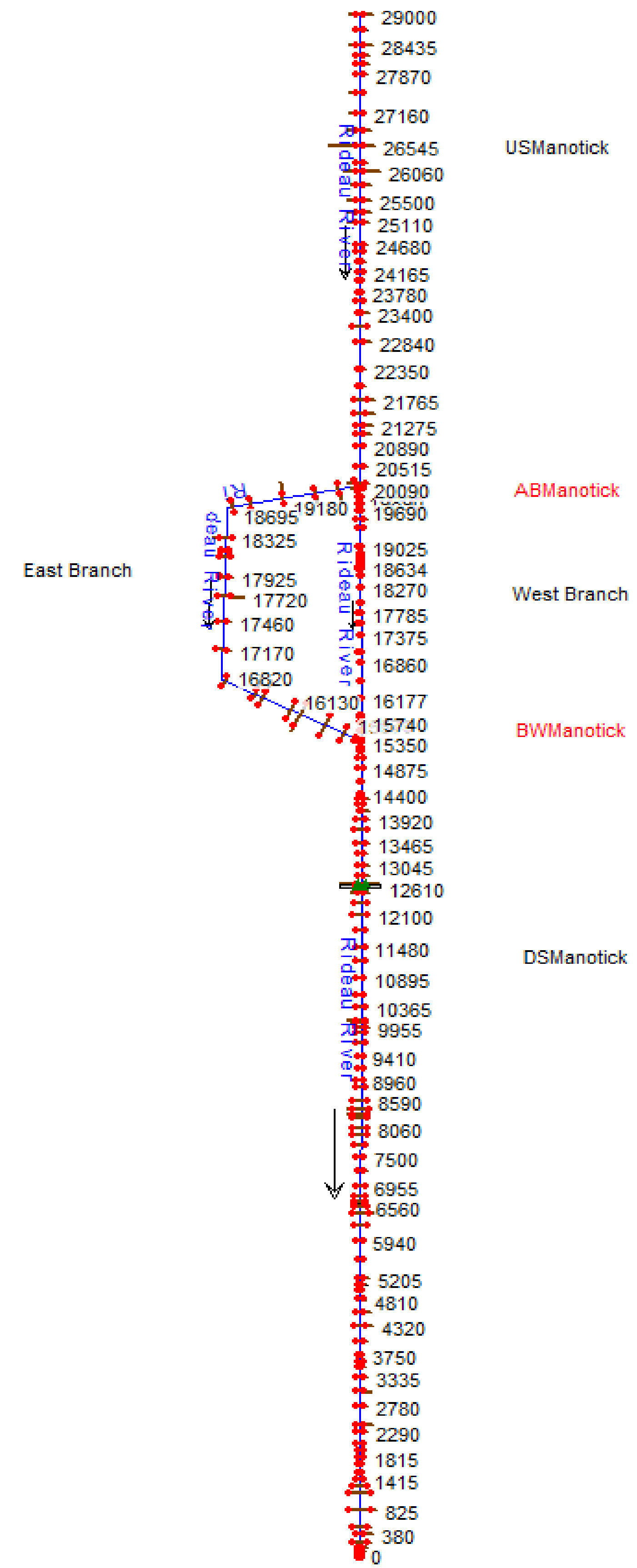
Map Scale: 1:20,000

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

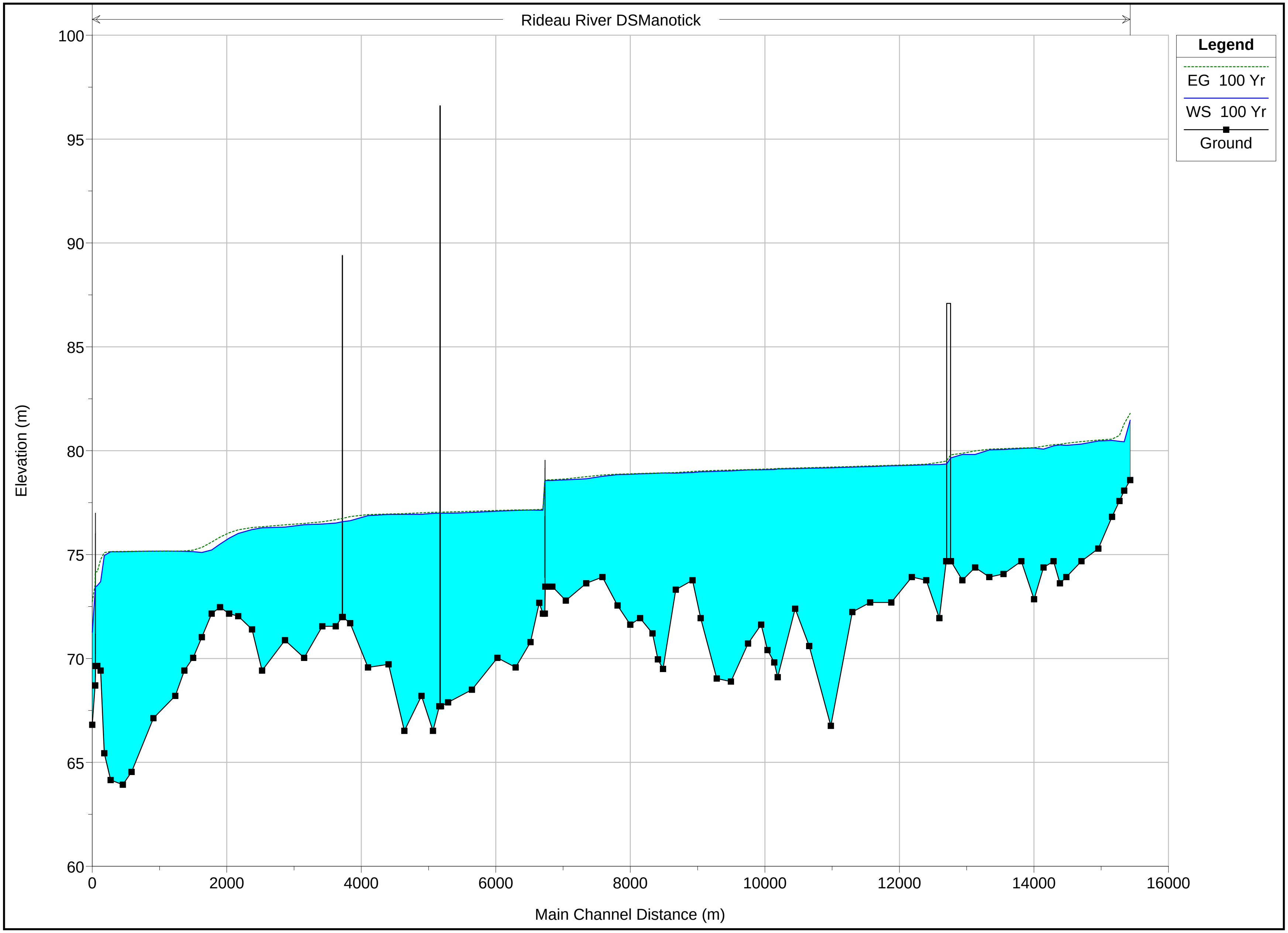
Created by: P.G.	
Modified by: P.G.	Date Modified: 27/07/2017
Published by:	Date Published: 27/07/2017

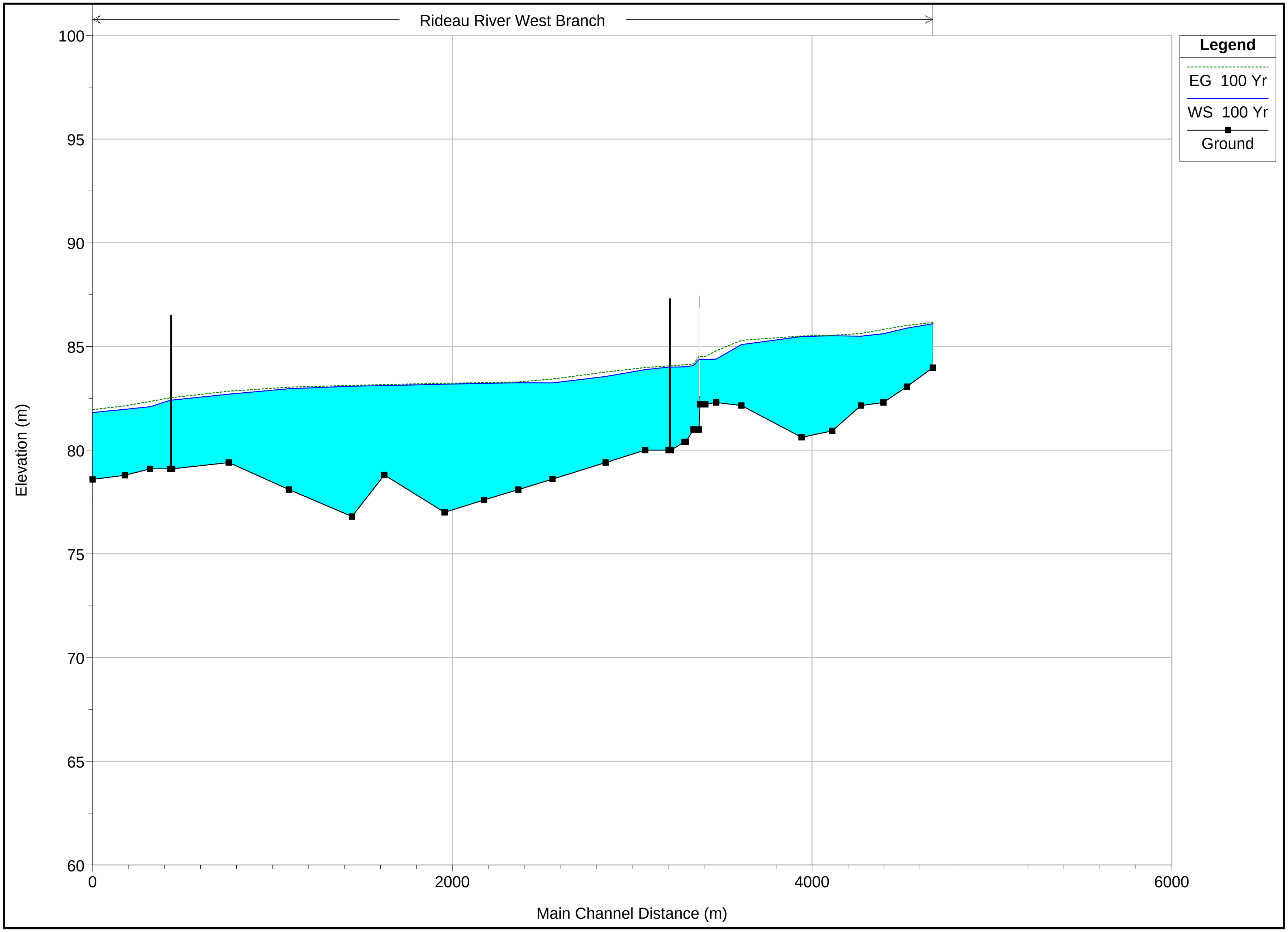
Appendix A

HEC-RAS Profiles and Cross-Sections

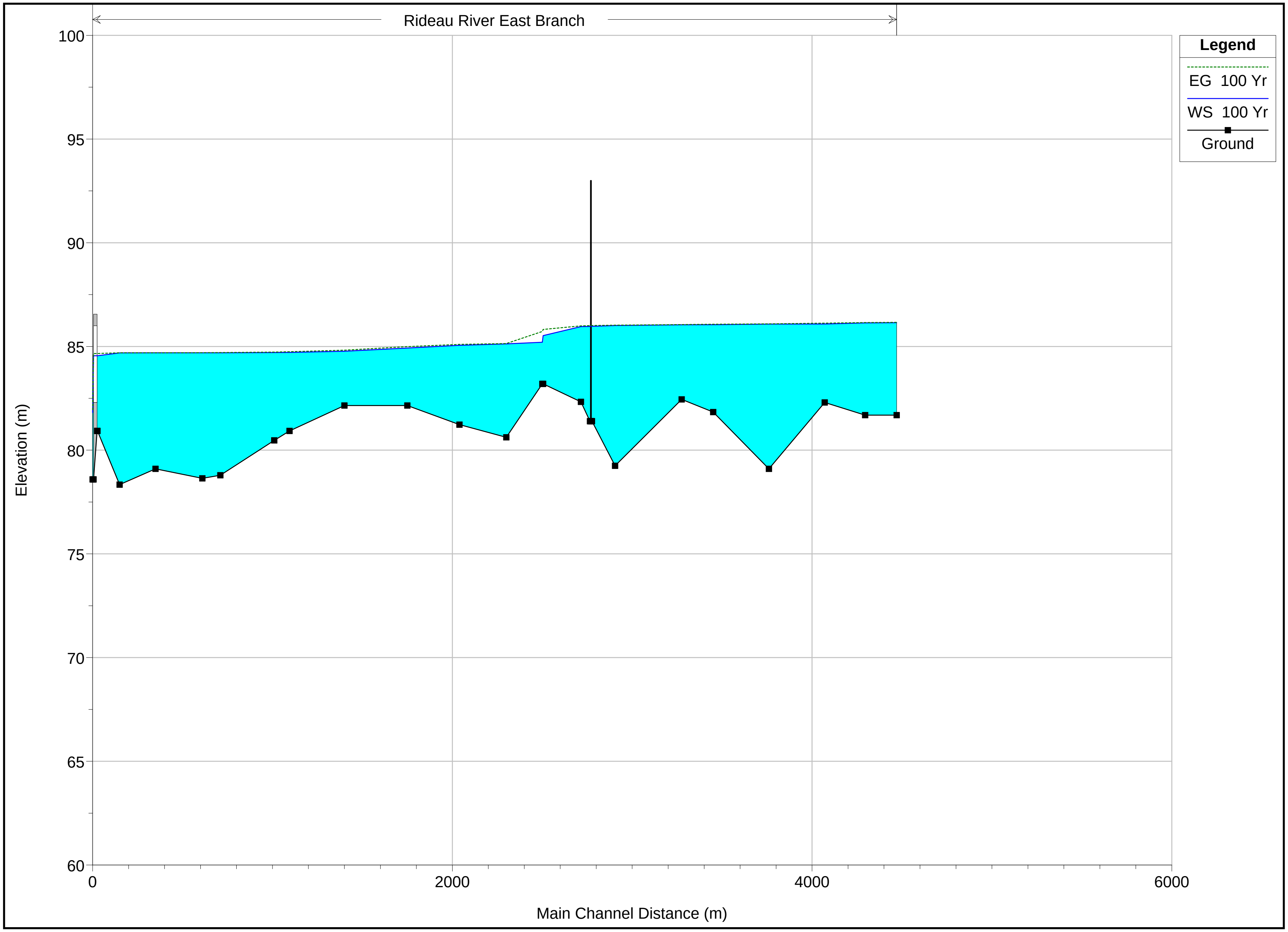


29000
28435
27870
27160
26545
USManotick
26060
25500
25110
24680
24165
23780
23400
22840
22350
21765
21275
20890
20515
20090
ABManotick
19180
18695
19690
18325
East Branch
19025
18634
17925
17720
18270
West Branch
17785
17460
17375
17170
16860
16820
16130
16177
15740
BWManotick
15350
14875
14400
13920
13465
13045
12610
12100
11480
DSManotick
10895
10365
9955
9410
8960
8590
8060
7500
6955
6560
5940
5205
4810
4320
3750
3335
2780
2290
1815
1415
825
380
0
Rideau River

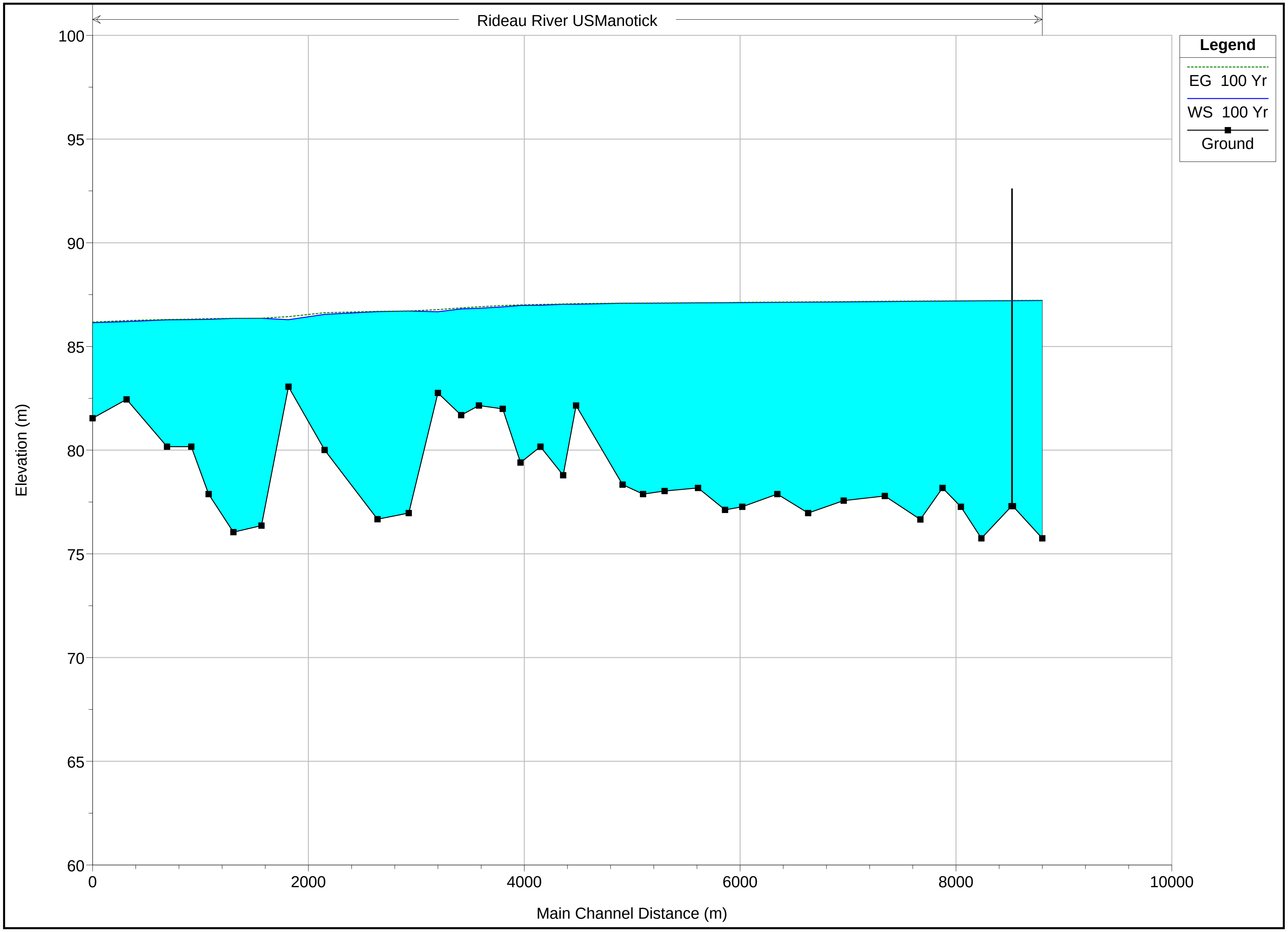

Rideau River DSManotick
Legend
EG 100 Yr
WS 100 Yr
Ground
Elevation (m)
Main Channel Distance (m)
100
95
90
85
80
75
70
65
60
0
2000
4000
6000
8000
10000
12000
14000
16000



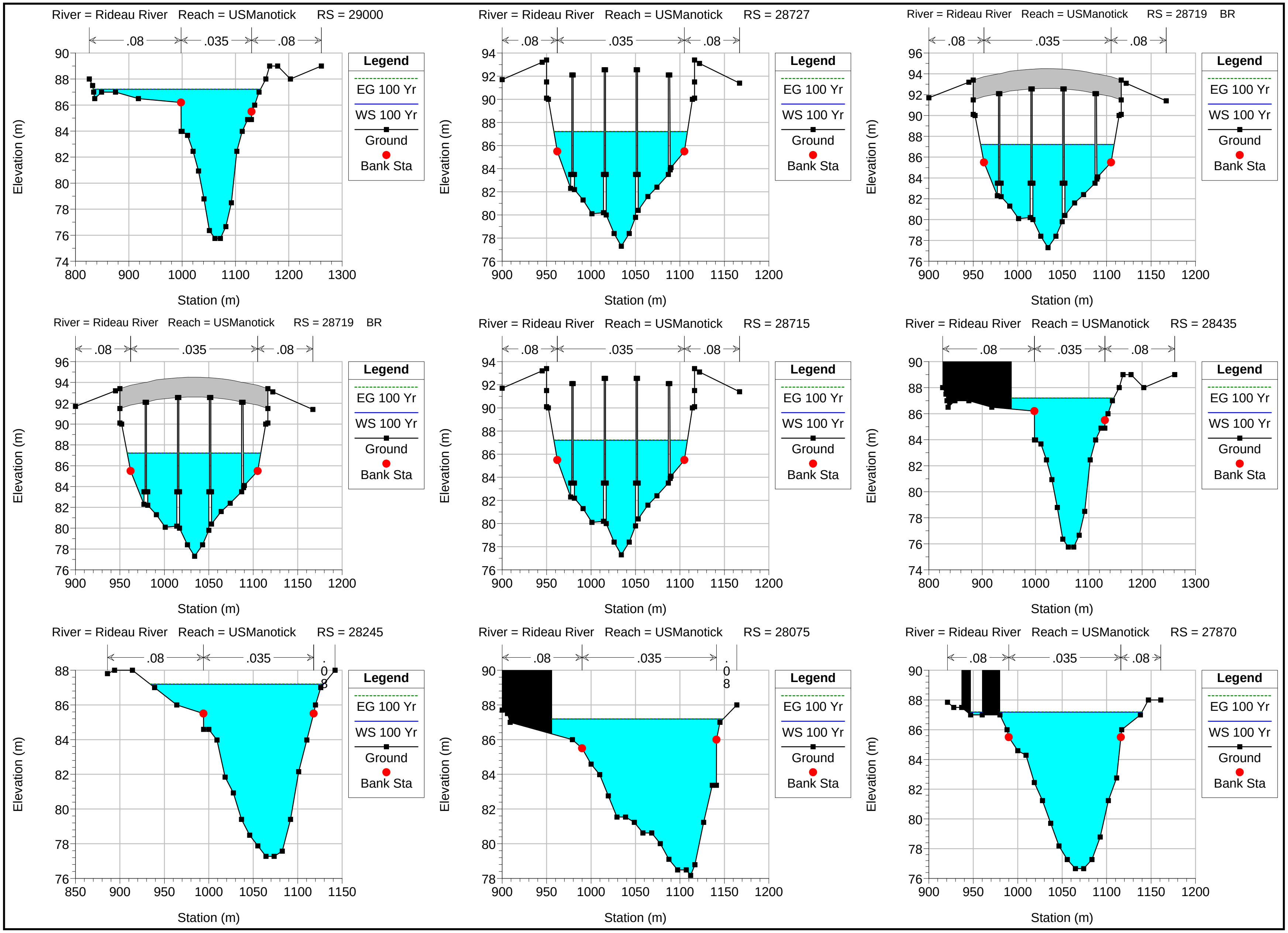
Rideau River West Branch
Legend
EG 100 Yr
WS 100 Yr
Ground
Elevation (m)
Main Channel Distance (m)
100
95
90
85
80
75
70
65
60
0
2000
4000
6000



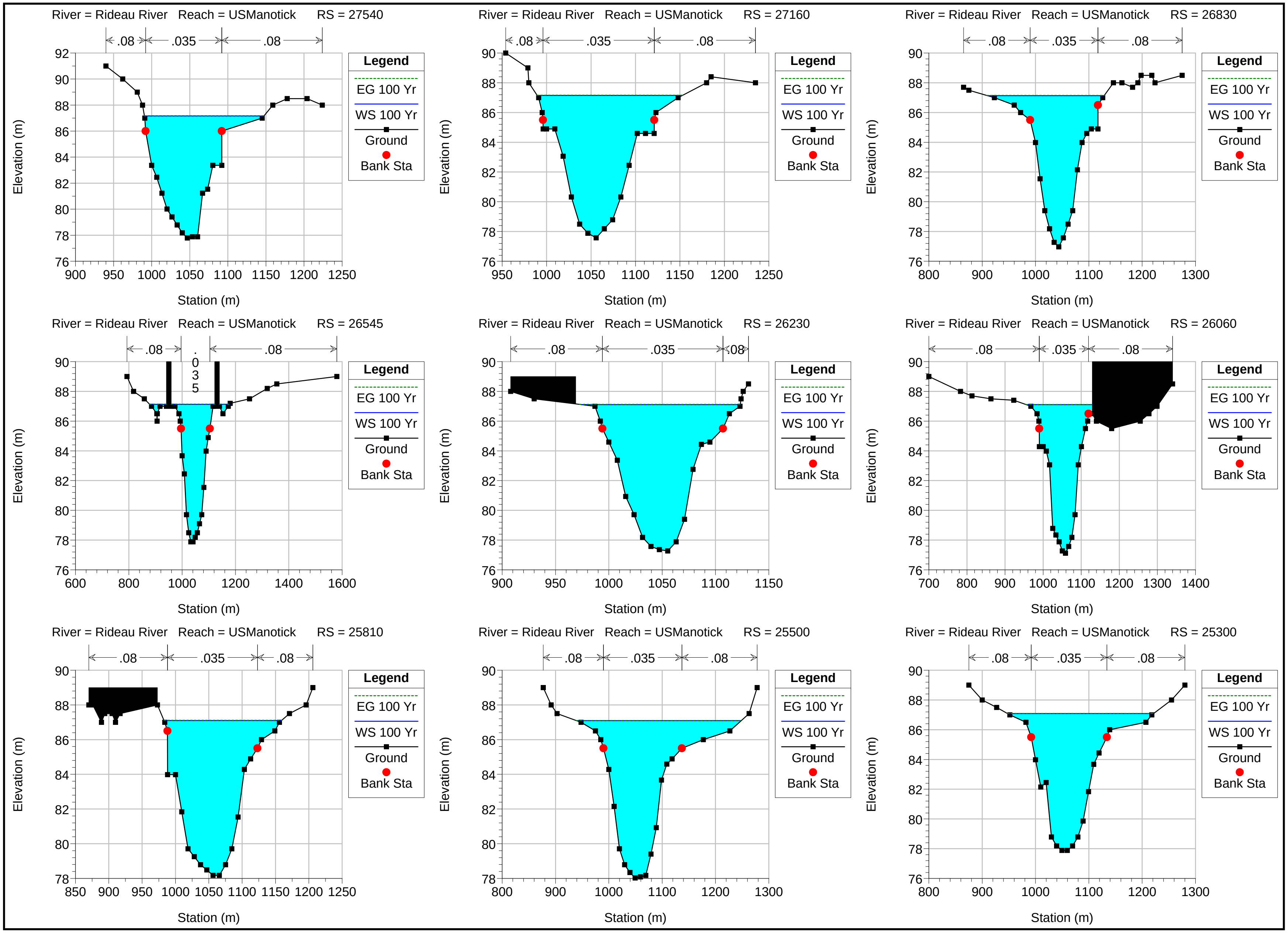
Rideau River East Branch
Legend
EG 100 Yr
WS 100 Yr
Ground
Elevation (m)
Main Channel Distance (m)
100
95
90
85
80
75
70
65
60
0
2000
4000
6000

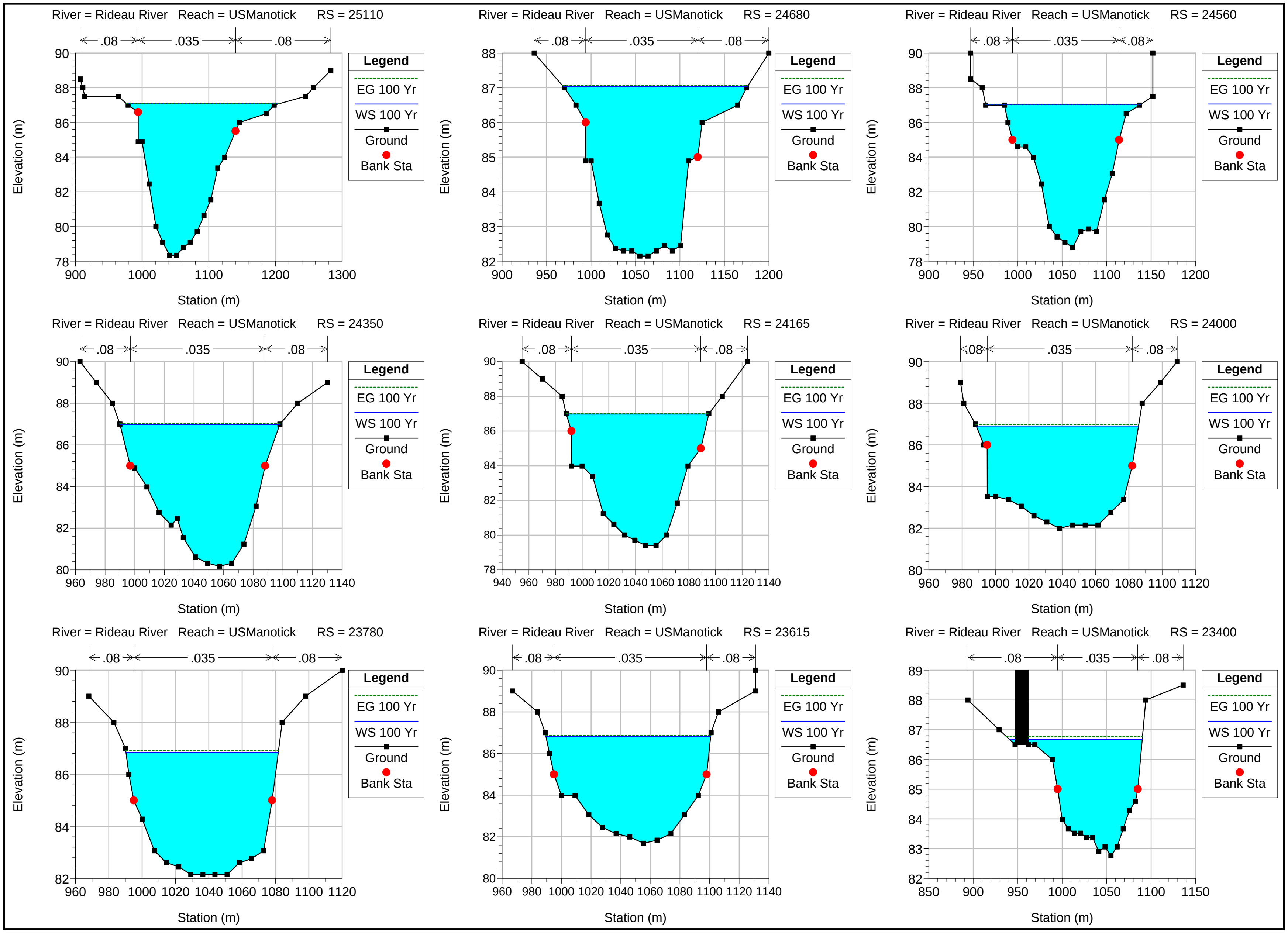


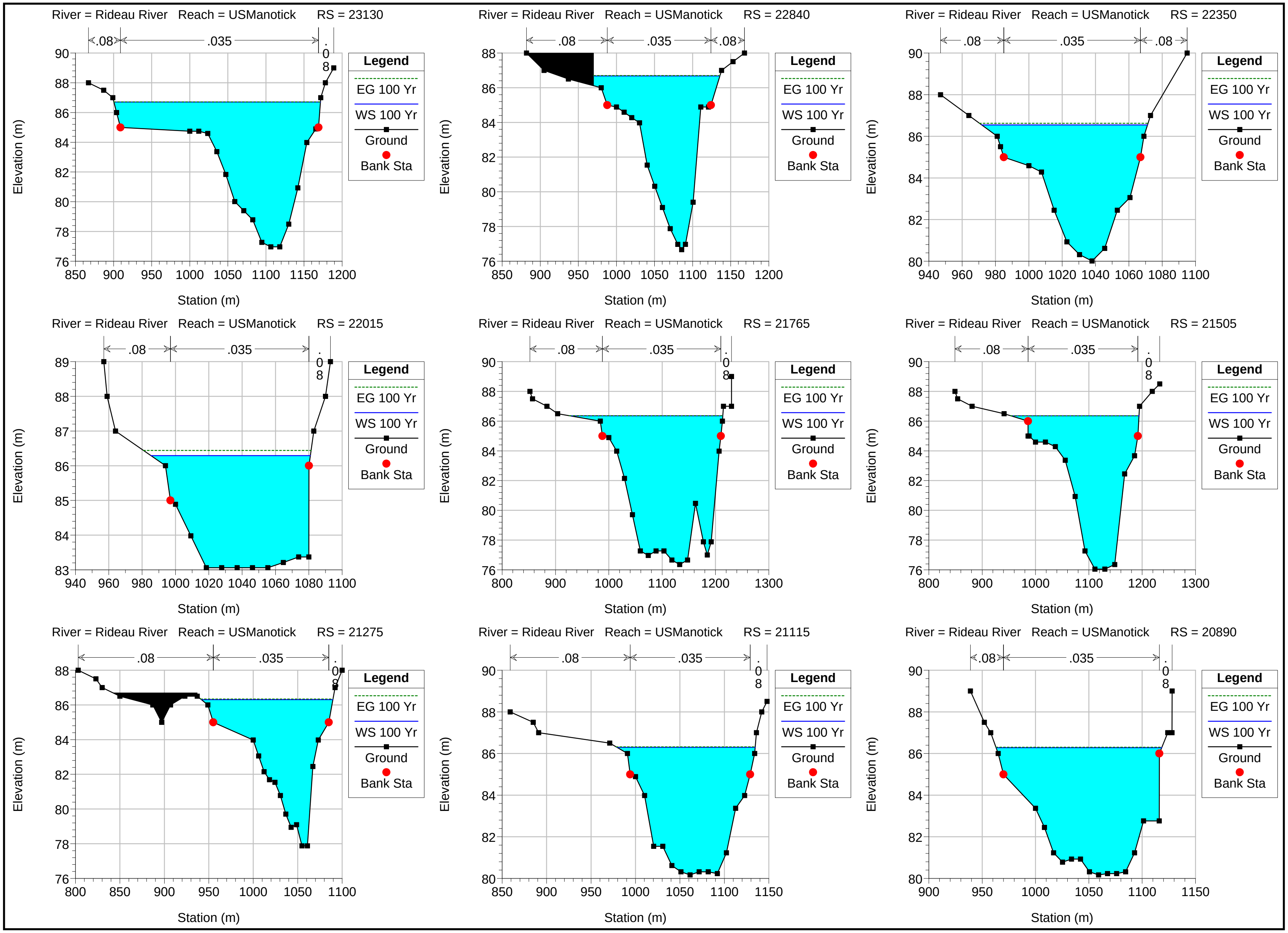
Rideau River USManotick
Legend
EG 100 Yr
WS 100 Yr
Ground
Elevation (m)
100
95
90
85
80
75
70
65
60
0
2000
4000
6000
8000
10000
Main Channel Distance (m)

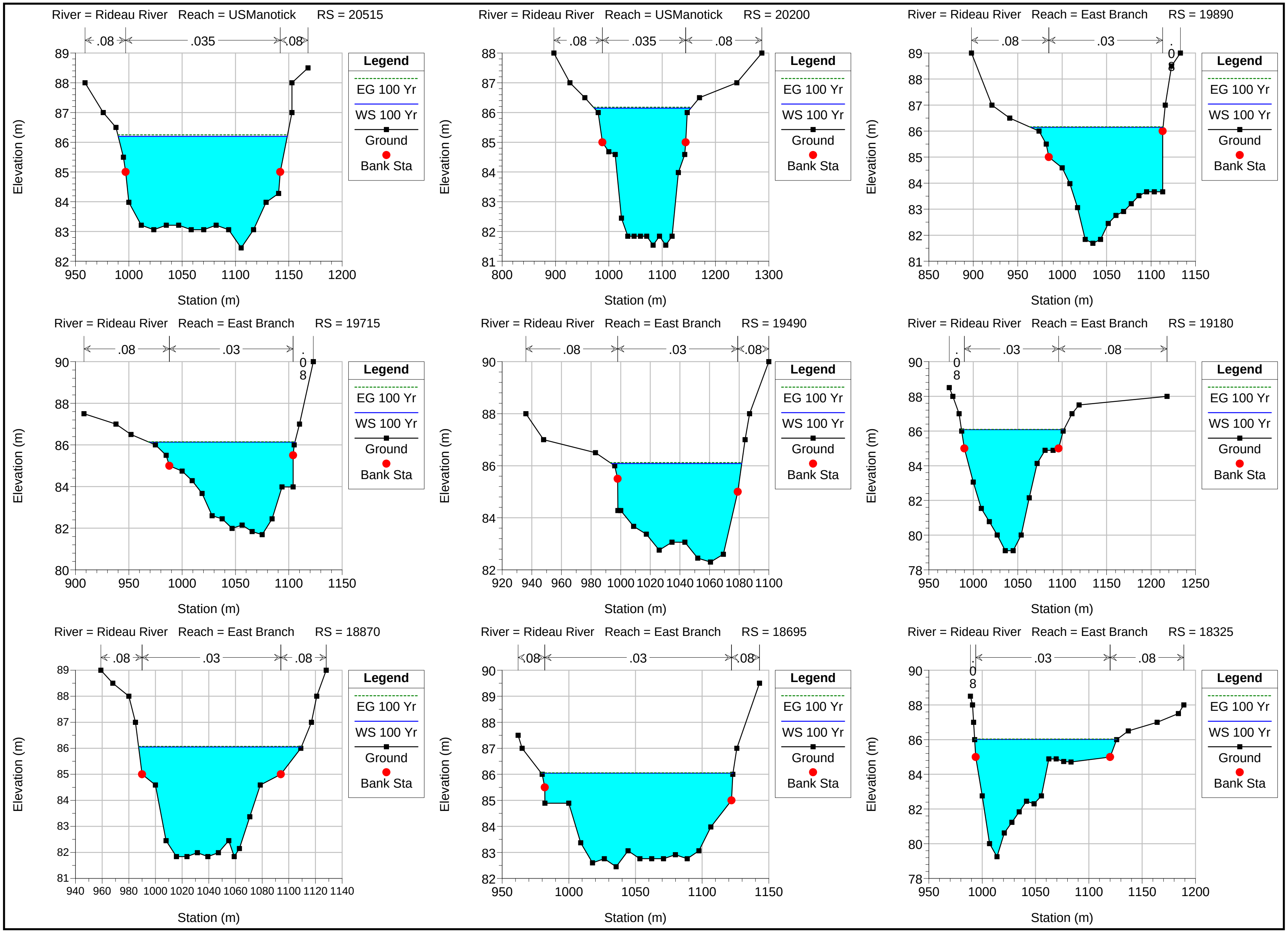


River = Rideau River Reach = USManotick RS = 29000
.08 .035 .08
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = USManotick RS = 28727
.08 .035 .08
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = USManotick RS = 28719 BR
.08 .035 .08
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = USManotick RS = 28719 BR
.08 .035 .08
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = USManotick RS = 28715
.08 .035 .08
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = USManotick RS = 28435
.08 .035 .08
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = USManotick RS = 28245
.08 .035 .08
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = USManotick RS = 28075
.08 .035 .08
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = USManotick RS = 27870
.08 .035 .08
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta

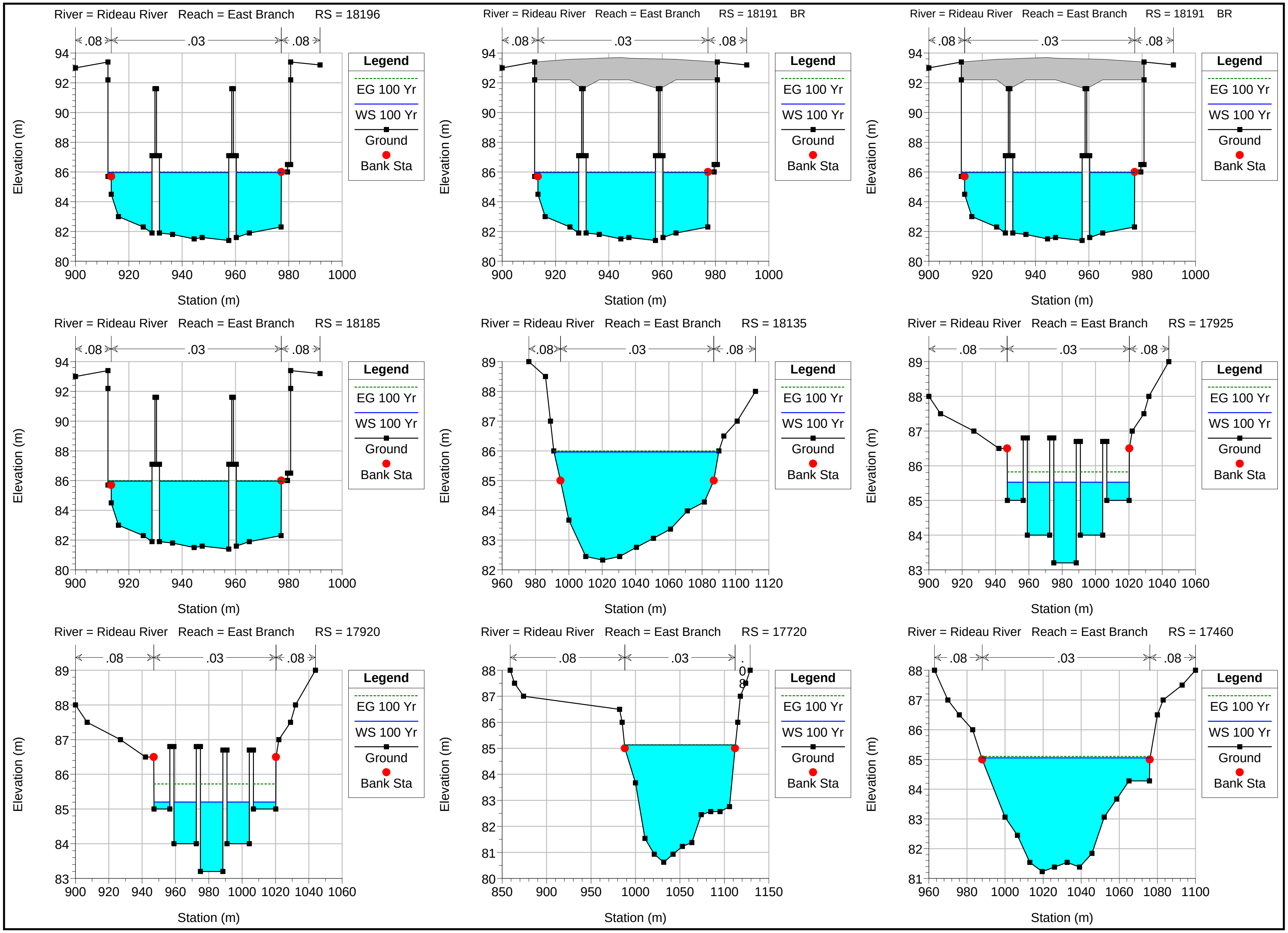

River = Rideau River Reach = USManotick RS = 27540
River = Rideau River Reach = USManotick RS = 27160
River = Rideau River Reach = USManotick RS = 26830
River = Rideau River Reach = USManotick RS = 26545
River = Rideau River Reach = USManotick RS = 26230
River = Rideau River Reach = USManotick RS = 26060
River = Rideau River Reach = USManotick RS = 25810
River = Rideau River Reach = USManotick RS = 25500
River = Rideau River Reach = USManotick RS = 25300
.08
.035
.08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)

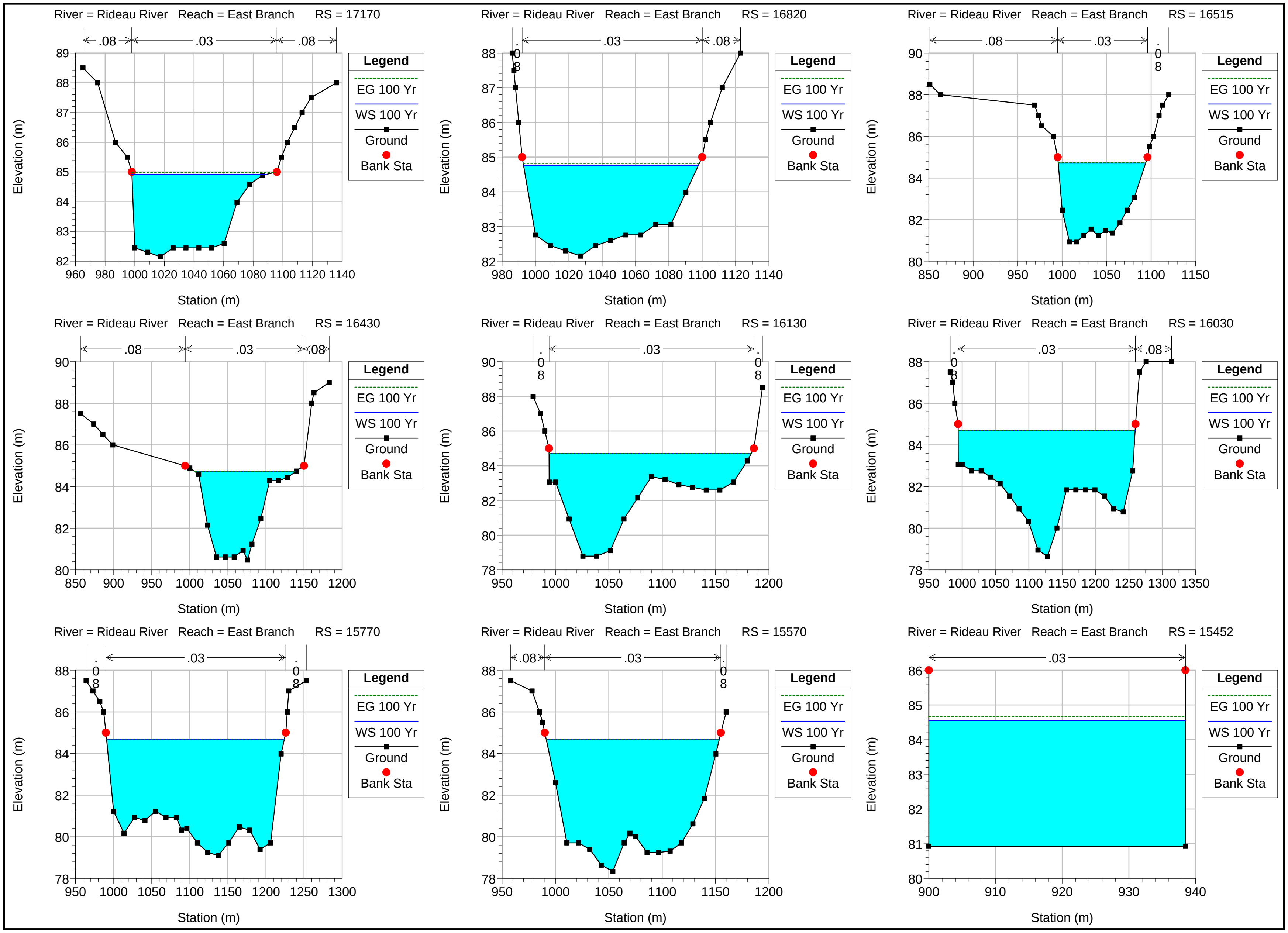

River = Rideau River Reach = USManotick RS = 25110
River = Rideau River Reach = USManotick RS = 24680
River = Rideau River Reach = USManotick RS = 24560
River = Rideau River Reach = USManotick RS = 24350
River = Rideau River Reach = USManotick RS = 24165
River = Rideau River Reach = USManotick RS = 24000
River = Rideau River Reach = USManotick RS = 23780
River = Rideau River Reach = USManotick RS = 23615
River = Rideau River Reach = USManotick RS = 23400
.08
.035
.08
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta


River = Rideau River Reach = USManotick RS = 23130
River = Rideau River Reach = USManotick RS = 22840
River = Rideau River Reach = USManotick RS = 22350
River = Rideau River Reach = USManotick RS = 22015
River = Rideau River Reach = USManotick RS = 21765
River = Rideau River Reach = USManotick RS = 21505
River = Rideau River Reach = USManotick RS = 21275
River = Rideau River Reach = USManotick RS = 21115
River = Rideau River Reach = USManotick RS = 20890
.08
.035
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)

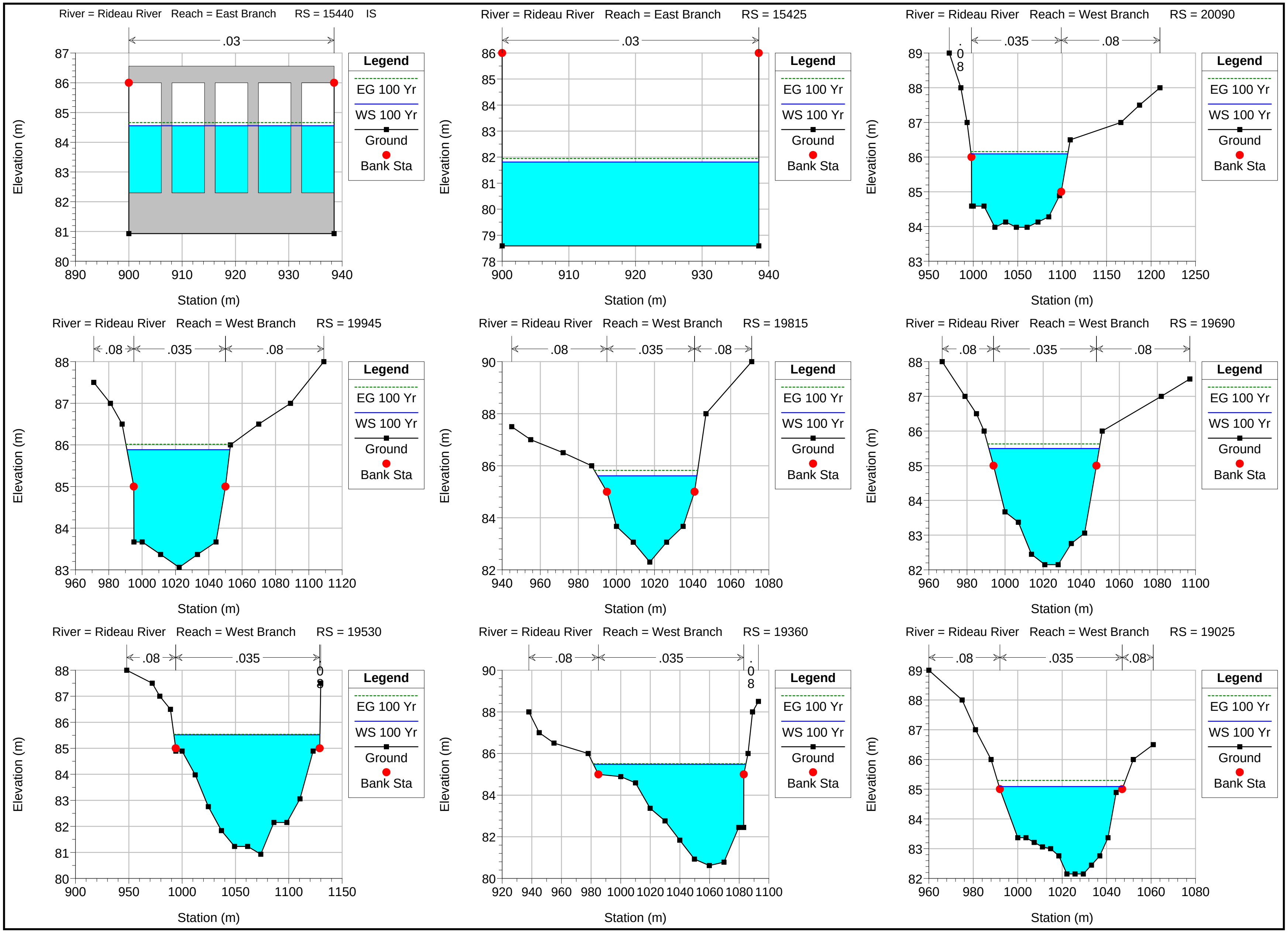


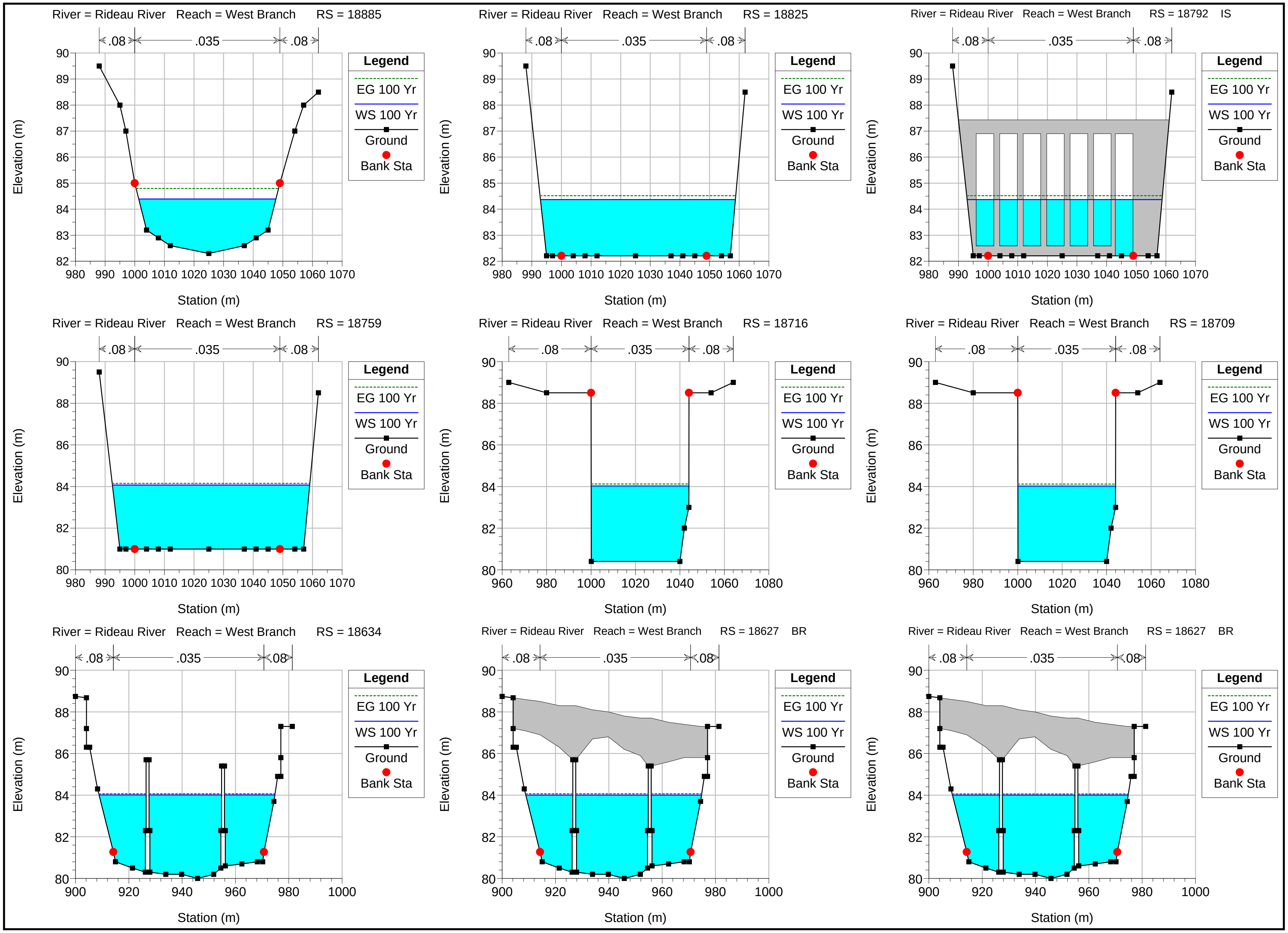
River = Rideau River Reach = USManotick RS = 20515
.08 .035 .08
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = USManotick RS = 20200
.08 .035 .08
River = Rideau River Reach = East Branch RS = 19890
.08 .03 .08
River = Rideau River Reach = East Branch RS = 19715
.08 .03 .08
River = Rideau River Reach = East Branch RS = 19490
.08 .03 .08
River = Rideau River Reach = East Branch RS = 19180
.08 .03 .08
River = Rideau River Reach = East Branch RS = 18870
.08 .03 .08
River = Rideau River Reach = East Branch RS = 18695
.08 .03 .08
River = Rideau River Reach = East Branch RS = 18325
.08 .03 .08


River = Rideau River Reach = East Branch RS = 18196
.08 .03 .08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = East Branch RS = 18191 BR
.08 .03 .08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = East Branch RS = 18191 BR
.08 .03 .08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = East Branch RS = 18185
.08 .03 .08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = East Branch RS = 18135
.08 .03 .08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = East Branch RS = 17925
.08 .03 .08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = East Branch RS = 17920
.08 .03 .08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = East Branch RS = 17720
.08 .03 .08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = East Branch RS = 17460
.08 .03 .08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)

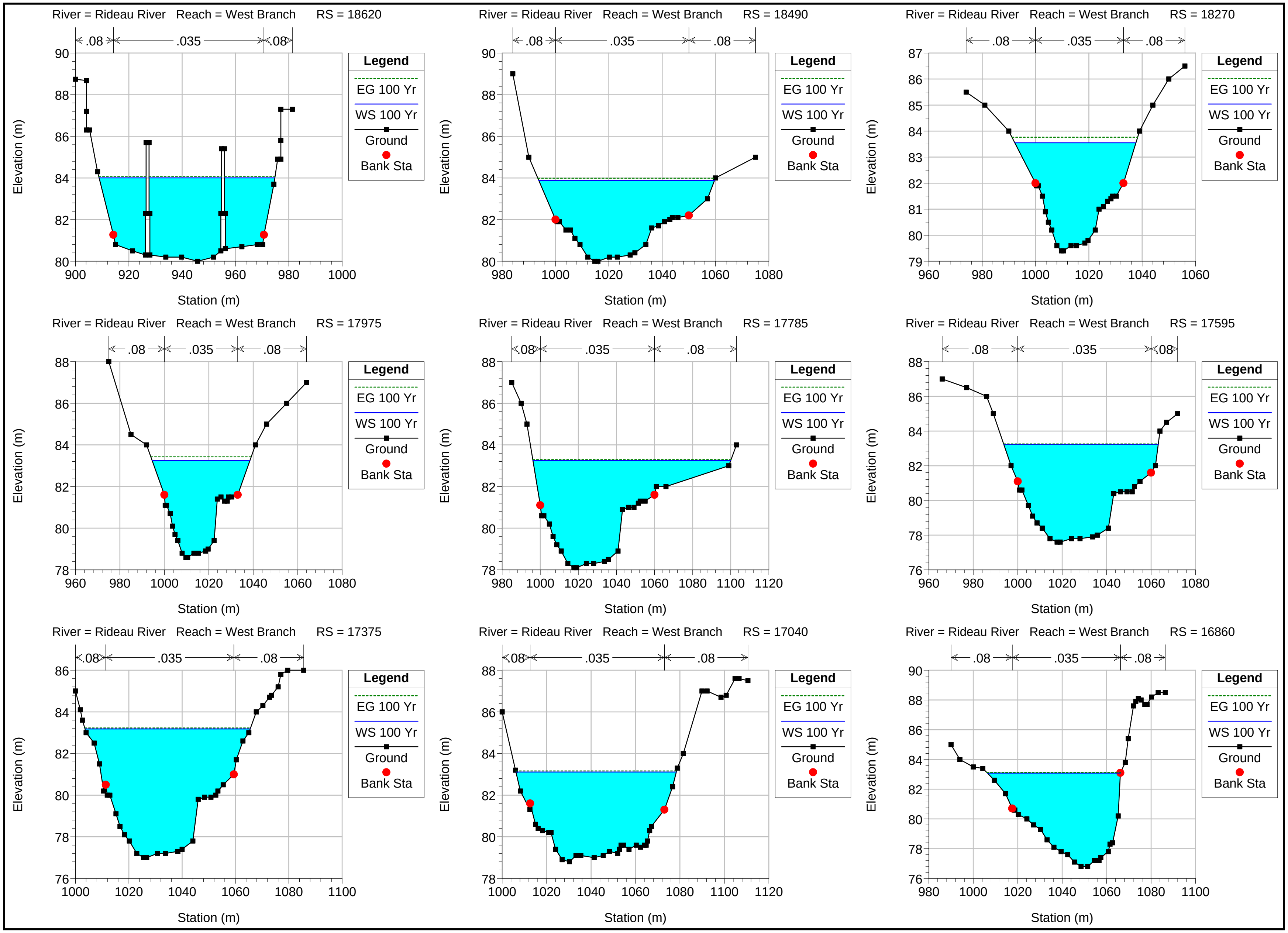


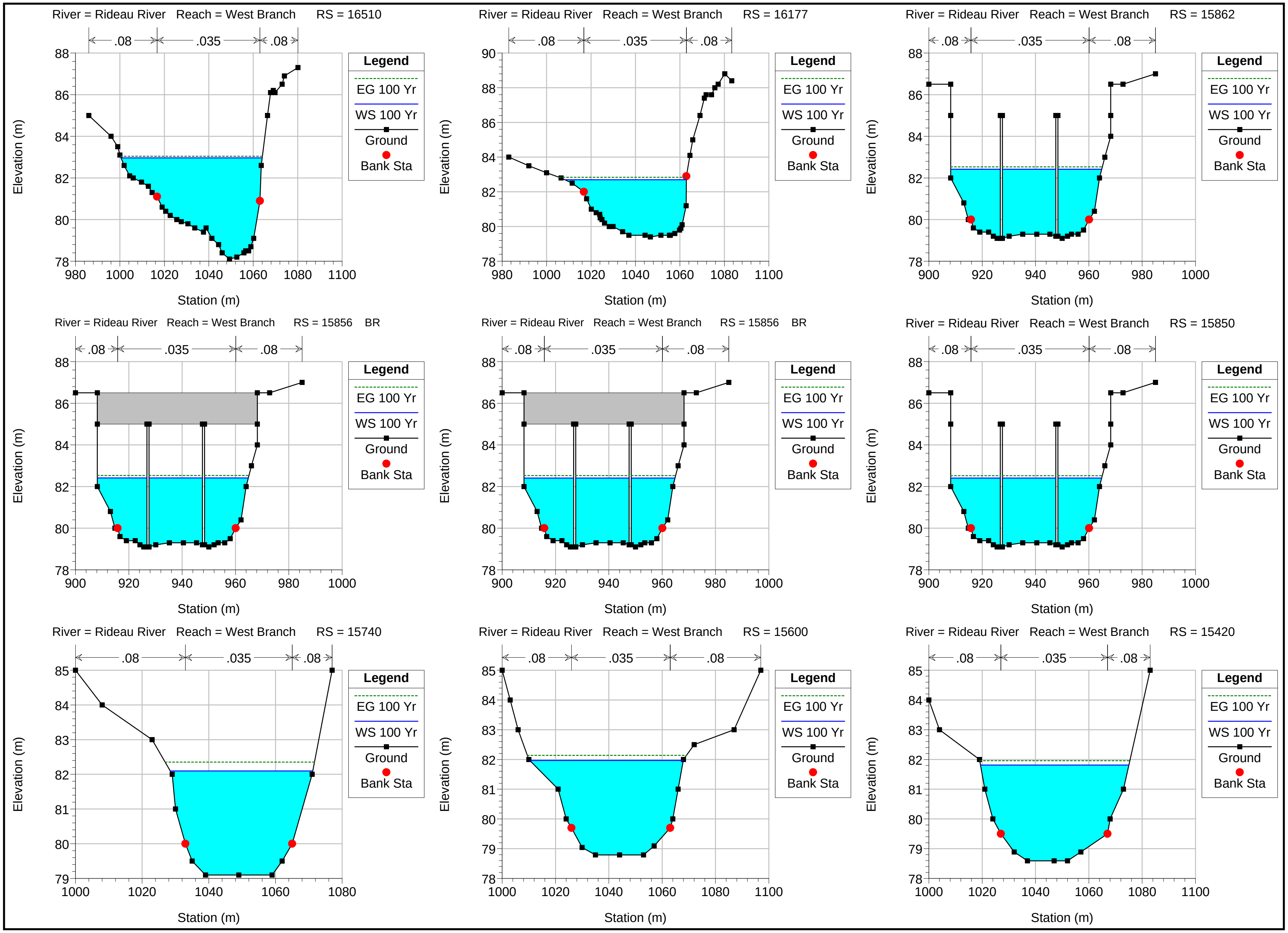
River = Rideau River Reach = East Branch RS = 17170
.08 .03 .08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = East Branch RS = 16820
.08 .03 .08
River = Rideau River Reach = East Branch RS = 16515
.08 .03 .08
River = Rideau River Reach = East Branch RS = 16430
.08 .03 .08
River = Rideau River Reach = East Branch RS = 16130
.08 .03 .08
River = Rideau River Reach = East Branch RS = 16030
.08 .03 .08
River = Rideau River Reach = East Branch RS = 15770
.08 .03 .08
River = Rideau River Reach = East Branch RS = 15570
.08 .03 .08
River = Rideau River Reach = East Branch RS = 15452
.03


River = Rideau River Reach = East Branch RS = 15440 IS
River = Rideau River Reach = East Branch RS = 15425
River = Rideau River Reach = West Branch RS = 20090
River = Rideau River Reach = West Branch RS = 19945
River = Rideau River Reach = West Branch RS = 19815
River = Rideau River Reach = West Branch RS = 19690
River = Rideau River Reach = West Branch RS = 19530
River = Rideau River Reach = West Branch RS = 19360
River = Rideau River Reach = West Branch RS = 19025
.03
.08
.035
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)

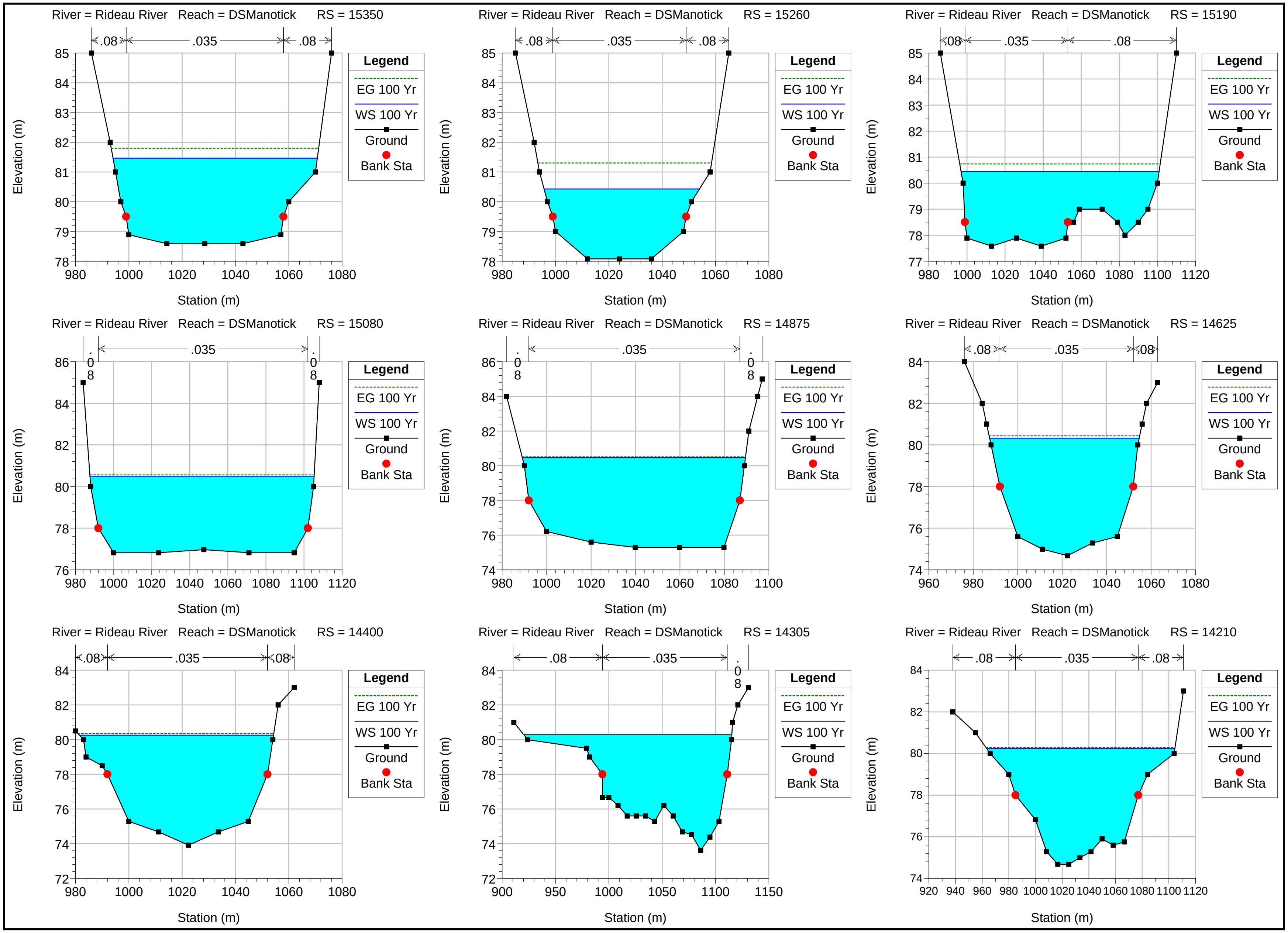


River = Rideau River Reach = West Branch RS = 18885
River = Rideau River Reach = West Branch RS = 18825
River = Rideau River Reach = West Branch RS = 18792 IS
River = Rideau River Reach = West Branch RS = 18759
River = Rideau River Reach = West Branch RS = 18716
River = Rideau River Reach = West Branch RS = 18709
River = Rideau River Reach = West Branch RS = 18634
River = Rideau River Reach = West Branch RS = 18627 BR
River = Rideau River Reach = West Branch RS = 18627 BR
.08
.035
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)

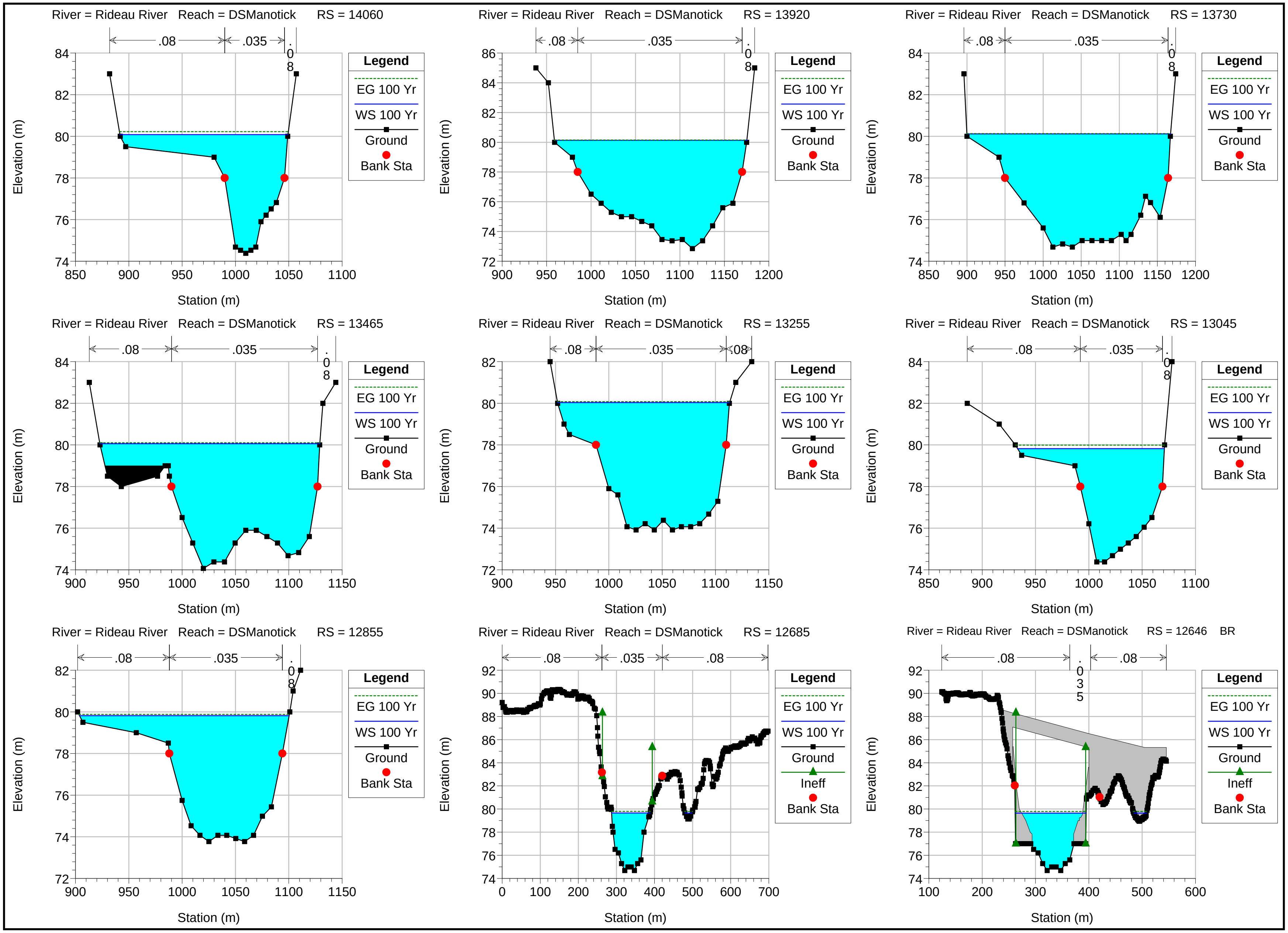

River = Rideau River Reach = West Branch RS = 18620
.08 .035 .08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = West Branch RS = 18490
.08 .035 .08
River = Rideau River Reach = West Branch RS = 18270
.08 .035 .08
River = Rideau River Reach = West Branch RS = 17975
.08 .035 .08
River = Rideau River Reach = West Branch RS = 17785
.08 .035 .08
River = Rideau River Reach = West Branch RS = 17595
.08 .035 .08
River = Rideau River Reach = West Branch RS = 17375
.08 .035 .08
River = Rideau River Reach = West Branch RS = 17040
.08 .035 .08
River = Rideau River Reach = West Branch RS = 16860
.08 .035 .08

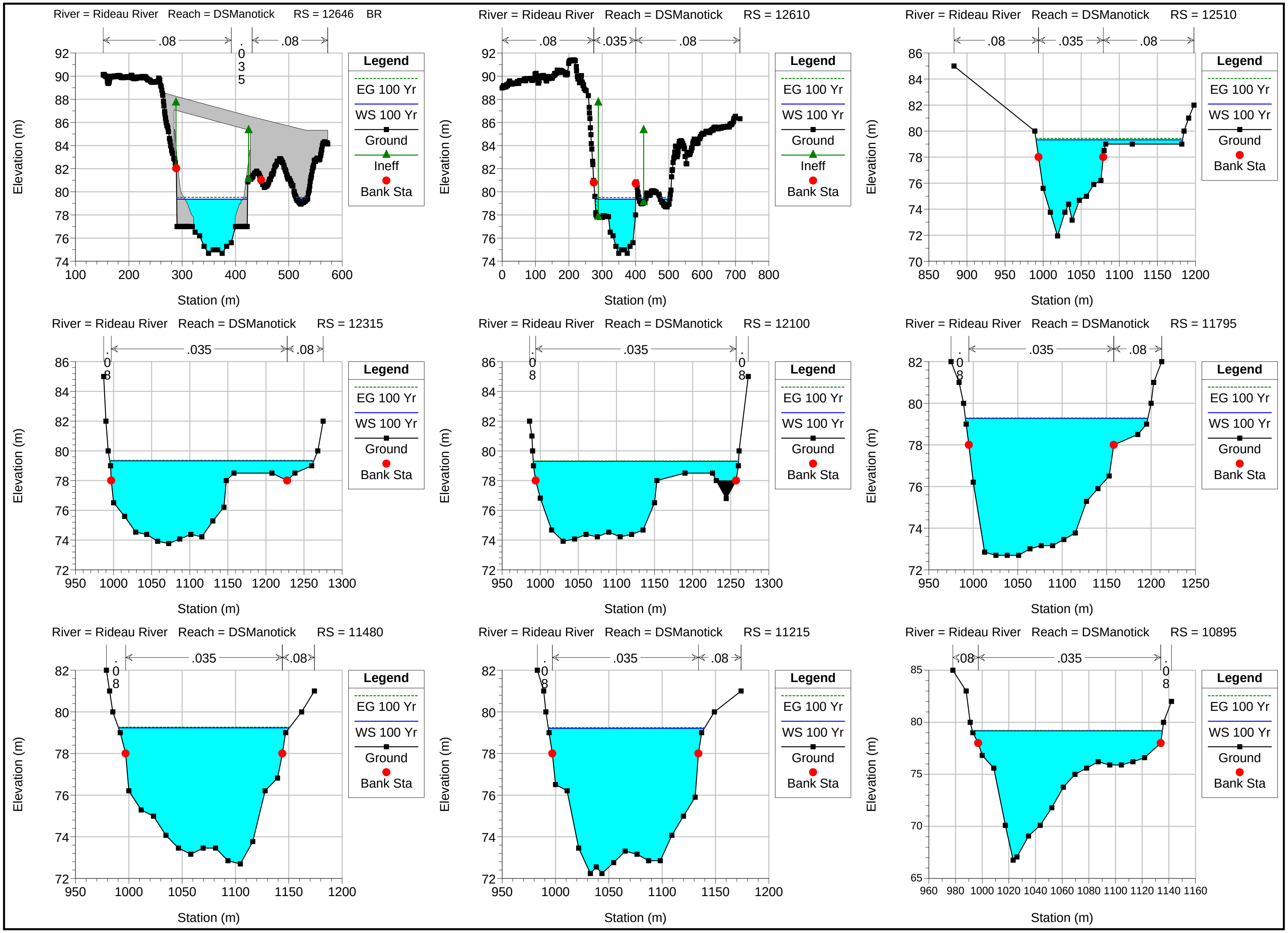


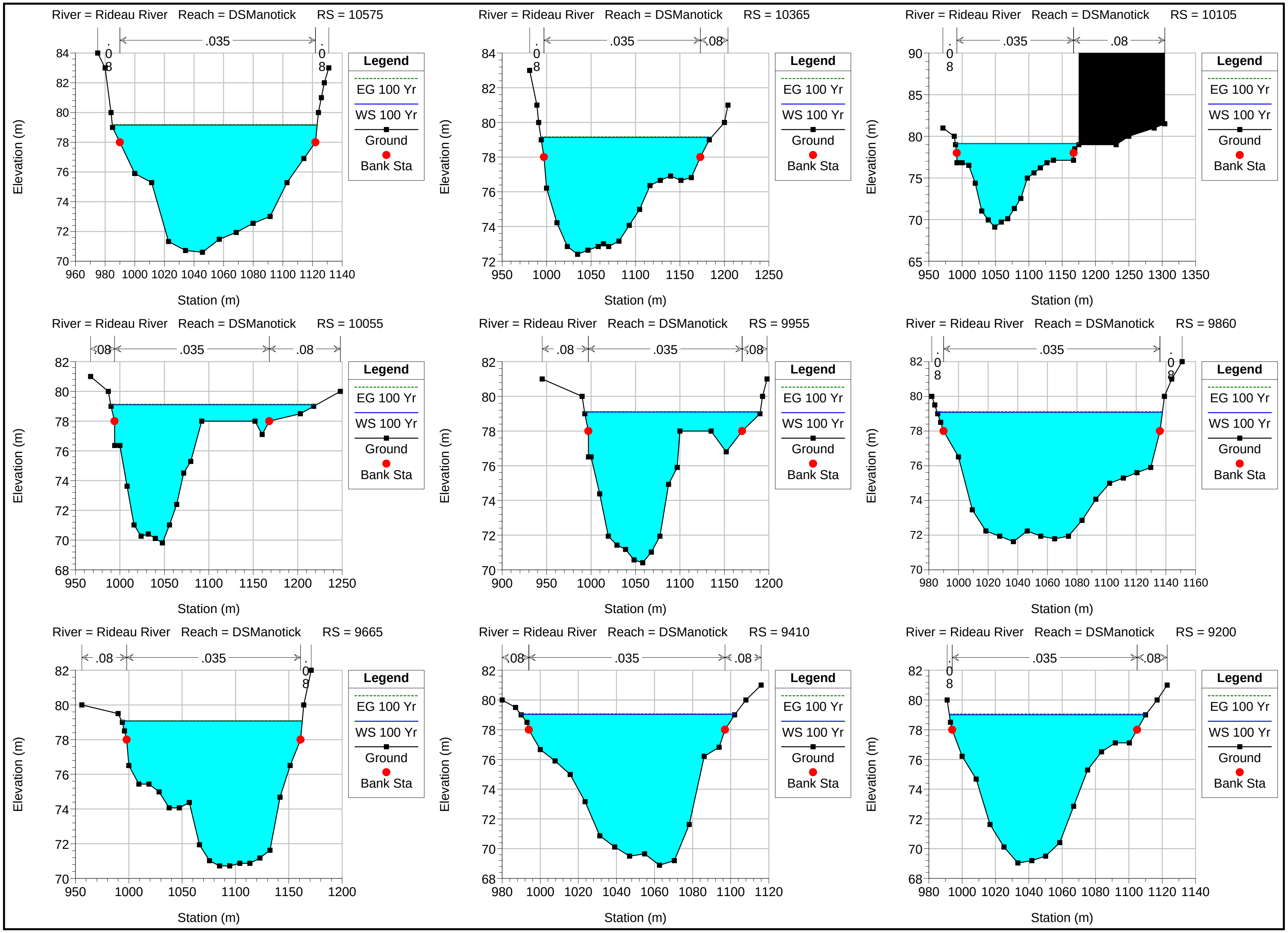
River = Rideau River Reach = West Branch RS = 16510
River = Rideau River Reach = West Branch RS = 16177
River = Rideau River Reach = West Branch RS = 15862
River = Rideau River Reach = West Branch RS = 15856 BR
River = Rideau River Reach = West Branch RS = 15856 BR
River = Rideau River Reach = West Branch RS = 15850
River = Rideau River Reach = West Branch RS = 15740
River = Rideau River Reach = West Branch RS = 15600
River = Rideau River Reach = West Branch RS = 15420
.08
.035
.08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)

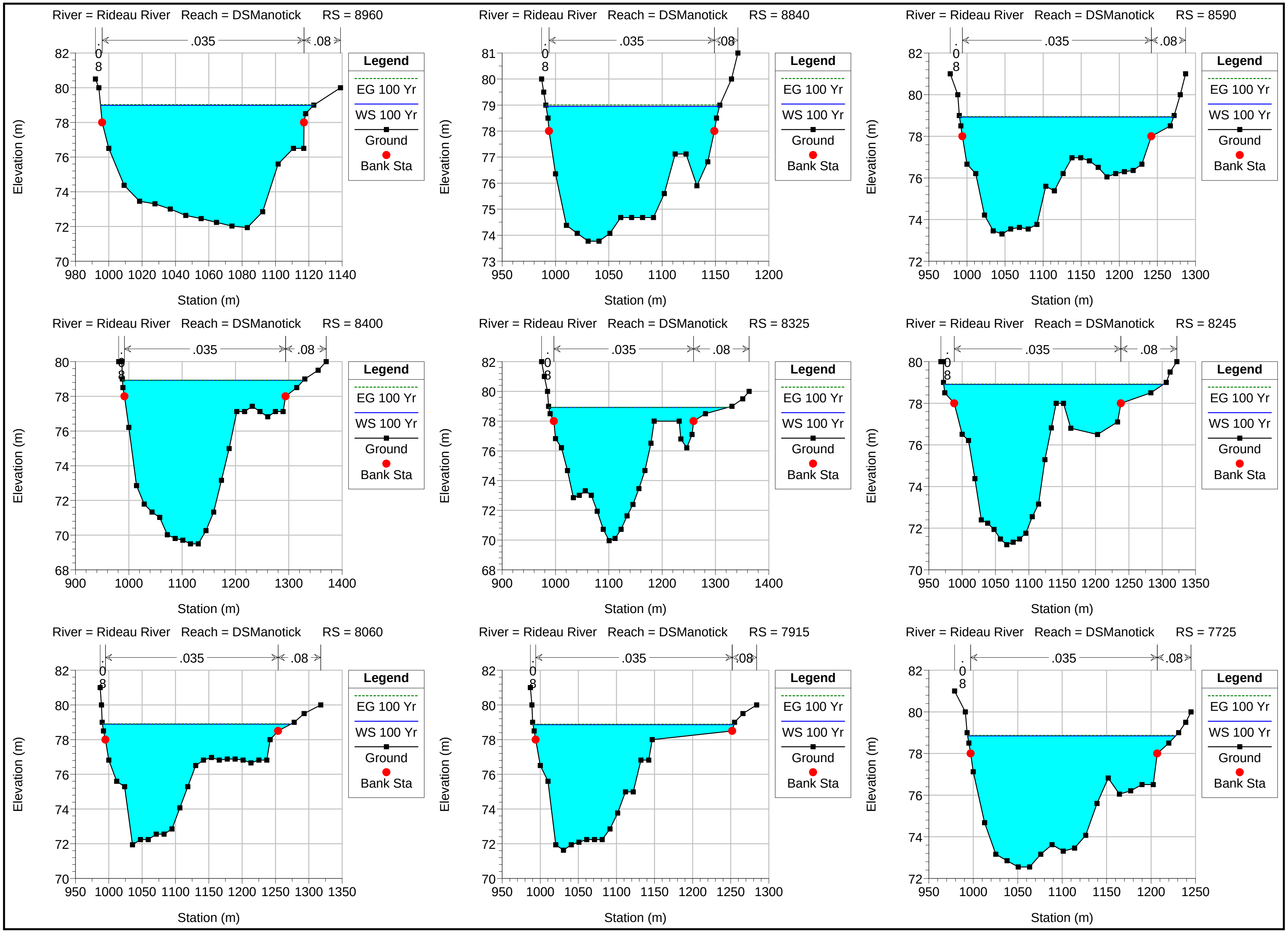


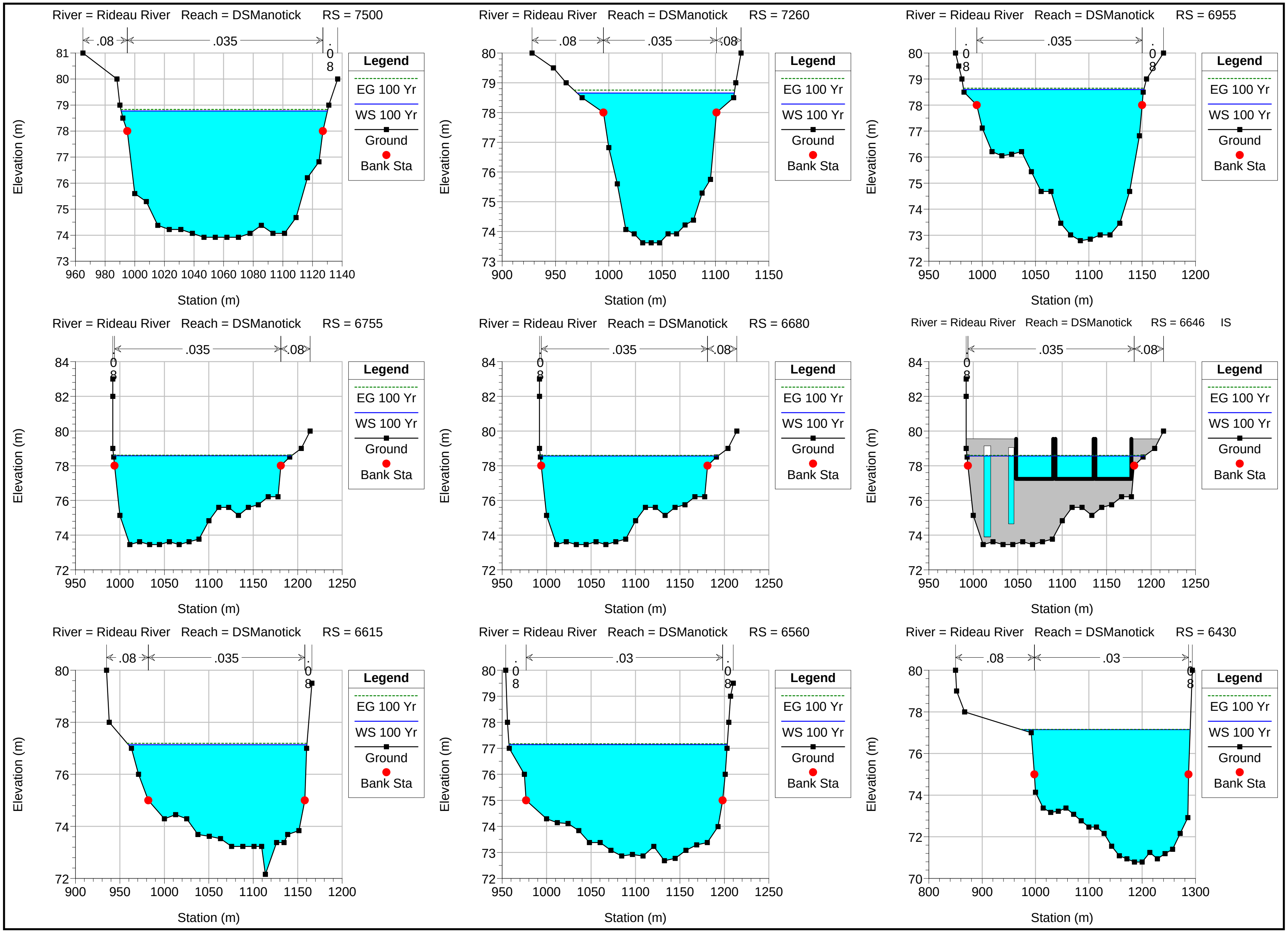
River = Rideau River Reach = DSManotick RS = 15350
.08
.035
.08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = 15260
.08
.035
.08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = 15190
.08
.035
.08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = 15080
.035
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = 14875
.035
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = 14625
.08
.035
.08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = 14400
.08
.035
.08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = 14305
.08
.035
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = 14210
.08
.035
.08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)

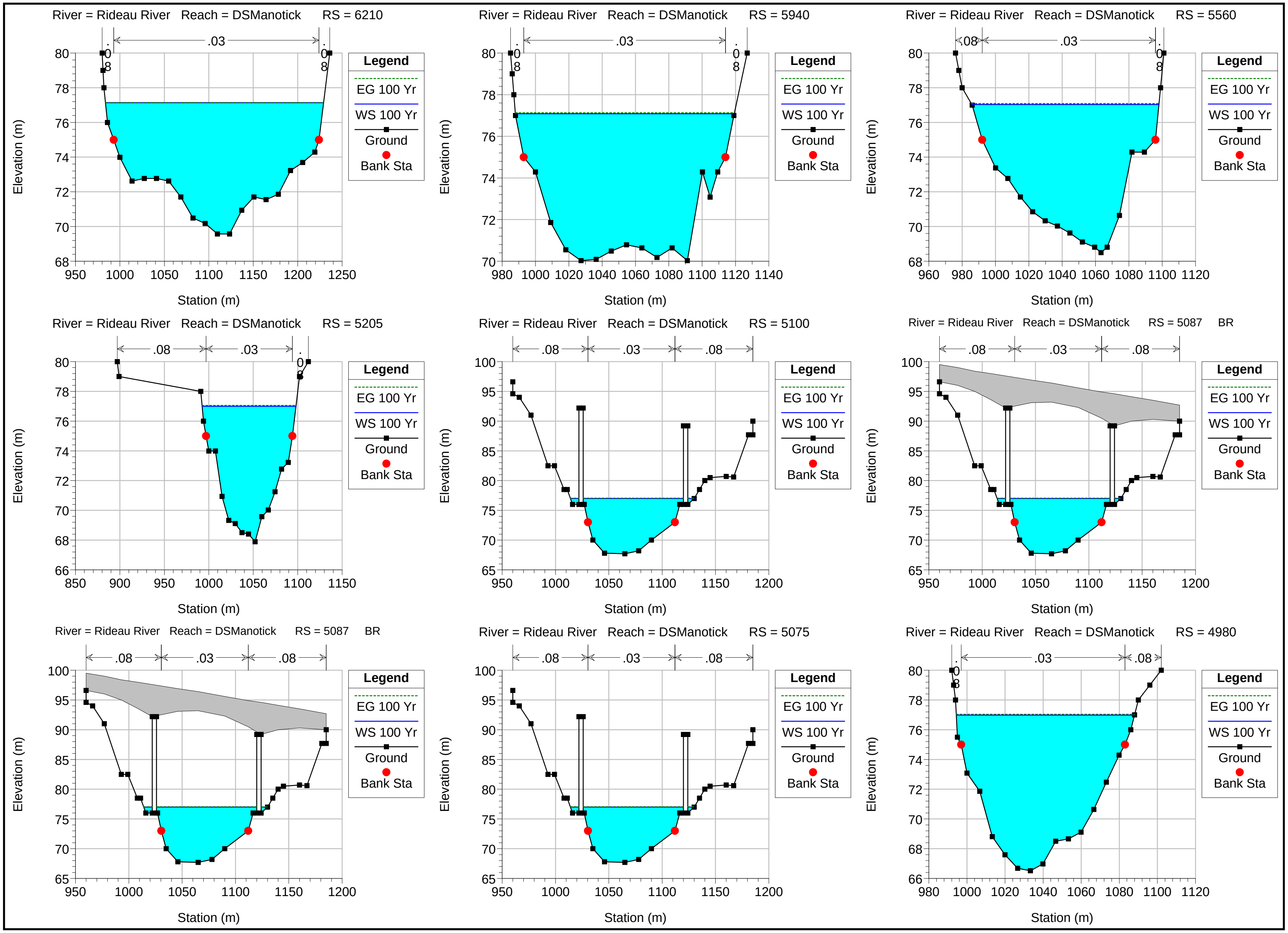

River = Rideau River Reach = DSManotick RS = 14060
.08
.035
.08
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
River = Rideau River Reach = DSManotick RS = 13920
River = Rideau River Reach = DSManotick RS = 13730
River = Rideau River Reach = DSManotick RS = 13465
River = Rideau River Reach = DSManotick RS = 13255
River = Rideau River Reach = DSManotick RS = 13045
River = Rideau River Reach = DSManotick RS = 12855
River = Rideau River Reach = DSManotick RS = 12685
Ineff
River = Rideau River Reach = DSManotick RS = 12646 BR
.035

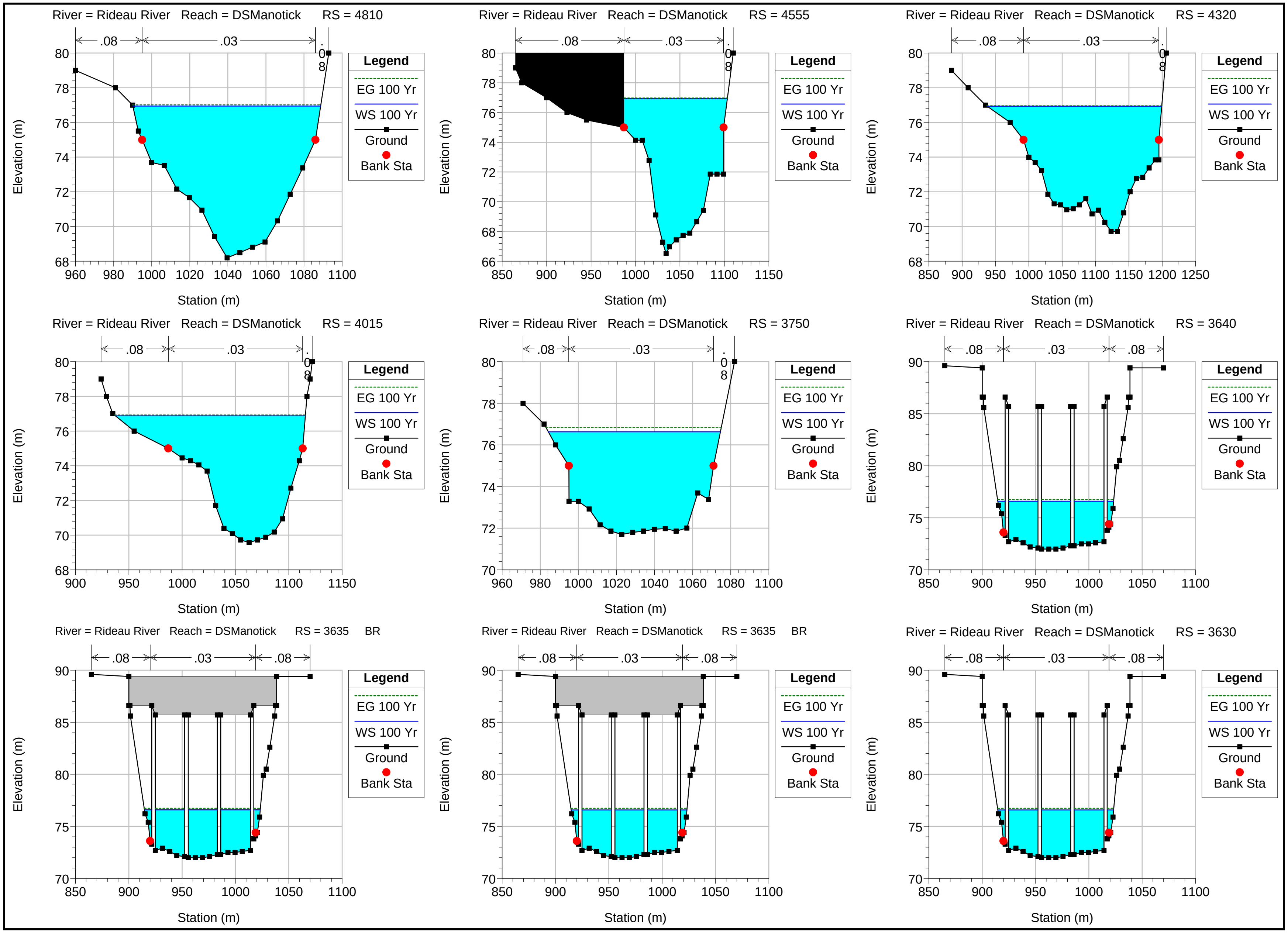

River = Rideau River Reach = DSManotick RS = 12646 BR
.08 .035 .08
Legend
EG 100 Yr
WS 100 Yr
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = 12610
.08 .035 .08
Legend
EG 100 Yr
WS 100 Yr
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = 12510
.08 .035 .08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = 12315
.08 .035 .08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = 12100
.08 .035 .08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = 11795
.08 .035 .08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = 11480
.08 .035 .08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = 11215
.08 .035 .08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = 10895
.08 .035 .08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)

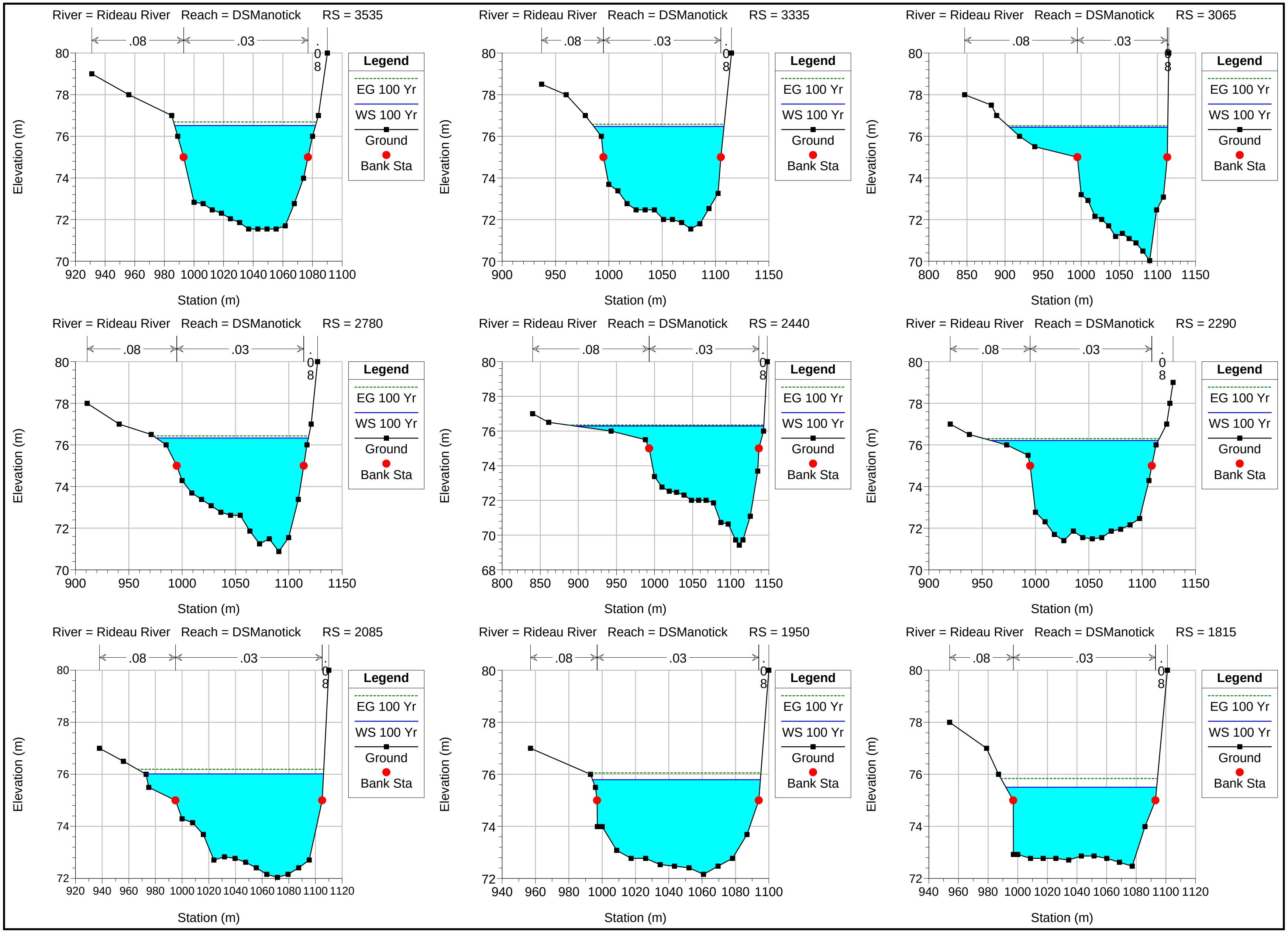

River = Rideau River Reach = DSManotick RS = 10575
River = Rideau River Reach = DSManotick RS = 10365
River = Rideau River Reach = DSManotick RS = 10105
River = Rideau River Reach = DSManotick RS = 10055
River = Rideau River Reach = DSManotick RS = 9955
River = Rideau River Reach = DSManotick RS = 9860
River = Rideau River Reach = DSManotick RS = 9665
River = Rideau River Reach = DSManotick RS = 9410
River = Rideau River Reach = DSManotick RS = 9200
.035
.08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)

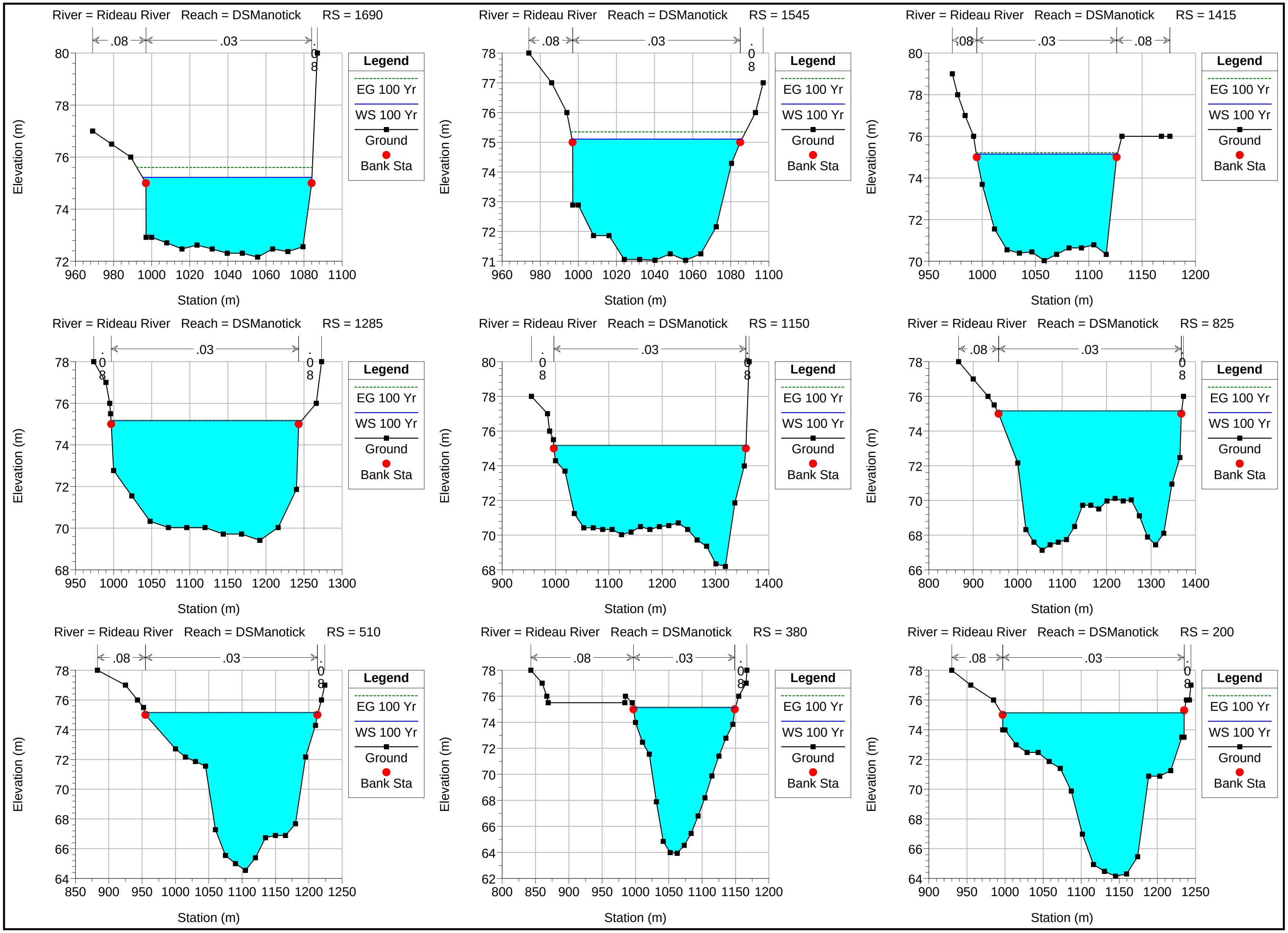

River = Rideau River Reach = DSManotick RS = 8960
River = Rideau River Reach = DSManotick RS = 8840
River = Rideau River Reach = DSManotick RS = 8590
River = Rideau River Reach = DSManotick RS = 8400
River = Rideau River Reach = DSManotick RS = 8325
River = Rideau River Reach = DSManotick RS = 8245
River = Rideau River Reach = DSManotick RS = 8060
River = Rideau River Reach = DSManotick RS = 7915
River = Rideau River Reach = DSManotick RS = 7725
.08
.035
.08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)

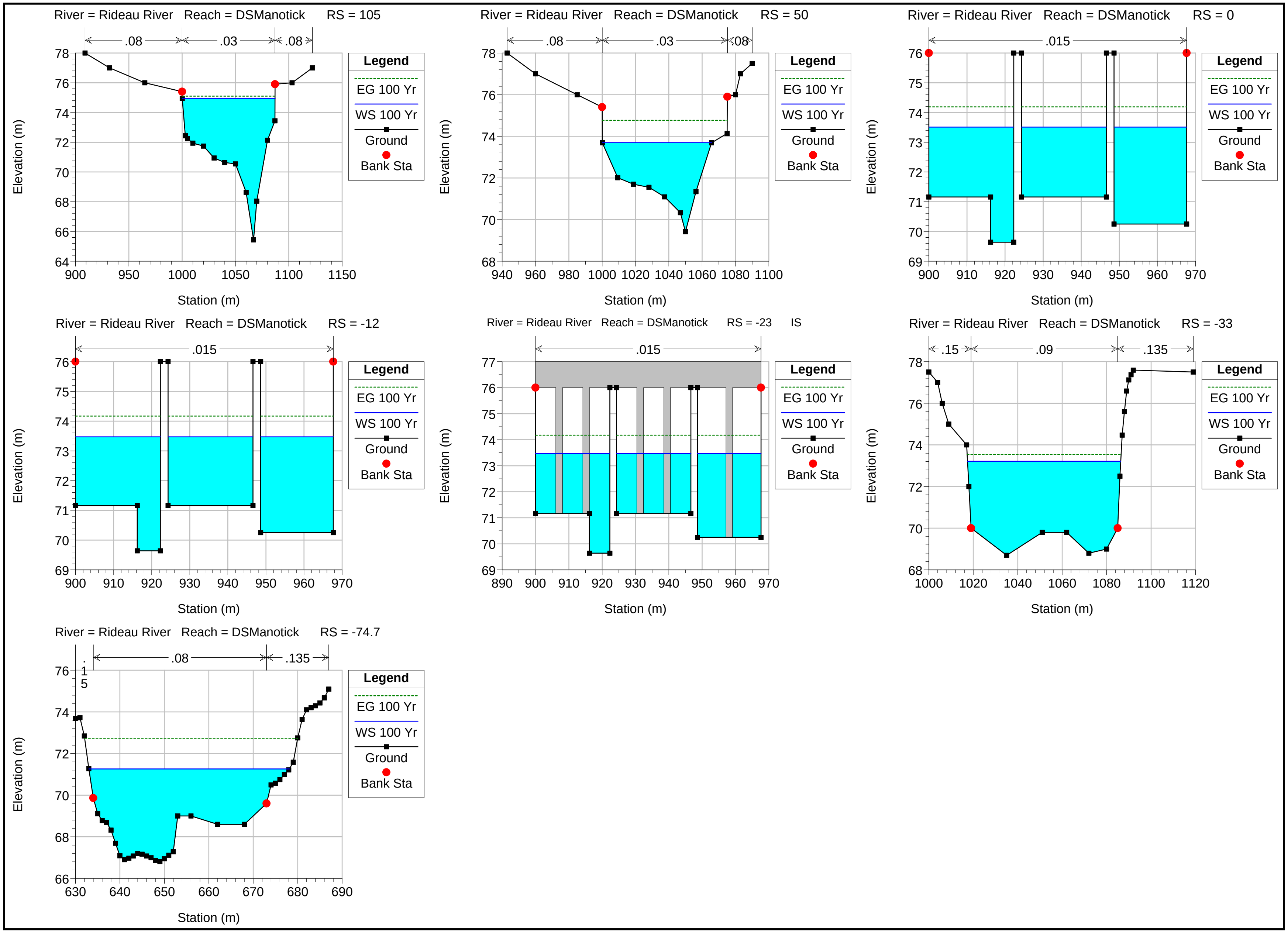

River = Rideau River Reach = DSManotick RS = 7500
.08
.035
.08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = 7260
.08
.035
.08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = 6955
.08
.035
.08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = 6755
.08
.035
.08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = 6680
.08
.035
.08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = 6646 IS
.08
.035
.08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = 6615
.08
.035
.08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = 6560
.08
.03
.08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = 6430
.08
.03
.08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)


River = Rideau River Reach = DSManotick RS = 6210
River = Rideau River Reach = DSManotick RS = 5940
River = Rideau River Reach = DSManotick RS = 5560
River = Rideau River Reach = DSManotick RS = 5205
River = Rideau River Reach = DSManotick RS = 5100
River = Rideau River Reach = DSManotick RS = 5087 BR
River = Rideau River Reach = DSManotick RS = 5087 BR
River = Rideau River Reach = DSManotick RS = 5075
River = Rideau River Reach = DSManotick RS = 4980
.08
.03
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)


River = Rideau River Reach = DSManotick RS = 4810
River = Rideau River Reach = DSManotick RS = 4555
River = Rideau River Reach = DSManotick RS = 4320
River = Rideau River Reach = DSManotick RS = 4015
River = Rideau River Reach = DSManotick RS = 3750
River = Rideau River Reach = DSManotick RS = 3640
River = Rideau River Reach = DSManotick RS = 3635 BR
River = Rideau River Reach = DSManotick RS = 3635 BR
River = Rideau River Reach = DSManotick RS = 3630
.08
.03
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)


River = Rideau River Reach = DSManotick RS = 3535
River = Rideau River Reach = DSManotick RS = 3335
River = Rideau River Reach = DSManotick RS = 3065
River = Rideau River Reach = DSManotick RS = 2780
River = Rideau River Reach = DSManotick RS = 2440
River = Rideau River Reach = DSManotick RS = 2290
River = Rideau River Reach = DSManotick RS = 2085
River = Rideau River Reach = DSManotick RS = 1950
River = Rideau River Reach = DSManotick RS = 1815
.08
.03
.08
Elevation (m)
Station (m)
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta


River = Rideau River Reach = DSManotick RS = 1690
River = Rideau River Reach = DSManotick RS = 1545
River = Rideau River Reach = DSManotick RS = 1415
River = Rideau River Reach = DSManotick RS = 1285
River = Rideau River Reach = DSManotick RS = 1150
River = Rideau River Reach = DSManotick RS = 825
River = Rideau River Reach = DSManotick RS = 510
River = Rideau River Reach = DSManotick RS = 380
River = Rideau River Reach = DSManotick RS = 200
.08
.03
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)



River = Rideau River Reach = DSManotick RS = 105
.08
.03
.08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = 50
.08
.03
.08
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = 0
.015
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = -12
.015
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = -23 IS
.015
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = -33
.15
.09
.135
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
River = Rideau River Reach = DSManotick RS = -74.7
.15
.08
.135
Legend
EG 100 Yr
WS 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)

Table A.1 Manning's n per Cross Section.

Cross Section (m)	Reach	Left Overbank	Channel	Right Overbank
29000.00	USManotick	0.08	0.035	0.08
28727.00	USManotick	0.08	0.035	0.08
28715.00	USManotick	0.08	0.035	0.08
28435.00	USManotick	0.08	0.035	0.08
28245.00	USManotick	0.08	0.035	0.08
28075	USManotick	0.08	0.035	0.08
27870	USManotick	0.08	0.035	0.08
27540	USManotick	0.08	0.035	0.08
27160	USManotick	0.08	0.035	0.08
26830	USManotick	0.08	0.035	0.08
26545	USManotick	0.08	0.035	0.08
26230	USManotick	0.08	0.035	0.08
26060	USManotick	0.08	0.035	0.08
25810	USManotick	0.08	0.035	0.08
25500	USManotick	0.08	0.035	0.08
25300	USManotick	0.08	0.035	0.08
25110	USManotick	0.08	0.035	0.08
24680	USManotick	0.08	0.035	0.08
24560	USManotick	0.08	0.035	0.08
24350	USManotick	0.08	0.035	0.08
24165	USManotick	0.08	0.035	0.08
24000	USManotick	0.08	0.035	0.08
23780	USManotick	0.08	0.035	0.08
23615	USManotick	0.08	0.035	0.08
23400	USManotick	0.08	0.035	0.08
23130	USManotick	0.08	0.035	0.08
22840	USManotick	0.08	0.035	0.08
22350	USManotick	0.08	0.035	0.08
22015	USManotick	0.08	0.035	0.08
21765	USManotick	0.08	0.035	0.08
21505	USManotick	0.08	0.035	0.08
21275	USManotick	0.08	0.035	0.08
21115	USManotick	0.08	0.035	0.08
20890	USManotick	0.08	0.035	0.08
20515	USManotick	0.08	0.035	0.08
20200	USManotick	0.08	0.035	0.08
19890	East Branch	0.08	0.03	0.08
19715	East Branch	0.08	0.03	0.08
19490	East Branch	0.08	0.03	0.08
19180	East Branch	0.08	0.03	0.08
18870	East Branch	0.08	0.03	0.08

18695	East Branch	0.08	0.03	0.08
18325	East Branch	0.08	0.03	0.08
18196	East Branch	0.08	0.03	0.08
18185	East Branch	0.08	0.03	0.08
18135	East Branch	0.08	0.03	0.08
17925	East Branch	0.08	0.03	0.08
17920	East Branch	0.08	0.03	0.08
17720	East Branch	0.08	0.03	0.08
17460	East Branch	0.08	0.03	0.08
17170	East Branch	0.08	0.03	0.08
16820	East Branch	0.08	0.03	0.08
16515	East Branch	0.08	0.03	0.08
16430	East Branch	0.08	0.03	0.08
16130	East Branch	0.08	0.03	0.08
16030	East Branch	0.08	0.03	0.08
15770	East Branch	0.08	0.03	0.08
15570	East Branch	0.08	0.03	0.08
15452	East Branch	0.08	0.03	0.08
15425	East Branch	0.08	0.03	0.08
20090	West Branch	0.08	0.035	0.08
19945	West Branch	0.08	0.035	0.08
19815	West Branch	0.08	0.035	0.08
19690	West Branch	0.08	0.035	0.08
19530	West Branch	0.08	0.035	0.08
19360	West Branch	0.08	0.035	0.08
19025	West Branch	0.08	0.035	0.08
18885	West Branch	0.08	0.035	0.08
18825	West Branch	0.08	0.035	0.08
18759	West Branch	0.08	0.035	0.08
18716	West Branch	0.08	0.035	0.08
18709	West Branch	0.08	0.035	0.08
18634	West Branch	0.08	0.035	0.08
18620	West Branch	0.08	0.035	0.08
18490	West Branch	0.08	0.035	0.08
18270	West Branch	0.08	0.035	0.08
17975	West Branch	0.08	0.035	0.08
17785	West Branch	0.08	0.035	0.08
17595	West Branch	0.08	0.035	0.08
17375	West Branch	0.08	0.035	0.08
17040	West Branch	0.08	0.035	0.08
16860	West Branch	0.08	0.035	0.08
16510	West Branch	0.08	0.035	0.08
16177	West Branch	0.08	0.035	0.08
15862	West Branch	0.08	0.035	0.08

15850	West Branch	0.08	0.035	0.08
15740	West Branch	0.08	0.035	0.08
15600	West Branch	0.08	0.035	0.08
15420	West Branch	0.08	0.035	0.08
15350	DSManotick	0.08	0.035	0.08
15260	DSManotick	0.08	0.035	0.08
15190	DSManotick	0.08	0.035	0.08
15080	DSManotick	0.08	0.035	0.08
14875	DSManotick	0.08	0.035	0.08
14625	DSManotick	0.08	0.035	0.08
14400	DSManotick	0.08	0.035	0.08
14305	DSManotick	0.08	0.035	0.08
14210	DSManotick	0.08	0.035	0.08
14060	DSManotick	0.08	0.035	0.08
13920	DSManotick	0.08	0.035	0.08
13730	DSManotick	0.08	0.035	0.08
13465	DSManotick	0.08	0.035	0.08
13255	DSManotick	0.08	0.035	0.08
13045	DSManotick	0.08	0.035	0.08
12855	DSManotick	0.08	0.035	0.08
12685	DSManotick	0.08	0.035	0.08
12610	DSManotick	0.08	0.035	0.08
12510	DSManotick	0.08	0.035	0.08
12315	DSManotick	0.08	0.035	0.08
12100	DSManotick	0.08	0.035	0.08
11795	DSManotick	0.08	0.035	0.08
11480	DSManotick	0.08	0.035	0.08
11215	DSManotick	0.08	0.035	0.08
10895	DSManotick	0.08	0.035	0.08
10575	DSManotick	0.08	0.035	0.08
10365	DSManotick	0.08	0.035	0.08
10105	DSManotick	0.08	0.035	0.08
10055	DSManotick	0.08	0.035	0.08
9955	DSManotick	0.08	0.035	0.08
9860	DSManotick	0.08	0.035	0.08
9665	DSManotick	0.08	0.035	0.08
9410	DSManotick	0.08	0.035	0.08
9200	DSManotick	0.08	0.035	0.08
8960	DSManotick	0.08	0.035	0.08
8840	DSManotick	0.08	0.035	0.08
8590	DSManotick	0.08	0.035	0.08
8400	DSManotick	0.08	0.035	0.08
8325	DSManotick	0.08	0.035	0.08
8245	DSManotick	0.08	0.035	0.08

8060	DSManotick	0.08	0.035	0.08
7915	DSManotick	0.08	0.035	0.08
7725	DSManotick	0.08	0.035	0.08
7500	DSManotick	0.08	0.035	0.08
7260	DSManotick	0.08	0.035	0.08
6955	DSManotick	0.08	0.035	0.08
6755	DSManotick	0.08	0.035	0.08
6680	DSManotick	0.08	0.035	0.08
6615	DSManotick	0.08	0.035	0.08
6560	DSManotick	0.08	0.03	0.08
6430	DSManotick	0.08	0.03	0.08
6210	DSManotick	0.08	0.03	0.08
5940	DSManotick	0.08	0.03	0.08
5560	DSManotick	0.08	0.03	0.08
5205	DSManotick	0.08	0.03	0.08
5100	DSManotick	0.08	0.03	0.08
5075	DSManotick	0.08	0.03	0.08
4980	DSManotick	0.08	0.03	0.08
4810	DSManotick	0.08	0.03	0.08
4555	DSManotick	0.08	0.03	0.08
4320	DSManotick	0.08	0.03	0.08
4015	DSManotick	0.08	0.03	0.08
3750	DSManotick	0.08	0.03	0.08
3640	DSManotick	0.08	0.03	0.08
3630	DSManotick	0.08	0.03	0.08
3535	DSManotick	0.08	0.03	0.08
3335	DSManotick	0.08	0.03	0.08
3065	DSManotick	0.08	0.03	0.08
2780	DSManotick	0.08	0.03	0.08
2440	DSManotick	0.08	0.03	0.08
2290	DSManotick	0.08	0.03	0.08
2085	DSManotick	0.08	0.03	0.08
1950	DSManotick	0.08	0.03	0.08
1815	DSManotick	0.08	0.03	0.08
1690	DSManotick	0.08	0.03	0.08
1545	DSManotick	0.08	0.03	0.08
1415	DSManotick	0.08	0.03	0.08
1285	DSManotick	0.08	0.03	0.08
1150	DSManotick	0.08	0.03	0.08
825	DSManotick	0.08	0.03	0.08
510	DSManotick	0.08	0.03	0.08
380	DSManotick	0.08	0.03	0.08
200	DSManotick	0.08	0.03	0.08
105	DSManotick	0.08	0.03	0.08

50	DSManotick	0.08	0.03	0.08
0	DSManotick	0.08	0.015	0.08
-12	DSManotick	0.08	0.015	0.08
-33	DSManotick	0.15	0.09	0.135
-74.7	DSManotick	0.15	0.08	0.135

Appendix B

Field Verification of LIDAR Data

Figure B.1 Field Verification of Lidar Data

Legend

Survey Data Points

RIDEAU VALLEY CONSERVATION AUTHORITY

1:125,000

Projection Note: NAD 1983 UTM Zone 18N

Created by: SNolan

Date Modified: 10/30/2015

Figure B.2 Field Verification of LIDAR Data for the Rideau River from Hogs Back to Kars.

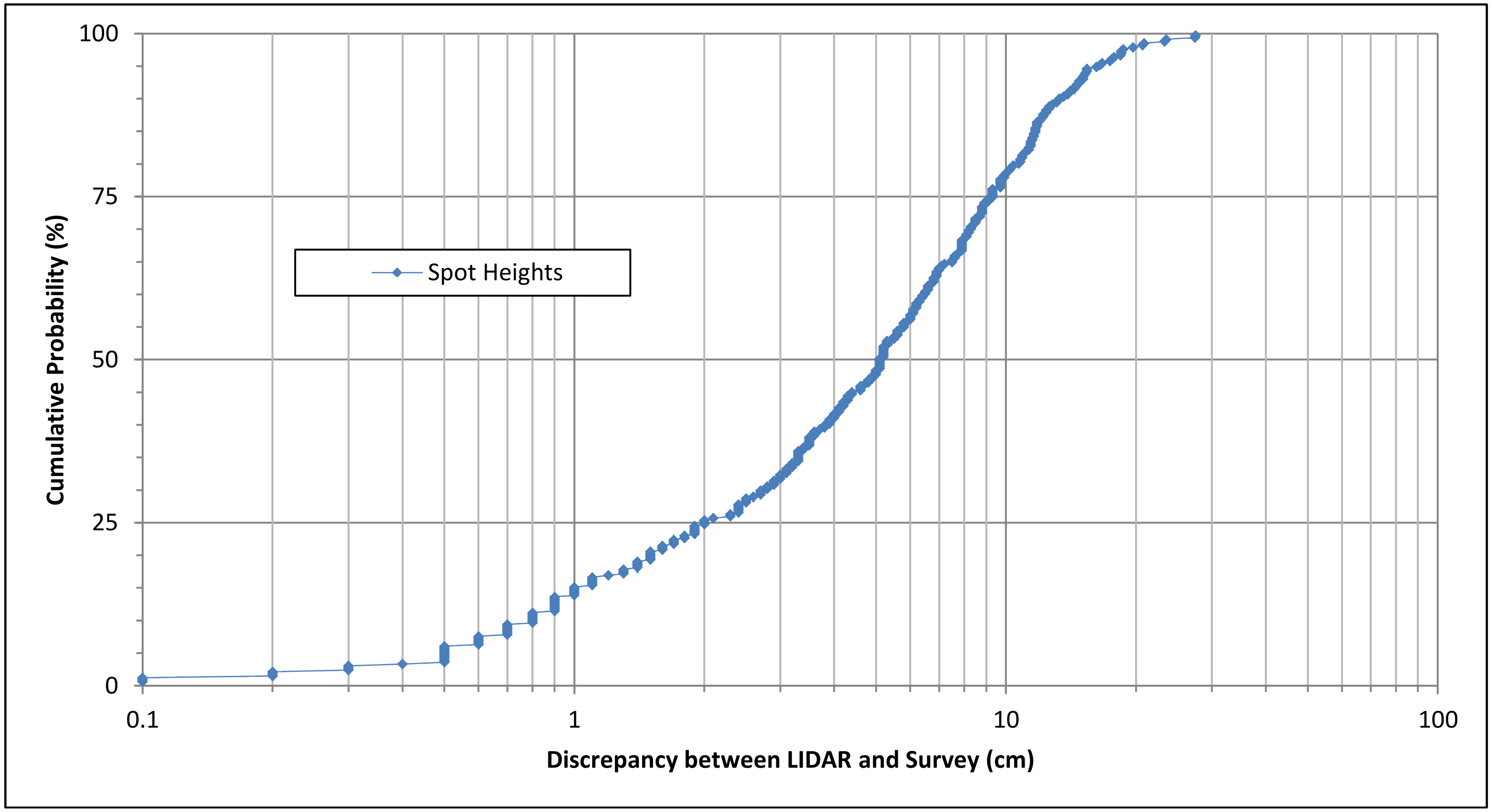


Table B.1 Field Verification of LIDAR Data (Spot Heights).

	Lidar Points	2015 RVCA Field Survey - Rideau River from Hogs Back to Kars									
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**
rideau-1	79.81	445534.66	5024503.11	80.05	0.007	0.011	4/6/2013 9:42		-0.235	23.5	
rideau-2	79.74	445532.93	5024501.16	79.92	0.007	0.011	4/6/2013 9:42		-0.176	17.6	
rideau-3	79.67	445530.69	5024498.43	79.75	0.007	0.010	4/6/2013 9:43		-0.082	8.2	
rideau-4	79.65	445528.17	5024495.33	79.56	0.007	0.011	4/6/2013 9:43		0.093	9.3	
rideau-5	79.64	445525.99	5024492.04	79.37	0.007	0.011	4/6/2013 9:43		0.275	27.5	
rideau-8	79.20	445518.29	5024483.42	78.97	0.008	0.013	4/6/2013 9:45		0.233	23.3	
rideau-9	78.92	445516.09	5024479.18	78.84	0.009	0.013	4/6/2013 9:45		0.079	7.9	
rideau-10	78.36	445520.17	5024470.75	78.63	0.010	0.013	4/6/2013 9:46		-0.274	27.4	
rideau-11	78.10	445521.84	5024467.96	78.27	0.010	0.015	4/6/2013 9:46		-0.174	17.4	
rideau-12	77.83	445523.56	5024465.45	77.98	0.009	0.013	4/6/2013 9:46		-0.154	15.4	
rideau-13	77.58	445525.62	5024462.55	77.65	0.009	0.014	4/6/2013 9:47		-0.070	7.0	
rideau-14	77.23	445527.91	5024459.38	77.33	0.009	0.013	4/6/2013 9:47		-0.101	10.1	
rideau-15	77.06	445530.43	5024455.77	77.07	0.013	0.016	4/6/2013 9:48		-0.005	0.5	
rideau-16	76.79	445532.82	5024452.22	76.79	0.012	0.015	4/6/2013 9:48		0.001	0.1	
rideau-17	76.54	445535.48	5024448.07	76.48	0.011	0.019	4/6/2013 9:48		0.060	6.0	
rideau-18	67.70	445201.64	5025354.30	67.66	0.010	0.013	4/6/2013 9:59		0.036	3.6	
rideau-19	67.51	445203.60	5025356.55	67.49	0.011	0.014	4/6/2013 9:59		0.017	1.7	
rideau-20	67.38	445206.17	5025359.23	67.33	0.009	0.012	4/6/2013 10:00		0.051	5.1	
rideau-21	67.10	445208.45	5025361.81	67.18	0.009	0.012	4/6/2013 10:00		-0.084	8.4	
rideau-22	67.08	445211.06	5025364.61	67.03	0.009	0.013	4/6/2013 10:01		0.053	5.3	
rideau-23	66.76	445213.99	5025367.82	66.84	0.010	0.013	4/6/2013 10:01		-0.083	8.3	
rideau-24	66.68	445217.07	5025371.08	66.64	0.009	0.012	4/6/2013 10:01		0.043	4.3	
rideau-25	66.41	445220.40	5025374.58	66.46	0.011	0.015	4/6/2013 10:02		-0.049	4.9	
rideau-26	66.24	445223.40	5025377.86	66.24	0.012	0.016	4/6/2013 10:02		0.000	0.0	
rideau-27	66.14	445225.49	5025380.05	66.15	0.013	0.016	4/6/2013 10:03		-0.014	1.4	
rideau-28	66.00	445227.81	5025382.60	65.94	0.015	0.019	4/6/2013 10:03		0.061	6.1	
rideau-29	65.75	445230.22	5025384.88	65.87	0.013	0.019	4/6/2013 10:04		-0.115	11.5	
rideau-30	65.64	445232.93	5025388.03	65.71	0.010	0.020	4/6/2013 10:06		-0.071	7.1	
spot1	76.8316	445518.73	5024346.22	76.94	0.008	0.013	5/22/2015 9:28		-0.108	10.8	
spot2	77.175	445516.63	5024354.28	77.16	0.011	0.018	5/22/2015 9:29		0.016	1.6	
spot3	77.4535	445514.85	5024362.98	77.44	0.014	0.02	5/22/2015 9:30		0.015	1.5	
spot4	78.1024	445517.05	5024378.95	78.06	0.015	0.02	5/22/2015 9:31		0.040	4.0	
spot5	78.2504	445521.98	5024387.59	78.23	0.014	0.019	5/22/2015 9:31		0.024	2.4	
spot6	78.3531	445515.36	5024393.27	78.31	0.015	0.02	5/22/2015 9:32		0.047	4.7	
spot7	78.4972	445508.21	5024398.03	78.47	0.013	0.019	5/22/2015 9:33		0.024	2.4	
spot8	78.4474	445500.86	5024396.78	78.44	0.014	0.019	5/22/2015 9:34		0.009	0.9	
spot9	78.4981	445494.14	5024393.96	78.42	0.014	0.019	5/22/2015 9:34		0.078	7.8	
spot13	77.9937	445425.32	5024347.89	77.96	0.014	0.019	5/22/2015 9:37		0.037	3.7	

spot14	77.8313	445414.50	5024341.05	77.78	0.014	0.019	5/22/2015 9:37		0.048	4.8	
spot15	77.7565	445406.97	5024335.97	77.69	0.014	0.019	5/22/2015 9:37		0.067	6.7	
spot16	77.7321	445398.92	5024330.71	77.67	0.015	0.02	5/22/2015 9:38		0.058	5.8	
spot17	77.7078	445391.71	5024325.75	77.69	0.014	0.019	5/22/2015 9:38		0.017	1.7	
spot18	77.6826	445383.45	5024318.72	77.69	0.015	0.019	5/22/2015 9:40		-0.006	0.6	
spot19	77.606	445375.48	5024313.43	77.64	0.015	0.02	5/22/2015 9:40		-0.031	3.1	
spot20	77.7673	445363.24	5024304.89	77.65	0.014	0.019	5/22/2015 9:41		0.114	11.4	
spot21	77.5638	445358.89	5024296.54	77.54	0.014	0.019	5/22/2015 9:41		0.024	2.4	
spot22	77.1953	445356.69	5024288.76	77.18	0.014	0.019	5/22/2015 9:42		0.018	1.8	
spot23	76.5255	445354.33	5024279.70	76.53	0.014	0.02	5/22/2015 9:42		-0.008	0.8	
spot24	75.7095	445358.05	5024268.23	75.68	0.013	0.019	5/22/2015 9:42		0.032	3.2	
spot25	75.8048	445339.14	5024266.42	75.76	0.013	0.019	5/22/2015 9:43		0.050	5.0	
spot26	90.2282	445573.27	5020834.27	90.17	0.007	0.011	5/22/2015 10:14		0.063	6.3	
spot27	90.0845	445579.51	5020827.10	90.03	0.007	0.011	5/22/2015 10:15		0.058	5.8	
spot28	90.006	445582.08	5020818.17	89.91	0.007	0.012	5/22/2015 10:15		0.100	10.0	
spot29	89.9728	445578.42	5020810.02	89.92	0.009	0.015	5/22/2015 10:15		0.050	5.0	
spot30	89.9072	445569.00	5020811.37	89.90	0.007	0.013	5/22/2015 10:16		0.011	1.1	
spot31	89.9622	445566.13	5020819.28	89.93	0.008	0.013	5/22/2015 10:16		0.029	2.9	
spot32	90.2038	445571.86	5020837.91	90.18	0.008	0.014	5/22/2015 10:17		0.024	2.4	
spot33	90.3056	445573.39	5020846.23	90.30	0.008	0.014	5/22/2015 10:17		0.009	0.9	
spot34	90.4131	445575.07	5020855.20	90.37	0.009	0.016	5/22/2015 10:17		0.040	4.0	
spot35	90.5056	445576.91	5020863.73	90.48	0.01	0.016	5/22/2015 10:18		0.031	3.1	
spot36	90.5869	445579.22	5020872.49	90.55	0.008	0.015	5/22/2015 10:18		0.035	3.5	
spot37	90.6799	445583.27	5020880.84	90.65	0.008	0.015	5/22/2015 10:18		0.033	3.3	
spot38	90.8078	445588.68	5020887.63	90.74	0.01	0.017	5/22/2015 10:18		0.065	6.5	
spot39	90.8897	445595.03	5020893.04	90.89	0.009	0.016	5/22/2015 10:19		0.001	0.1	
spot40	90.9529	445604.33	5020899.13	90.91	0.009	0.017	5/22/2015 10:19		0.044	4.4	
spot41	88.6571	445213.91	5013522.94	88.54	0.009	0.015	5/22/2015 10:31		0.113	11.3	
spot42	88.7778	445206.48	5013526.31	88.63	0.01	0.018	5/22/2015 10:31		0.152	15.2	
spot43	88.7462	445201.51	5013528.37	88.71	0.011	0.019	5/22/2015 10:32		0.036	3.6	
spot44	88.8936	445195.32	5013531.01	88.80	0.012	0.02	5/22/2015 10:32		0.099	9.9	
spot45	88.9513	445189.73	5013532.34	88.90	0.011	0.019	5/22/2015 10:33		0.051	5.1	
spot46	88.8406	445196.88	5013538.49	88.85	0.012	0.02	5/22/2015 10:36		-0.009	0.9	
spot47	88.7133	445204.71	5013534.78	88.69	0.012	0.02	5/22/2015 10:37		0.023	2.3	
spot48	88.759	445212.65	5013531.18	88.56	0.012	0.02	5/22/2015 10:37		0.197	19.7	
spot49	88.6439	445219.55	5013536.49	88.52	0.012	0.02	5/22/2015 10:38		0.124	12.4	
spot50	88.741	445211.58	5013540.29	88.62	0.012	0.02	5/22/2015 10:38		0.118	11.8	
spot51	88.8338	445204.34	5013543.69	88.75	0.011	0.02	5/22/2015 10:38		0.085	8.5	
spot52	88.9393	445199.49	5013549.11	88.88	0.011	0.019	5/22/2015 10:39		0.055	5.5	
spot53	88.7687	445207.08	5013550.67	88.72	0.012	0.02	5/22/2015 10:40		0.046	4.6	
spot54	88.6572	445221.10	5013555.23	88.57	0.012	0.02	5/22/2015 10:41		0.091	9.1	
spot55	88.704	445230.52	5013555.95	88.56	0.012	0.02	5/22/2015 10:42		0.148	14.8	

spot56	88.2856	445240.69	5013564.13	88.17	0.012	0.02	5/22/2015 10:43		0.121	12.1	
spot57	88.2917	445252.06	5013571.36	88.24	0.012	0.02	5/22/2015 10:44		0.057	5.7	
spot58	88.3677	445260.98	5013583.19	88.34	0.012	0.02	5/22/2015 10:44		0.029	2.9	
spot59	88.4592	445266.42	5013592.78	88.43	0.012	0.02	5/22/2015 10:45		0.027	2.7	
spot60	88.4719	445270.07	5013604.02	88.43	0.012	0.02	5/22/2015 10:46		0.041	4.1	
spot61	88.5147	445270.91	5013612.57	88.43	0.013	0.02	5/22/2015 10:47		0.081	8.1	
spot62	88.3725	445271.36	5013637.82	88.28	0.011	0.018	5/22/2015 10:48		0.091	9.1	
spot63	88.3529	445272.40	5013646.28	88.30	0.011	0.018	5/22/2015 10:48		0.052	5.2	
spot64	88.3377	445273.59	5013655.11	88.32	0.011	0.018	5/22/2015 10:49		0.015	1.5	
spot65	88.3304	445275.15	5013661.17	88.30	0.012	0.02	5/22/2015 10:49		0.026	2.6	
spot66	89.3727	445267.14	5011107.80	89.23	0.011	0.018	5/22/2015 10:58		0.140	14.0	
spot67	89.1734	445256.90	5011104.91	89.09	0.011	0.018	5/22/2015 10:59		0.088	8.8	
spot68	89.1609	445250.59	5011101.14	89.04	0.011	0.018	5/22/2015 10:59		0.126	12.6	
spot69	89.0727	445244.89	5011098.05	88.95	0.011	0.018	5/22/2015 11:00		0.120	12.0	
spot70	89.0035	445239.12	5011095.08	88.84	0.011	0.019	5/22/2015 11:00		0.165	16.5	
spot71	88.9063	445233.02	5011091.83	88.73	0.011	0.018	5/22/2015 11:01		0.178	17.8	
spot72	88.7857	445227.56	5011088.75	88.63	0.011	0.018	5/22/2015 11:01		0.153	15.3	
spot73	88.6477	445221.05	5011085.23	88.50	0.011	0.018	5/22/2015 11:01		0.151	15.1	
spot74	88.5404	445214.96	5011081.77	88.33	0.01	0.019	5/22/2015 11:02		0.209	20.9	
spot75	88.32	445207.25	5011077.68	88.14	0.012	0.02	5/22/2015 11:02		0.185	18.5	
spot76	88.1595	445201.61	5011074.42	88.04	0.012	0.02	5/22/2015 11:05		0.124	12.4	
spot77	87.9836	445193.46	5011069.82	87.92	0.012	0.02	5/22/2015 11:06		0.060	6.0	
spot78	87.9826	445184.91	5011065.61	87.80	0.012	0.02	5/22/2015 11:06		0.184	18.4	
spot79	87.9327	445176.46	5011061.08	87.73	0.012	0.02	5/22/2015 11:07		0.207	20.7	
spot80	87.9317	445169.38	5011057.09	87.75	0.012	0.02	5/22/2015 11:07		0.185	18.5	
spot81	86.3562	444825.33	5010983.84	86.19	0.01	0.016	5/22/2015 11:10		0.162	16.2	
spot82	86.4763	444830.31	5010989.71	86.33	0.011	0.019	5/22/2015 11:10		0.148	14.8	
spot83	86.6958	444807.06	5011003.96	86.61	0.012	0.019	5/22/2015 11:12		0.088	8.8	
spot84	86.801	444814.37	5010999.76	86.65	0.012	0.02	5/22/2015 11:12		0.151	15.1	
spot85	86.7772	444823.19	5010998.31	86.64	0.012	0.02	5/22/2015 11:13		0.136	13.6	
spot86	86.7085	444833.78	5010997.03	86.56	0.012	0.02	5/22/2015 11:14		0.145	14.5	
spot87	86.7079	444843.75	5010996.99	86.54	0.012	0.02	5/22/2015 11:16		0.167	16.7	
spot88	86.604	444851.57	5010997.51	86.49	0.012	0.02	5/22/2015 11:17		0.115	11.5	
spot89	86.5339	444864.97	5010999.69	86.42	0.012	0.02	5/22/2015 11:19		0.110	11.0	
spot90	86.5967	444881.21	5011006.25	86.41	0.012	0.02	5/22/2015 11:23		0.187	18.7	
spot91	90.0077	446619.05	5009214.92	89.97	0.012	0.02	5/22/2015 11:37		0.038	3.8	
spot92	89.8048	446627.33	5009212.96	89.78	0.011	0.019	5/22/2015 11:37		0.027	2.7	
spot93	89.6475	446635.44	5009209.35	89.58	0.012	0.02	5/22/2015 11:37		0.066	6.6	
spot94	89.3938	446637.73	5009201.31	89.34	0.011	0.018	5/22/2015 11:38		0.052	5.2	
spot95	89.1414	446637.09	5009191.76	89.07	0.011	0.018	5/22/2015 11:38		0.070	7.0	
spot96	89.2166	446632.20	5009194.80	89.15	0.01	0.016	5/22/2015 11:43		0.068	6.8	
spot97	89.5759	446627.02	5009202.83	89.50	0.01	0.016	5/22/2015 11:43		0.075	7.5	

spot98	90.1268	446609.03	5009207.17	90.13	0.01	0.016	5/22/2015 11:44		-0.002	0.2	
spot99	90.383	446604.02	5009213.28	90.38	0.011	0.018	5/22/2015 11:44		0.006	0.6	
spot100	90.51	446599.64	5009218.13	90.49	0.011	0.017	5/22/2015 11:45		0.025	2.5	
spot101	90.6689	446594.00	5009224.17	90.63	0.009	0.016	5/22/2015 11:45		0.042	4.2	
spot102	90.8052	446588.53	5009229.32	90.75	0.01	0.016	5/22/2015 11:45		0.051	5.1	
spot103	90.8474	446583.43	5009227.96	90.83	0.01	0.018	5/22/2015 11:46		0.021	2.1	
spot104	90.855	446583.26	5009216.23	90.79	0.012	0.017	5/22/2015 11:46		0.061	6.1	
spot105	90.6109	446581.51	5009207.95	90.61	0.011	0.017	5/22/2015 11:46		0.005	0.5	
spot106	90.275	446578.59	5009200.47	90.26	0.011	0.017	5/22/2015 11:47		0.016	1.6	
spot107	89.9754	446574.42	5009193.65	89.96	0.011	0.017	5/22/2015 11:47		0.019	1.9	
spot108	89.7747	446567.98	5009187.88	89.81	0.013	0.017	5/22/2015 11:47		-0.035	3.5	
spot109	89.6534	446560.01	5009183.45	89.58	0.011	0.018	5/22/2015 11:48		0.069	6.9	
spot110	89.3961	446551.76	5009178.62	89.38	0.011	0.018	5/22/2015 11:48		0.013	1.3	
spot111	89.0897	446542.83	5009173.25	89.05	0.011	0.018	5/22/2015 11:48		0.044	4.4	
spot112	88.5244	446532.87	5009167.72	88.54	0.011	0.018	5/22/2015 11:48		-0.019	1.9	
spot113	88.1792	446524.30	5009165.04	88.16	0.012	0.019	5/22/2015 11:49		0.020	2.0	
spot114	87.3969	446498.56	5009159.36	87.35	0.012	0.019	5/22/2015 11:50		0.052	5.2	
spot115	88.235	446510.42	5009175.05	88.19	0.013	0.02	5/22/2015 11:52		0.041	4.1	
spot116	89.9045	446607.19	5008781.58	89.76	0.013	0.02	5/22/2015 12:00		0.141	14.1	
spot117	89.809	446603.40	5008789.70	89.74	0.012	0.019	5/22/2015 12:01		0.069	6.9	
spot118	89.8422	446607.66	5008796.34	89.73	0.012	0.019	5/22/2015 12:02		0.114	11.4	
spot119	89.7655	446612.74	5008801.89	89.66	0.012	0.018	5/22/2015 12:02		0.103	10.3	
spot120	89.7823	446619.55	5008798.25	89.66	0.013	0.02	5/22/2015 12:03		0.122	12.2	
spot121	89.7536	446625.78	5008794.82	89.63	0.013	0.02	5/22/2015 12:03		0.122	12.2	
spot122	89.7644	446632.57	5008789.09	89.63	0.013	0.02	5/22/2015 12:03		0.132	13.2	
spot123	89.8551	446638.28	5008782.80	89.78	0.013	0.02	5/22/2015 12:03		0.075	7.5	
spot124	89.9686	446632.87	5008775.72	89.82	0.013	0.02	5/22/2015 12:06		0.146	14.6	
spot125	90.0122	446628.36	5008769.58	89.90	0.013	0.02	5/22/2015 12:06		0.117	11.7	
spot126	90.0542	446622.95	5008762.40	89.92	0.013	0.02	5/22/2015 12:07		0.133	13.3	
spot127	90.0586	446618.04	5008755.16	89.92	0.013	0.02	5/22/2015 12:09		0.139	13.9	
spot128	89.8928	446623.89	5008747.89	89.88	0.013	0.02	5/22/2015 12:11		0.011	1.1	
spot129	89.8972	446632.21	5008742.12	89.86	0.013	0.02	5/22/2015 12:13		0.035	3.5	
spot130	90.1098	446635.25	5008728.28	90.12	0.012	0.02	5/22/2015 12:16		-0.008	0.8	
spot131	90.2369	446642.96	5008722.15	90.13	0.012	0.02	5/22/2015 12:19		0.111	11.1	
spot157	83.7971	444559.60	5012535.10	83.72	0.012	0.02	5/22/2015 13:21		0.079	7.9	
spot158	83.678	444562.31	5012541.68	83.64	0.012	0.018	5/22/2015 13:22		0.043	4.3	
spot159	83.6669	444564.82	5012549.19	83.57	0.012	0.02	5/22/2015 13:22		0.097	9.7	
spot160	83.4693	444567.64	5012556.57	83.46	0.012	0.019	5/22/2015 13:22		0.014	1.4	
spot161	83.2254	444575.53	5012577.84	83.16	0.013	0.02	5/22/2015 13:25		0.064	6.4	
spot162	83.222	444578.89	5012585.59	83.13	0.014	0.02	5/22/2015 13:25		0.097	9.7	
spot163	83.1547	444581.56	5012593.35	83.10	0.012	0.02	5/22/2015 13:26		0.052	5.2	
spot164	83.1372	444584.23	5012601.83	83.08	0.013	0.019	5/22/2015 13:26		0.055	5.5	

spot165	83.0581	444587.75	5012615.19	82.98	0.013	0.02	5/22/2015 13:27		0.076	7.6	
spot166	83.0167	444589.57	5012623.58	82.92	0.013	0.02	5/22/2015 13:27		0.093	9.3	
spot167	82.9775	444590.77	5012631.36	82.87	0.012	0.019	5/22/2015 13:28		0.107	10.7	
spot168	82.895	444592.21	5012640.12	82.85	0.013	0.02	5/22/2015 13:29		0.048	4.8	
spot169	82.8846	444592.46	5012694.01	82.79	0.013	0.019	5/22/2015 13:31		0.097	9.7	
spot170	82.83	444592.37	5012703.20	82.75	0.013	0.019	5/22/2015 13:31		0.079	7.9	
spot171	82.9025	444591.13	5012712.37	82.81	0.012	0.02	5/22/2015 13:34		0.097	9.7	
spot172	82.885	444591.34	5012720.93	82.77	0.013	0.02	5/22/2015 13:34		0.113	11.3	
spot173	82.8115	444591.12	5012730.31	82.73	0.013	0.019	5/22/2015 13:35		0.085	8.5	
spot174	82.8119	444590.78	5012739.25	82.74	0.012	0.02	5/22/2015 13:35		0.069	6.9	
spot175	82.8501	444590.50	5012748.42	82.77	0.013	0.019	5/22/2015 13:36		0.079	7.9	
spot176	82.8794	444590.04	5012756.86	82.81	0.013	0.02	5/22/2015 13:36		0.065	6.5	
spot177	82.8789	444589.72	5012766.56	82.88	0.012	0.019	5/22/2015 13:36		0.003	0.3	
spot178	83.0235	444589.48	5012776.27	82.96	0.012	0.02	5/22/2015 13:37		0.066	6.6	
spot179	83.1311	444587.73	5012784.34	83.10	0.012	0.02	5/22/2015 13:39		0.032	3.2	
spot180	83.2641	444586.33	5012794.33	83.18	0.013	0.02	5/22/2015 13:40		0.088	8.8	
spot181	83.507	445009.91	5014561.67	83.39	0.012	0.02	5/22/2015 13:46		0.116	11.6	
spot182	83.8437	445014.47	5014570.45	83.74	0.012	0.02	5/22/2015 13:50		0.104	10.4	
spot183	84.1267	445017.30	5014576.65	83.98	0.011	0.02	5/22/2015 13:51		0.144	14.4	
spot184	85.9465	445046.90	5014649.64	85.86	0.011	0.019	5/22/2015 14:03		0.085	8.5	
spot185	86.0046	445050.56	5014657.07	85.91	0.01	0.018	5/22/2015 14:04		0.099	9.9	
spot186	86.0455	445053.84	5014663.84	85.89	0.009	0.02	5/22/2015 14:04		0.154	15.4	
spot187	86.0258	445057.55	5014671.15	85.91	0.011	0.019	5/22/2015 14:05		0.117	11.7	
spot188	85.7548	445080.70	5014732.96	85.66	0.01	0.018	5/22/2015 14:09		0.097	9.7	
spot189	85.6552	445083.21	5014739.25	85.60	0.011	0.02	5/22/2015 14:09		0.059	5.9	
spot190	79.153	445275.19	5018904.18	79.08	0.01	0.018	5/22/2015 14:27		0.072	7.2	
spot191	87.8162	447185.39	5007610.07	87.76	0.015	0.019	5/26/2015 9:20		0.052	5.2	
spot192	87.9745	447178.36	5007607.25	87.98	0.015	0.02	5/26/2015 9:20		-0.007	0.7	
spot193	88.1051	447169.75	5007607.57	88.10	0.015	0.02	5/26/2015 9:21		0.003	0.3	
spot194	88.2209	447161.14	5007607.87	88.21	0.013	0.017	5/26/2015 9:21		0.012	1.2	
spot195	88.4357	447153.12	5007607.34	88.45	0.013	0.018	5/26/2015 9:21		-0.016	1.6	
spot196	88.7524	447146.63	5007603.02	88.75	0.014	0.019	5/26/2015 9:22		0.001	0.1	
spot197	89.072	447140.45	5007598.48	89.08	0.014	0.02	5/26/2015 9:22		-0.009	0.9	
spot198	89.3172	447133.92	5007593.75	89.33	0.015	0.02	5/26/2015 9:22		-0.010	1.0	
spot199	89.5527	447127.83	5007588.93	89.58	0.014	0.019	5/26/2015 9:23		-0.028	2.8	
spot200	89.8771	447120.87	5007583.87	89.87	0.013	0.019	5/26/2015 9:23		0.010	1.0	
spot201	90.0896	447114.76	5007578.97	90.15	0.015	0.02	5/26/2015 9:23		-0.062	6.2	
spot202	90.5037	447108.58	5007574.48	90.47	0.014	0.019	5/26/2015 9:24		0.034	3.4	
spot203	90.9087	447101.82	5007569.01	90.91	0.014	0.019	5/26/2015 9:24		-0.002	0.2	
spot204	91.3578	447095.68	5007563.72	91.32	0.013	0.019	5/26/2015 9:25		0.036	3.6	
spot205	91.7357	447089.97	5007558.46	91.69	0.014	0.019	5/26/2015 9:25		0.043	4.3	
spot206	92.0806	447084.81	5007553.24	92.09	0.014	0.019	5/26/2015 9:25		-0.010	1.0	

spot207	92.5458	447079.21	5007547.67	92.52	0.013	0.018	5/26/2015 9:25		0.031	3.1	
spot208	92.8281	447073.72	5007542.59	92.81	0.013	0.018	5/26/2015 9:26		0.014	1.4	
spot209	93.186	447067.60	5007536.49	93.16	0.012	0.017	5/26/2015 9:26		0.028	2.8	
spot210	93.4288	447062.13	5007530.59	93.38	0.012	0.017	5/26/2015 9:26		0.046	4.6	
spot211	90.4592	447790.46	5006912.46	90.53	0.013	0.019	5/26/2015 9:32		-0.066	6.6	
spot212	90.1751	447797.05	5006916.44	90.20	0.013	0.018	5/26/2015 9:33		-0.020	2.0	
spot213	89.9171	447803.10	5006919.68	89.93	0.013	0.018	5/26/2015 9:33		-0.009	0.9	
spot214	89.5999	447808.38	5006922.78	89.69	0.013	0.018	5/26/2015 9:34		-0.088	8.8	
spot215	89.397	447814.57	5006926.13	89.45	0.013	0.019	5/26/2015 9:34		-0.050	5.0	
spot216	89.1816	447820.32	5006929.24	89.26	0.014	0.02	5/26/2015 9:35		-0.079	7.9	
spot217	89.0135	447826.86	5006932.73	89.07	0.013	0.019	5/26/2015 9:35		-0.052	5.2	
spot218	88.9108	447832.56	5006936.14	88.92	0.013	0.018	5/26/2015 9:36		-0.011	1.1	
spot219	88.7967	447838.78	5006939.37	88.80	0.013	0.019	5/26/2015 9:36		-0.006	0.6	
spot220	88.608	447846.40	5006943.72	88.68	0.014	0.019	5/26/2015 9:36		-0.068	6.8	
spot221	88.5628	447852.73	5006947.52	88.62	0.014	0.02	5/26/2015 9:37		-0.060	6.0	
spot222	88.4289	447860.87	5006952.20	88.52	0.014	0.02	5/26/2015 9:37		-0.087	8.7	
spot223	88.3908	447871.58	5006957.85	88.44	0.014	0.02	5/26/2015 9:38		-0.049	4.9	
spot224	88.3549	447879.71	5006962.75	88.39	0.014	0.02	5/26/2015 9:38		-0.034	3.4	
spot225	88.2422	447887.75	5006969.75	88.31	0.014	0.02	5/26/2015 9:39		-0.064	6.4	
spot226	89.885	448685.66	5006349.36	89.89	0.013	0.02	5/26/2015 9:47		-0.005	0.5	
spot227	90.0564	448692.50	5006344.80	90.03	0.013	0.02	5/26/2015 9:48		0.024	2.4	
spot228	90.1538	448701.25	5006340.69	90.14	0.013	0.02	5/26/2015 9:52		0.014	1.4	
spot229	90.2936	448708.06	5006335.23	90.24	0.013	0.02	5/26/2015 9:53		0.056	5.6	
spot230	90.3536	448715.00	5006329.54	90.35	0.012	0.02	5/26/2015 9:55		0.007	0.7	
spot231	90.4729	448721.12	5006323.33	90.47	0.012	0.02	5/26/2015 9:56		0.005	0.5	
spot232	90.5098	448719.70	5006314.70	90.53	0.011	0.02	5/26/2015 9:58		-0.019	1.9	
spot233	90.4686	448713.33	5006310.89	90.51	0.011	0.02	5/26/2015 10:00		-0.039	3.9	
spot234	90.4486	448705.46	5006306.06	90.56	0.011	0.02	5/26/2015 10:02		-0.109	10.9	
spot235	90.4969	448697.48	5006301.62	90.54	0.01	0.02	5/26/2015 10:05		-0.039	3.9	
spot236	90.5269	448685.36	5006298.01	90.61	0.011	0.02	5/26/2015 10:06		-0.083	8.3	
spot237	90.5466	448676.73	5006293.70	90.56	0.012	0.02	5/26/2015 10:07		-0.011	1.1	
spot238	90.4432	448668.53	5006290.23	90.46	0.012	0.02	5/26/2015 10:09		-0.020	2.0	
spot239	90.3842	448660.40	5006285.68	90.44	0.012	0.02	5/26/2015 10:10		-0.053	5.3	
spot240	90.2829	448651.97	5006281.57	90.35	0.012	0.02	5/26/2015 10:12		-0.062	6.2	
spot241	88.996	449543.05	5004889.55	89.07	0.01	0.017	5/26/2015 10:18		-0.076	7.6	
spot242	88.9299	449547.78	5004880.91	89.02	0.012	0.019	5/26/2015 10:19		-0.093	9.3	
spot243	88.8908	449552.34	5004872.52	88.94	0.011	0.018	5/26/2015 10:19		-0.053	5.3	
spot244	88.8072	449557.18	5004863.36	88.89	0.012	0.019	5/26/2015 10:20		-0.079	7.9	
spot245	88.7789	449562.01	5004854.38	88.85	0.012	0.019	5/26/2015 10:21		-0.068	6.8	
spot246	88.7521	449566.63	5004845.60	88.80	0.011	0.017	5/26/2015 10:22		-0.051	5.1	
spot247	88.7501	449570.21	5004838.96	88.78	0.011	0.018	5/26/2015 10:22		-0.030	3.0	
spot248	88.6449	449574.05	5004831.45	88.74	0.011	0.018	5/26/2015 10:23		-0.093	9.3	

spot249	88.642	449577.91	5004824.04	88.70	0.012	0.02	5/26/2015 10:23		-0.062	6.2	
spot250	88.5964	449581.87	5004816.16	88.69	0.012	0.019	5/26/2015 10:24		-0.089	8.9	
spot251	88.5625	449586.02	5004807.78	88.66	0.011	0.019	5/26/2015 10:24		-0.093	9.3	
spot252	88.5253	449589.88	5004799.65	88.61	0.011	0.018	5/26/2015 10:25		-0.089	8.9	
spot253	88.5012	449593.79	5004791.52	88.58	0.012	0.019	5/26/2015 10:25		-0.080	8.0	
spot254	88.503	449597.95	5004782.74	88.57	0.011	0.019	5/26/2015 10:25		-0.063	6.3	
spot255	88.4499	449602.01	5004773.96	88.51	0.011	0.018	5/26/2015 10:26		-0.061	6.1	
spot256	88.3641	449605.95	5004765.37	88.48	0.012	0.019	5/26/2015 10:26		-0.116	11.6	
spot257	88.3152	449609.81	5004756.94	88.44	0.012	0.02	5/26/2015 10:27		-0.126	12.6	
spot258	88.2907	449613.83	5004748.25	88.37	0.012	0.019	5/26/2015 10:27		-0.082	8.2	
spot259	88.2385	449617.75	5004739.28	88.33	0.012	0.02	5/26/2015 10:27		-0.087	8.7	
spot260	88.1664	449621.57	5004730.62	88.28	0.012	0.02	5/26/2015 10:28		-0.109	10.9	
spot261	88.1089	449625.50	5004721.77	88.24	0.012	0.019	5/26/2015 10:28		-0.131	13.1	
spot262	88.1072	449629.05	5004713.30	88.22	0.011	0.018	5/26/2015 10:29		-0.108	10.8	
spot263	88.0856	449632.47	5004704.66	88.20	0.01	0.017	5/26/2015 10:30		-0.114	11.4	
spot264	88.1523	449636.10	5004696.30	88.21	0.011	0.018	5/26/2015 10:31		-0.056	5.6	
spot265	88.1687	449639.56	5004687.58	88.22	0.011	0.018	5/26/2015 10:31		-0.046	4.6	
spot266	88.1276	449643.07	5004678.86	88.25	0.012	0.02	5/26/2015 10:31		-0.118	11.8	
spot267	88.1195	449646.43	5004670.34	88.24	0.011	0.019	5/26/2015 10:32		-0.117	11.7	
spot268	88.104	449649.80	5004661.86	88.23	0.011	0.018	5/26/2015 10:32		-0.128	12.8	
spot269	88.1371	449653.12	5004653.12	88.24	0.011	0.018	5/26/2015 10:32		-0.102	10.2	
spot270	88.1405	449656.46	5004644.60	88.26	0.01	0.017	5/26/2015 10:32		-0.118	11.8	
spot271	88.1192	450759.61	5002171.68	88.15	0.008	0.013	5/26/2015 10:38		-0.030	3.0	
spot272	88.086	450762.23	5002162.34	88.12	0.011	0.017	5/26/2015 10:39		-0.035	3.5	
spot273	88.026	450764.79	5002152.03	88.06	0.011	0.018	5/26/2015 10:39		-0.032	3.2	
spot274	87.9951	450767.01	5002142.84	88.05	0.012	0.019	5/26/2015 10:39		-0.056	5.6	
spot275	87.9734	450769.30	5002133.86	88.05	0.012	0.02	5/26/2015 10:40		-0.081	8.1	
spot276	87.9809	450770.78	5002126.22	88.02	0.012	0.02	5/26/2015 10:40		-0.038	3.8	
spot277	88.0255	450772.26	5002117.91	88.06	0.012	0.02	5/26/2015 10:40		-0.033	3.3	
spot278	88.0313	450773.96	5002109.34	88.06	0.011	0.018	5/26/2015 10:41		-0.033	3.3	
spot279	88.0287	450775.70	5002102.31	88.09	0.011	0.018	5/26/2015 10:41		-0.058	5.8	
spot280	88.0903	450777.30	5002094.90	88.11	0.011	0.018	5/26/2015 10:41		-0.015	1.5	
spot281	88.0562	450778.86	5002087.19	88.13	0.011	0.018	5/26/2015 10:42		-0.077	7.7	
spot282	88.1226	450780.63	5002080.01	88.17	0.012	0.019	5/26/2015 10:42		-0.042	4.2	
spot283	88.1526	450782.21	5002071.48	88.16	0.011	0.018	5/26/2015 10:42		-0.003	0.3	
spot284	88.1367	450783.16	5002065.05	88.17	0.011	0.018	5/26/2015 10:43		-0.033	3.3	
spot285	88.1439	450784.18	5002056.24	88.17	0.011	0.019	5/26/2015 10:43		-0.027	2.7	
spot286	88.1545	450785.43	5002049.51	88.20	0.011	0.019	5/26/2015 10:44		-0.040	4.0	
spot287	88.1566	450786.47	5002041.40	88.21	0.011	0.019	5/26/2015 10:44		-0.051	5.1	
spot288	88.2492	450787.91	5002034.06	88.24	0.011	0.019	5/26/2015 10:44		0.005	0.5	
spot289	88.2432	450787.89	5002027.29	88.24	0.011	0.018	5/26/2015 10:45		0.007	0.7	
spot290	88.2482	450787.62	5002018.66	88.21	0.011	0.018	5/26/2015 10:45		0.039	3.9	

spot291	88.2096	450787.34	5002011.58	88.19	0.01	0.019	5/26/2015 10:45		0.019	1.9	
spot292	88.1871	450786.83	5002003.17	88.19	0.012	0.019	5/26/2015 10:45		-0.004	0.4	
spot293	88.2115	450785.20	5001979.88	88.24	0.011	0.02	5/26/2015 10:48		-0.025	2.5	
spot294	88.2489	450779.92	5001952.86	88.24	0.011	0.02	5/26/2015 10:50		0.011	1.1	
spot295	88.3548	450775.33	5001945.21	88.32	0.011	0.019	5/26/2015 10:51		0.033	3.3	
spot296	88.3328	450771.90	5001935.93	88.35	0.011	0.019	5/26/2015 10:51		-0.013	1.3	
spot297	88.3677	450768.99	5001928.46	88.36	0.011	0.02	5/26/2015 10:51		0.005	0.5	
spot298	88.3796	450765.44	5001921.23	88.34	0.011	0.02	5/26/2015 10:52		0.042	4.2	
spot299	88.3191	450762.00	5001914.87	88.32	0.011	0.019	5/26/2015 10:52		-0.005	0.5	
spot300	88.3286	450757.12	5001906.34	88.31	0.011	0.019	5/26/2015 10:52		0.015	1.5	
spot301	86.8825	449042.39	4999745.59	86.87	0.009	0.017	5/26/2015 11:03		0.009	0.9	
spot302	86.8648	449037.03	4999741.27	86.86	0.012	0.02	5/26/2015 11:04		0.009	0.9	
spot303	86.8107	449032.00	4999739.21	86.84	0.012	0.02	5/26/2015 11:04		-0.033	3.3	
spot304	86.8008	449025.93	4999735.37	86.81	0.01	0.018	5/26/2015 11:04		-0.007	0.7	
spot305	86.8319	449020.95	4999730.25	86.84	0.011	0.019	5/26/2015 11:05		-0.005	0.5	
spot306	86.9126	449016.14	4999724.22	86.90	0.011	0.019	5/26/2015 11:05		0.013	1.3	
spot307	86.9643	449018.13	4999717.80	86.97	0.011	0.019	5/26/2015 11:05		-0.006	0.6	
spot308	86.9898	449021.36	4999711.88	86.98	0.011	0.018	5/26/2015 11:06		0.015	1.5	
spot309	86.9358	449028.77	4999714.68	86.95	0.011	0.019	5/26/2015 11:06		-0.010	1.0	
spot310	86.9364	449036.65	4999716.94	86.94	0.011	0.018	5/26/2015 11:06		-0.008	0.8	
spot311	86.9632	449042.81	4999721.79	86.94	0.012	0.018	5/26/2015 11:07		0.025	2.5	
spot312	86.8525	449048.96	4999725.95	86.88	0.011	0.019	5/26/2015 11:07		-0.029	2.9	
spot313	86.8592	449056.83	4999724.83	86.85	0.011	0.018	5/26/2015 11:08		0.009	0.9	
spot314	86.8378	449062.12	4999719.69	86.84	0.011	0.019	5/26/2015 11:08		0.002	0.2	
spot315	86.8635	449063.64	4999712.59	86.86	0.011	0.019	5/26/2015 11:08		0.008	0.8	
spot316	86.9004	449065.28	4999705.99	86.89	0.011	0.019	5/26/2015 11:08		0.007	0.7	
spot317	86.8185	449071.11	4999705.88	86.81	0.011	0.019	5/26/2015 11:09		0.007	0.7	
spot318	86.7579	449075.80	4999710.79	86.72	0.011	0.019	5/26/2015 11:09		0.035	3.5	
spot319	86.7629	449074.40	4999717.34	86.74	0.011	0.02	5/26/2015 11:09		0.023	2.3	
spot320	86.7178	449073.26	4999724.05	86.76	0.011	0.02	5/26/2015 11:10		-0.041	4.1	
spot321	86.7424	449070.85	4999731.65	86.75	0.012	0.019	5/26/2015 11:10		-0.005	0.5	
spot322	86.7572	449068.47	4999739.05	86.75	0.011	0.018	5/26/2015 11:10		0.006	0.6	

spot323	86.7811	449067.43	4999746.51	86.81	0.01	0.019	5/26/2015 11:11		-0.030	3.0	
spot324	86.8419	449056.88	4999745.42	86.83	0.011	0.019	5/26/2015 11:11		0.008	0.8	
spot325	86.9047	449051.06	4999744.53	86.89	0.011	0.019	5/26/2015 11:11		0.018	1.8	
spot326	86.9	449049.48	4999736.41	86.91	0.011	0.019	5/26/2015 11:12		-0.010	1.0	
spot327	86.8813	449041.55	4999733.99	86.90	0.011	0.019	5/26/2015 11:12		-0.017	1.7	
spot328	86.8527	449034.90	4999731.75	86.87	0.011	0.019	5/26/2015 11:12		-0.019	1.9	
spot329	86.932	449028.45	4999726.77	86.88	0.01	0.018	5/26/2015 11:12		0.051	5.1	
spot330	86.922	449038.28	4999725.31	86.91	0.011	0.019	5/26/2015 11:13		0.008	0.8	
									Mean △Z :	6.3	0 yes out of 330 spot elevations
									Median △Z :	5.1	
									Max △Z :	27.5	
									Min △Z :	0.0	

Discarded Points

spot10	73.8657	445488.94	5024390.67	78.38	0.013	0.017	5/22/2015 9:35	New construction since lidar flown.	-4.515	451.5	Yes
spot11	72.2383	445472.44	5024379.34	78.29	0.014	0.018	5/22/2015 9:35	New construction since lidar flown.	-6.055	605.5	Yes
spot12	71.9938	445440.09	5024357.86	78.11	0.012	0.017	5/22/2015 9:36	New construction since lidar flown.	-6.113	611.3	Yes
spot132	89.5475	444254.19	5010748.82	89.44	0.012	0.02	5/22/2015 12:51	New construction since lidar flown.	0.103	10.3	
spot133	89.4734	444253.35	5010740.29	89.61	0.014	0.019	5/22/2015 12:51	New construction since lidar flown.	-0.133	13.3	
spot134	89.7868	444259.14	5010732.80	89.80	0.01	0.02	5/22/2015 12:52	New construction since lidar flown.	-0.014	1.4	
spot135	89.9828	444264.95	5010725.46	90.02	0.013	0.02	5/22/2015 12:52	New construction since lidar flown.	-0.033	3.3	
spot136	90.0235	444262.52	5010717.18	90.13	0.013	0.02	5/22/2015 12:53	New construction since lidar flown.	-0.103	10.3	
spot137	90.32	444255.51	5010710.94	90.27	0.013	0.02	5/22/2015 12:53	New construction since lidar flown.	0.049	4.9	
spot138	90.3889	444246.54	5010710.47	90.36	0.013	0.02	5/22/2015 12:53	New construction since lidar flown.	0.028	2.8	
spot139	90.5143	444239.39	5010707.02	90.54	0.013	0.02	5/22/2015 12:53	New construction since lidar flown.	-0.022	2.2	
spot140	90.465	444235.41	5010700.49	90.57	0.013	0.02	5/22/2015 12:54	New construction since lidar flown.	-0.103	10.3	
spot141	90.7211	444244.22	5010702.73	90.72	0.013	0.02	5/22/2015 12:54	New construction since lidar flown.	0.001	0.1	
spot142	90.5453	444233.67	5010695.77	90.60	0.012	0.019	5/22/2015 12:55	New construction since lidar flown.	-0.058	5.8	
spot143	90.6992	444233.59	5010686.76	90.68	0.012	0.019	5/22/2015 12:56	New construction since lidar flown.	0.021	2.1	
spot144	90.7584	444235.99	5010678.50	90.65	0.013	0.019	5/22/2015 12:56	New construction since lidar flown.	0.111	11.1	

spot145	90.6809	444237.60	5010670.72	90.73	0.013	0.02	5/22/2015 12:56	New construction since lidar flown.	-0.048	4.8	
spot146	90.8329	444240.41	5010663.58	90.76	0.013	0.02	5/22/2015 12:57	New construction since lidar flown.	0.073	7.3	
spot147	90.9123	444244.24	5010656.51	90.81	0.013	0.02	5/22/2015 12:57	New construction since lidar flown.	0.106	10.6	
spot148	90.9616	444249.25	5010649.39	90.86	0.013	0.02	5/22/2015 12:57	New construction since lidar flown.	0.101	10.1	
spot149	90.7602	444255.33	5010642.76	90.83	0.01	0.02	5/22/2015 12:58	New construction since lidar flown.	-0.065	6.5	
spot150	90.7513	444262.02	5010637.13	90.64	0.012	0.02	5/22/2015 12:58	New construction since lidar flown.	0.107	10.7	
spot151	90.2271	444269.93	5010632.64	90.46	0.012	0.02	5/22/2015 12:59	New construction since lidar flown.	-0.231	23.1	
spot152	89.9242	444277.83	5010627.98	90.24	0.012	0.02	5/22/2015 12:59	New construction since lidar flown.	-0.320	32.0	
spot153	89.8031	444265.55	5010739.62	90.08	0.012	0.019	5/22/2015 13:13	New construction since lidar flown.	-0.278	27.8	
spot154	89.8793	444270.23	5010732.41	90.10	0.011	0.018	5/22/2015 13:13	New construction since lidar flown.	-0.222	22.2	
spot155	89.9609	444271.93	5010723.23	90.23	0.012	0.017	5/22/2015 13:13	New construction since lidar flown.	-0.271	27.1	
spot156	89.9044	444266.34	5010715.91	90.25	0.012	0.018	5/22/2015 13:14	New construction since lidar flown.	-0.341	34.1	Yes

Appendix C

Buildings and Islands in Floodplain – RVCA Policy

Ferdous Ahmed

From: Ewan Hardie
Sent: Wednesday, June 29, 2016 10:35 AM
To: Ferdous Ahmed
Subject: Buildings in the Floodplain Guidelines

Hi Ferdous,
As discussed at recent meetings please consider the following guidelines when undertaking floodplain mapping projects

Effective June 13th 2016, when plotting floodlines RVCA staff will use the following guidelines in order to apply a conservative approach to the delineation of the regulatory floodplain, specifically in areas that have buildings that are in the floodplain or affected by the floodplain:

1. Include any buildings in the floodplain that have any part of the footprint touching the floodplain. This is done to be conservative based on the lack of knowledge on the conditions around the buildings: soil conditions, window wells, walk out doors, building egress are all not known at the time of a floodplain mapping study so it is wise to adopt a conservative approach and include building footprints in the floodplain.
2. With regards to dry islands in and around buildings, islands will be removed if they did not meet the minimum mapping unit acceptable for the data. An envelope of 2 metres around building footprints is to be considered. If the floodplain comes close to or is in this 2m building envelope the entire envelope should be included in the floodplain. This approach is also consistent with the above approach (building footprints) in that the lack of knowledge of the conditions around the building forces the uses of a conservative approach, which is to remove the islands
3. In cases where a building has been included in the floodplain (because of the above criteria), the adjacent building will need to be included in the floodplain as well because of a lack of data in between the buildings and/or the 2m building envelope rule.
4. In the case of townhome or connected type buildings and the floodplain touching the foundations, the building footprint should be included up to the next visible unit partition where the elevation changes

Thanks

Ewan Hardie

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Ferdous Ahmed

From: Ewan Hardie
Sent: Thursday, July 6, 2017 5:12 PM
To: Ferdous Ahmed
Cc: Brian Stratton
Subject: Floodplain delineation guidance

Good Afternoon Ferdous,

As discussed here is the documentation of the guidance that was given to RVCA staff when it comes to plotting floodlines using LiDAR data for this most recent project.

Guidance:

When delineating the regulatory flood water levels, RVCA staff will follow a precautionary principle to include island areas in the floodplain that are up to 1000 square metres.

Ewan Hardie

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