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Technical Memorandum

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Subject: **Flood Risk and Generic Regulation Limits Mapping along Otter and Hutton Creeks**

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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 Otter Creek (from Otter Lake outlet to the Rideau River) and Hutton Creek (from the Motts Mills Dam to its confluence with Otter Creek). The project has been done in accordance with the technical guidelines set out under the Canada-Ontario Flood Damage Reduction Program (FDRP) (MNR, 1986), and the technical guide for the flood hazard delineation in Ontario (MNR, 2002) as laid out by the Ontario Ministry of Natural Resources. The regulation limit mapping – combining flood, steep slope and wetland hazards – has been completed in accordance with Conservation Ontario (2005) guidelines and RVCA's (2005) internal reference manual.

The 1:100 year flood risk lines and regulation limit 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

Introduction

This report provides a summary of the analytical methods used and underlying assumptions applied in the preparation of flood plain mapping for Otter Creek from Otter Lake outlet to the Rideau River and Hutton Creek from Motts Mills Dam to its confluence with Otter Creek. 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.

This study was undertaken because this area is experiencing development pressure and because required data for hazard delineation is in place.

The regulation limit mapping – combining the flood risk, steep slope and wetland hazards – has been completed in accordance with Conservation Ontario (2005) guidelines and RVCA's (2005) reference manual.

The 1:100 year flood risk lines and regulation limit 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 discharge values derived from long term simulations using the RVCA's Mike11 model are our best estimate, at the present time, of expected flows during flood events of given return periods at key locations within the Otter-Hutton system, and have been used for flood risk calculations.

Previous Studies

There has been no study in the past specifically addressing the flood or other hazards along the Otter and Hutton creeks. However, a number of hydrotechnical studies were done in adjacent areas that are helpful in setting the context.

The reach of the Rideau River (Smiths Falls to Kars) was mapped in 1976 using a backwater calculation model named RBACK (James F. McLaren 1976). Only the 1:100 year flood levels were computed and plotted on a 1:5,000 scale map. As the Otter-Hutton system empties into the Rideau River, the flood levels computed in this study is used as the downstream boundary condition for the present study.

Major tributaries of the Rideau River from Smiths Falls to Kars were mapped by James F. MacLaren (1983) on behalf of the RVCA. Spring floods of nine tributaries including Otter Creek were estimated by first estimating the mean annual flood as a function of watershed characteristics; and then estimating the design floods by multiplying the mean annual flood by a factor, which in turn was determined by a frequency analysis of the pooled data from a number of streams in this region. We may note that this method, although appropriate at that time considering available data and technology, was rather crude with many assumptions and approximations. Furthermore, uncalibrated HYMO models were used at representative tributaries to estimate the rainfall-generated summer flows. Comparing spring and summer floods, it was concluded that the spring floods are larger for the tributary basins investigated with area ranging from 4.0 to 50.9 square miles (10.3 to 131.8 km^2). Thereafter, the spring floods were used to calculate the flood levels. The hydraulic computation was done using the HEC-2 model, and the floodplain plotted on phot-mosaic sheets. About 3 km of Otter Creek was mapped for an estimated 1:100 year flow of 94.3 cms (3330 cfs).

An operational review of the Motts Mills Dam at the outlet of Hutton Marsh was completed by RVCA (2009), which, among other things, dealt with hydrological aspects of the dam. The flood flow and the corresponding head water level behind the dam were calculated. The purpose of this study was to assemble pertinent information to help decide the future of this 60 years old dam.

In a recent study, RVCA (2010a) estimated and compared flood flows at the outlet of all significant lakes using various methods for the purposes of determining regulatory flood levels. It was recommended that the Regional Frequency Analysis Method of the FDRP (MNR 1986) be adopted for this purpose, in the absence of more detailed information and site-specific analysis. Otter Lake was included in this study, along with 90 other lakes.

Furthermore, in 2011, a detailed study on the Otter Lake was done by RVCA (2011a), in which flood flows using various methods were computed. It was found that the RVCA's Mike11 model, which is the most detailed representation of the watershed hydrology and utilized all available data, produces the most appropriate flood flows and therefore the best estimate of flood elevation in the case of Otter Lake. This Mike11 model, after further refinement, is used in the present study for hydrologic calculations.

Study Area

The study area extends along the entire length of Otter and Hutton creeks from the Rideau River to the Otter Lake and Hutton Marsh respectively (Figure 1). The following streams were included in this study:

- Otter Creek – from Otter Lake outlet to Rideau River (25 km)
- Hutton Creek – from Motts Mills Dam to Otter Creek (15 km)

The area mapped includes lands within the Township of Rideau Lakes and the Township of Elizabethtown-Kitley.

Topographical Mapping

High quality topography is the key to high quality flood risk mapping. For this study, digital elevation models and one metre elevation contours were derived from low altitude aerial photography.

Aerial photo: The DRAPE imagery was collected in May-July 2008 at a scale of 1:16,667. This high quality colored photo clearly shows the rivers, creeks, land use, houses, buildings, roads, infrastructure, vegetation and other details.

DTM: Aeroquest Mapcon (2013) was commissioned by RVCA to produce a DTM from the 2008 DRAPE imagery (Figure 2) for flood mapping purposes according to the specifications of the FDRP program (MNR, 1986). Contour lines were drawn at 1.0 m intervals with 0.5 m interpolated lines. Other standard layers showing bridges, depressions, etc. were also produced.

About 188 spot heights were collected by RVCA technicians in 2013 using survey grade GPS equipment (Trimble R8). This data, in addition to ground control points, was used by Aeroquest Mapcon to confirm that the DTM met the FDRP specifications. 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; for contour crossings, it is 0.50 m.

Hydrological Analysis

A watershed modeling approach using long term simulation has been taken to estimate flood discharges in the Otter-Hutton system for various flood frequencies (or return periods).

Determining design floods using long-term watershed simulation is a relatively new approach that is increasingly being used around the world to estimate flows for ungauged basins where long-term climatic data is available. The advantages of this method and its recent uses are described by Boughton and Droop (2003), DEFRA (2005) and Lamb (2005). Advantages of this method over traditional event-based methods are numerous and varied. The main advantage is the automatic accounting of antecedent moisture condition at every time step, which is also taken into account in event-based designs but in a rather arbitrary and/or conservative way. Integrated watershed models, like Mike11 used here, can furthermore account for the heterogeneity of basins, river and lake attenuation, varied response time of basins, water control structures and their operation policies. With the development of sophisticated watershed modeling techniques and increasing computer power, this method is now being increasingly used in Europe, Australia, the United States and South Africa. At RVCA, we have started the use of continuous simulation method, and, in the last few years, have actually used it for floodplain management along the Tay River (RVCA 2010b, 2013) and various inland lakes (RVCA 2011a, 2011b, 2012a, 2012b, 2012c).

Use of this watershed modeling approach using long term simulation for the Otter-Hutton system is based on the following considerations:

a) There is no streamflow measurement in this area.
b) Recently, RVCA has installed automatic water level recorders at Otter Lake and Hutton Marsh. So far, we have about 3 years of water level data. This limited amount of data is not suitable for any statistical analysis.
c) Local residents have been recording water levels at the Otter Lake Road culvert on a non-continuous basis since 2003. These data may or may not include actual annual maximum water levels, and the period of record is

short (10 years). Statistical analysis methods (frequency analysis) cannot therefore be used.

d) Stream flows in the study area are influenced by the attenuating effect of natural storage in lakes and wetlands.

e) Runoff is contributed to small streams from a number of subwatersheds that connect to the creeks within the study area, each with its own hydrologic characteristics such as runoff volume to drainage area ratio, and hydrograph peakedness. This leads to spatial and temporal differences in hydrologic response, which Mike11 model can capture.

f) In a detailed study on the Otter Lake (RVCA, 2011a), a number of flow estimation techniques were compared, and the flood quantiles derived from the Mike11 model were found most appropriate for flood risk determination on the shorelines of Otter Lake. This inference was based on a number of technical reasoning, such as the consistency of the Mike11 results with measured water level data at Otter Lake, consideration of the runoff volume generated during 1:100 year storm events, and the ability of Mike11 model to take into account lakes and structures.

g) In areas within RVCA with limited streamflow measurement, the Mike11 model has been successfully used for deriving flood quantiles suitable for flood risk mapping (RVCA, 2010b, 2011a, 2011b, 2012a, 2012b, 2012c, 2013). Both rivers and lakes have been mapped using this technique.

h) An integrated model such as Mike11 lends itself to suitable modifications that allow one to estimate and examine the effects of man-made infrastructure such as road, bridge, culvert and dam. In other words, it is relatively easy to compute both existing and naturalized flows.

Using the watershed modeling approach (described in more details later in this report), the Mike11 model of the Otter-Hutton system was used to generate long term synthetic streamflow records at key locations within the watershed (Figure 5). Figure 3 shows the catchments and hydrodynamic line of the Mike11 model. Figure 6 shows the simulated flow and water level series at Otter Lake as an example. Annual maximum flows were then extracted from the synthetic streamflow record and subjected to a statistical analysis to estimate flows for various flood frequencies at those locations.

An integrated hydrologic/hydraulic model of the Middle Rideau Watershed was originally developed during 2004-2007 as reported in RVCA (2007). The original Mike11 model, encompassing the whole Middle Rideau subwatershed including the Otter-Hutton system, was built at a regional scale and did not account for many smaller features (such as road crossings, Otter Lake outlet and the Motts Mills Dam). As a part of this study, a new local-scale model for the Otter-Hutton system was built which incorporated all of these. This system was simulated from 1940 to 2011 (as dictated by the availability of data), producing 72 years of simulated flow data at key locations. The frequency analysis was done using the CFA program of Environment Canada (Pilon and Harvey, 1993); the flood quintiles derived from this analysis are listed in Table 1 and plotted in Figures 9 and 10. Figures 7 and 8 compare the flows at the outlet of Otter Lake and at the Motts Mills Dam to previous estimates.

The rainfall-runoff module of the Mike11 model (NAM) simulates various processes of runoff generation. The theoretical background and modeling methodology are given in DHI (2004) and DHI (2003) respectively; interested readers are referred to these documents for the full detail. Very briefly, NAM represents various components of the runoff-generating phenomenon by continuously accounting for the water content in four different storages, each of which represents a different physical element of the catchment (snow, surface, lower zone and groundwater storage). Rainfall, potential evapotranspiration and temperature are needed to run the model, while nine parameters are used to characterize the physical features of the catchment such as land use, vegetation, soil type, etc. As described in RVCA (2007), the parameters have been determined through autocalibration of the entire Middle Rideau watershed at Andrewsville gauge location (02LA011; also known as Below Merrickville), and then adjusted as warranted by local conditions for individual subwatersheds. The snowmelt component of the NAM module – important for cold regions with high spring freshet – uses a simple degree-day method. Snow accumulation and melt are calculated based on the precipitation and temperature.

This updated model for the Otter-Hutton system (called Update 2014A[1]) was used to simulate the long-term flow series for a period from 1940 through 2011. The NAM parameters – mostly taken from earlier studies (RVCA, 2007, 2011a) – are listed in Table 5. The wetlands are shown in Figure 4, whose characteristics are reflected in the NAM parameters. The hydrodynamic component of the Mike 11 accounts for the hydrologic routing of flow (once it enters the river system) in channels and other significant waterbodies, and the man-made controls at their outlets (Otter Lake culvert and Motts Mills Dam). The model comprises of the following features:

- 4 catchments modeled by NAM module
- 31 km of Otter Creek (102 cross-sections)
- 15 km of Hutton Creek (48 cross-sections)
- Otter Lake and its outlet (culvert under Otter Lake Road)
- Hutton Marsh and Motts Mills Dam[2]
- 18 culverts and 5 bridges

The model computed daily time series of flow and water level along the hydrodynamic network (Figure 3). The flow data were extracted at key locations (Figure 5) and were then subjected to standard flood frequency analysis. The CFA program of Environment Canada (Pilon and Harvey, 1993) was used; various frequency distributions were visually inspected to determine the most appropriate distribution at each flow calculation node. The design floods with various return periods are shown in Table 1. The model was simulated from 1940 through 2011, thus providing 72 years of synthetic data for the flood frequency analysis.

The Mike11 model was used to simulate the following 4 scenarios:

1. Baseline (existing condition; 'regulated'; all road crossings and dams (e.g., outlet culvert of Otter Lake and Motts Mills Dam at the outlet of Hutton Marsh) included)
2. Naturalized ('unregulated' condition; no dams, no road crossings)
3. Test 1 (Baseline; but no road crossings; only dams)

[1] So called because a similar Mike11 model was built previously by RVCA (2011a) for the same area.
[2] Excerpts from RVCA (2009), detailing the configuration of Motts Mills Dam and associated computation, are included in Appendix D. This computational procedure was incorporated in the Mike11 model.

4. Test 2 (Baseline; but no dams; only road crossings)

Estimated flood flows for all four scenarios are tabulated in Tables 1 to 4 and plotted in Figures 11 and 12.

Both FDRP (MNR, 1986) and Hazard Guidelines (MNR, 2002) guidelines suggest using the naturalized flow as opposed to the regulated flow when there is a significant difference between them.

The FDRP Manual (MNR, 1986) states: "In flood frequency analysis of peak flows, the initial assumption is made that floods are natural events that can be described by a particular probability distribution. If man has imposed his will upon a stream in such a way as to affect peak flows, then they are no longer natural events and no distribution is applicable. Thus, the first step in undertaking a frequency analysis is the conversion of regulated stream flows to natural conditions. This is achieved by removing the effect of regulatory installations, such as dams and diversions, if they have a significant influence on the flood peak. If their influence is small, however, conversion is not required, but it is always necessary to estimate their effect prior to judging the significance thereof."

The subsequently published Hazard Guidelines (MNR, 2002) states: "In flood frequency analysis of peak flows, the initial assumption is made that floods are random and independent events that can be described by a particular probability distribution. If a stream is regulated sufficiently to affect the resulting peak flows, then they are no longer random and independent events; a probability distribution which assumes randomness and independence is not applicable. The first step in undertaking frequency analysis is to determine the influence of regulation on the streamflows. If necessary, the conversion of regulated streamflows to natural conditions is achieved by removing the effect of dams and diversions. … Downstream of the culvert or bridge, the natural flood line should be used for delineating the flood hazard, making no allowance for the temporary upstream ponding."

In the case of Otter-Hutton system, the difference between regulated and naturalized flows was found to be substantial – in the order of 5 to 30% (see Tables 1 and 2).

It was, therefore, decided that the <u>naturalized</u> flows would be used for the purposes of flood hazard mapping.

The flows listed in Table 1 have been used in the hydraulic analysis for the flood mapping of Otter and Hutton creeks, as described in the following pages.

MNR (2002) recommends that the attenuating effect of temporarily detained waters upstream of road embankments should not be taken into account for the calculation of flood discharges. Test 1 simulates such a situation without road crossings but with dams; this generates flows very close to those under existing or regulated condition. Test 2 on the other hand, with road crossings but without dams, produces flows slightly less than naturalized flows. All this indicates that for the Otter-Hutton system, the dams significantly reduce the downstream flood magnitude, but the current road network has no significant impact. However, the use of 'naturalized' flows in flood risk delineation – as done here – ensures that the downstream risk assessment and development decisions based on it do not become contingent on the continued presence or modifications of the dams (e.g, Otter Lake outlet culvert and Motts Mills Dam).

Hydraulic Computations

Following standard procedures (MNR, 1986; USACE, 1990, 2010), a steady-state hydraulic model of Otter and Hutton creeks was built. The HEC-RAS model (version 4.1.0) developed by the US Army Corps of Engineers (USACE, 2010) was used. This has 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.

<u>Cross-Sections</u>: River and flood plain cross-sections – the basic building blocks of hydraulic models – were generated from the high quality DTM using standard GIS software. For the most part, this procedure captured the floodplain as well as the low flow channel in sufficient detail to be used in floodplain mapping. However, in some places, especially near road crossings, the low channel was adjusted based on field observation.

In total, 144 cross-sections were used in the model. Distances between sections along the stream center and left and right overbanks were calculated using GIS software. Bridges and culverts were inserted at appropriate locations.

Channel Roughness: Following standard procedures (Chow, 1959), the resistance of the channel under possible high water conditions was estimated from aerial photos and field inspections. The Manning's roughness coefficient was generally 0.035 in the main channel, and varied from 0.05 to 0.08 for the floodplains. These values were then further adjusted during the calibration process. The final values are listed in Table 16.

High Water Level: On three occasions during the 2015 spring freshet, measurements of water level at 13 road crossings along the creeks were taken. These data were used in the calibration and validation of the hydraulic models.

Bridges/Culverts: Starting in 2014, RVCA staff conducted a survey of the 24 bridges and culverts (Table 6) crossing the streams within the study area. Their physical dimensions and other pertinent data were collected by ground survey, or taken from other sources when appropriate. The coefficients of contraction and expansion associated with bridges/culverts were estimated from available information using standard procedures (USACE, 1990, 2010). Appendix C contains pictures of some of the structures.

The design flows from the hydrologic analysis (discussed above), with return periods ranging from 2 to 500 years (Table 7), were used in the HEC-RAS model. The boundary conditions, i.e., water levels (Table 8) at the downstream end (Otter Creek, Cross-section 5), were taken or estimated from the James F. MacLaren (1976) report and Parks Canada's navigation level (Acres, 1994). The confluence of Otter and Hutton creeks was designated as an internal junction with matching water levels in accordance with accepted procedures (USACE, 1990, 2010).

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 and culverts. During the calibration process, adjustments of model parameters – mainly the channel and floodplain resistance and contraction and expansion coefficients – were made as necessary.

Calibration:

During the spring of 2015, high water measurements at key locations were taken on three separate days:

- 10 April 2015

- 17 April 2015
- 5 May 2015

Using the measured water level data of May 5th (deemed the best), the model was calibrated, mainly by adjusting the Manning's roughness coefficient of the main channel and occasionally of the flood plain (Table 9, Figures 13 and 14).

This usually sufficed except in the reach between Farm Crossing 1 and Anglican Church Road, where the make-shift structure under Farm Crossing 1 (Figure 15) – comprising of three irregular culverts and the large leaks in between big rocks – could not be satisfactorily modeled. Here, in addition to the three culverts, we introduced a fictitious box culvert to capture the flow through the leaks (Figure 15). This approach worked well and a satisfactory calibration was achieved.

Since there is no flow measurement, the measured water level in the Otter Lake was used – in combination with the outlet structure configuration – to calculate the flow at this location. Flows at other locations were then estimated using the ratios that were calculated from the estimated flows for different return periods (Table 1). The same was done at the Motts Mills Dam. These flows for May 5th – estimated not measured (Figures 16 and 17) – were then used in the HEC-RAS model to compute water levels and energy grades. The measured water level near the Rideau River was used as the downstream boundary condition.

During May 5th (a roughly 2 year event), high water levels were collected by RVCA staff using photographs and survey grade Trimble. These water level data and the estimated flows were then used to calibrate the HEC-RAS model. As shown in Table 9, the model could be adjusted to compute water level with a reasonable degree of accurately. It yields a slightly conservative overall estimate of water level (3-4 cm).

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 predicts elevations within 30 cm of observation; whereas FEMA (US Federal Emergency Management Agency) suggests a 15 cm tolerance (Heastead Methods 2003; Bentley Systems 2007). Our model adequately satisfies both criteria at most of the locations. Our approach of slight conservatism 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).

Validation:

After the calibration was done, the model was run for two validation events (17^{th} April and 10^{th} April). The measured water level data and the estimated flow data were the used to run the model. The results are shown in Tables 10 and 11 and in Figures 13 and 14. The first validation (17^{th} April) was as good as the calibration, while the second validation (10^{th} April) exhibited a somewhat inferior performance, with average discrepancy of -11 and 13 cm for the Otter and Hutton creeks respectively. However, the performance is within the acceptance tolerance of 15-30 cm.

Based on the calibration and two validations and the fact that no flow measurements are available, we conclude that the model is good enough for the purposes of flood plain mapping.

Once calibrated and validated, the model was run with the design floods. Typical water surface profiles and all cross-sections are included in Appendices A and B. Head losses at road crossings as computed by the model are listed in Table 12. The 1:100 year computed water surface elevations and other parameters are shown in Table 13.

Computed water surface elevations for various flood events with return periods ranging from 2 to 500 years are presented in Tables 14 and 15. It should be pointed out that the model has been calibrated for events with small flows (in the order of 2 years or less); therefore the water surface elevations for other events – simulated using the same parameters, especially the Manning's roughness coefficient – are only approximate but are expected to be on the conservative side. This is because the river roughness varies with flow magnitude, with higher resistance associated with lower flows.

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.

Sensitivity Analysis:

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

- 1:100 year flow increased by 10%
- 1:100 year flow increased by 20%
- 1:100 year flow increased by 30%
- 1:100 year flow decreased by 10%
- 1:100 year flow decreased by 20%
- 1:100 year flows decreased by 30%

Figures 18 and 19 show the computed water surface profiles and the differences in computed water levels for each condition. Figures 20 and 21 indicates that the computed water surface elevations are more sensitive to the discharge value near the bridges, which is typically observed and is caused by the constriction and high velocity, and thus the dominance of inertia in relation to bed resistance. However, the bridge constriction should not be counted on for the subdued change in water level, since the modification or removal of a bridge can cause the water level to bounce back to the "normal position".

The sensitivity analysis indicates that the computed water level can vary by about 5 to 15 cm for a 20% variation in flow, which is typical in the hydrologic estimation of design flow. For a 30% increase in flow, the water level can go up by 25 cm at some locations.

The sensitivity analysis has demonstrated that the RVCA's policy of requiring a minimum of 0.30 centimetres of freeboard in the design of flood-proofing measures for buildings and structures within or adjacent to flood prone areas will generally be sufficient[3]. It also provides an indication of the potential effect of changes in the expected flood flows that might result from more gradual trends such as climate change.

Selection of Regulatory Flood Levels

As per Section 3 of the Provincial Policy Statement under the Planning Act (MMAH 2005, 2014), the regulatory flood in Zone 2, which includes the RVCA, is the 1:100 year flood. Depending on the local hydraulic conditions, the computed water surface elevation, the energy grade or a value in between is generally taken as the Regulatory Flood Level (RFL). Engineering judgment is applied to recommend an appropriate value for the regulatory flood level at each cross-section, using the model outputs and considering hydraulic characteristics of the river reach, and the inherent limitations of the numerical model.

When the stream velocity is relatively low and varies only gradually over relatively long river reaches, the 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 streamflow

[3] In the absence of any streamflow data within the Otter-Hutton area, the present hydrologic analysis is based on a Mike11 model, which was originally calibrated for the Middle Rideau Subwatershed, a much larger basin. Calibration of hydraulic model is again based on estimated flows, not measured flows. The resulting flood risk delineation has thus been without the benefit of measured streamflow data, and contains a higher degree of uncertainty. As such, proponents of substantial development in this area should use more caution than usual in selecting the freeboard. We recommend using a higher freeboard commensurate with the level of protection desired.

velocity and depth (and hence energy state) from one cross-section to the next. Accordingly, the regulatory flood level at the upstream cross-section is taken to be equivalent to the downstream water surface elevation in these situations.

In all cases, the RFL is always between the computed water level and energy grade line. Hence, for the sake of simplicity and consistency, the energy grade elevation is often used as the RFL in delineating flood hazard areas. The use of energy grade as the RFL has been RVCA's standards practice during the last few years.

For the present study, the regulatory flood levels were set equal to the computed energy grade and are tabulated in Table 13, along with the computed water surface elevations and energy grades at each cross-section in the model[4].

Flood Line Delineation

Plotting of 1:100 year flood lines or flood risk limits was carried out using RFLs. Given the topographical information in the form of contour lines at 0.5 m interval, the inundated area below the RFLs was delineated manually or by using automated computer programs. In the present case, it was done manually because of the complexities of the topography and flow paths. However, this was cross-checked with the flood lines generated using the HEC-GeoRAS program version 4.3.93 (USACE, 2011), which has the ability to plot flood lines on topographical maps. This gave us an additional degree of quality control.

The flood lies for Otter Creek has been plotted from the downstream side of Otter Lake Road to the upstream side of Jasper Road. For Hutton Creek, it is from the downstream side of the Motts Mills Dam to the confluence with Otter Creek.

<u>Buildings in the floodplain:</u>

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

[4] The HEC-RAS model extended beyond the area where regulatory flood levels (RFL) were sought. Thus, no RFL has been assigned in the Otter Lake, Hutton Marsh or along Otter Creek downstream of Jasper Road.

(Appendix E), 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 arises for accurate flood line delineation near buildings, site-specific information be taken into account when dealing with flood risk at these locations. It is the practice of RVCA to refine flood lines when more accurate information becomes available.

<u>Flood mapping data in GIS:</u>

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. Figures 22 and 23 show the floodplain, cross-sections, contour lines, and the RFL along the Otter and Hutton creeks respectively.

Regulation Limit Lines

In keeping with the Generic Regulation (O.Reg. 97/04), regulation limits are delineated based on the natural hazards (flooding erosion, unstable soil or bedrock) or hazardous features (wetland, lakeshore or valley) with the largest upland extent, including applicable allowances. It is RVCA's practice to draw regulation lines as and when hazard information becomes available.

In the Otter-Hutton area, we have now the following information:

- Flood hazard delineation (as determined during this study)
- Steep slope hazard (as determined during this study)
- Wetlands (as per 2010 MNR information)
- There is no information on other types of hazards

Based on the above information, the regulation limits have been plotted along the Otter and Hutton creek corridors (see RVCA Regulation Map No. 142, 143, 157, 158, 159, 175 and 176 – published simultaneously with this report). These maps show the regulation limits as well as other pertinent hazard limits. This regulation limit lines are drawn in accordance with the guidelines set by Conservation Ontario (2005) and RVCA's own internal protocol (RVCA 2005) as depicted in Figures 24 and 25. Note that the regulation lines takes into account all hazards associated not only with Otter and Hutton creeks, but other streams in this vicinity such as the Rideau River. It is noted that wetlands are generally the most dominant hazard in this area.

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

Project Deliverables

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

1) The Flood/Regulation 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)
3) The HEC-RAS model files (input and output)
4) The position and orientation of cross-sections used in the HEC-RAS model, in GIS format (shape files) – which, when used in conjunction with the HEC-RAS model output files and Table 13, 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
5) The RVCA Regulation Limit Map Sheet No. 142, 143, 157, 158, 159, 175 and 176
6) The regulation limit lines in GIS format (shape files)

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

Closure

The hydrotechnical and cartographic procedures used in this study generally conform to present day standards for flood hazard delineation, as set out in the MNR's Natural Hazards Technical Guide (MNR, 2002). The regulation limit lines have been drawn according to the guidelines of Conservation Ontario (2005) and RVCA's own procedures (RVCA 2005). The resulting 1:100 year flood lines and generic regulation limit 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.

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Table 1 Estimated flood quantiles based on Mike11 simulation (Naturalized condition; no dams, no crossings)

		Otter Creek just downstream of the Otter lake outlet culvert	Otter Creek Upstream of Angilican Church Road	Otter creek upstream of Kelly's Road	Otter creek upstream of Hunter's Road	Otter Creek Just Upstream of the confluence with Hutton Creek	Otter Creek downstream of the confluence with Hutton Creek	Hutton Creek downstream of the Motts Mill dam	Hutton Creek just upstream of a Private Crossing.	Hutton Creek between H22 and H24	Hutton Creek just upstream of County Road 29	Hutton Creek just upstream of Kitly Line 1	Hutton Creek just upstream of townline Road	Hutton Creek just upstream of the confluence with Otter Creek
	Extraction point ID	**O21**	**O22**	**O23**	**O24**	**O25**	**O26**	**H21**	**H22**	**H23**	**H24**	**H25**	**H26**	**H27**
Return period (years)	1.003	1.29	1.69	2.13	2.95	3.60	6.18	1.26	1.39	1.63	1.86	1.87	2.30	2.49
	1.05	1.79	2.46	3.00	4.16	5.12	8.98	1.69	2.08	2.41	2.77	2.95	3.44	3.82
	1.25	2.33	3.23	3.91	5.42	6.66	11.80	2.18	2.75	3.17	3.67	3.94	4.57	5.07
	2	3.07	4.25	5.13	7.08	8.69	15.40	2.93	3.58	4.13	4.77	5.15	5.96	6.59
	5	4.08	5.63	6.75	9.26	11.30	19.80	4.07	4.57	5.27	6.08	6.62	7.61	8.41
	10	4.75	6.55	7.81	10.60	13.00	22.40	4.91	5.15	5.94	6.85	7.51	8.58	9.50
	20	5.40	7.44	8.80	11.90	14.50	24.90	5.77	5.67	6.54	7.53	8.29	9.44	10.50
	50	6.24	8.60	10.10	13.60	16.50	27.90	6.99	6.28	7.25	8.34	9.23	10.50	11.70
	100	**6.88**	**9.47**	**11.00**	**14.80**	**17.90**	**30.00**	**7.98**	**6.71**	**7.75**	**8.91**	**9.87**	**11.20**	**12.50**
	200	7.54	10.30	12.00	16.00	19.40	32.00	9.05	7.12	8.23	9.44	10.50	11.80	13.40
	500	8.42	11.50	13.30	17.70	21.20	34.70	10.60	7.63	8.83	10.10	11.20	12.70	14.40
	Adopted Distribution*	**LP3**	**GEV**	**LP3**	**LP3**	**3PLN**	**LP3**	**LP3**	**LP3**	**LP3**	**LP3**	**GEV**	**LP3**	**3PLN**

*Flood frequency distribution used: GEV (Gumbel Extreme Value), 3PLN (Three Parameter Log Normal), LP3 (Log Pearson Type III), and WBY (Wakeby)

Note: Mike11 model (Update 2014A) was run from 1935 through 2011; frequency analysis was performed on 72 years of simulated data (1940-2011)

Table 2 Estimated flood quantiles based on Mike11 simulation (Regulated condition, with dams, with crossings)

		Otter Creek just downstream of the Otter lake outlet culvert	Otter Creek Upstream of Angilican Church Road	Otter creek upstream of Kelly's Road	Otter creek upstream of Hunter's Road	Otter Creek Just Upstream of the confluence with Hutton Creek	Otter Creek downstream of the confluence with Hutton Creek	Hutton Creek downstream of the Motts Mill dam	Hutton Creek just upstream of a Private Crossing.	Hutton Creek between H22 and H24	Hutton Creek just upstream of County Road 29	Hutton Creek just upstream of Kitly Line 1	Hutton Creek just upstream of townline Road	Hutton Creek just upstream of the confluence with Otter Creek
	Extraction point ID	**O21**	**O22**	**O23**	**O24**	**O25**	**O26**	**H21**	**H22**	**H23**	**H24**	**H25**	**H26**	**H27**
Return period (years)	1.003	1.02	1.32	1.82	2.62	3.25	5.67	1.02	1.26	1.48	1.73	1.74	2.16	2.36
	1.05	1.51	2.09	2.63	3.77	4.70	8.37	1.56	1.93	2.25	2.61	2.79	3.27	3.64
	1.25	2.01	2.80	3.44	4.93	6.13	11.10	2.09	2.59	3.01	3.49	3.76	4.37	4.86
	2	2.63	3.69	4.48	6.39	7.95	14.40	2.76	3.42	3.96	4.58	4.95	5.74	6.36
	5	3.40	4.78	5.77	8.20	10.20	18.50	3.56	4.41	5.10	5.89	6.42	7.38	8.17
	10	3.87	5.45	6.56	9.30	11.60	20.90	4.03	5.00	5.77	6.67	7.30	8.36	9.27
	20	4.29	6.04	7.28	10.30	12.90	23.10	4.44	5.52	6.36	7.35	8.10	9.22	10.30
	50	4.80	6.76	8.16	11.50	14.50	25.70	4.93	6.13	7.07	8.17	9.05	10.20	11.50
	100	**5.17**	**7.27**	**8.80**	**12.40**	**15.70**	**27.60**	**5.28**	**6.57**	**7.57**	**8.75**	**9.70**	**11.00**	**12.30**
	200	5.52	7.74	9.41	13.30	16.90	29.40	5.60	6.98	8.04	9.29	10.30	11.70	13.20
	500	5.97	8.31	10.20	14.40	18.40	31.60	6.00	7.49	8.63	9.98	11.10	12.50	14.30
	Adopted Distribution*	**LP3**	**GEV**	**LP3**	**LP3**	**3PLN**	**LP3**	**LP3**	**LP3**	**LP3**	**LP3**	**GEV**	**LP3**	**3PLN**

*Flood frequency distribution used: GEV (Gumbel Extreme Value), 3PLN (Three Parameter Log Normal), LP3 (Log Pearson Type III), and WBY (Wakeby)

Note: Mike11 model (Update 2014A) was run from 1935 through 2011; frequency analysis was performed on 72 years of simulated data (1940-2011)

Table 3 Estimated flood quantiles based on Mike11 simulation (Test 1, no crossings, only dams)

		Otter Creek just downstream of the Otter lake outlet culvert	Otter Creek Upstream of Angilican Church Road	Otter creek upstream of Kelly's Road	Otter creek upstream of Hunter's Road	Otter Creek Just Upstream of the confluence with Hutton Creek	Otter Creek downstream of the confluence with Hutton Creek	Hutton Creek downstream of the Motts Mill dam	Hutton Creek just upstream of a Private Crossing.	Hutton Creek between H22 and H24	Hutton Creek just upstream of County Road 29	Hutton Creek just upstream of Kitly Line 1	Hutton Creek just upstream of townline Road	Hutton Creek just upstream of the confluence with Otter Creek
	Extraction point ID	**O21**	**O22**	**O23**	**O24**	**O25**	**O26**	**H21**	**H22**	**H23**	**H24**	**H25**	**H26**	**H27**
Return period (years)	1.003	1.02	1.33	1.91	2.79	3.45	5.88	1.02	1.26	1.48	1.73	1.74	2.17	2.37
	1.05	1.51	2.10	2.71	3.95	4.91	8.59	1.56	1.93	2.25	2.61	2.79	3.27	3.65
	1.25	2.01	2.82	3.53	5.11	6.35	11.30	2.09	2.59	3.01	3.49	3.76	4.38	4.87
	2	2.63	3.72	4.58	6.59	8.20	14.70	2.76	3.42	3.96	4.58	4.96	5.75	6.38
	5	3.40	4.85	5.93	8.47	10.50	18.80	3.56	4.41	5.10	5.89	6.42	7.40	8.20
	10	3.87	5.54	6.77	9.63	12.00	21.30	4.03	5.00	5.77	6.67	7.31	8.37	9.30
	20	4.29	6.18	7.54	10.70	13.40	23.60	4.44	5.52	6.36	7.35	8.10	9.24	10.30
	50	4.80	6.95	8.51	12.00	15.00	26.30	4.93	6.13	7.07	8.17	9.05	10.30	11.50
	100	**5.17**	**7.49**	**9.22**	**13.00**	**16.30**	**28.20**	**5.28**	**6.57**	**7.57**	**8.75**	**9.71**	**11.00**	**12.40**
	200	5.52	8.01	9.92	13.90	17.50	30.10	5.60	6.98	8.04	9.29	10.30	11.70	13.20
	500	5.97	8.65	10.80	15.10	19.10	32.50	6.00	7.49	8.63	9.98	11.10	12.50	14.40
	Adopted Distribution*	**LP3**	**GEV**	**LP3**	**LP3**	**3PLN**	**LP3**	**LP3**	**LP3**	**LP3**	**LP3**	**GEV**	**LP3**	**3PLN**

*Flood frequency distribution used: GEV (Gumbel Extreme Value), 3PLN (Three Parameter Log Normal), LP3 (Log Pearson Type III), and WBY (Wakeby)

Note: Mike11 model (Update 2014A) was run from 1935 through 2011; frequency analysis was performed on 72 years of simulated data (1940-2011)

Table 4 Estimated flood quantiles based on Mike11 simulation (Test 2, no dams, only crossings)

	Otter Creek just downstream of the Otter lake outlet culvert	Otter Creek Upstream of Angilican Church Road	Otter creek upstream of Kelly's Road	Otter creek upstream of Hunter's Road	Otter Creek Just Upstream of the confluence with Hutton Creek	Otter Creek downstream of the confluence with Hutton Creek	Hutton Creek downstream of the Motts Mill dam	Hutton Creek just upstream of a Private Crossing.	Hutton Creek between H22 and H24	Hutton Creek just upstream of County Road 29	Hutton Creek just upstream of Kitly Line 1	Hutton Creek just upstream of townline Road	Hutton Creek just upstream of the confluence with Otter Creek
Extraction point ID	**O21**	**O22**	**O23**	**O24**	**O25**	**O26**	**H21**	**H22**	**H23**	**H24**	**H25**	**H26**	**H27**
Return period (years) 1.003	1.29	1.68	2.06	2.78	3.35	5.93	1.36	1.41	1.63	1.87	1.88	2.17	2.48
1.05	1.79	2.45	2.93	4.01	4.91	8.73	1.74	2.08	2.41	2.77	2.95	3.27	3.81
1.25	2.33	3.20	3.83	5.26	6.46	11.50	2.18	2.75	3.17	3.66	3.93	4.38	5.05
2	3.07	4.19	5.01	6.88	8.44	15.00	2.86	3.57	4.13	4.77	5.15	5.75	6.57
5	4.08	5.52	6.54	8.91	10.90	19.30	3.92	4.57	5.27	6.08	6.62	7.40	8.38
10	4.75	6.39	7.52	10.20	12.50	21.90	4.71	5.16	5.94	6.86	7.51	8.37	9.47
20	5.40	7.22	8.42	11.30	13.90	24.20	5.54	5.69	6.54	7.55	8.30	9.24	10.40
50	6.24	8.29	9.56	12.80	15.60	27.00	6.73	6.32	7.25	8.37	9.24	10.30	11.60
100	**6.88**	**9.08**	**10.40**	**13.80**	**16.90**	**29.00**	**7.70**	**6.76**	**7.75**	**8.94**	**9.90**	**11.00**	**12.50**
200	7.54	9.87	11.20	14.80	18.20	30.90	8.76	7.18	8.23	9.49	10.50	11.70	13.30
500	8.42	10.90	12.30	16.20	19.90	33.30	10.30	7.71	8.83	10.20	11.20	12.50	14.40
Adopted Distribution*	**LP3**	**GEV**	**LP3**	**LP3**	**3PLN**	**LP3**	**LP3**	**LP3**	**LP3**	**LP3**	**GEV**	**LP3**	**3PLN**

*Flood frequency distribution used: GEV (Gumbel Extreme Value), 3PLN (Three Parameter Log Normal), LP3 (Log Pearson Type III), and WBY (Wakeby)
Note: Mike11 model (Update 2014A) was run from 1935 through 2011; frequency analysis was performed on 72 years of simulated data (1940-2011)

Table 5 NAM parameters used in Mike 11 model

Sub-catchment Name	Area (km^2)	Umax (mm)	Lmax (mm)	CQOF (-)	CKIF (hr)	CK1,2 (hr)	TOF (-)	TIF (-)	TG (-)	CKBF (hr)
		Maximum water content in surface storage	Maximum water content in rootzone storage	Overland flow runoff coefficient	Time constant for routing interflow	Time constant for routing overland flow	Root zone threshold value for overland flow	Root zone threshold value for interflow	Rootzone threshold value for GW recharge	Time constant for routing baseflow
OTTER LAKE	36.3534	21.1	209	0.106	550	49.7	0.530	0.709	0.295	252
OTTER CR	54.8879	25.1	251	0.103	549	49.7	0.530	0.709	0.295	250
HUTTON CR B	24.5640	24.7	247	0.102	550	49.7	0.540	0.71	0.298	249
HUTTON CR A	33.8725	24.9	249	0.104	552	49.7	0.540	0.71	0.298	249

Table 6 Bridges and culverts

Stream/Reach	Location	Bridge/ Culvert	Chainage (m)	Bounding Cross Sections	Upstream Invert[1] (m)	Downstream Invert[1] (m)	Upstream Obvert[1] (m)	Downstream Obvert[1] (m)	Width[1] (m)	Height[1] (m)	Length[2] (m)
Otter/Reach 1	Otter Lake road[3]	C	22962	2405 & 2400	123.97	124.02	125.72	125.77	2.44	1.75	15.30
Otter/Reach 1	Rideau Ferry road	C	18091	2345 & 2340	122.70	122.62	124.60	124.52	5.84	1.90	10.39
Otter/Reach 1	Black Smith road	C	17961	2335 & 2330	122.52	122.38	123.77	123.63	6.09	1.25	14.30
Otter/Reach 1	HWY 15	C	17773	2320 & 2315	122.20	122.14	123.90	123.84	5.87	1.70	19.55
Otter/Reach 1	Anglican Church road/County road 1	C	17333	2305 & 2300	121.49	121.50	123.89	123.90	7.50	2.40	10.34
Otter/Reach 1	Private crossing #1 Culvert #1	C	16498	2290 & 2285	121.92	122.01	122.52	122.61	Diameter	0.60	2.90
Otter/Reach 1	Private crossing #1 Culvert #2	C	16498	2290 & 2285	121.96	121.84	122.96	122.84	Diameter	1.00	3.00
Otter/Reach 1	Private crossing #1 Culvert #3	C	16498	2290 & 2285	121.85	121.85	122.65	122.65	Diameter	0.80	3.00
Otter/Reach 1	Private crossing #2	C	15644	2275 & 2270	120.67	120.64	122.00	121.97	5.00	1.33	5.00
Otter/Reach 1	Private crossing #3 x 2 Archways	C	15117	2260 & 2255	120.62	120.68	122.12	122.18	1.20	1.50	4.50
Otter/Reach 1	Private crossing #4	C	14546	2245 & 2240	120.45	120.43	121.92	121.90	Diameter	1.47	6.00
Otter/Reach 1	Cataraqui Trail	B	14301	2235 & 2230	119.83	119.83	124.31	124.33	6.50	4.50	3.50
Otter/Reach 1	Kelly's road	C	13451	2210 & 2205	118.47	118.45	120.97	120.95	6.45	2.50	10.86
Otter/Reach 1	Hunter's road	C	6173	2140 & 2135	109.87	109.85	111.97	111.65	7.38	1.80	7.08
Otter/Reach 1	Private crossing #6 Culvert #1	C	5027	2115 & 2110	107.54	107.68	108.54	108.68	Diameter	1.00	8.80
Otter/Reach 1	Private crossing #6 Culvert #2	C	5027	2115 & 2110	107.59	107.67	108.59	108.67	Diameter	1.00	8.50
Otter/Reach 1	Private crossing #6 Culvert #3	C	5027	2115 & 2110	107.74	107.46	108.74	108.46	Diameter	1.00	8.90
Otter/Reach 1	Private crossing #7 Set #1 x 3 Culverts	C	3828	2090 & 2085	106.63	106.56	107.63	107.56	Diameter	1.00	9.90
Otter/Reach 1	Private crossing #7 Set #2 x 2 Culverts	C	3828	2090 & 2085	106.62	106.58	107.62	107.58	Diameter	1.00	9.90
Otter/Reach 1	Private crossing #7 Set #3 x 2 Culverts	C	3828	2090 & 2085	107.15	107.04	107.65	107.54	Diameter	0.50	5.80
Otter/Reach 1	Private crossing #8 x 2 Culverts	C	3128	2070 & 2065	106.16	106.06	107.16	107.06	Diameter	1.00	9.00

1) RVCA Survey August 2014 unless otherwise indicated

2) From Arial photos as well as GPS coordinates from RVCA Survey August 2014

3) Otter Lake Road Culvert information taken from Otter Flood Plain Mapping Report (RVCA, 2011)

4) Motts Mill Dam dimentions used in the models are taken from Motts Mill Dam Operational Review Report (RVCA, 2009)

Table 6 Bridges and culverts (Continued)

Stream/Reach	Location	Bridge/ Culvert	Chainage (m)	Bounding Cross Sections	Upstream Invert[1] (m)	Downstream Invert[1] (m)	Upstream Obvert[1] (m)	Downstream Obvert[1] (m)	Width[1] (m)	Height[1] (m)	Length[2] (m)
Otter/Reach 1	County Road 29	B	2730	2055 & 2050	105.83	105.83	108.47	108.48	10.67	2.40	11.84
Otter/Reach 1	Purcell road Culvert #1	C	2289	2040 & 2035	104.91	105.06	106.56	106.71	Diameter	1.65	9.23
Otter/Reach 1	Purcell road Culvert #2	C	2289	2040 & 2035	104.83	105.23	106.23	106.63	Diameter	1.40	9.23
Otter/Reach 1	Purcell road Culvert #3	C	2289	2040 & 2035	105.08	105.09	106.98	106.99	Diameter	1.90	9.23
Otter/Reach 2	Railway crossing	B	967	35 & 30	104.42	104.42	107.55	107.56	8.61	3.13	4.10
Otter/Reach 2	County Road 17	B	178	15 & 10	104.31	104.31	107.26	107.26	14.30	2.95	9.97
Hutton/Reach 1	Motts Mill Dam[4]	Dam	12620	3215 & 3210	-	-	-	-	-	-	-
Hutton/Reach 1	County Road 1	C	12388	3200 & 3190	119.49	119.29	121.09	120.89	4.90	1.60	8.50
Hutton/Reach 1	County Road 29	B	6628	3105 & 3100	114.44	114.44	115.92	115.93	10.25	1.49	15.28
Hutton/Reach 1	Kitly Line 1	C	5247	3080 & 3075	113.56	113.58	115.16	115.18	6.10	1.60	5.25
Hutton/Reach 1	Private crossing #5 x 4	C	2966	3055 & 3050	108.62	108.58	109.12	109.08	Diameter	0.50	5.00
Hutton/Reach 1	Townline road	C	2482	3045 & 3040	106.82	106.80	108.62	108.60	6.10	1.80	8.33

1) RVCA Survey August 2014 unless otherwise indicated

2) From Arial photos as well as GPS coordinates from RVCA Survey August 2014

3) Otter Lake Road Culvert information taken from Otter Flood Plain Mapping Report (RVCA, 2011)

4) Motts Mill Dam dimentions used in the models are taken from Motts Mill Dam Operational Review Report (RVCA, 2009)

Table 7 Design flows used in HEC-RAS model

River/Creek	Reach	Cross Section	Flows (cms)							
		ID	500 year	200 year	100 year	50 year	20 year	10 year	5 year	2 year
Otter Creek	Reach 1	2420	8.42	7.54	6.88	6.24	5.40	4.75	4.08	3.07
Otter Creek	Reach 1	2410	11.50	10.30	9.47	8.60	7.44	6.55	5.63	4.25
Otter Creek	Reach 1	2310	13.30	12.00	11.00	10.10	8.80	7.81	6.75	5.13
Otter Creek	Reach 1	2215	17.70	16.00	14.80	13.60	11.90	10.60	9.26	7.08
Otter Creek	Reach 1	2145	21.20	19.40	17.90	16.50	14.50	13.00	11.30	8.69
Otter Creek	Reach 2	50	34.70	32.00	30.00	27.90	24.90	22.40	19.80	15.40
Hutton Creek	Reach 1	3245	10.60	9.05	7.98	6.99	5.77	4.91	4.07	2.93
Hutton Creek	Reach 1	3225	7.63	7.12	6.71	6.28	5.67	5.15	4.57	3.58
Hutton Creek	Reach 1	3165	8.83	8.23	7.75	7.25	6.54	5.94	5.27	4.13
Hutton Creek	Reach 1	3135	10.10	9.44	8.91	8.34	7.53	6.85	6.08	4.77
Hutton Creek	Reach 1	3110	11.20	10.50	9.87	9.23	8.29	7.51	6.62	5.15
Hutton Creek	Reach 1	3085	12.70	11.80	11.20	10.50	9.44	8.58	7.61	5.96
Hutton Creek	Reach 1	3045	14.40	13.40	12.50	11.70	10.50	9.50	8.41	6.59

Table 8 Downstream boundary condition at Rideau River

Event	Water Level in Rideau River (m)	Source
500 year	106.92	Extrapolated
200 year	106.86	Extrapolated
100 year	106.8	MacLaren 1976[1]
50 year	106.74	Interpolated
20 year	106.69	Interpolated
10 year	106.6	Interpolated
5 year	106.52	Interpolated
2 year	106.41	ACRES 1994[2]

1) 100 Year Water Level From James F. MacLaren Report on Rideau River Floodline mapping (Smith Falls to Kars), June 1976.

2) Based on High Navigation level from the Rideau Canal Water Management Study. ACRES International Limited, June 1994.

Table 9 Observed vs computed water levels on May 5, 2015 (Calibration)

OTTER	Nearest cross section	Measured water level. 12:45 pm to 2:45 pm on May 5, 2015	Computed water level (HEC-RAS model)	WL difference (model-obs)
		(m)	(m)	(cm)
Otter lake road (U/S)	x-2405	124.872	125.05	18
Otter Lake road (D/S)	x-2400	124.979	125.00	2
Rideau ferry road (U/S)	x-2345	123.076	123.12	4
Rideau ferry road (D/S)	x-2340	123.079	123.10	2
Anglican church road (U/S)	x-2305	122.768	122.86	9
Anglican church road (D/S)	x-2300	122.736	122.86	12
Kelly road (U/S)	x-2210	119.451	119.47	2
Kelly road (D/S)	x-2205	119.44	119.46	2
Hunter's road (U/S)	x-2140	110.426	110.45	2
Hunter's road (D/S)	x-2135	110.405	110.43	3
County road 29 (U/S)	x-2055	106.384	106.41	3
County road 29 (D/S)	x-2050	106.34	106.38	4
Purcell Road (U/S)	x-2040	106.166	106.26	9
Purcell Road (D/S)	x-2035	106.169	106.18	1
County rd 17, Jasper Rd (U/S)	x-15	106.12	106.11	-1
County rd 17, Jasper Rd (D/S)	x-10	106.1	106.09	-1
average WL difference				***4***

HUTTON	Nearest cross section	Measured water level. 12:45 pm to 2:45 pm on May 5, 2015	Computed water level (HEC-RAS model)	WL difference (model-obs)
		(m)	(m)	(cm)
Motts mills dam	x-3215	123.6	123.63	3
County road 1 (U/S)	x-3200	119.619	119.69	7
County road 1 (D/S)	x-3190	119.562	119.61	5
County road 29 (U/S)	x-3105	115.422	115.45	3
County road 29 (D/S)	x-3100	115.446	115.45	0
Kitley Line 1 (U/S)	x-3080	114.228	114.25	2
Kitley Line 1 (D/S)	x-3075	114.229	114.25	2
Townline road (U/S)	x-3045	107.329	107.35	2
Townline road (D/S)	x-3040	107.322	107.35	3
average WL difference				***3***

Table 10 Observed vs computed water levels on April 17, 2015 (Validation 1)

OTTER	Nearest cross section	Measured water level. 10:00 am to 2:30 pm on April 17, 2015	Computed water level (HEC-RAS model)	WL difference (model-obs)
		(m)	(m)	(cm)
Otter lake road (U/S)	x-2405	124.992	125.11	12
Otter Lake road (D/S)	x-2400	124.959	125.04	8
Rideau ferry road (U/S)	x-2345	123.186	123.17	-2
Rideau ferry road (D/S)	x-2340	123.179	123.15	-3
Anglican church road (U/S)	x-2305	122.878	122.94	6
Anglican church road (D/S)	x-2300	122.856	122.94	8
Kelly road (U/S)	x-2210	119.551	119.54	-1
Kelly road (D/S)	x-2205	119.56	119.53	-3
Hunter's road (U/S)	x-2140	110.556	110.55	-1
Hunter's road (D/S)	x-2135	110.565	110.53	-4
County road 29 (U/S)	x-2055	106.524	106.53	1
County road 29 (D/S)	x-2050	106.48	106.52	4
Purcell Road (U/S)	x-2040	106.096	106.32	22
Purcell Road (D/S)	x-2035	106.079	106.19	11
County rd 17, Jasper Rd (U/S)	x-15	106.07	106.08	1
County rd 17, Jasper Rd (D/S)	x-10	106.056	106.04	-2
average WL difference				***4***

HUTTON	Nearest cross section	Measured water level. 12:00 pm to 1:00 pm on April 17, 2015	Computed water level (HEC-RAS model)	WL difference (model-obs)
		(m)	(m)	(cm)
Motts mills dam	x-3215	123.694	123.73	4
County road 1 (U/S)	x-3200	119.724	119.80	8
County road 1 (D/S)	x-3190	119.719	119.47	-25*
County road 29 (U/S)	x-3105	115.692	115.70	1
County road 29 (D/S)	x-3100	115.726	115.69	-4
Kitley Line 1 (U/S)	x-3080	114.518	114.49	-3
Kitley Line 1 (D/S)	x-3075	114.519	114.49	-3
Townline road (U/S)	x-3045	107.689	107.82	13
Townline road (D/S)	x-3040	107.672	107.82	15
average WL difference				***4***

* Supercritical flow through the culvert. Energy grid is more appropriate to use.
Not included in the average computation.

Table 11 Observed vs computed water levels on April 10, 2015 (Validation 2)

OTTER	Nearest cross section	Measured water level. 12:15 pm to 2:30 pm on April 10, 2015	Computed water level (HEC-RAS model)	WL difference (model-obs)
		(m)	(m)	(cm)
Otter lake road (U/S)	x-2405	124.985	125.08	9
Otter Lake road (D/S)	x-2400	124.95	125.02	7
Rideau ferry road (U/S)	x-2345	123.266	123.14	-13
Rideau ferry road (D/S)	x-2340	123.242	123.12	-12
Anglican church road (U/S)	x-2305	122.966	122.89	-8
Anglican church road (D/S)	x-2300	122.978	122.89	-9
Kelly road (U/S)	x-2210	119.739	119.48	-26
Kelly road (D/S)	x-2205	119.695	119.47	-22
Hunter's road (U/S)	x-2140	110.736	110.47	-27
Hunter's road (D/S)	x-2135	110.723	110.44	-28
County road 29 (U/S)	x-2055	106.659	106.43	-23
Purcell Road (U/S)	x-2040	106.333	106.27	-6
Purcell Road (D/S)	x-2035	106.247	106.19	-6
County rd 17, Jasper Rd (U/S)	x-15	106.136	106.13	-1
County rd 17, Jasper Rd (D/S)	x-10	106.116	106.10	-2
average WL difference				***-11***

HUTTON	Nearest cross section	Measured water level. 3:00 pm to 3:30 pm on April 10, 2015	Computed water level (HEC-RAS model)	WL difference (model-obs)
		(m)	(m)	(cm)
Motts mills dam	x-3215	123.809	123.87	6
County road 1 (U/S)	x-3200	119.839	119.93	9
County road 1 (D/S)	x-3190	119.786	119.57	-22*
County road 29 (U/S)	x-3105	115.852	115.96	11
County road 29 (D/S)	x-3100	115.858	115.93	7
Kitley Line 1 (U/S)	x-3080	114.69	114.73	4
Kitley Line 1 (D/S)	x-3075	114.66	114.72	6
Townline road (U/S)	x-3045	107.926	108.24	31
Townline road (D/S)	x-3040	107.927	108.24	31
average WL difference				***13***

* Supercritical flow through the culvert. Energy grid is more appropriate to use. Not included in the average computation.

Table 12 Head loss at bridges/culverts (during 1:100 Year flood)

Stream/Reach	Location	Chainage (m)	Upstream Invert (m)	Downstream Invert (m)	Upstream Obvert (m)	Downstream Obvert (m)	E.G. Elev. u/s of Structure (m)	E.G. Elev. d/s of Structure (m)	Head Loss (cm)
Otter/Reach 1	Otter Lake road	22962	123.97	124.02	125.72	125.77	125.94	125.83	11
Otter/Reach 1	Rideau Ferry road	18091	122.70	122.62	124.60	124.52	123.73	123.68	5
Otter/Reach 1	Black Smith road	17961	122.52	122.38	123.77	123.63	123.51	123.5	1
Otter/Reach 1	HWY 15	17773	122.20	122.14	123.90	123.84	123.42	123.42	0
Otter/Reach 1	Anglican Church road/County road 1	17333	121.49	121.50	123.89	123.90	123.37	123.36	1
Otter/Reach 1	Private crossing #1 Culvert #1	16498	121.92	122.01	245.23	245.32	123.31	123.31	0
Otter/Reach 1	Private crossing #1 Culvert #2	16498	121.96	121.84	244.68	244.56	123.31	123.31	0
Otter/Reach 1	Private crossing #1 Culvert #3	16498	121.85	121.85	244.56	244.56	123.31	123.31	0
Otter/Reach 1	Private crossing #2	15644	120.67	120.64	122.00	121.97	122.72	122.72	0
Otter/Reach 1	Private crossing #3 x 2 Archways	15117	120.62	120.68	241.71	241.77	122.71	122.71	0
Otter/Reach 1	Private crossing #4	14546	120.45	120.43	121.92	121.90	122.09	122.09	0
Otter/Reach 1	Cataraqui Trail	14301	119.83	119.83	124.31	124.33	121.09	121.09	0
Otter/Reach 1	Kelly's road	13451	118.47	118.45	120.97	120.95	119.95	119.93	2
Otter/Reach 1	Hunter's road	6173	109.87	109.85	111.97	111.65	111.17	111.15	2
Otter/Reach 1	Private crossing #6 Culvert #1	5027	107.54	107.68	215.20	215.34	108.96	108.93	3
Otter/Reach 1	Private crossing #6 Culvert #2	5027	107.59	107.67	214.97	215.05	108.96	108.93	3
Otter/Reach 1	Private crossing #6 Culvert #3	5027	107.74	107.46	215.09	214.81	108.96	108.93	3
Otter/Reach 1	Private crossing #7 Set #1 x 3 Culverts	3828	106.63	106.56	213.55	213.48	108.03	108.02	1
Otter/Reach 1	Private crossing #7 Set #2 x 2 Culverts	3828	106.62	106.58	213.45	213.41	108.03	108.02	1
Otter/Reach 1	Private crossing #7 Set #3 x 2 Culverts	3828	107.15	107.04	229.46	229.35	108.03	108.02	1
Otter/Reach 1	Private crossing #8 x 2 Culverts	3128	106.16	106.06	226.47	226.37	107.67	107.66	1

E.G. Elev. - Energy Grade Elevation output from HEC-RAS Model, RVCA 2015

Table 12 Head loss at bridges/culverts (during 1:100 Year flood) (continued)

Stream/Reach	Location	Chainage (m)	Upstream Invert (m)	Downstream Invert (m)	Upstream Obvert (m)	Downstream Obvert (m)	E.G. Elev. u/s of Structure (m)	E.G. Elev. d/s of Structure (m)	Head Loss (m)
Otter/Reach 1	County Road 29	2730	105.83	105.83	108.47	108.48	107.38	107.38	0
Otter/Reach 1	Purcell road Culvert #1	2289	104.91	105.06	219.93	220.08	107.35	107.35	0
Otter/Reach 1	Purcell road Culvert #2	2289	104.83	105.23	214.52	214.92	107.35	107.35	0
Otter/Reach 1	Purcell road Culvert #3	2289	105.08	105.09	213.54	213.55	107.35	107.35	0
Otter/Reach 2	Railway crossing	967	104.42	104.42	107.55	107.56	106.93	106.92	1
Otter/Reach 2	County Road 17	178	104.31	104.31	107.26	107.26	106.84	106.83	1
Hutton/Reach 1	Motts Mill Dam	12620	-	-	-	-	124.01	122.31	170
Hutton/Reach 1	County Road 1	12388	119.49	119.29	121.09	120.89	120.36	120.31	5
Hutton/Reach 1	County Road 29	6628	114.44	114.44	115.92	115.93	116.31	116.18	13
Hutton/Reach 1	Kitly Line 1	5247	113.56	113.58	115.16	115.18	115.03	115.02	1
Hutton/Reach 1	Private crossing #5 x 4	2966	108.62	108.58	109.12	109.08	109.69	109.69	0
Hutton/Reach 1	Townline road	2482	106.82	106.80	108.62	108.60	108.46	108.46	0

E.G. Elev. - Energy Grade Elevation output from HEC-RAS Model, RVCA 2015

Table 13: Regulatory Flood Levels for 100 Year Flood

Stream	Reach	XS ID	Q (total) (cms)	Computed WSEL (m)	EGL (m)	RFL (m)
Otter Creek	Reach 1	2420	6.88	126.20	126.20	Outside mapping area
	Reach 1	2415	6.88	126.20	126.20	
	Reach 1	2410	9.47	126.20	126.20	
	Reach 1	2405	9.47	126.01	126.18	
	Reach 1	Otter Lake Road				
	Reach 1	2400	9.47	125.17	125.74	125.74
	Reach 1	2395	9.47	125.24	125.26	125.26
	Reach 1	2392	9.47	125.09	125.09	125.09
	Reach 1	2390	9.47	125.01	125.02	125.02
	Reach 1	2385	9.47	124.89	124.89	124.89
	Reach 1	2380	9.47	124.83	124.83	124.83
	Reach 1	2375	9.47	124.18	124.26	124.26
	Reach 1	2370	9.47	123.93	123.94	123.94
	Reach 1	2365	9.47	123.91	123.91	123.91
	Reach 1	2360	9.47	123.90	123.90	123.90
	Reach 1	2355	9.47	123.89	123.89	123.89
	Reach 1	2350	9.47	123.88	123.88	123.88
	Reach 1	2345	9.47	123.71	123.86	123.86
	Reach 1	Rideau Ferry Road				
	Reach 1	2340	9.47	123.46	123.68	123.68
	Reach 1	2335	9.47	123.39	123.55	123.55
	Reach 1	Black Smith Road				
	Reach 1	2330	9.47	123.38	123.50	123.50
	Reach 1	2325	9.47	123.43	123.46	123.46
	Reach 1	2320	9.47	123.35	123.44	123.44
	Reach 1	HWY 15				
	Reach 1	2315	9.47	123.39	123.39	123.39
	Reach 1	2310	11.00	123.39	123.39	123.39
	Reach 1	2305	11.00	123.35	123.38	123.38
	Reach 1	Anglican Church Road				
	Reach 1	2300	11.00	123.33	123.36	123.36
	Reach 1	2295	11.00	123.34	123.34	123.34
	Reach 1	2290	11.00	123.28	123.31	123.31
	Reach 1	Private Crossing #1				
	Reach 1	2285	11.00	123.00	123.05	123.05
	Reach 1	2280	11.00	122.81	122.84	122.84
	Reach 1	2275	11.00	122.72	122.72	122.72
	Reach 1	Private Crossing #2				
	Reach 1	2270	11.00	122.72	122.72	122.72

Table 13: Regulatory Flood Levels for 100 Year Flood (Continued)

Stream	Reach	XS ID	Q (total) (cms)	Computed WSEL (m)	EGL (m)	RFL (m)
Otter Creek	Reach 1	2265	11.00	122.71	122.71	122.71
	Reach 1	2260	11.00	122.71	122.71	122.71
	Reach 1	Private Crossing #3				
	Reach 1	2255	11.00	122.10	122.10	122.10
	Reach 1	2250	11.00	122.10	122.10	122.10
	Reach 1	2245	11.00	122.09	122.09	122.09
	Reach 1	Private Crossing #4				
	Reach 1	2240	11.00	121.30	121.32	121.32
	Reach 1	2235	11.00	121.00	121.11	121.11
	Reach 1	Cataraqui Trail				
	Reach 1	2230	11.00	120.97	121.08	121.08
	Reach 1	2225	11.00	120.57	120.63	120.63
	Reach 1	2220	11.00	120.37	120.38	120.38
	Reach 1	2215	14.80	120.22	120.23	120.23
	Reach 1	2210	14.80	119.90	120.03	120.03
	Reach 1	Kelly's Road				
	Reach 1	2205	14.80	119.78	119.93	119.93
	Reach 1	2200	14.80	119.34	119.35	119.35
	Reach 1	2195	14.80	118.27	118.27	118.27
	Reach 1	2190	14.80	117.54	117.56	117.56
	Reach 1	2185	14.80	115.37	115.58	115.58
	Reach 1	2180	14.80	113.35	113.35	113.35
	Reach 1	2175	14.80	113.20	113.20	113.20
	Reach 1	2170	14.80	113.13	113.13	113.13
	Reach 1	2165	14.80	113.07	113.07	113.07
	Reach 1	2160	14.80	112.81	112.90	112.90
	Reach 1	2155	14.80	112.31	112.32	112.32
	Reach 1	2150	14.80	111.71	111.83	111.83
	Reach 1	2145	17.90	111.61	111.62	111.62
	Reach 1	2140	17.90	111.14	111.32	111.32
	Reach 1	Hunter's Road				
	Reach 1	2135	17.90	110.86	111.15	111.15
	Reach 1	2130	17.90	110.20	110.23	110.23
	Reach 1	2125	17.90	109.23	109.47	109.47
	Reach 1	2120	17.90	108.98	108.99	108.99
	Reach 1	2115	17.90	108.95	108.96	108.96
	Reach 1	Private Crossing #6				
	Reach 1	2110	17.90	108.57	108.58	108.58
	Reach 1	2105	17.90	108.45	108.47	108.47

Table 13: Regulatory Flood Levels for 100 Year Flood (Continued)

Stream	Reach	XS ID	Q (total) (cms)	Computed WSEL (m)	EGL (m)	RFL (m)
Otter Creek	Reach 1	2100	17.90	108.07	108.11	108.11
	Reach 1	2095	17.90	108.08	108.08	108.08
	Reach 1	2090	17.90	108.02	108.03	108.03
	Reach 1	Private Crossing #7				
	Reach 1	2085	17.90	107.83	107.84	107.84
	Reach 1	2080	17.90	107.80	107.81	107.81
	Reach 1	2075	17.90	107.70	107.70	107.70
	Reach 1	2070	17.90	107.67	107.67	107.67
	Reach 1	Private Crossing #8				
	Reach 1	2065	17.90	107.53	107.54	107.54
	Reach 1	2060	17.90	107.46	107.47	107.47
	Reach 1	2055	17.90	107.34	107.40	107.40
	Reach 1	County Road 29				
	Reach 1	2050	17.90	107.31	107.38	107.38
	Reach 1	2045	17.90	107.35	107.36	107.36
	Reach 1	2040	17.90	107.35	107.35	107.35
	Reach 1	Purcell Road				
	Reach 1	2035	17.90	106.92	106.99	106.99
	Reach 1	2030	17.90	106.96	106.97	106.97
	Reach 1	2025	17.90	106.96	106.97	106.97
	Reach 1	2020	17.90	106.96	106.97	106.97
	Reach 1	2015	17.90	106.96	106.96	106.96
	Reach 1	2010	17.90	106.96	106.96	106.96
	Reach 1	2005	17.90	106.96	106.96	106.96
	Reach 1	2000	17.90	106.96	106.96	106.96
	Reach 2	50	30.00	106.96	106.96	106.96
	Reach 2	45	30.00	106.96	106.96	106.96
	Reach 2	40	30.00	106.96	106.96	106.96
	Reach 2	35	30.00	106.85	106.95	106.95
	Reach 2	Railway crossing				
	Reach 2	30	30.00	106.79	106.89	106.89
	Reach 2	25	30.00	106.86	106.86	106.86
	Reach 2	20	30.00	106.86	106.86	106.86
	Reach 2	15	30.00	106.81	106.85	106.85
	Reach 2	County Road 17				
	Reach 2	10	30.00	106.77	106.81	Outside mapping area
	Reach 2	5	30.00	106.80	106.80	

Table 13: Regulatory Flood Levels for 100 Year Flood (Continued)

Stream	Reach	XS ID	Q (total) (cms)	Computed WSEL (m)	EGL (m)	RFL (m)
Hutton Creek	Reach 1	3245	7.98	124.01	124.01	Outside mapping area
	Reach 1	3240	7.98	124.01	124.01	
	Reach 1	3235	7.98	124.01	124.01	
	Reach 1	3230	7.98	124.01	124.01	
	Reach 1	3225	6.71	124.01	124.01	
	Reach 1	3220	6.71	124.01	124.01	
	Reach 1	3215	6.71	124.01	124.01	
	Reach 1	Motts Mill Dam				
	Reach 1	3210	6.71	122.28	122.31	122.31
	Reach 1	3205	6.71	121.76	121.79	121.79
	Reach 1	3200	6.71	120.26	120.50	120.50
	Reach 1	County Road 1				
	Reach 1	3190	6.71	120.00	120.19	120.19
	Reach 1	3185	6.71	119.32	119.32	119.32
	Reach 1	3180	6.71	118.19	118.30	118.30
	Reach 1	3175	6.71	117.02	117.02	117.02
	Reach 1	3170	6.71	117.02	117.02	117.02
	Reach 1	3165	7.75	117.00	117.00	117.00
	Reach 1	3160	7.75	116.93	116.93	116.93
	Reach 1	3155	7.75	116.92	116.92	116.92
	Reach 1	3150	7.75	116.84	116.84	116.84
	Reach 1	3145	7.75	116.58	116.58	116.58
	Reach 1	3140	7.75	116.54	116.54	116.54
	Reach 1	3135	8.91	116.53	116.53	116.53
	Reach 1	3130	8.91	116.52	116.52	116.52
	Reach 1	3125	8.91	116.50	116.50	116.50
	Reach 1	3120	8.91	116.46	116.46	116.46
	Reach 1	3115	8.91	116.40	116.40	116.40
	Reach 1	3110	9.87	116.40	116.40	116.40
	Reach 1	3105	9.87	116.32	116.33	116.33
	Reach 1	County Road 29				
	Reach 1	3100	9.87	116.13	116.15	116.15
	Reach 1	3090	9.87	115.57	115.57	115.57
	Reach 1	3085	11.20	115.46	115.46	115.46
	Reach 1	3080	11.20	114.99	115.07	115.07
	Reach 1	Kitly Line 1				
	Reach 1	3075	11.20	114.93	115.02	115.02
	Reach 1	3070	11.20	114.06	114.07	114.07
	Reach 1	3065	11.20	112.16	112.25	112.25

Table 13: Regulatory Flood Levels for 100 Year Flood (Continued)

Stream	Reach	XS ID	Q (total) (cms)	Computed WSEL (m)	EGL (m)	RFL (m)
Hutton Creek	Reach 1	3060	11.20	110.05	110.06	110.06
	Reach 1	3055	11.20	109.68	109.69	109.69
	Reach 1	Private Crossing #5				
	Reach 1	3050	11.20	109.68	109.69	109.69
	Reach 1	3045	12.50	108.42	108.51	108.51
	Reach 1	Townline Road				
	Reach 1	3040	12.50	108.38	108.46	108.46
	Reach 1	3035	12.50	106.95	106.98	106.98
	Reach 1	3030	12.50	106.97	106.97	106.97
	Reach 1	3025	12.50	106.97	106.97	106.97
	Reach 1	3020	12.50	106.97	106.97	106.97
	Reach 1	3015	12.50	106.97	106.97	106.97
	Reach 1	3010	12.50	106.97	106.97	106.97
	Reach 1	3005	12.50	106.97	106.97	106.97
	Reach 1	3000	12.50	106.96	106.96	106.96

Table 14: Flow and Computed Water Level for 50-year to 500-year Flood Event

Stream	Reach	XS ID	Flow (cms) and Computed WSEL (m) for Different flood events							
			Q500	WL500	Q200	WL200	Q100	WL100	Q50	WL50
Otter Creek	Reach 1	2420	8.42	126.72	7.54	125.87	6.88	126.20	6.24	126.04
	Reach 1	2415	8.42	126.72	7.54	125.87	6.88	126.20	6.24	126.04
	Reach 1	2410	11.50	126.72	10.30	125.87	9.47	126.20	8.60	126.04
	Reach 1	2405	11.50	126.55	10.30	125.68	9.47	126.01	8.60	125.85
	Reach 1	Otter lake Road								
	Reach 1	2400	11.50	125.33	10.30	125.02	9.47	125.17	8.60	125.10
	Reach 1	2395	11.50	125.29	10.30	125.19	9.47	125.24	8.60	125.21
	Reach 1	2392	11.50	125.14	10.30	125.04	9.47	125.09	8.60	125.07
	Reach 1	2390	11.50	125.07	10.30	124.96	9.47	125.01	8.60	124.99
	Reach 1	2385	11.50	124.94	10.30	124.84	9.47	124.89	8.60	124.86
	Reach 1	2380	11.50	124.88	10.30	124.78	9.47	124.83	8.60	124.80
	Reach 1	2375	11.50	124.19	10.30	124.20	9.47	124.18	8.60	124.19
	Reach 1	2370	11.50	124.07	10.30	123.83	9.47	123.93	8.60	123.88
	Reach 1	2365	11.50	124.06	10.30	123.79	9.47	123.91	8.60	123.85
	Reach 1	2360	11.50	124.05	10.30	123.77	9.47	123.90	8.60	123.84
	Reach 1	2355	11.50	124.04	10.30	123.75	9.47	123.89	8.60	123.82
	Reach 1	2350	11.50	124.04	10.30	123.74	9.47	123.88	8.60	123.81
	Reach 1	2345	11.50	123.85	10.30	123.58	9.47	123.71	8.60	123.65
	Reach 1	Rideau Ferry Road								
	Reach 1	2340	11.50	123.56	10.30	123.38	9.47	123.46	8.60	123.42
	Reach 1	2335	11.50	123.50	10.30	123.30	9.47	123.39	8.60	123.34
	Reach 1	Black Smith Road								
	Reach 1	2330	11.50	123.47	10.30	123.30	9.47	123.38	8.60	123.34
	Reach 1	2325	11.50	123.54	10.30	123.34	9.47	123.43	8.60	123.39
	Reach 1	2320	11.50	123.43	10.30	123.28	9.47	123.35	8.60	123.32
	Reach 1	HWY 15								
	Reach 1	2315	11.50	123.47	10.30	123.31	9.47	123.39	8.60	123.35
	Reach 1	2310	13.30	123.47	12.00	123.31	11.00	123.39	10.10	123.35
	Reach 1	2305	13.30	123.42	12.00	123.28	11.00	123.35	10.10	123.31
	Reach 1	Anglican Church Road								
	Reach 1	2300	13.30	123.40	12.00	123.27	11.00	123.33	10.10	123.30
	Reach 1	2295	13.30	123.41	12.00	123.27	11.00	123.34	10.10	123.30
	Reach 1	2290	13.30	123.34	12.00	123.22	11.00	123.28	10.10	123.25
	Reach 1	Private Crossing #1								
	Reach 1	2285	13.30	123.07	12.00	122.95	11.00	123.00	10.10	122.97
	Reach 1	2280	13.30	122.87	12.00	122.76	11.00	122.81	10.10	122.79
	Reach 1	2275	13.30	122.77	12.00	122.68	11.00	122.72	10.10	122.71
	Reach 1	Private Crossing #2								
	Reach 1	2270	13.30	122.77	12.00	122.68	11.00	122.72	10.10	122.70

Table 14: Flow and Computed Water Level for 50-year to 500-year Flood Event (Continued)

Stream	Reach	XS ID	Flow (cms) and Computed WSEL (m) for Different flood events							
			Q500	WL500	Q200	WL200	Q100	WL100	Q50	WL50
Otter Creek	Reach 1	2265	13.30	122.76	12.00	122.68	11.00	122.71	10.10	122.70
	Reach 1	2260	13.30	122.75	12.00	122.67	11.00	122.71	10.10	122.70
	Reach 1	Private Crossing #3								
	Reach 1	2255	13.30	122.12	12.00	122.09	11.00	122.10	10.10	122.10
	Reach 1	2250	13.30	122.12	12.00	122.09	11.00	122.10	10.10	122.10
	Reach 1	2245	13.30	122.11	12.00	122.08	11.00	122.09	10.10	122.09
	Reach 1	Private Crossing #4								
	Reach 1	2240	13.30	121.41	12.00	121.22	11.00	121.30	10.10	121.26
	Reach 1	2235	13.30	121.09	12.00	120.93	11.00	121.00	10.10	120.96
	Reach 1	Cataraqui Trail								
	Reach 1	2230	13.30	121.05	12.00	120.90	11.00	120.97	10.10	120.93
	Reach 1	2225	13.30	120.64	12.00	120.52	11.00	120.57	10.10	120.54
	Reach 1	2220	13.30	120.47	12.00	120.32	11.00	120.37	10.10	120.33
	Reach 1	2215	17.70	120.35	16.00	120.15	14.80	120.22	13.60	120.16
	Reach 1	2210	17.70	120.01	16.00	119.83	14.80	119.90	13.60	119.85
	Reach 1	Kelly's Road								
	Reach 1	2205	17.70	119.85	16.00	119.73	14.80	119.78	13.60	119.74
	Reach 1	2200	17.70	119.40	16.00	119.30	14.80	119.34	13.60	119.31
	Reach 1	2195	17.70	118.31	16.00	118.25	14.80	118.27	13.60	118.25
	Reach 1	2190	17.70	117.57	16.00	117.53	14.80	117.54	13.60	117.53
	Reach 1	2185	17.70	115.42	16.00	115.34	14.80	115.37	13.60	115.34
	Reach 1	2180	17.70	113.41	16.00	113.31	14.80	113.35	13.60	113.32
	Reach 1	2175	17.70	113.27	16.00	113.17	14.80	113.20	13.60	113.17
	Reach 1	2170	17.70	113.20	16.00	113.09	14.80	113.13	13.60	113.10
	Reach 1	2165	17.70	113.14	16.00	113.03	14.80	113.07	13.60	113.04
	Reach 1	2160	17.70	112.88	16.00	112.78	14.80	112.81	13.60	112.78
	Reach 1	2155	17.70	112.36	16.00	112.28	14.80	112.31	13.60	112.29
	Reach 1	2150	17.70	111.83	16.00	111.69	14.80	111.71	13.60	111.68
	Reach 1	2145	21.20	111.74	19.40	111.57	17.90	111.61	16.50	111.56
	Reach 1	2140	21.20	111.29	19.40	111.09	17.90	111.14	16.50	111.07
	Reach 1	Hunter's Road								
	Reach 1	2135	21.20	110.96	19.40	110.82	17.90	110.86	16.50	110.81
	Reach 1	2130	21.20	110.30	19.40	110.17	17.90	110.20	16.50	110.15
	Reach 1	2125	21.20	109.29	19.40	109.21	17.90	109.23	16.50	109.20
	Reach 1	2120	21.20	109.02	19.40	108.97	17.90	108.98	16.50	108.96
	Reach 1	2115	21.20	108.99	19.40	108.94	17.90	108.95	16.50	108.93
	Reach 1	Private Crossing #6								
	Reach 1	2110	21.20	108.64	19.40	108.55	17.90	108.57	16.50	108.54
	Reach 1	2105	21.20	108.52	19.40	108.43	17.90	108.45	16.50	108.42

Table 14: Flow and Computed Water Level for 50-year to 500-year Flood Event (Continued)

Stream	Reach	XS ID	Flow (cms) and Computed WSEL (m) for Different flood events							
			Q500	WL500	Q200	WL200	Q100	WL100	Q50	WL50
Otter Creek	Reach 1	2100	21.20	108.11	19.40	108.06	17.90	108.07	16.50	108.05
	Reach 1	2095	21.20	108.12	19.40	108.06	17.90	108.08	16.50	108.06
	Reach 1	2090	21.20	108.05	19.40	108.01	17.90	108.02	16.50	108.01
	Reach 1	Private Crossing #7								
	Reach 1	2085	21.20	107.91	19.40	107.80	17.90	107.83	16.50	107.79
	Reach 1	2080	21.20	107.85	19.40	107.78	17.90	107.80	16.50	107.77
	Reach 1	2075	21.20	107.72	19.40	107.68	17.90	107.70	16.50	107.67
	Reach 1	2070	21.20	107.69	19.40	107.66	17.90	107.67	16.50	107.65
	Reach 1	Private Crossing #8								
	Reach 1	2065	21.20	107.61	19.40	107.52	17.90	107.53	16.50	107.50
	Reach 1	2060	21.20	107.53	19.40	107.45	17.90	107.46	16.50	107.42
	Reach 1	2055	21.20	107.39	19.40	107.34	17.90	107.34	16.50	107.32
	Reach 1	County Road 29								
	Reach 1	2050	21.20	107.35	19.40	107.32	17.90	107.31	16.50	107.29
	Reach 1	2045	21.20	107.40	19.40	107.35	17.90	107.35	16.50	107.33
	Reach 1	2040	21.20	107.40	19.40	107.35	17.90	107.35	16.50	107.33
	Reach 1	Purcell Road								
	Reach 1	2035	21.20	107.05	19.40	106.97	17.90	106.92	16.50	106.85
	Reach 1	2030	21.20	107.11	19.40	107.01	17.90	106.96	16.50	106.89
	Reach 1	2025	21.20	107.11	19.40	107.01	17.90	106.96	16.50	106.89
	Reach 1	2020	21.20	107.11	19.40	107.01	17.90	106.96	16.50	106.89
	Reach 1	2015	21.20	107.11	19.40	107.01	17.90	106.96	16.50	106.89
	Reach 1	2010	21.20	107.11	19.40	107.01	17.90	106.96	16.50	106.89
	Reach 1	2005	21.20	107.11	19.40	107.01	17.90	106.96	16.50	106.89
	Reach 1	2000	21.20	107.11	19.40	107.01	17.90	106.96	16.50	106.89
	Reach 2	50	34.70	107.11	32.00	107.01	30.00	106.96	27.90	106.89
	Reach 2	45	34.70	107.11	32.00	107.01	30.00	106.96	27.90	106.89
	Reach 2	40	34.70	107.11	32.00	107.01	30.00	106.96	27.90	106.89
	Reach 2	35	34.70	106.97	32.00	106.90	30.00	106.85	27.90	106.78
	Reach 2	Railway crossing								
	Reach 2	30	34.70	106.90	32.00	106.85	30.00	106.79	27.90	106.73
	Reach 2	25	34.70	106.99	32.00	106.91	30.00	106.86	27.90	106.79
	Reach 2	20	34.70	106.99	32.00	106.91	30.00	106.86	27.90	106.79
	Reach 2	15	34.70	106.93	32.00	106.87	30.00	106.81	27.90	106.75
	Reach 2	County Road 17								
	Reach 2	10	34.70	106.89	32.00	106.84	30.00	106.77	27.90	106.72
	Reach 2	5	34.70	106.92	32.00	106.86	30.00	106.80	27.90	106.74

Table 14: Flow and Computed Water Level for 50-year to 500-year Flood Event (Continued)

Stream	Reach	XS ID	Flow (cms) and Computed WSEL (m) for Different flood events							
			Q500	WL500	Q200	WL200	Q100	WL100	Q50	WL50
Hutton Creek	Reach 1	3245	10.60	124.06	9.05	124.02	7.98	124.01	6.99	123.98
	Reach 1	3240	10.60	124.06	9.05	124.02	7.98	124.01	6.99	123.98
	Reach 1	3235	10.60	124.06	9.05	124.02	7.98	124.01	6.99	123.98
	Reach 1	3230	10.60	124.06	9.05	124.02	7.98	124.01	6.99	123.98
	Reach 1	3225	7.63	124.06	7.12	124.02	6.71	124.01	6.28	123.98
	Reach 1	3220	7.63	124.06	7.12	124.02	6.71	124.01	6.28	123.98
	Reach 1	3215	7.63	124.06	7.12	124.02	6.71	124.01	6.28	123.98
	Reach 1	Motts Mill Dam								
	Reach 1	3210	7.63	122.34	7.12	122.30	6.71	122.28	6.28	122.25
	Reach 1	3205	7.63	121.81	7.12	121.78	6.71	121.76	6.28	121.75
	Reach 1	3200	7.63	120.36	7.12	120.29	6.71	120.26	6.28	120.19
	Reach 1	County Road 1								
	Reach 1	3190	7.63	120.05	7.12	120.02	6.71	120.00	6.28	119.98
	Reach 1	3185	7.63	119.36	7.12	119.33	6.71	119.32	6.28	119.30
	Reach 1	3180	7.63	118.21	7.12	118.20	6.71	118.19	6.28	118.18
	Reach 1	3175	7.63	117.05	7.12	117.03	6.71	117.02	6.28	117.01
	Reach 1	3170	7.63	117.05	7.12	117.02	6.71	117.02	6.28	117.00
	Reach 1	3165	8.83	117.03	8.23	117.01	7.75	117.00	7.25	116.99
	Reach 1	3160	8.83	116.95	8.23	116.93	7.75	116.93	7.25	116.92
	Reach 1	3155	8.83	116.94	8.23	116.92	7.75	116.92	7.25	116.91
	Reach 1	3150	8.83	116.84	8.23	116.84	7.75	116.84	7.25	116.84
	Reach 1	3145	8.83	116.65	8.23	116.60	7.75	116.58	7.25	116.55
	Reach 1	3140	8.83	116.63	8.23	116.57	7.75	116.54	7.25	116.51
	Reach 1	3135	10.10	116.62	9.44	116.56	8.91	116.53	8.34	116.50
	Reach 1	3130	10.10	116.61	9.44	116.55	8.91	116.52	8.34	116.48
	Reach 1	3125	10.10	116.59	9.44	116.53	8.91	116.50	8.34	116.45
	Reach 1	3120	10.10	116.57	9.44	116.49	8.91	116.46	8.34	116.40
	Reach 1	3115	10.10	116.52	9.44	116.44	8.91	116.40	8.34	116.34
	Reach 1	3110	11.20	116.52	10.50	116.43	9.87	116.40	9.23	116.34
	Reach 1	3105	11.20	116.43	10.50	116.35	9.87	116.32	9.23	116.26
	Reach 1	County Road 29								
	Reach 1	3100	11.20	116.20	10.50	116.15	9.87	116.13	9.23	116.09
	Reach 1	3090	11.20	115.61	10.50	115.58	9.87	115.57	9.23	115.55
	Reach 1	3085	12.70	115.52	11.80	115.48	11.20	115.46	10.50	115.44
	Reach 1	3080	12.70	115.07	11.80	115.01	11.20	114.99	10.50	114.95
	Reach 1	Kitly Line 1								
	Reach 1	3075	12.70	115.00	11.80	114.95	11.20	114.93	10.50	114.90
	Reach 1	3070	12.70	114.11	11.80	114.08	11.20	114.06	10.50	114.04
	Reach 1	3065	12.70	112.18	11.80	112.17	11.20	112.16	10.50	112.15

Table 14: Flow and Computed Water Level for 50-year to 500-year Flood Event (Continued)

Stream	Reach	XS ID	Flow (cms) and Computed WSEL (m) for Different flood events							
			Q500	WL500	Q200	WL200	Q100	WL100	Q50	WL50
Hutton Creek	Reach 1	3060	12.70	110.09	11.80	110.07	11.20	110.05	10.50	110.04
Hutton Creek	Reach 1	3055	12.70	109.74	11.80	109.70	11.20	109.68	10.50	109.67
Hutton Creek	Reach 1	Private Crossing #5								
Hutton Creek	Reach 1	3050	12.70	109.73	11.80	109.70	11.20	109.68	10.50	109.66
Hutton Creek	Reach 1	3045	14.40	108.50	13.40	108.46	12.50	108.42	11.70	108.38
Hutton Creek	Reach 1	Townline Road								
Hutton Creek	Reach 1	3040	14.40	108.43	13.40	108.41	12.50	108.38	11.70	108.33
Hutton Creek	Reach 1	3035	14.40	107.10	13.40	107.00	12.50	106.95	11.70	106.88
Hutton Creek	Reach 1	3030	14.40	107.12	13.40	107.01	12.50	106.97	11.70	106.90
Hutton Creek	Reach 1	3025	14.40	107.12	13.40	107.01	12.50	106.97	11.70	106.90
Hutton Creek	Reach 1	3020	14.40	107.12	13.40	107.01	12.50	106.97	11.70	106.90
Hutton Creek	Reach 1	3015	14.40	107.12	13.40	107.01	12.50	106.97	11.70	106.90
Hutton Creek	Reach 1	3010	14.40	107.11	13.40	107.01	12.50	106.97	11.70	106.90
Hutton Creek	Reach 1	3005	14.40	107.11	13.40	107.01	12.50	106.97	11.70	106.89
Hutton Creek	Reach 1	3000	14.40	107.11	13.40	107.01	12.50	106.96	11.70	106.89

Table 15: Flow and Computed Water Level for 2-year to 20-year Flood Event

Stream	Reach	XS ID	Flow (cms) and Computed WSEL (m) for Different flood events							
			Q20	WL20	Q10	WL10	Q5	WL5	Q2	WL2
Otter Creek	Reach 1	2420	5.40	125.81	4.75	125.63	4.08	125.44	3.07	125.17
	Reach 1	2415	5.40	125.81	4.75	125.63	4.08	125.44	3.07	125.17
	Reach 1	2410	7.44	125.81	6.55	125.63	5.63	125.44	4.25	125.17
	Reach 1	2405	7.44	125.62	6.55	125.45	5.63	125.27	4.25	125.03
	Reach 1	Otter lake Road								
	Reach 1	2400	7.44	125.04	6.55	125.07	5.63	125.07	4.25	125.03
	Reach 1	2395	7.44	125.18	6.55	125.15	5.63	125.11	4.25	125.04
	Reach 1	2392	7.44	125.04	6.55	125.01	5.63	124.98	4.25	124.93
	Reach 1	2390	7.44	124.95	6.55	124.92	5.63	124.89	4.25	124.83
	Reach 1	2385	7.44	124.83	6.55	124.80	5.63	124.76	4.25	124.71
	Reach 1	2380	7.44	124.77	6.55	124.74	5.63	124.70	4.25	124.65
	Reach 1	2375	7.44	124.21	6.55	124.21	5.63	124.20	4.25	124.16
	Reach 1	2370	7.44	123.81	6.55	123.76	5.63	123.72	4.25	123.65
	Reach 1	2365	7.44	123.76	6.55	123.70	5.63	123.64	4.25	123.55
	Reach 1	2360	7.44	123.75	6.55	123.69	5.63	123.62	4.25	123.52
	Reach 1	2355	7.44	123.73	6.55	123.65	5.63	123.57	4.25	123.45
	Reach 1	2350	7.44	123.72	6.55	123.64	5.63	123.55	4.25	123.42
	Reach 1	2345	7.44	123.56	6.55	123.49	5.63	123.42	4.25	123.29
	Reach 1	Rideau Ferry Road								
	Reach 1	2340	7.44	123.35	6.55	123.29	5.63	123.23	4.25	123.14
	Reach 1	2335	7.44	123.27	6.55	123.20	5.63	123.13	4.25	123.03
	Reach 1	Black Smith Road								
	Reach 1	2330	7.44	123.27	6.55	123.20	5.63	123.09	4.25	122.94
	Reach 1	2325	7.44	123.31	6.55	123.23	5.63	123.12	4.25	122.96
	Reach 1	2320	7.44	123.25	6.55	123.18	5.63	123.08	4.25	122.92
	Reach 1	HWY 15								
	Reach 1	2315	7.44	123.28	6.55	123.21	5.63	123.10	4.25	122.94
	Reach 1	2310	8.80	123.28	7.81	123.21	6.75	123.10	5.13	122.94
	Reach 1	2305	8.80	123.25	7.81	123.19	6.75	123.08	5.13	122.92
	Reach 1	Anglican Church Road								
	Reach 1	2300	8.80	123.24	7.81	123.17	6.75	123.07	5.13	122.92
	Reach 1	2295	8.80	123.24	7.81	123.17	6.75	123.06	5.13	122.91
	Reach 1	2290	8.80	123.19	7.81	123.13	6.75	123.02	5.13	122.86
	Reach 1	Private Crossing #1								
	Reach 1	2285	8.80	122.92	7.81	122.87	6.75	122.80	5.13	122.72
	Reach 1	2280	8.80	122.74	7.81	122.71	6.75	122.64	5.13	122.61
	Reach 1	2275	8.80	122.66	7.81	122.63	6.75	122.53	5.13	122.30
	Reach 1	Private Crossing #2								
	Reach 1	2270	8.80	122.66	7.81	122.63	6.75	122.52	5.13	122.30

Table 15: Flow and Computed Water Level for 2-year to 20-year Flood Event (Continued)

Stream	Reach	XS ID	Flow (cms) and Computed WSEL (m) for Different flood events							
			Q20	WL20	Q10	WL10	Q5	WL5	Q2	WL2
Otter Creek	Reach 1	2265	8.80	122.66	7.81	122.63	6.75	122.52	5.13	122.30
	Reach 1	2260	8.80	122.66	7.81	122.63	6.75	122.52	5.13	122.30
	Reach 1	Private Crossing #3								
	Reach 1	2255	8.80	122.07	7.81	122.06	6.75	122.05	5.13	122.02
	Reach 1	2250	8.80	122.07	7.81	122.06	6.75	122.05	5.13	122.02
	Reach 1	2245	8.80	122.06	7.81	122.05	6.75	122.05	5.13	122.02
	Reach 1	Private Crossing #4								
	Reach 1	2240	8.80	121.19	7.81	121.13	6.75	121.06	5.13	120.94
	Reach 1	2235	8.80	120.90	7.81	120.85	6.75	120.79	5.13	120.68
	Reach 1	Cataraqui Trail								
	Reach 1	2230	8.80	120.87	7.81	120.82	6.75	120.76	5.13	120.66
	Reach 1	2225	8.80	120.50	7.81	120.47	6.75	120.43	5.13	120.36
	Reach 1	2220	8.80	120.27	7.81	120.23	6.75	120.19	5.13	120.13
	Reach 1	2215	11.90	120.08	10.60	120.02	9.26	119.94	7.08	119.81
	Reach 1	2210	11.90	119.78	10.60	119.72	9.26	119.65	7.08	119.53
	Reach 1	Kelly's Road								
	Reach 1	2205	11.90	119.69	10.60	119.64	9.26	119.60	7.08	119.49
	Reach 1	2200	11.90	119.27	10.60	119.23	9.26	119.18	7.08	119.11
	Reach 1	2195	11.90	118.22	10.60	118.20	9.26	118.17	7.08	118.12
	Reach 1	2190	11.90	117.51	10.60	117.50	9.26	117.48	7.08	117.46
	Reach 1	2185	11.90	115.31	10.60	115.28	9.26	115.24	7.08	115.19
	Reach 1	2180	11.90	113.28	10.60	113.25	9.26	113.21	7.08	113.15
	Reach 1	2175	11.90	113.13	10.60	113.10	9.26	113.06	7.08	112.98
	Reach 1	2170	11.90	113.06	10.60	113.02	9.26	112.98	7.08	112.90
	Reach 1	2165	11.90	112.99	10.60	112.96	9.26	112.91	7.08	112.82
	Reach 1	2160	11.90	112.74	10.60	112.71	9.26	112.67	7.08	112.61
	Reach 1	2155	11.90	112.25	10.60	112.22	9.26	112.19	7.08	112.12
	Reach 1	2150	11.90	111.62	10.60	111.58	9.26	111.54	7.08	111.48
	Reach 1	2145	14.50	111.48	13.00	111.42	11.30	111.35	8.69	111.23
	Reach 1	2140	14.50	110.97	13.00	110.90	11.30	110.80	8.69	110.65
	Reach 1	Hunter's Road								
	Reach 1	2135	14.50	110.73	13.00	110.67	11.30	110.60	8.69	110.47
	Reach 1	2130	14.50	110.08	13.00	110.02	11.30	109.95	8.69	109.83
	Reach 1	2125	14.50	109.16	13.00	109.13	11.30	109.09	8.69	109.02
	Reach 1	2120	14.50	108.94	13.00	108.93	11.30	108.89	8.69	108.85
	Reach 1	2115	14.50	108.91	13.00	108.91	11.30	108.87	8.69	108.84
	Reach 1	Private Crossing #6								
	Reach 1	2110	14.50	108.49	13.00	108.45	11.30	108.40	8.69	108.27
	Reach 1	2105	14.50	108.38	13.00	108.34	11.30	108.29	8.69	108.16

Table 15: Flow and Computed Water Level for 2-year to 20-year Flood Event (Continued)

Stream	Reach	XS ID	Flow (cms) and Computed WSEL (m) for Different flood events							
			Q20	WL20	Q10	WL10	Q5	WL5	Q2	WL2
Otter Creek	Reach 1	2100	14.50	108.04	13.00	108.00	11.30	107.99	8.69	107.94
	Reach 1	2095	14.50	108.04	13.00	108.00	11.30	107.99	8.69	107.95
	Reach 1	2090	14.50	108.00	13.00	107.97	11.30	107.96	8.69	107.92
	Reach 1	Private Crossing #7								
	Reach 1	2085	14.50	107.76	13.00	107.72	11.30	107.68	8.69	107.61
	Reach 1	2080	14.50	107.74	13.00	107.70	11.30	107.66	8.69	107.60
	Reach 1	2075	14.50	107.65	13.00	107.62	11.30	107.60	8.69	107.55
	Reach 1	2070	14.50	107.63	13.00	107.61	11.30	107.58	8.69	107.54
	Reach 1	Private Crossing #8								
	Reach 1	2065	14.50	107.41	13.00	107.29	11.30	107.17	8.69	107.00
	Reach 1	2060	14.50	107.33	13.00	107.18	11.30	107.04	8.69	106.85
	Reach 1	2055	14.50	107.23	13.00	107.06	11.30	106.90	8.69	106.68
	Reach 1	County Road 29								
	Reach 1	2050	14.50	107.21	13.00	107.03	11.30	106.87	8.69	106.63
	Reach 1	2045	14.50	107.23	13.00	107.06	11.30	106.90	8.69	106.66
	Reach 1	2040	14.50	107.21	13.00	107.04	11.30	106.87	8.69	106.65
	Reach 1	Purcell Road								
	Reach 1	2035	14.50	106.78	13.00	106.69	11.30	106.59	8.69	106.46
	Reach 1	2030	14.50	106.82	13.00	106.72	11.30	106.62	8.69	106.48
	Reach 1	2025	14.50	106.82	13.00	106.72	11.30	106.62	8.69	106.48
	Reach 1	2020	14.50	106.82	13.00	106.72	11.30	106.62	8.69	106.48
	Reach 1	2015	14.50	106.82	13.00	106.72	11.30	106.62	8.69	106.48
	Reach 1	2010	14.50	106.82	13.00	106.72	11.30	106.62	8.69	106.48
	Reach 1	2005	14.50	106.82	13.00	106.72	11.30	106.62	8.69	106.48
	Reach 1	2000	14.50	106.82	13.00	106.72	11.30	106.62	8.69	106.48
	Reach 2	50	24.90	106.82	22.40	106.72	19.80	106.62	15.40	106.48
	Reach 2	45	24.90	106.82	22.40	106.72	19.80	106.62	15.40	106.48
	Reach 2	40	24.90	106.82	22.40	106.72	19.80	106.62	15.40	106.48
	Reach 2	35	24.90	106.73	22.40	106.64	19.80	106.55	15.40	106.44
	Reach 2	Railway crossing								
	Reach 2	30	24.90	106.68	22.40	106.59	19.80	106.51	15.40	106.41
	Reach 2	25	24.90	106.73	22.40	106.64	19.80	106.55	15.40	106.43
	Reach 2	20	24.90	106.73	22.40	106.64	19.80	106.55	15.40	106.43
	Reach 2	15	24.90	106.70	22.40	106.61	19.80	106.53	15.40	106.42
	Reach 2	County Road 17								
	Reach 2	10	24.90	106.67	22.40	106.58	19.80	106.51	15.40	106.40
	Reach 2	5	24.90	106.69	22.40	106.60	19.80	106.52	15.40	106.41

Table 15: Flow and Computed Water Level for 2-year to 20-year Flood Event (Continued)

Stream	Reach	XS ID	Flow (cms) and Computed WSEL (m) for Different flood events							
			Q20	WL20	Q10	WL10	Q5	WL5	Q2	WL2
Hutton Creek	Reach 1	3245	5.77	123.95	4.91	123.91	4.07	123.88	2.93	123.81
	Reach 1	3240	5.77	123.95	4.91	123.91	4.07	123.88	2.93	123.81
	Reach 1	3235	5.77	123.95	4.91	123.91	4.07	123.88	2.93	123.81
	Reach 1	3230	5.77	123.95	4.91	123.91	4.07	123.88	2.93	123.81
	Reach 1	3225	5.67	123.94	5.15	123.91	4.57	123.87	3.58	123.81
	Reach 1	3220	5.67	123.95	5.15	123.91	4.57	123.87	3.58	123.81
	Reach 1	3215	5.67	123.94	5.15	123.91	4.57	123.87	3.58	123.81
	Reach 1	Motts Mill Dam								
	Reach 1	3210	5.67	122.20	5.15	122.17	4.57	122.12	3.58	122.03
	Reach 1	3205	5.67	121.70	5.15	121.66	4.57	121.61	3.58	121.52
	Reach 1	3200	5.67	120.14	5.15	120.11	4.57	120.07	3.58	120.01
	Reach 1	County Road 1								
	Reach 1	3190	5.67	119.95	5.15	119.92	4.57	119.89	3.58	119.83
	Reach 1	3185	5.67	119.27	5.15	119.24	4.57	119.20	3.58	119.14
	Reach 1	3180	5.67	118.17	5.15	118.16	4.57	118.15	3.58	118.12
	Reach 1	3175	5.67	116.98	5.15	116.96	4.57	116.94	3.58	116.89
	Reach 1	3170	5.67	116.98	5.15	116.96	4.57	116.94	3.58	116.89
	Reach 1	3165	6.54	116.97	5.94	116.95	5.27	116.93	4.13	116.88
	Reach 1	3160	6.54	116.90	5.94	116.89	5.27	116.87	4.13	116.83
	Reach 1	3155	6.54	116.90	5.94	116.88	5.27	116.87	4.13	116.83
	Reach 1	3150	6.54	116.84	5.94	116.83	5.27	116.82	4.13	116.79
	Reach 1	3145	6.54	116.51	5.94	116.48	5.27	116.46	4.13	116.41
	Reach 1	3140	6.54	116.46	5.94	116.43	5.27	116.40	4.13	116.36
	Reach 1	3135	7.53	116.45	6.85	116.41	6.08	116.38	4.77	116.34
	Reach 1	3130	7.53	116.43	6.85	116.39	6.08	116.35	4.77	116.30
	Reach 1	3125	7.53	116.39	6.85	116.33	6.08	116.28	4.77	116.21
	Reach 1	3120	7.53	116.32	6.85	116.26	6.08	116.18	4.77	116.02
	Reach 1	3115	7.53	116.25	6.85	116.18	6.08	116.09	4.77	115.91
	Reach 1	3110	8.29	116.25	7.51	116.18	6.62	116.09	5.15	115.91
	Reach 1	3105	8.29	116.17	7.51	116.10	6.62	116.02	5.15	115.85
	Reach 1	County Road 29								
	Reach 1	3100	8.29	116.04	7.51	115.99	6.62	115.93	5.15	115.81
	Reach 1	3090	8.29	115.52	7.51	115.49	6.62	115.46	5.15	115.41
	Reach 1	3085	9.44	115.40	8.58	115.37	7.61	115.34	5.96	115.27
	Reach 1	3080	9.44	114.88	8.58	114.83	7.61	114.77	5.96	114.65
	Reach 1	Kitly Line 1								
	Reach 1	3075	9.44	114.84	8.58	114.79	7.61	114.74	5.96	114.62
	Reach 1	3070	9.44	114.01	8.58	113.98	7.61	113.94	5.96	113.87
	Reach 1	3065	9.44	112.14	8.58	112.13	7.61	112.12	5.96	112.09

Table 15: Flow and Computed Water Level for 2-year to 20-year Flood Event (Continued)

Stream	Reach	XS ID	Flow (cms) and Computed WSEL (m) for Different flood events							
			Q20	WL20	Q10	WL10	Q5	WL5	Q2	WL2
Hutton Creek	Reach 1	3060	9.44	110.01	8.58	109.99	7.61	109.96	5.96	110.00
	Reach 1	3055	9.44	109.64	8.58	109.62	7.61	109.60	5.96	109.32
	Reach 1	Private Crossing #5								
	Reach 1	3050	9.44	109.64	8.58	109.62	7.61	109.59	5.96	109.55
	Reach 1	3045	10.50	108.26	9.50	108.15	8.41	108.06	6.59	107.90
	Reach 1	Townline Road								
	Reach 1	3040	10.50	108.22	9.50	108.12	8.41	108.02	6.59	107.87
	Reach 1	3035	10.50	106.81	9.50	106.70	8.41	106.61	6.59	106.47
	Reach 1	3030	10.50	106.83	9.50	106.72	8.41	106.63	6.59	106.49
	Reach 1	3025	10.50	106.83	9.50	106.72	8.41	106.63	6.59	106.49
	Reach 1	3020	10.50	106.82	9.50	106.72	8.41	106.62	6.59	106.48
	Reach 1	3015	10.50	106.82	9.50	106.72	8.41	106.62	6.59	106.48
	Reach 1	3010	10.50	106.82	9.50	106.72	8.41	106.62	6.59	106.48
	Reach 1	3005	10.50	106.82	9.50	106.72	8.41	106.62	6.59	106.48
	Reach 1	3000	10.50	106.82	9.50	106.72	8.41	106.62	6.59	106.48

Table 16: Manning's n Roughness Coefficients

Stream	Reach	XS ID	Left Overbank n	Channel n	Right Overbank n
Otter Creek	Reach 1	2420	0.001	0.001	0.001
	Reach 1	2415	0.001	0.001	0.001
	Reach 1	2410	0.001	0.001	0.001
	Reach 1	2405	0.08	0.037	0.08
	Reach 1	Otter Lake Road			
	Reach 1	2400	0.08	0.037	0.08
	Reach 1	2395	0.08	0.037	0.08
	Reach 1	2392	0.08	0.037	0.08
	Reach 1	2390	0.08	0.037	0.08
	Reach 1	2385	0.08	0.037	0.08
	Reach 1	2380	0.08	0.037	0.08
	Reach 1	2375	0.08	0.037	0.08
	Reach 1	2370	0.08	0.037	0.08
	Reach 1	2365	0.08	0.037	0.08
	Reach 1	2360	0.08	0.037	0.08
	Reach 1	2355	0.08	0.037	0.08
	Reach 1	2350	0.08	0.037	0.08
	Reach 1	2345	0.08	0.037	0.08
	Reach 1	Rideau Ferry Road			
	Reach 1	2340	0.08	0.015	0.08
	Reach 1	2335	0.08	0.015	0.08
	Reach 1	Black Smith Road			
	Reach 1	2330	0.08	0.015	0.08
	Reach 1	2325	0.08	0.015	0.08
	Reach 1	2320	0.08	0.015	0.08
	Reach 1	HWY 15			
	Reach 1	2315	0.08	0.015	0.08
	Reach 1	2310	0.08	0.015	0.08
	Reach 1	2305	0.08	0.015	0.08
	Reach 1	Anglican Church Road			
	Reach 1	2300	0.08	0.03	0.08
	Reach 1	2295	0.08	0.03	0.08
	Reach 1	2290	0.08	0.03	0.08
	Reach 1	Private Crossing #1			
	Reach 1	2285	0.08	0.03	0.08
	Reach 1	2280	0.08	0.03	0.08
	Reach 1	2275	0.08	0.03	0.08
	Reach 1	Private Crossing #2			
	Reach 1	2270	0.08	0.03	0.08

Table 16: Manning's n Roughness Coefficients (Continued)

Stream	Reach	XS ID	Left Overbank n	Channel n	Right Overbank n
Otter Creek	Reach 1	2265	0.08	0.03	0.08
	Reach 1	2260	0.08	0.03	0.08
	Reach 1	Private Crossing #3			
	Reach 1	2255	0.08	0.03	0.08
	Reach 1	2250	0.08	0.03	0.08
	Reach 1	2245	0.08	0.03	0.08
	Reach 1	Private Crossing #4			
	Reach 1	2240	0.08	0.03	0.08
	Reach 1	2235	0.08	0.03	0.08
	Reach 1	Cataraqui Trail			
	Reach 1	2230	0.08	0.03	0.08
	Reach 1	2225	0.08	0.03	0.08
	Reach 1	2220	0.08	0.03	0.08
	Reach 1	2215	0.08	0.03	0.08
	Reach 1	2210	0.08	0.03	0.08
	Reach 1	Kelly's Road			
	Reach 1	2205	0.08	0.041	0.08
	Reach 1	2200	0.08	0.041	0.08
	Reach 1	2195	0.08	0.041	0.08
	Reach 1	2190	0.08	0.041	0.08
	Reach 1	2185	0.08	0.041	0.08
	Reach 1	2180	0.08	0.041	0.08
	Reach 1	2175	0.08	0.041	0.08
	Reach 1	2170	0.08	0.041	0.08
	Reach 1	2165	0.08	0.041	0.08
	Reach 1	2160	0.08	0.041	0.08
	Reach 1	2155	0.08	0.041	0.08
	Reach 1	2150	0.08	0.041	0.08
	Reach 1	2145	0.08	0.041	0.08
	Reach 1	2140	0.08	0.041	0.08
	Reach 1	Hunter's Road			
	Reach 1	2135	0.08	0.044	0.08
	Reach 1	2130	0.08	0.044	0.08
	Reach 1	2125	0.08	0.044	0.08
	Reach 1	2120	0.08	0.044	0.08
	Reach 1	2115	0.08	0.044	0.08
	Reach 1	Private Crossing #6			
	Reach 1	2110	0.08	0.044	0.08
	Reach 1	2105	0.08	0.044	0.08

Table 16: Manning's n Roughness Coefficients (Continued)

Stream	Reach	XS ID	Left Overbank n	Channel n	Right Overbank n
Otter Creek	Reach 1	2100	0.08	0.044	0.08
	Reach 1	2095	0.08	0.044	0.08
	Reach 1	2090	0.08	0.044	0.08
	Reach 1	Private Crossing #7			
	Reach 1	2085	0.08	0.044	0.08
	Reach 1	2080	0.08	0.044	0.08
	Reach 1	2075	0.08	0.044	0.08
	Reach 1	2070	0.08	0.044	0.08
	Reach 1	Private Crossing #8			
	Reach 1	2065	0.08	0.044	0.08
	Reach 1	2060	0.08	0.044	0.08
	Reach 1	2055	0.08	0.044	0.08
	Reach 1	County Road 29			
	Reach 1	2050	0.08	0.01	0.08
	Reach 1	2045	0.08	0.01	0.08
	Reach 1	2040	0.08	0.01	0.08
	Reach 1	Purcell Road			
	Reach 1	2035	0.08	0.02	0.08
	Reach 1	2030	0.08	0.02	0.08
	Reach 1	2025	0.08	0.02	0.08
	Reach 1	2020	0.08	0.02	0.08
	Reach 1	2015	0.08	0.02	0.08
	Reach 1	2010	0.08	0.02	0.08
	Reach 1	2005	0.08	0.02	0.08
	Reach 1	2000	0.08	0.02	0.08
	Reach 2	50	0.08	0.03	0.08
	Reach 2	45	0.08	0.03	0.08
	Reach 2	40	0.08	0.03	0.08
	Reach 2	35	0.08	0.03	0.08
	Reach 2	Railway crossing			
	Reach 2	30	0.08	0.03	0.08
	Reach 2	25	0.08	0.03	0.08
	Reach 2	20	0.08	0.03	0.08
	Reach 2	15	0.08	0.03	0.08
	Reach 2	County Road 17			
	Reach 2	10	0.08	0.03	0.08
	Reach 2	5	0.08	0.03	0.08

Table 16: Manning's n Roughness Coefficients (Continued)

Stream	Reach	XS ID	Left Overbank n	Channel n	Right Overbank n
Hutton Creek	Reach 1	3245	0.01	0.01	0.01
	Reach 1	3240	0.01	0.01	0.01
	Reach 1	3235	0.01	0.01	0.01
	Reach 1	3230	0.01	0.01	0.01
	Reach 1	3225	0.08	0.01	0.08
	Reach 1	3220	0.08	0.01	0.08
	Reach 1	3215	0.08	0.01	0.08
	Reach 1	Motts Mill Dam			
	Reach 1	3210	0.1	0.07	0.1
	Reach 1	3205	0.1	0.07	0.1
	Reach 1	3200	0.1	0.07	0.1
	Reach 1	County Road 1			
	Reach 1	3190	0.1	0.085	0.1
	Reach 1	3185	0.1	0.085	0.1
	Reach 1	3180	0.1	0.085	0.1
	Reach 1	3175	0.1	0.085	0.1
	Reach 1	3170	0.1	0.085	0.1
	Reach 1	3165	0.1	0.085	0.1
	Reach 1	3160	0.1	0.085	0.1
	Reach 1	3155	0.1	0.085	0.1
	Reach 1	3150	0.1	0.085	0.1
	Reach 1	3145	0.1	0.085	0.1
	Reach 1	3140	0.1	0.085	0.1
	Reach 1	3135	0.1	0.085	0.1
	Reach 1	3130	0.1	0.085	0.1
	Reach 1	3125	0.1	0.085	0.1
	Reach 1	3120	0.1	0.085	0.1
	Reach 1	3115	0.1	0.085	0.1
	Reach 1	3110	0.1	0.085	0.1
	Reach 1	3105	0.1	0.085	0.1
	Reach 1	County Road 29			
	Reach 1	3100	0.1	0.098	0.1
	Reach 1	3090	0.1	0.098	0.1
	Reach 1	3085	0.1	0.098	0.1
	Reach 1	3080	0.1	0.098	0.1
	Reach 1	Kitly Line 1			
	Reach 1	3075	0.1	0.07	0.1
	Reach 1	3070	0.1	0.07	0.1
	Reach 1	3065	0.1	0.07	0.1

Table 16: Manning's n Roughness Coefficients (Continued)

Stream	Reach	XS ID	Left Overbank n	Channel n	Right Overbank n
Hutton Creek	Reach 1	3060	0.1	0.07	0.1
	Reach 1	3055	0.1	0.07	0.1
	Reach 1	Private Crossing #5			
	Reach 1	3050	0.1	0.07	0.1
	Reach 1	3045	0.1	0.07	0.1
	Reach 1	Townline Road			
	Reach 1	3040	0.1	0.07	0.1
	Reach 1	3035	0.1	0.07	0.1
	Reach 1	3030	0.1	0.07	0.1
	Reach 1	3025	0.1	0.07	0.1
	Reach 1	3020	0.1	0.07	0.1
	Reach 1	3015	0.1	0.07	0.1
	Reach 1	3010	0.1	0.07	0.1
	Reach 1	3005	0.1	0.07	0.1
	Reach 1	3000	0.1	0.07	0.1

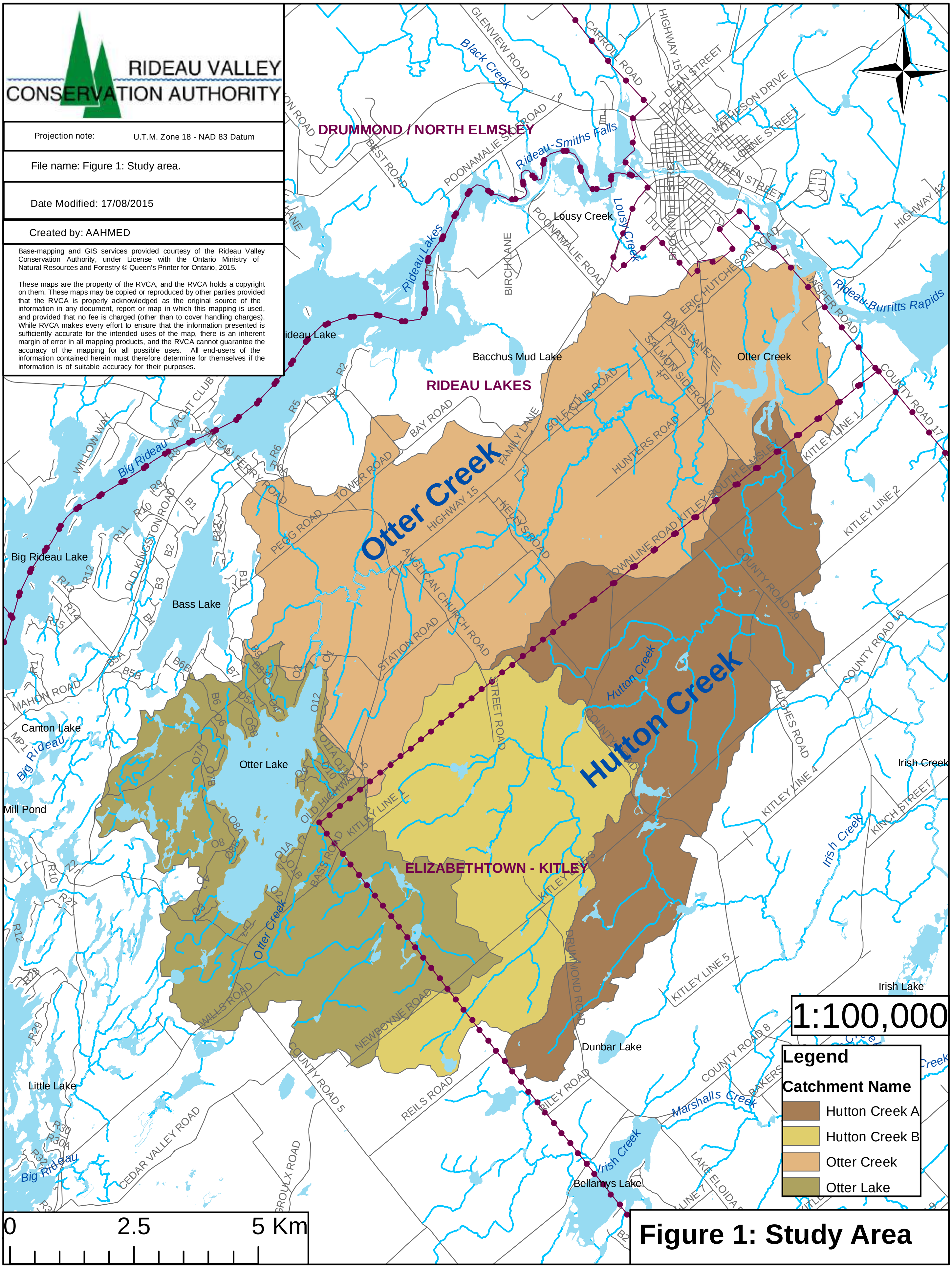


Figure 1: Study Area

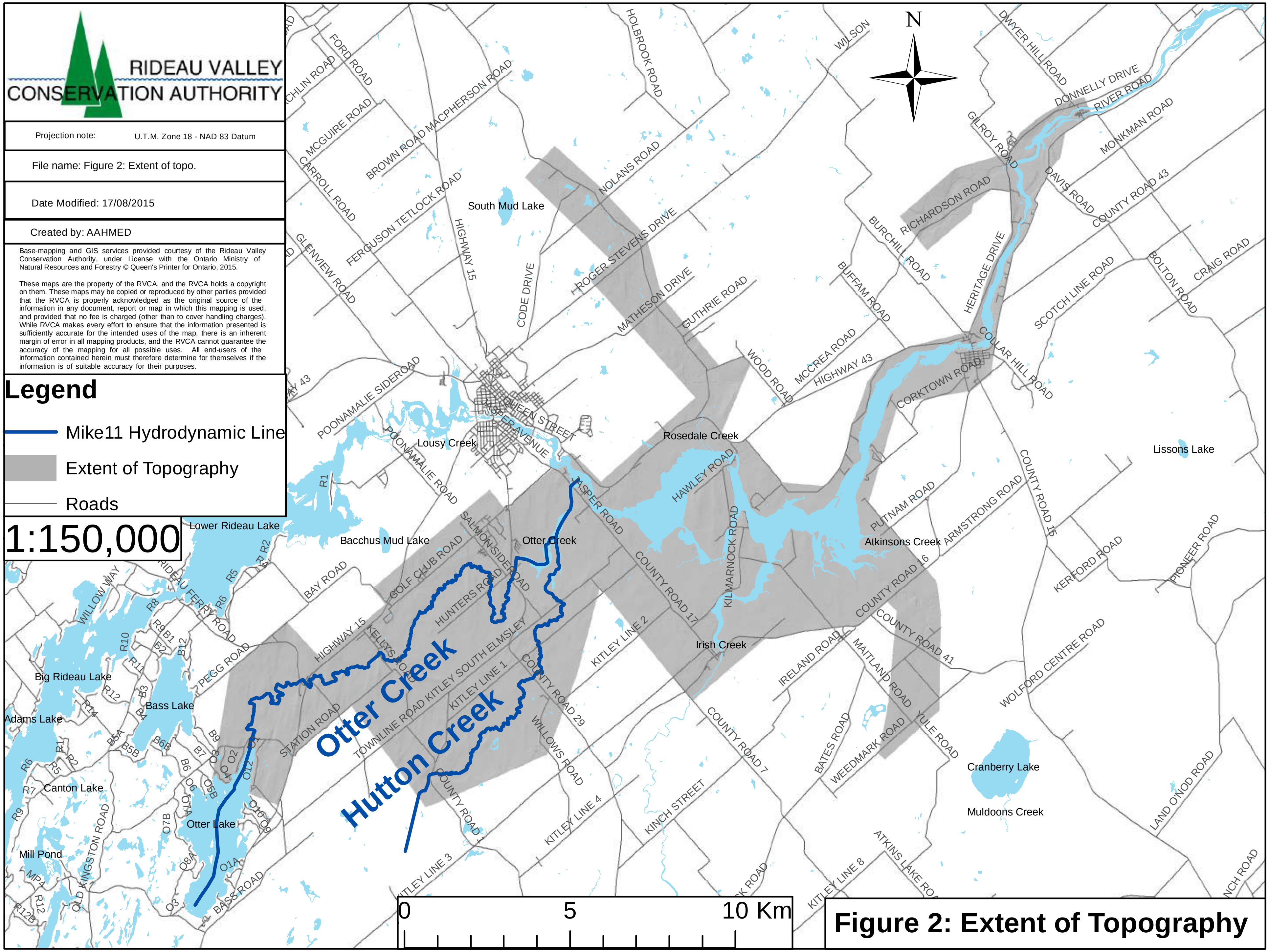


Figure 2: Extent of Topography

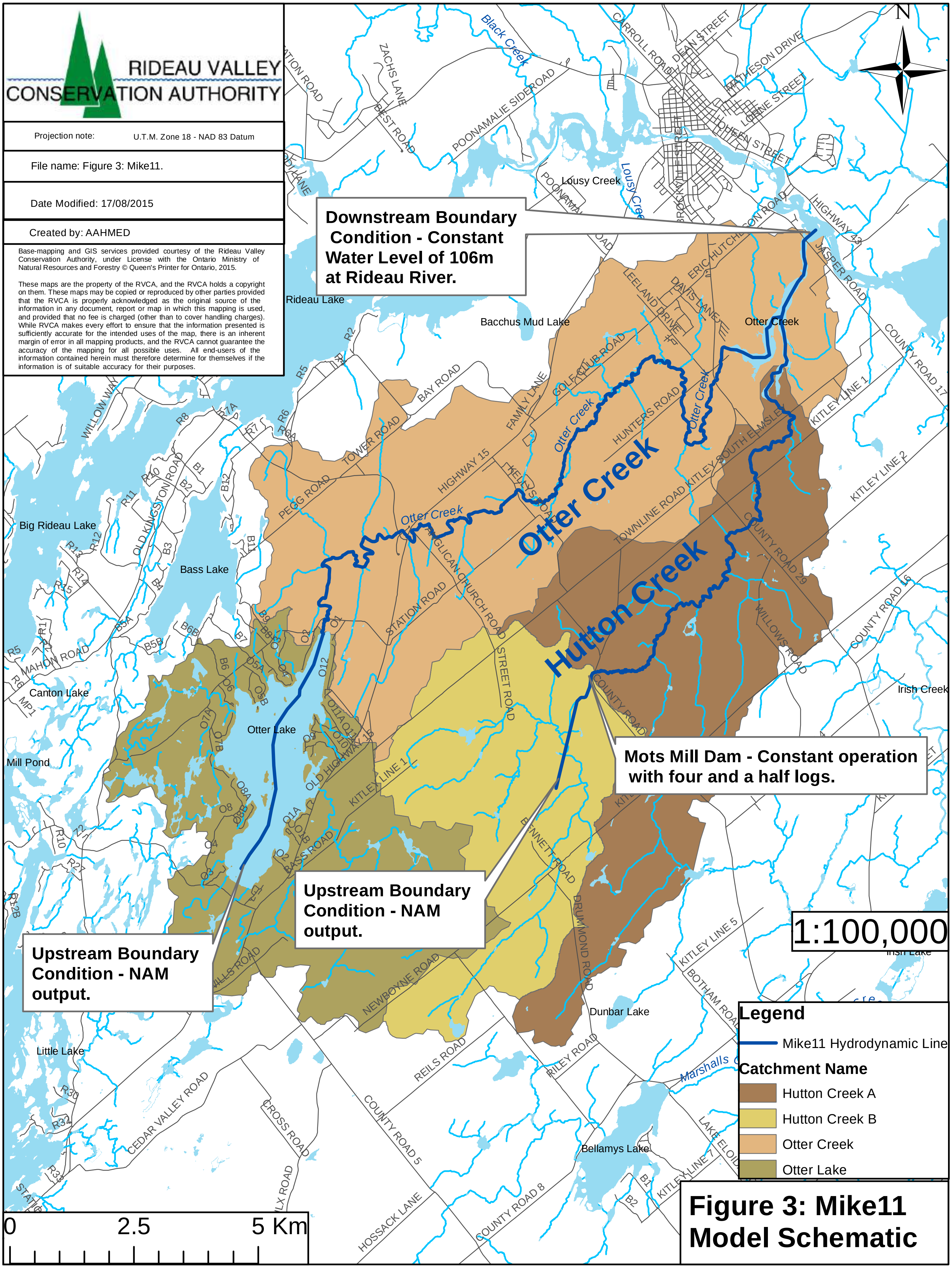


Figure 3: Mike11 Model Schematic

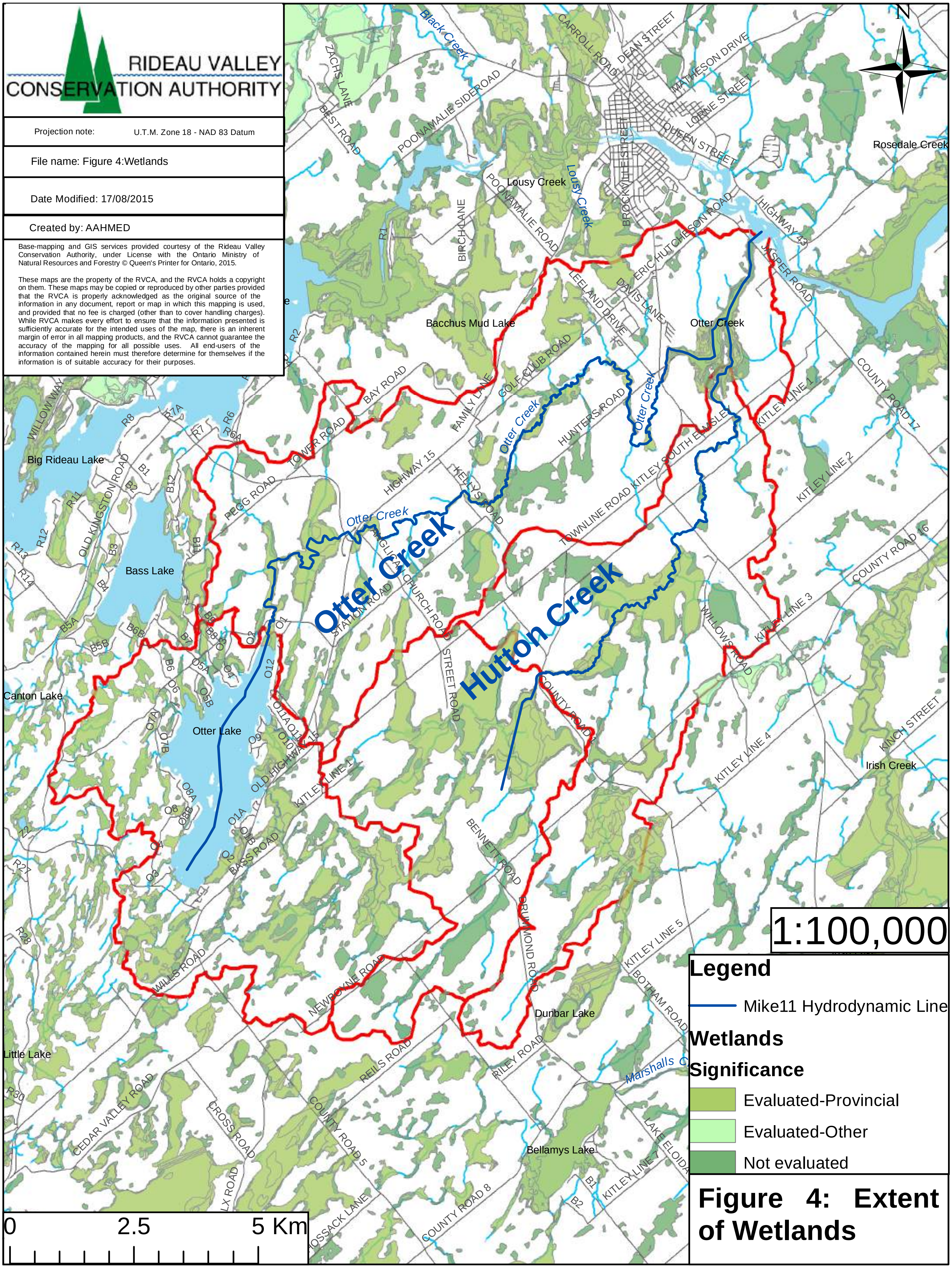


Figure 4: Extent of Wetlands

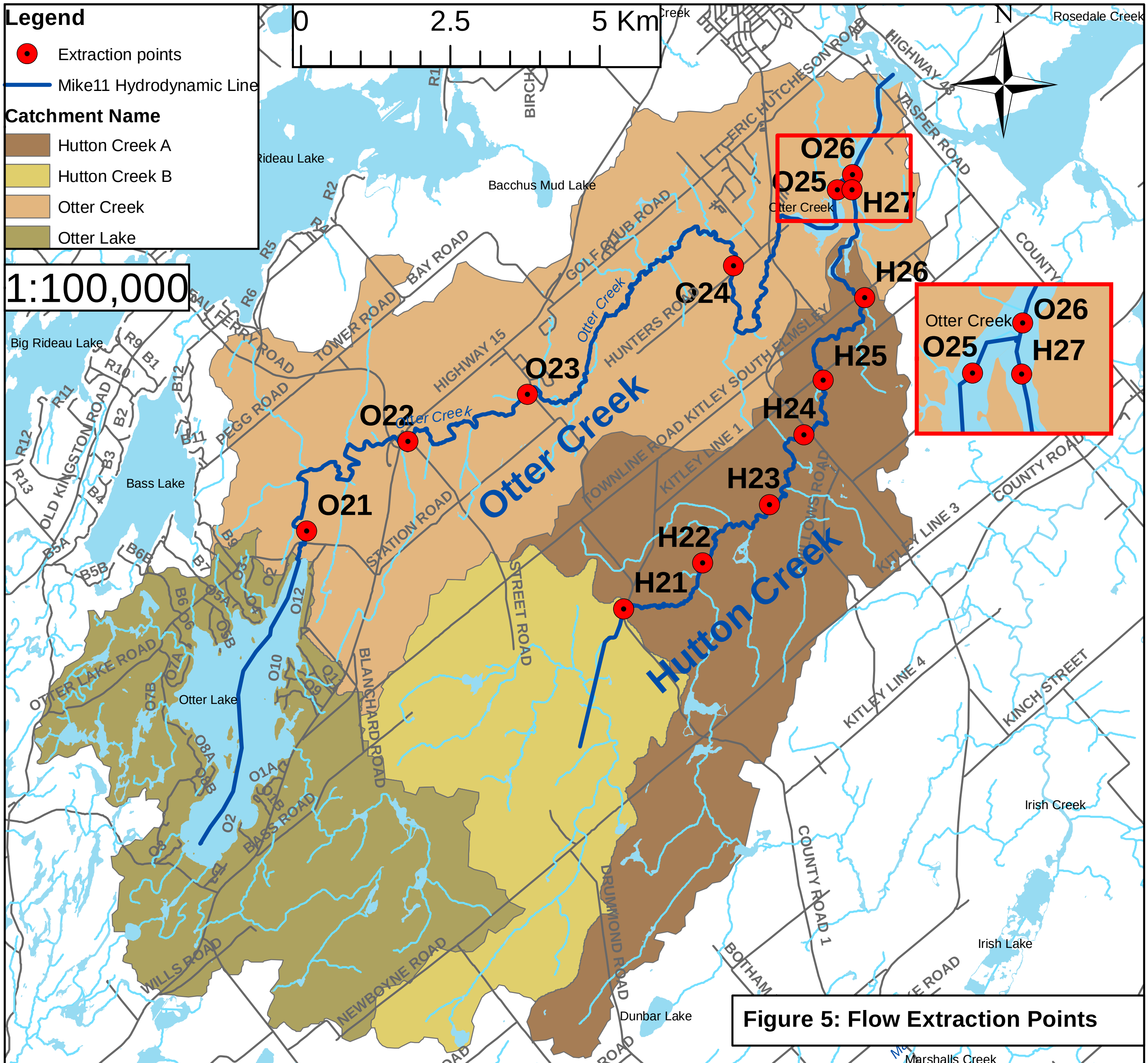


Figure 5: Flow Extraction Points

Extraction point ID	O21	O22	O23	O24	O25	O26	H21	H22	H23	H24	H25	H26	H27
	Otter Creek just downstream of the Otter lake outlet culvert	Otter Creek Upstream of Angilican church road	Otter creek upstream of Kelly's road	Otter creek upstream of Hunter's road	Otter Creek Just Upstream of the confluence with Hutton Creek	Otter Creek downstream of the confluence with Hutton Creek	Hutton Creek downstream of the Motts Mill dam	Hutton Creek just upstream of a Private Crossing.	Hutton Creek between H22 and H24	Hutton Creek just upstream of County road 29	Hutton Creek just upstream of Kitly Line 1	Hutton Creek just upstream of townline road	Hutton Creek just upstream of the confluence with Otter Creek
1.003	1.29	1.69	2.13	2.95	3.60	6.18	1.26	1.39	1.63	1.86	1.87	2.30	2.49
1.05	1.79	2.46	3.00	4.16	5.12	8.98	1.69	2.08	2.41	2.77	2.95	3.44	3.82
1.25	2.33	3.23	3.91	5.42	6.66	11.80	2.18	2.75	3.17	3.67	3.94	4.57	5.07
2	3.07	4.25	5.13	7.08	8.69	15.40	2.93	3.58	4.13	4.77	5.15	5.96	6.59
5	4.08	5.63	6.75	9.26	11.30	19.80	4.07	4.57	5.27	6.08	6.62	7.61	8.41
10	4.75	6.55	7.81	10.60	13.00	22.40	4.91	5.15	5.94	6.85	7.51	8.58	9.50
20	5.40	7.44	8.80	11.90	14.50	24.90	5.77	5.67	6.54	7.53	8.29	9.44	10.50
50	6.24	8.60	10.10	13.60	16.50	27.90	6.99	6.28	7.25	8.34	9.23	10.50	11.70
100	**6.88**	**9.47**	**11.00**	**14.80**	**17.90**	**30.00**	**7.98**	**6.71**	**7.75**	**8.91**	**9.87**	**11.20**	**12.50**
200	7.54	10.30	12.00	16.00	19.40	32.00	9.05	7.12	8.23	9.44	10.50	11.80	13.40
500	8.42	11.50	13.30	17.70	21.20	34.70	10.60	7.63	8.83	10.10	11.20	12.70	14.40

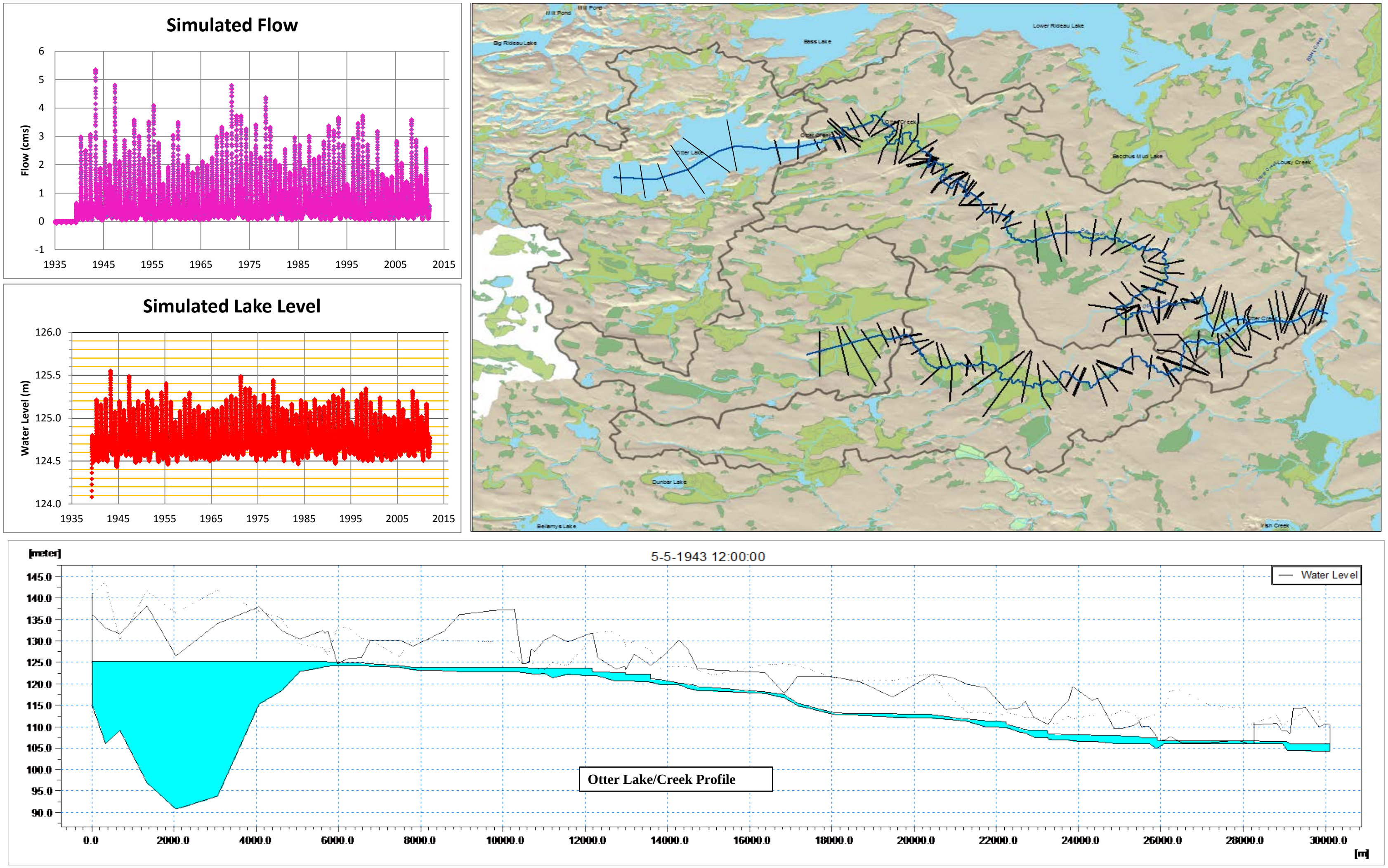
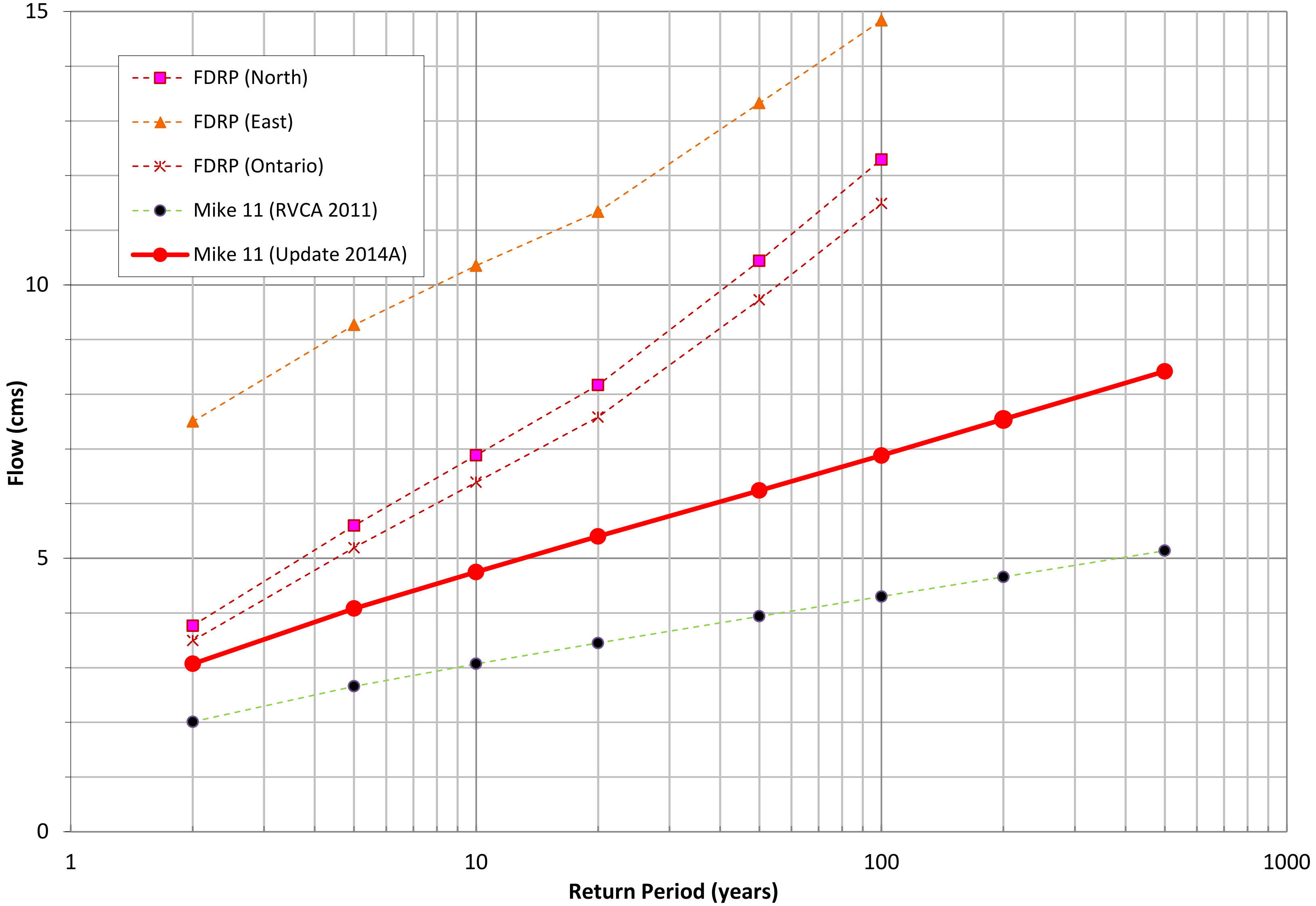


Figure 6: Mike 11 Model of the Otter - Hutton System

Figure 7: Estimated Flood Flows at Otter Lake Outlet



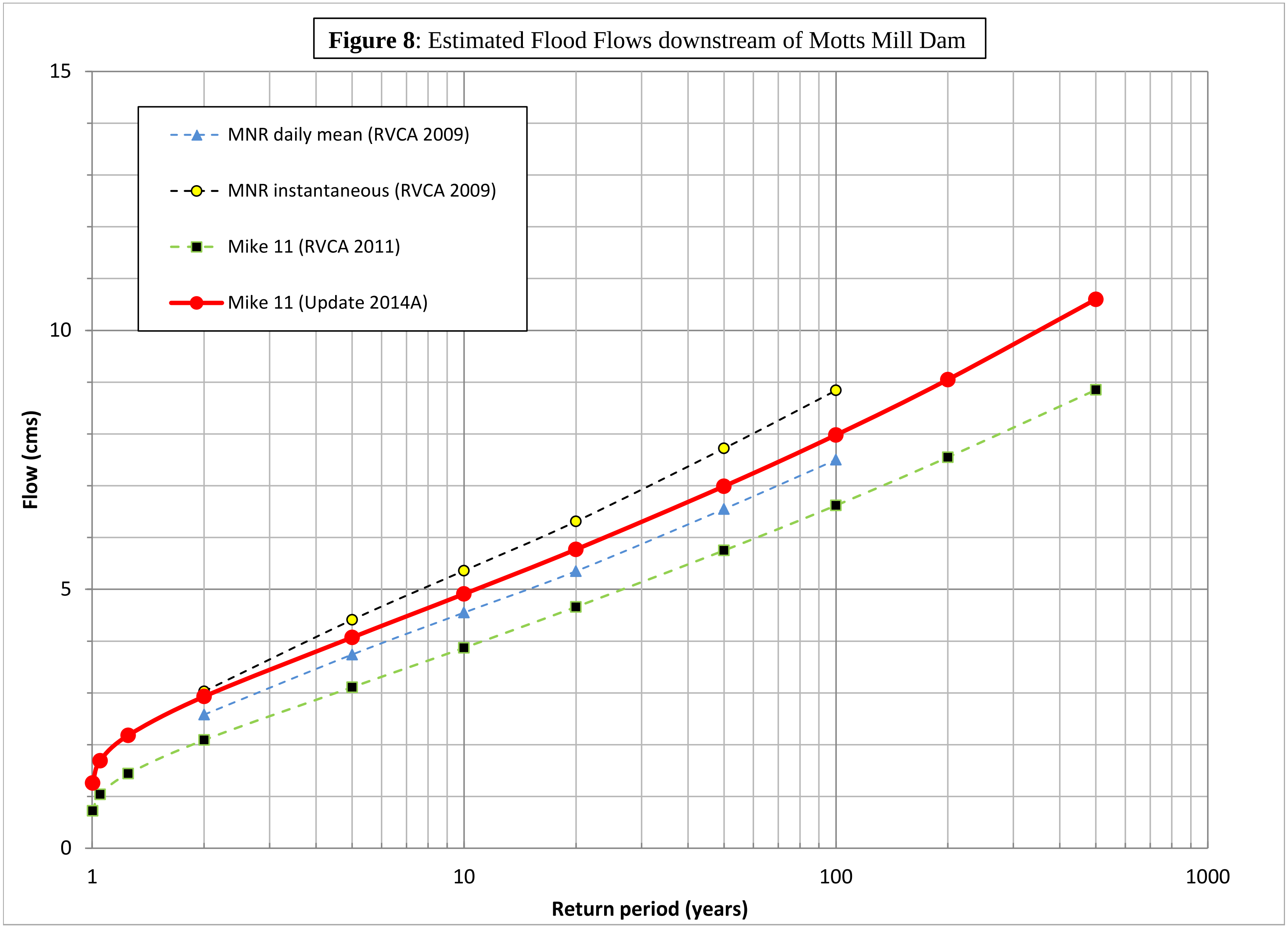


Figure 8: Estimated Flood Flows downstream of Motts Mill Dam
MNR daily mean (RVCA 2009)
MNR instantaneous (RVCA 2009)
Mike 11 (RVCA 2011)
Mike 11 (Update 2014A)
Flow (cms)
15
10
5
0
1
10
100
1000
Return period (years)

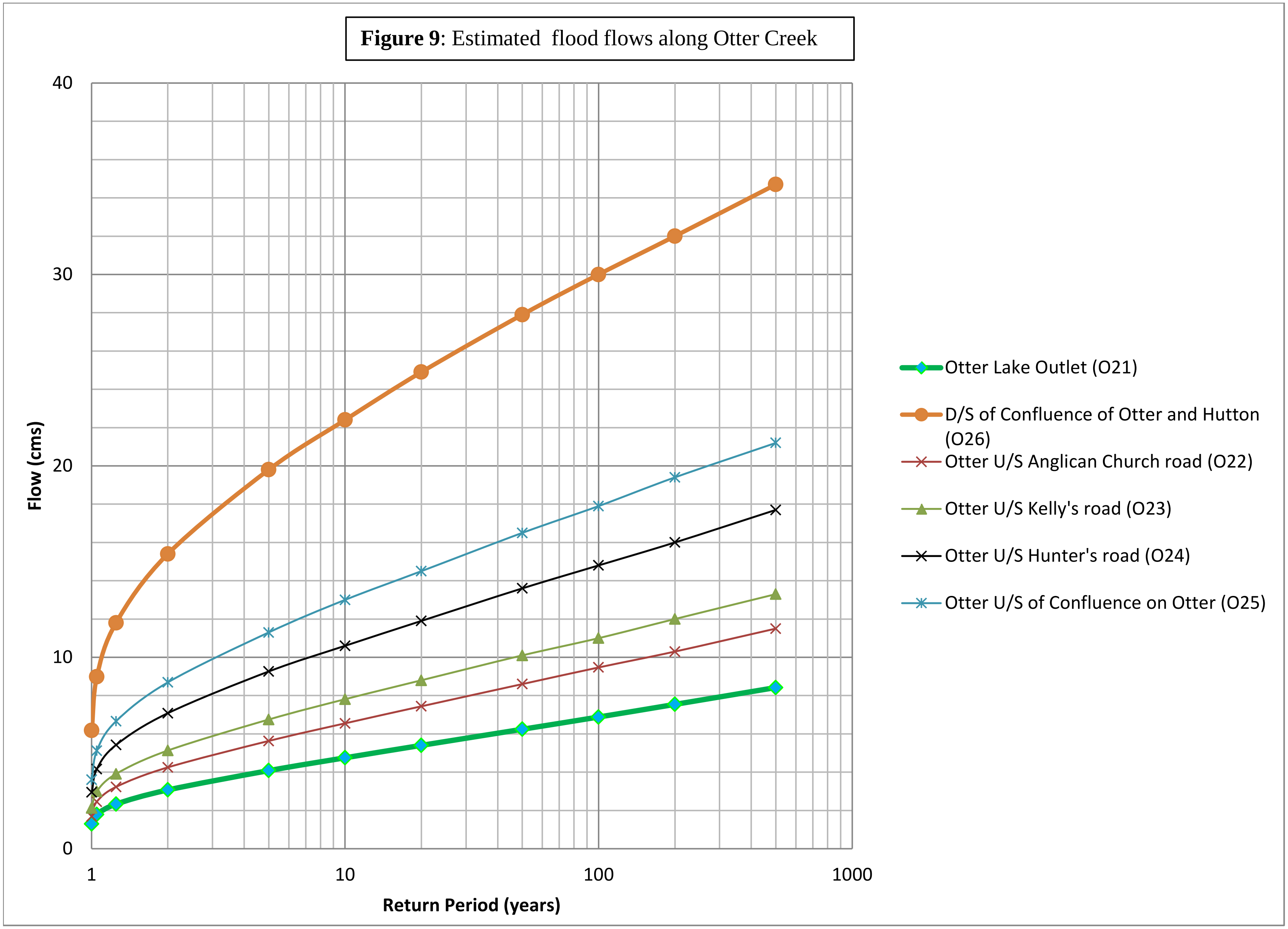


Figure 9: Estimated flood flows along Otter Creek
Flow (cms)
Return Period (years)
0
10
20
30
40
1
10
100
1000
Otter Lake Outlet (O21)
D/S of Confluence of Otter and Hutton (O26)
Otter U/S Anglican Church road (O22)
Otter U/S Kelly's road (O23)
Otter U/S Hunter's road (O24)
Otter U/S of Confluence on Otter (O25)

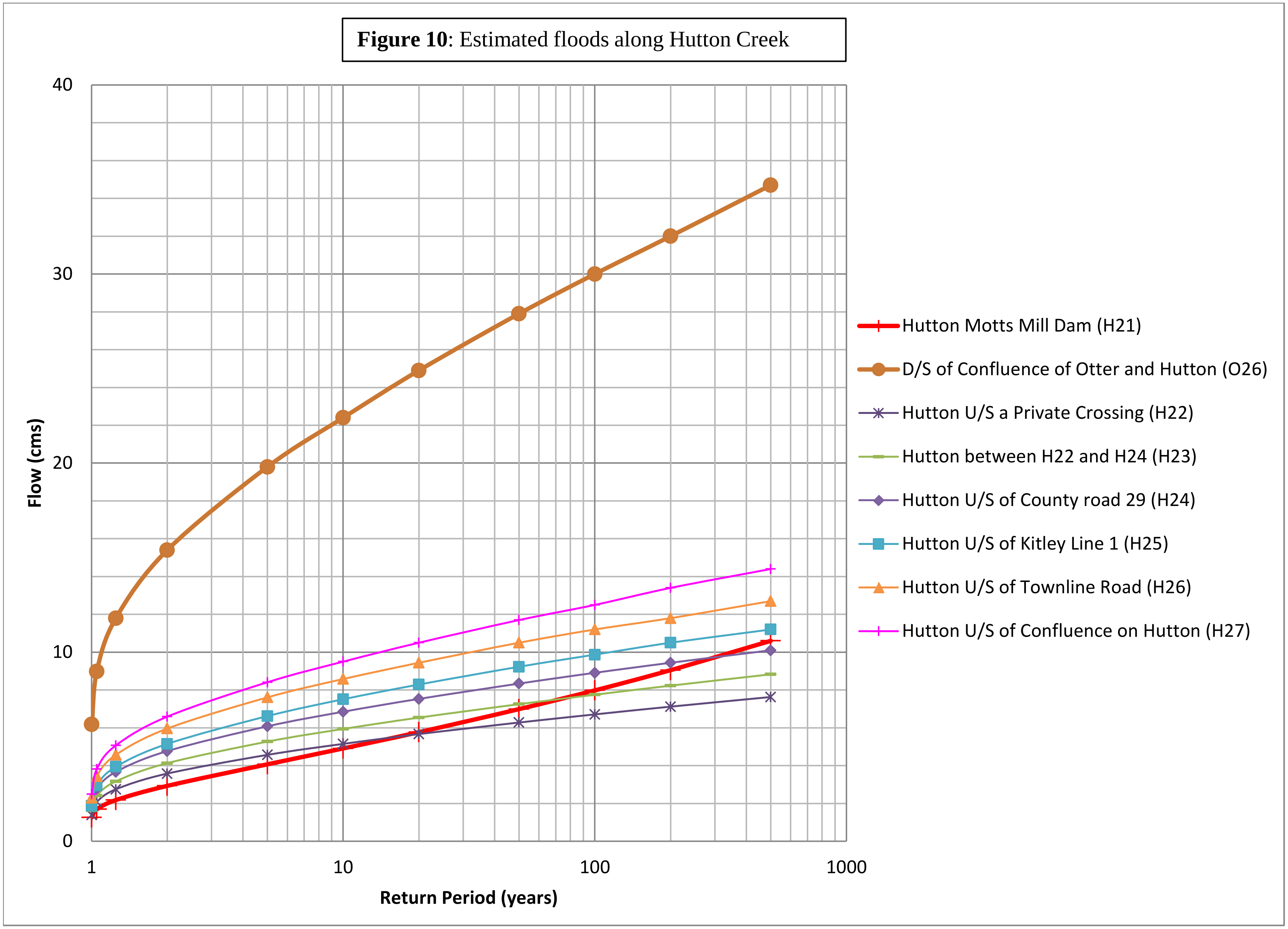


Figure 10: Estimated floods along Hutton Creek
Flow (cms)
40
30
20
10
0
1
10
100
1000
Return Period (years)
Hutton Motts Mill Dam (H21)
D/S of Confluence of Otter and Hutton (O26)
Hutton U/S a Private Crossing (H22)
Hutton between H22 and H24 (H23)
Hutton U/S of County road 29 (H24)
Hutton U/S of Kitley Line 1 (H25)
Hutton U/S of Townline Road (H26)
Hutton U/S of Confluence on Hutton (H27)

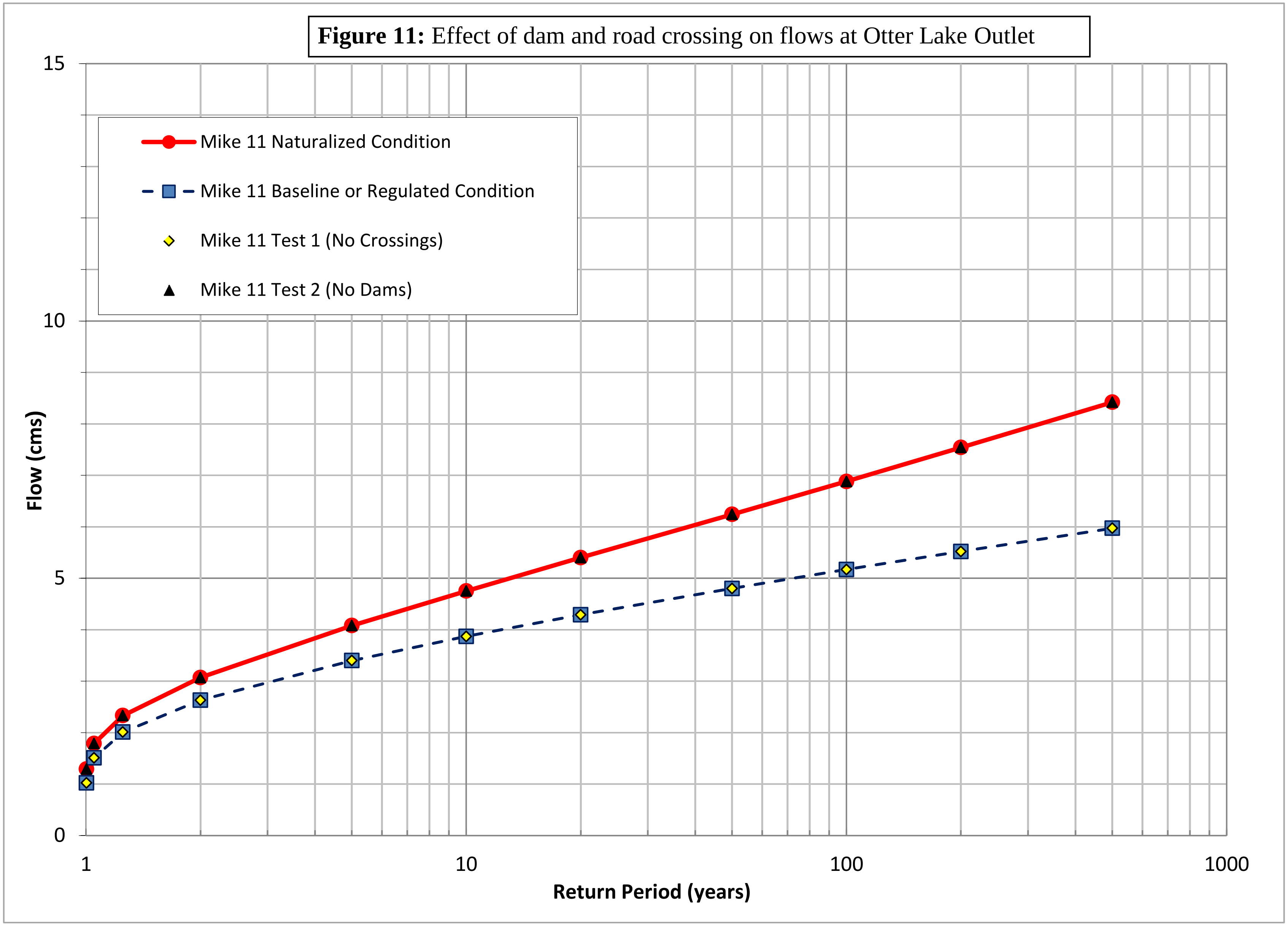


Figure 11: Effect of dam and road crossing on flows at Otter Lake Outlet
Mike 11 Naturalized Condition
Mike 11 Baseline or Regulated Condition
Mike 11 Test 1 (No Crossings)
Mike 11 Test 2 (No Dams)
Flow (cms)
0
5
10
15
1
10
100
1000
Return Period (years)

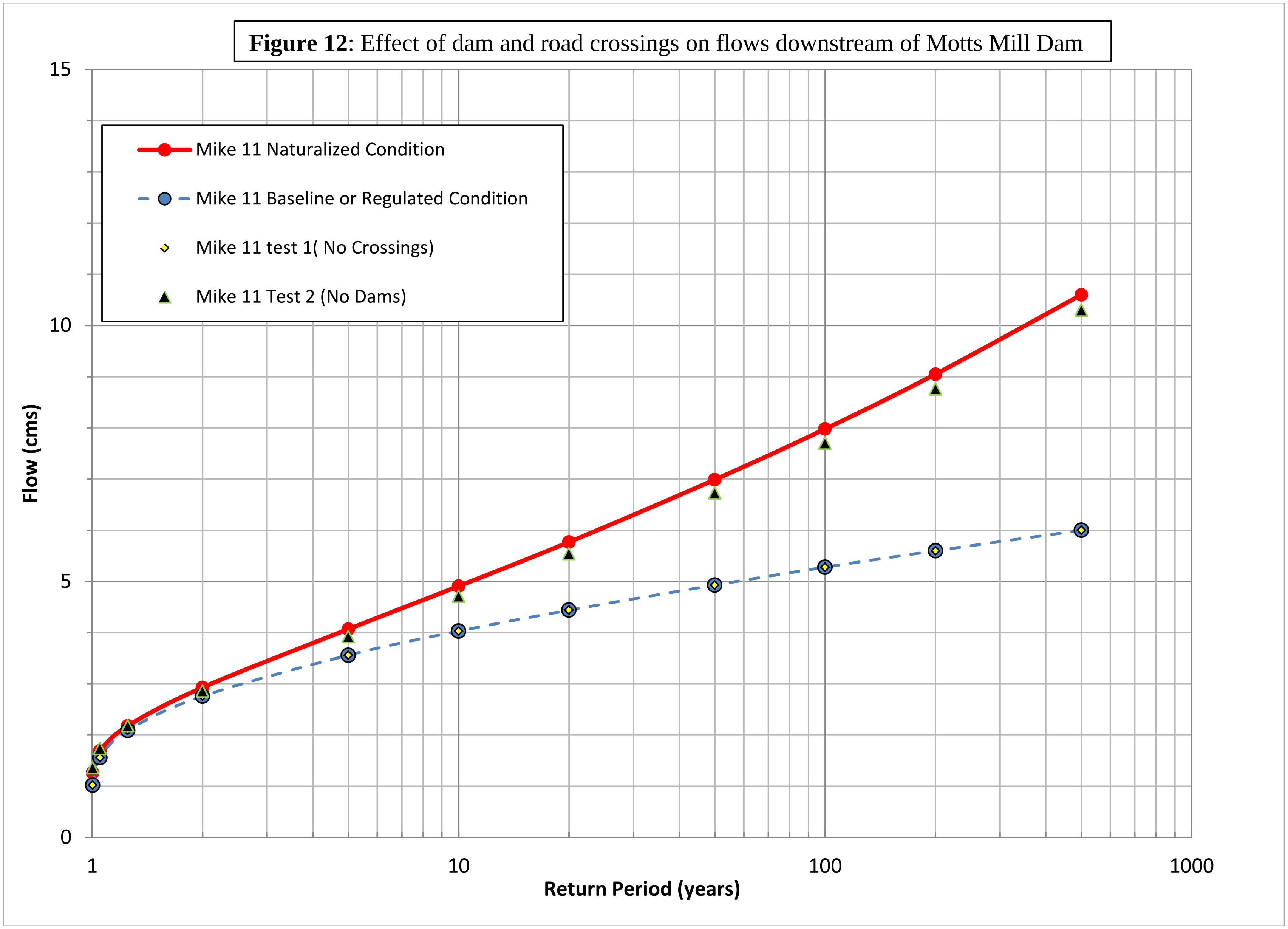


Figure 12: Effect of dam and road crossings on flows downstream of Motts Mill Dam
Mike 11 Naturalized Condition
Mike 11 Baseline or Regulated Condition
Mike 11 test 1(No Crossings)
Mike 11 Test 2 (No Dams)
Flow (cms)
15
10
5
0
1
10
100
1000
Return Period (years)

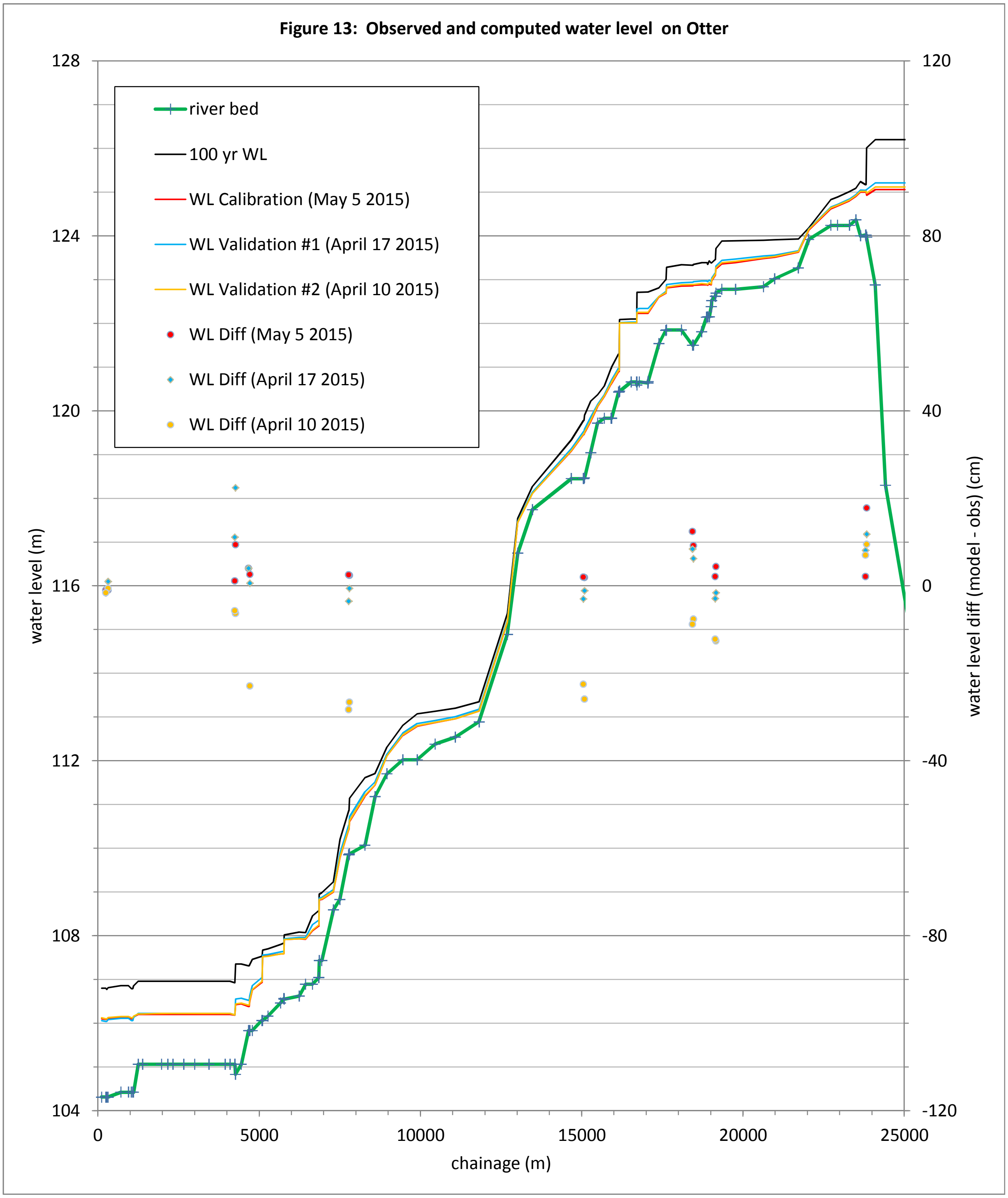


Figure 13: Observed and computed water level on Otter
river bed
100 yr WL
WL Calibration (May 5 2015)
WL Validation #1 (April 17 2015)
WL Validation #2 (April 10 2015)
WL Diff (May 5 2015)
WL Diff (April 17 2015)
WL Diff (April 10 2015)
water level (m)
water level diff (model - obs) (cm)
chainage (m)
128
124
120
116
112
108
104
120
80
40
0
-40
-80
-120
0
5000
10000
15000
20000
25000

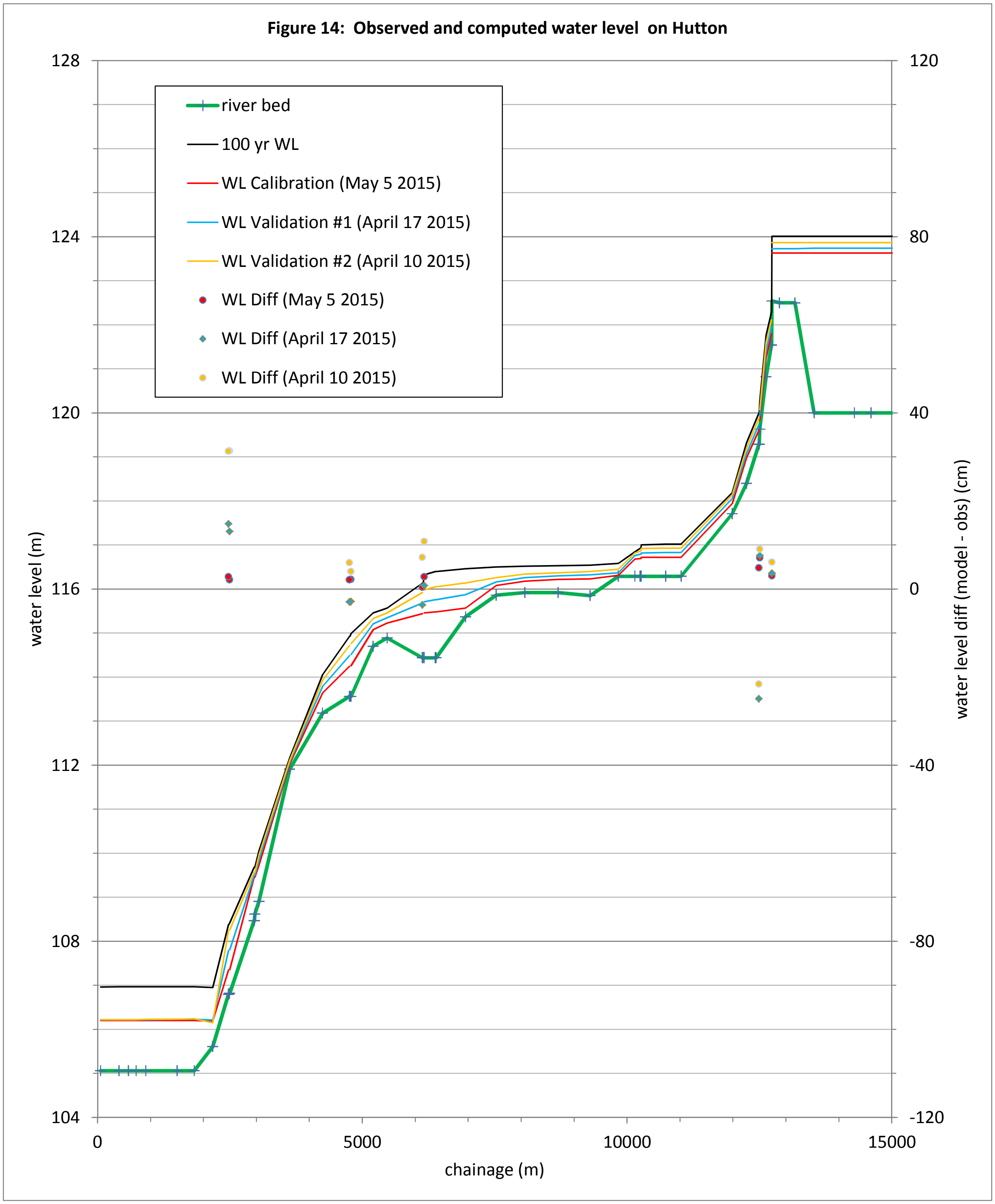


Figure 14: Observed and computed water level on Hutton
river bed
100 yr WL
WL Calibration (May 5 2015)
WL Validation #1 (April 17 2015)
WL Validation #2 (April 10 2015)
WL Diff (May 5 2015)
WL Diff (April 17 2015)
WL Diff (April 10 2015)
water level (m)
water level diff (model - obs) (cm)
chainage (m)
128
124
120
116
112
108
104
120
80
40
0
-40
-80
-120
0
5000
10000
15000

Figure 15: Farm 1 crossing on Otter Creek

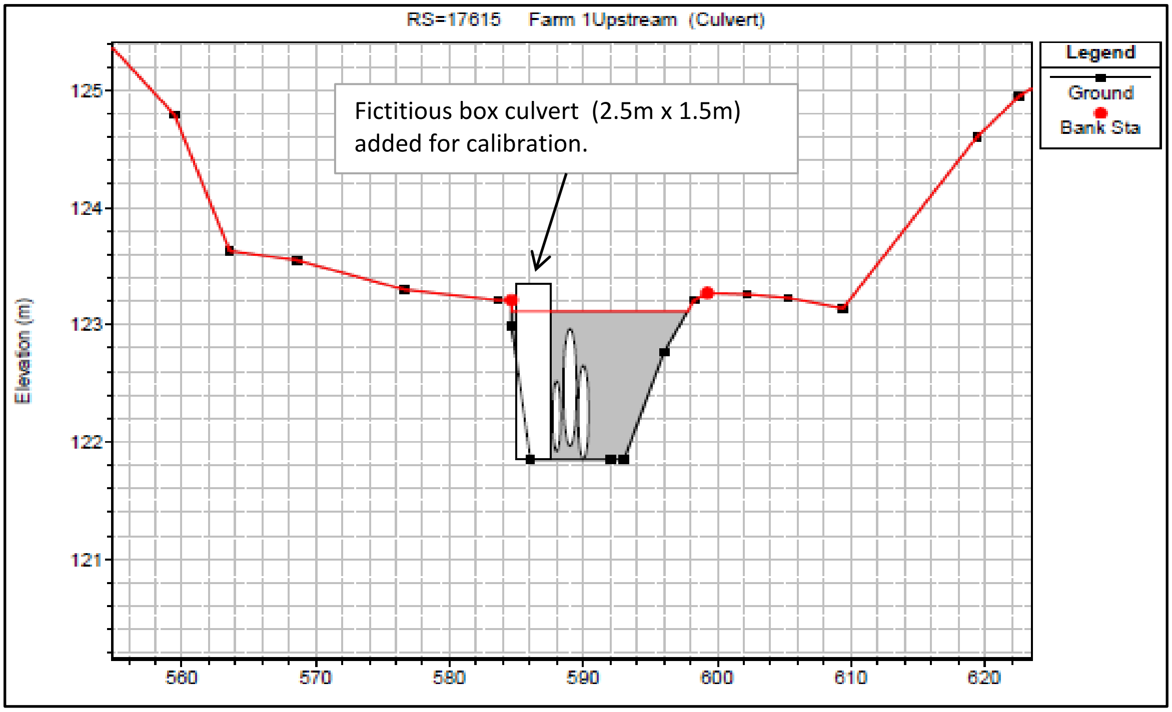
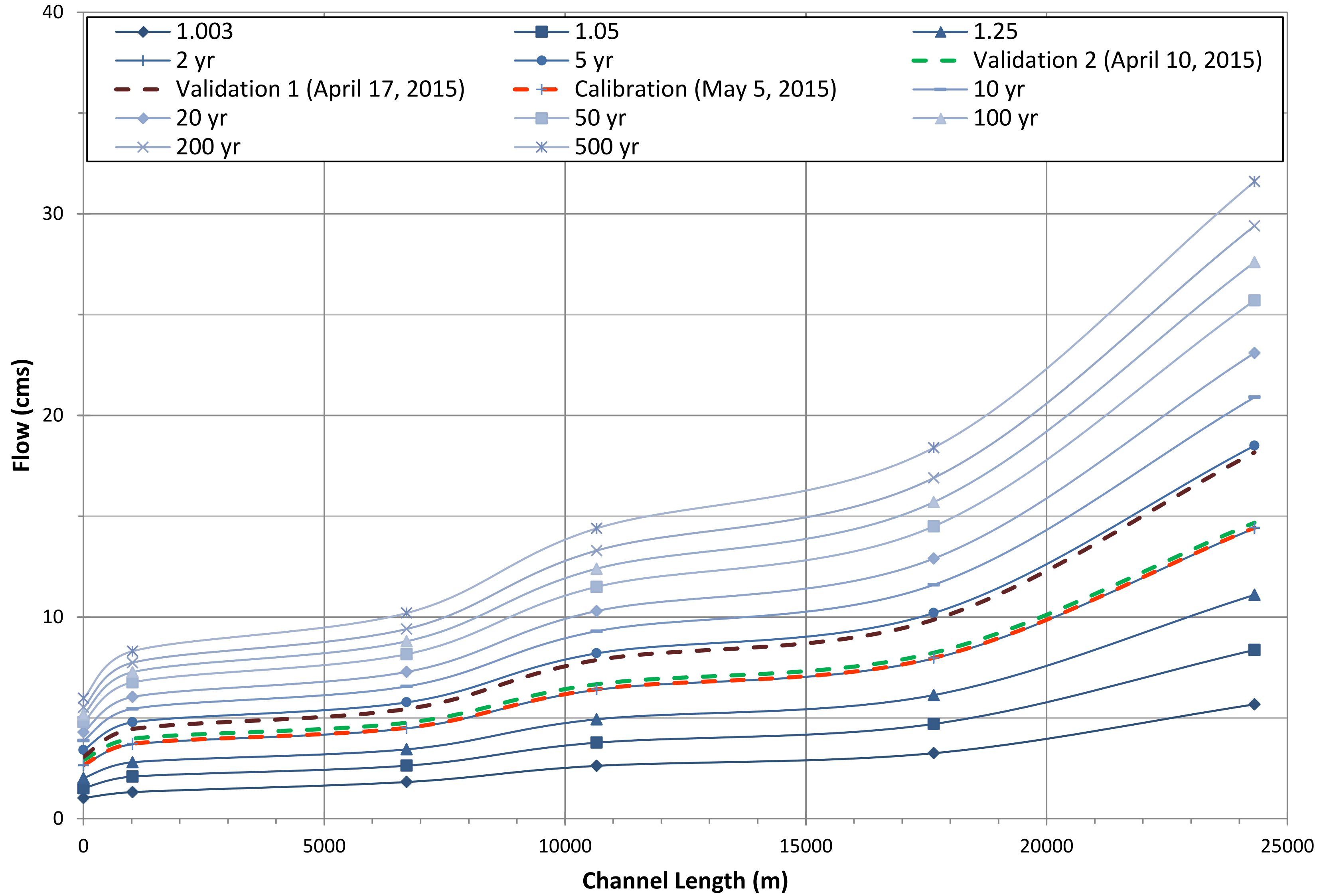


Figure 16 Estimated flows for calibration and validation (Otter Creek)



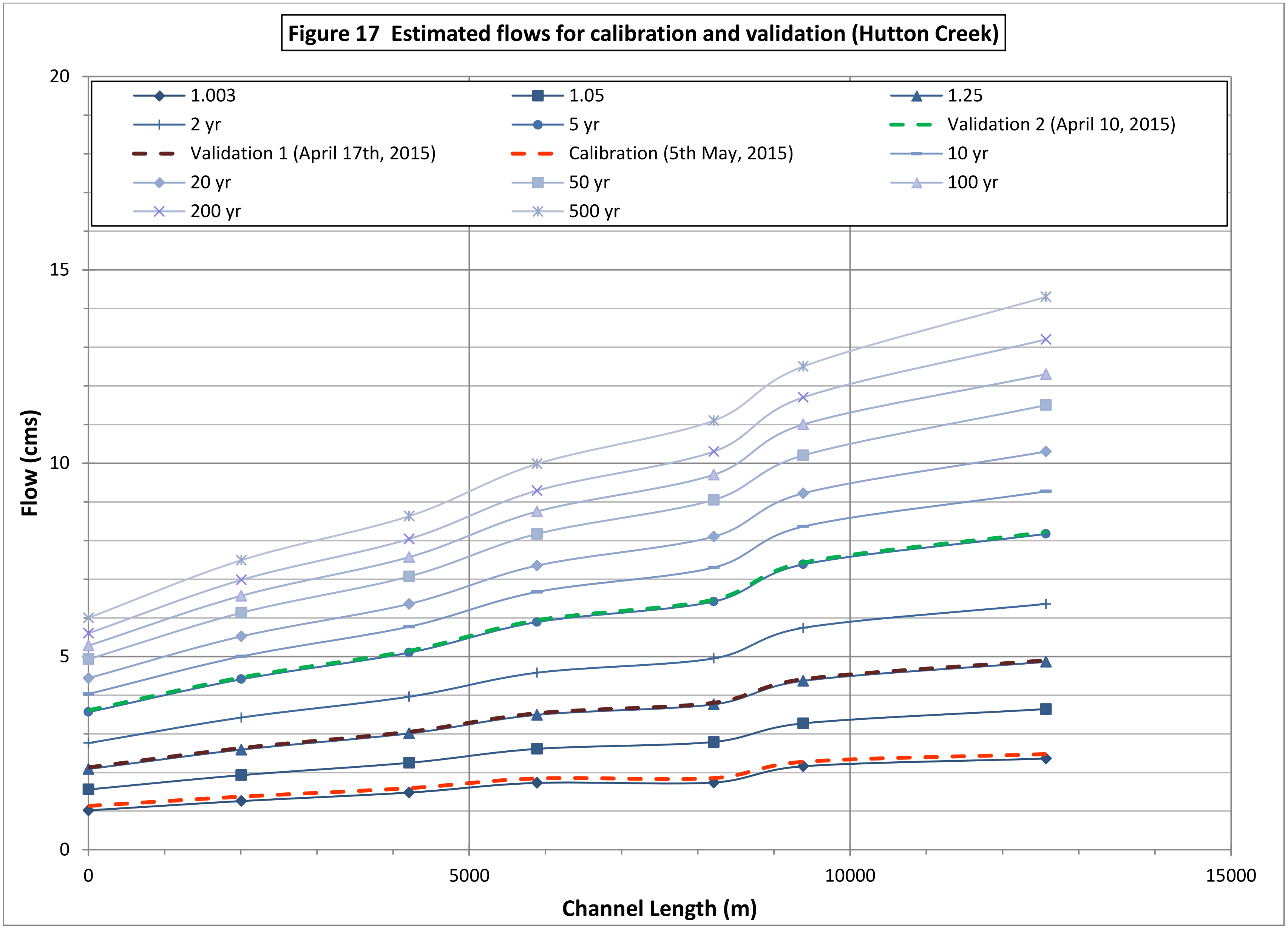


Figure 17 Estimated flows for calibration and validation (Hutton Creek)
1.003
1.05
1.25
2 yr
5 yr
Validation 2 (April 10, 2015)
Validation 1 (April 17th, 2015)
Calibration (5th May, 2015)
10 yr
20 yr
50 yr
100 yr
200 yr
500 yr
Flow (cms)
Channel Length (m)
0
5
10
15
20
0
5000
10000
15000

Figure 18: Sensitivity analysis of computed water level to design flow (Otter Creek

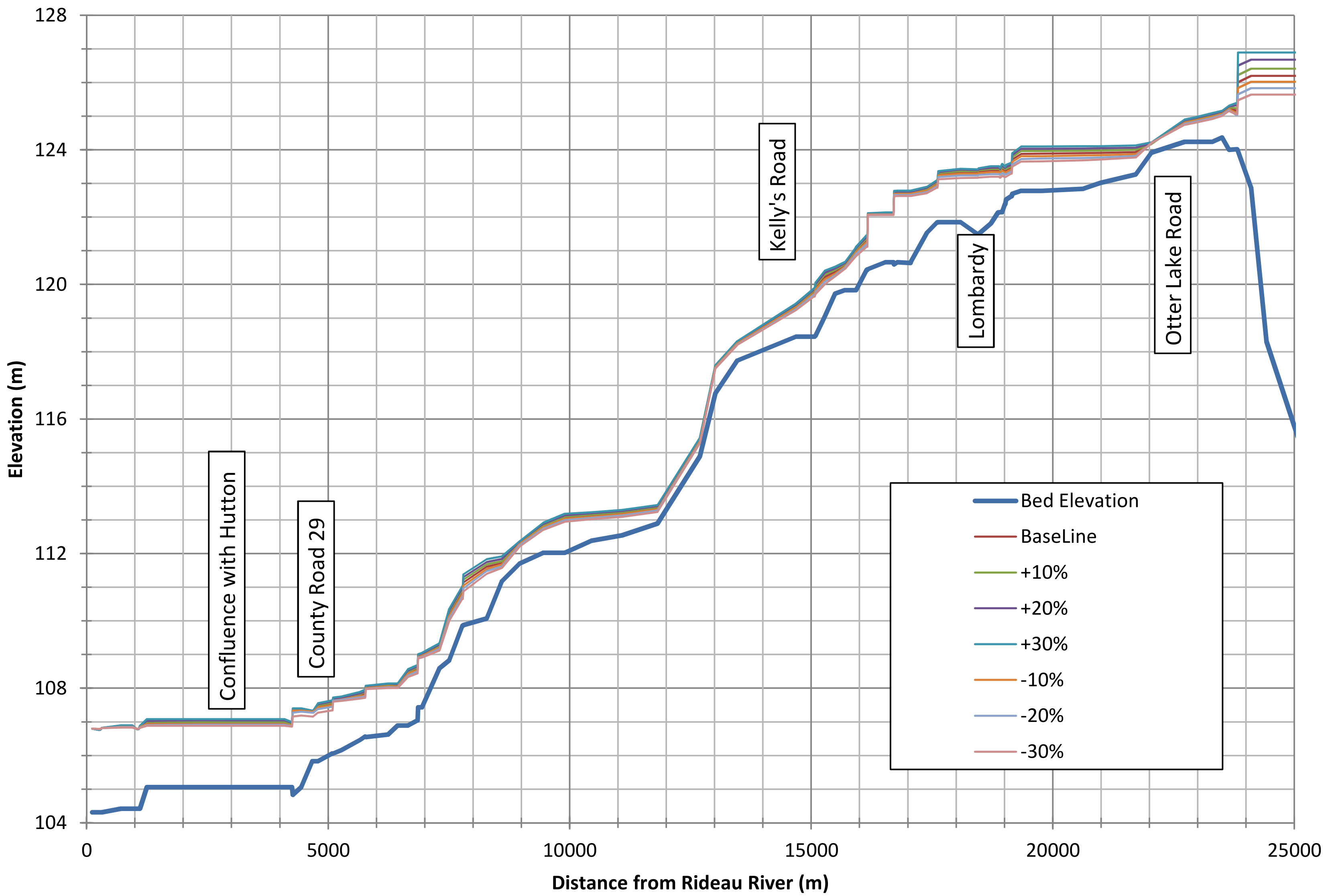
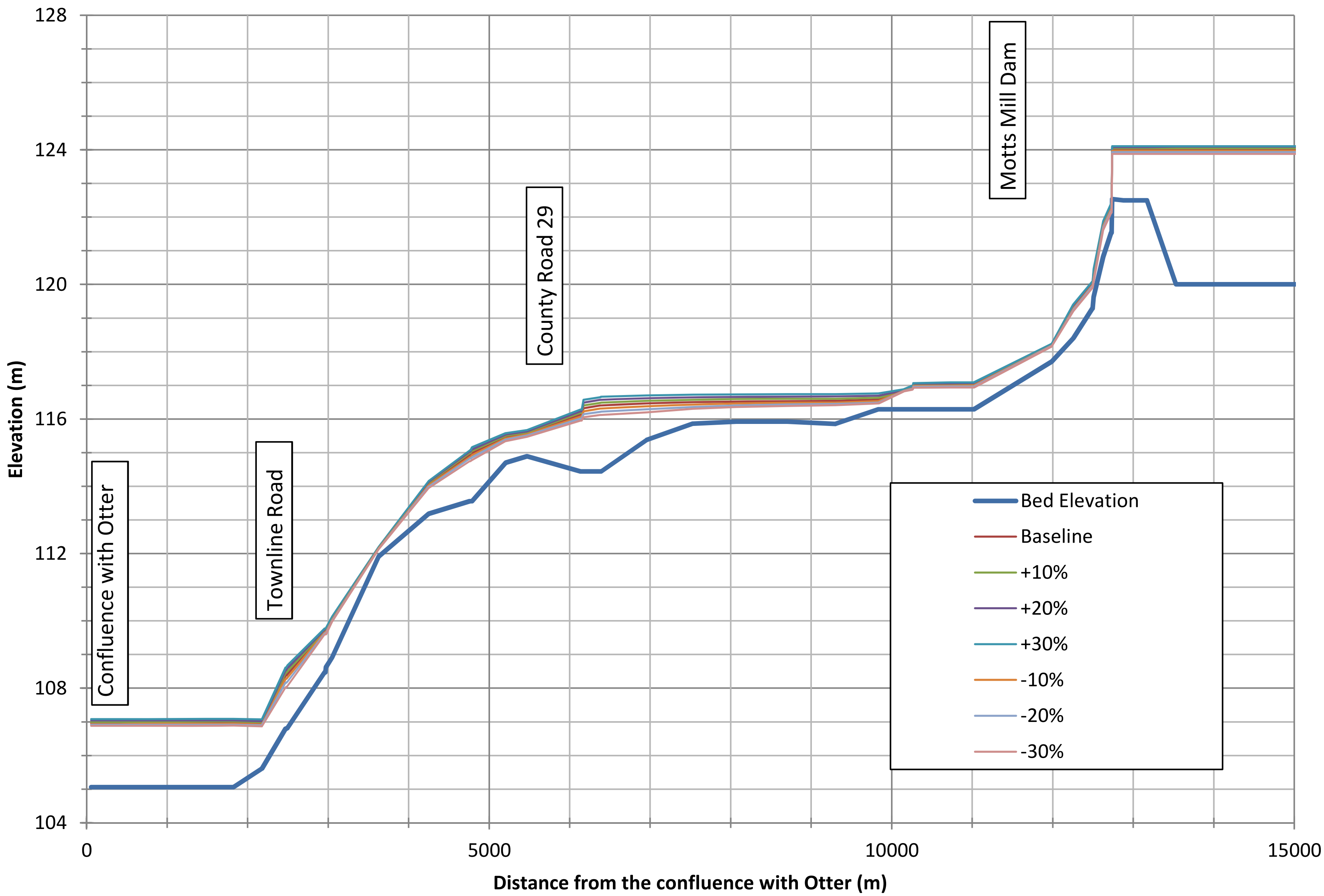


Figure 19: Sensitivity analysis of computed water level to design flow (Hutton Creek)



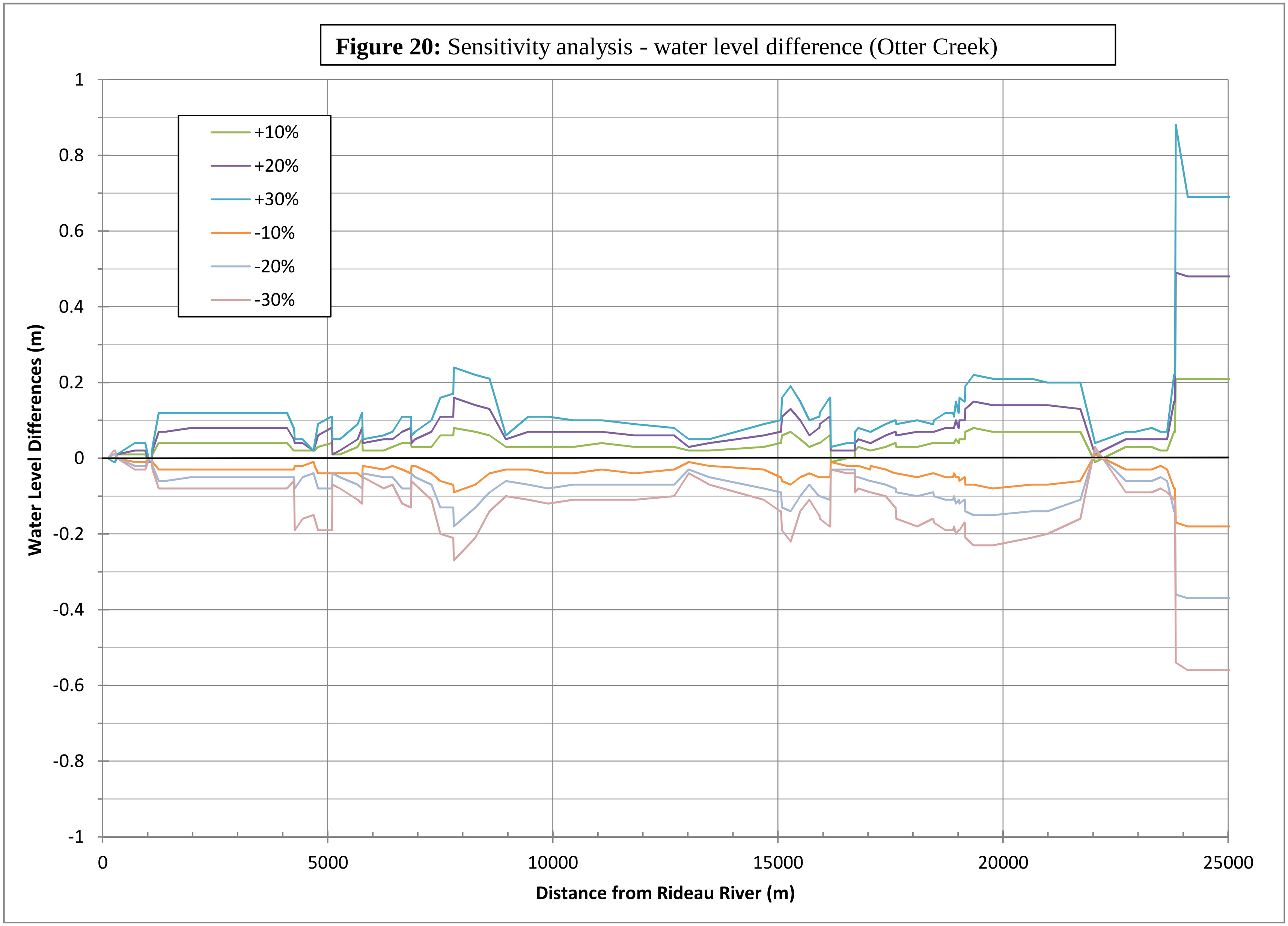
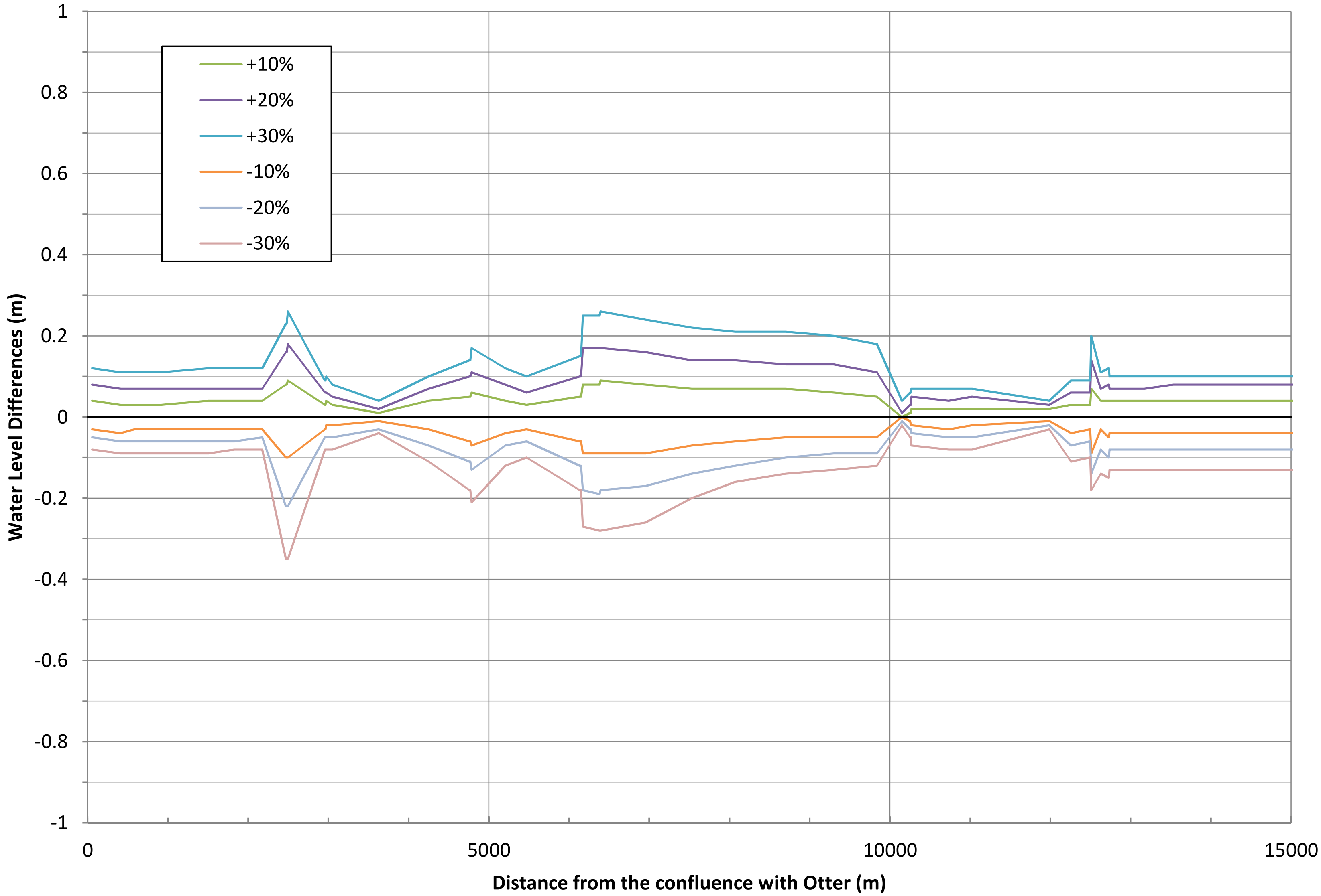


Figure 20: Sensitivity analysis - water level difference (Otter Creek)
+10%
+20%
+30%
-10%
-20%
-30%
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
Water Level Differences (m)
0
5000
10000
15000
20000
25000
Distance from Rideau River (m)

Figure 21: Sensitivity analysis - water level difference (Huton Creek)



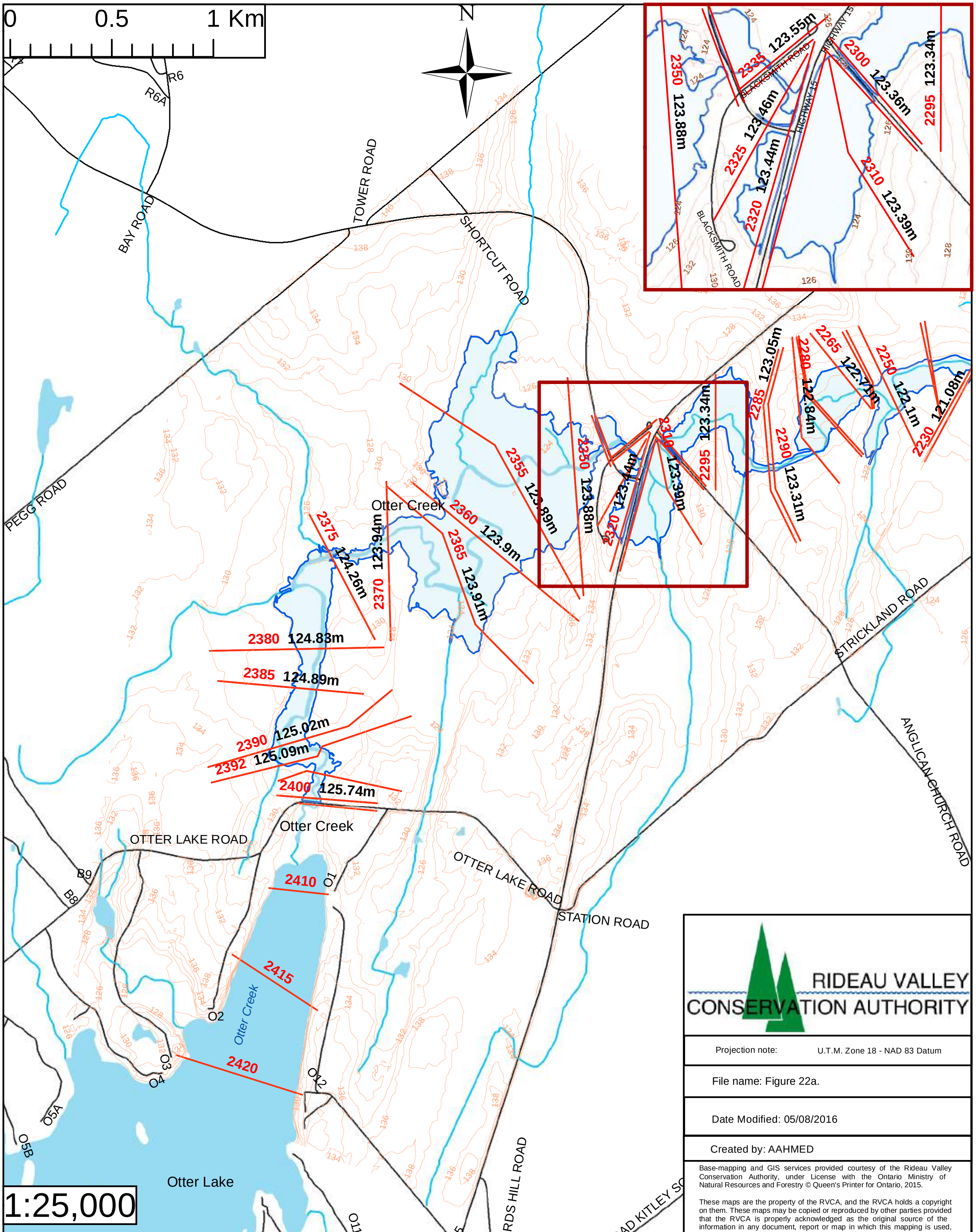


Figure 22a: Otter Cross Sections

RIDEAU VALLEY CONSERVATION AUTHORITY

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

File name: Figure 22a.

Date Modified: 05/08/2016

Created by: AAHMED

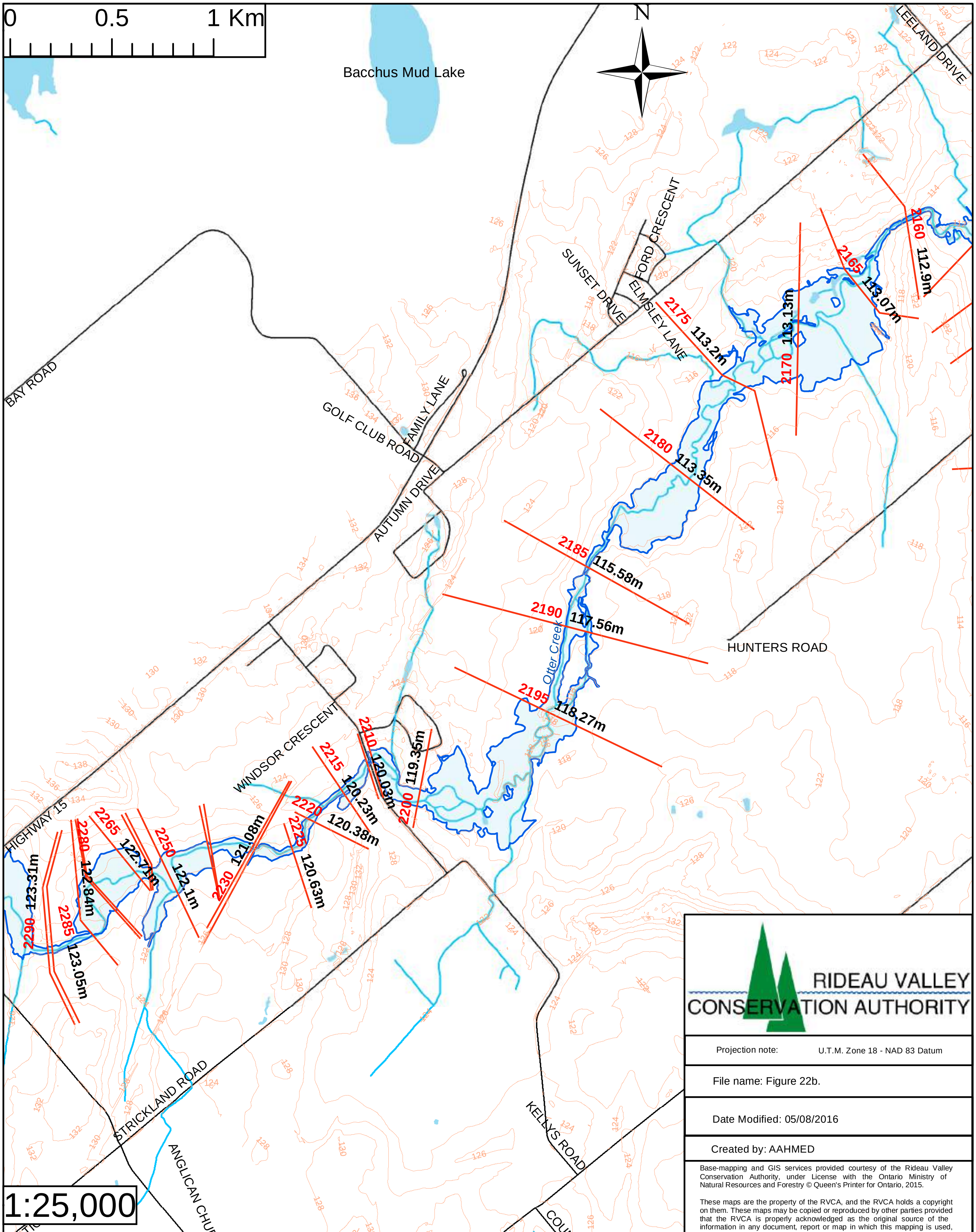


Figure 22b: Otter Cross Sections

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

File name: Figure 22b.

Date Modified: 05/08/2016

Created by: AAHMED

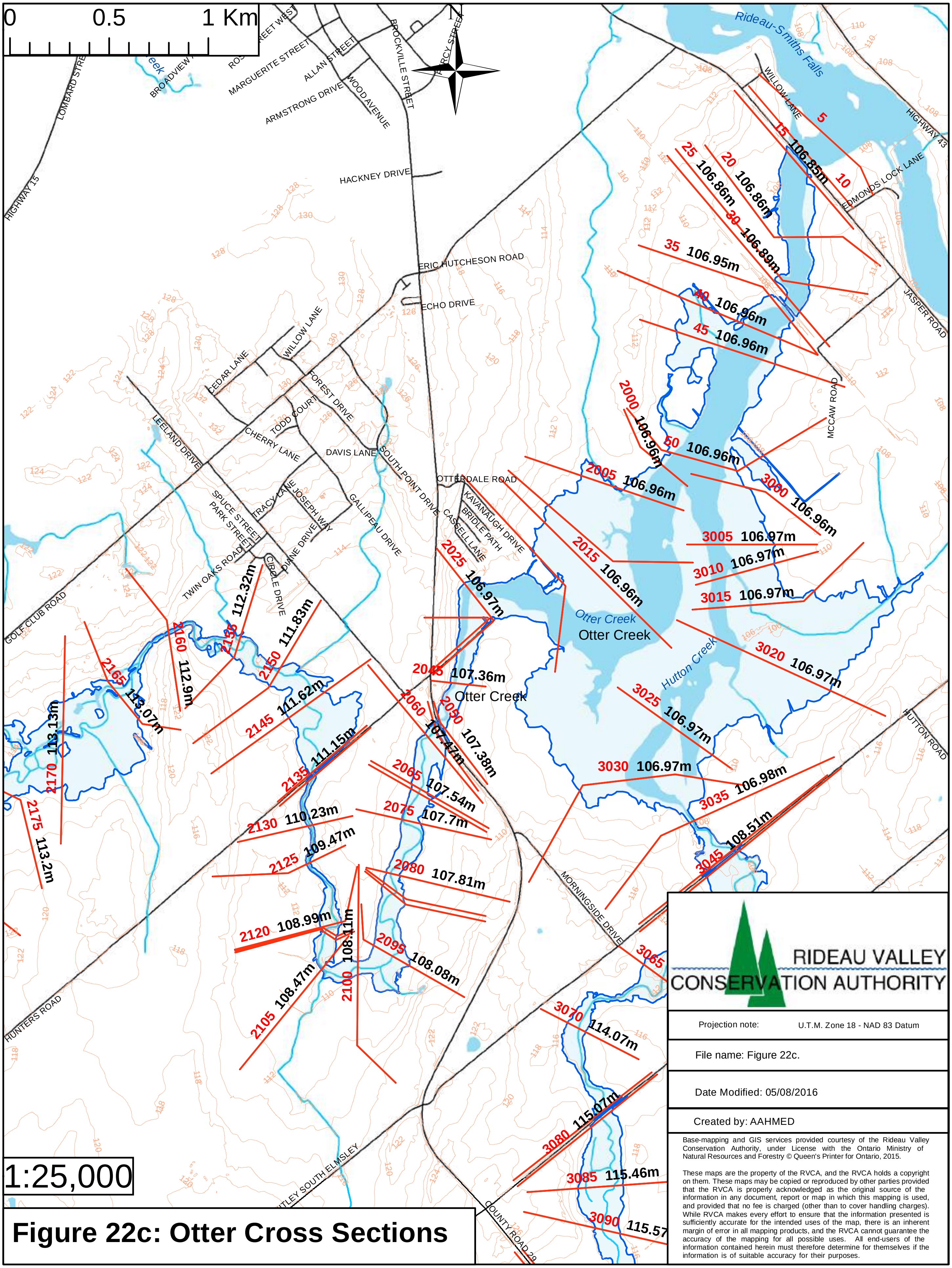


Figure 22c: Otter Cross Sections

RIDEAU VALLEY CONSERVATION AUTHORITY

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

File name: Figure 22c.

Date Modified: 05/08/2016

Created by: AAHMED

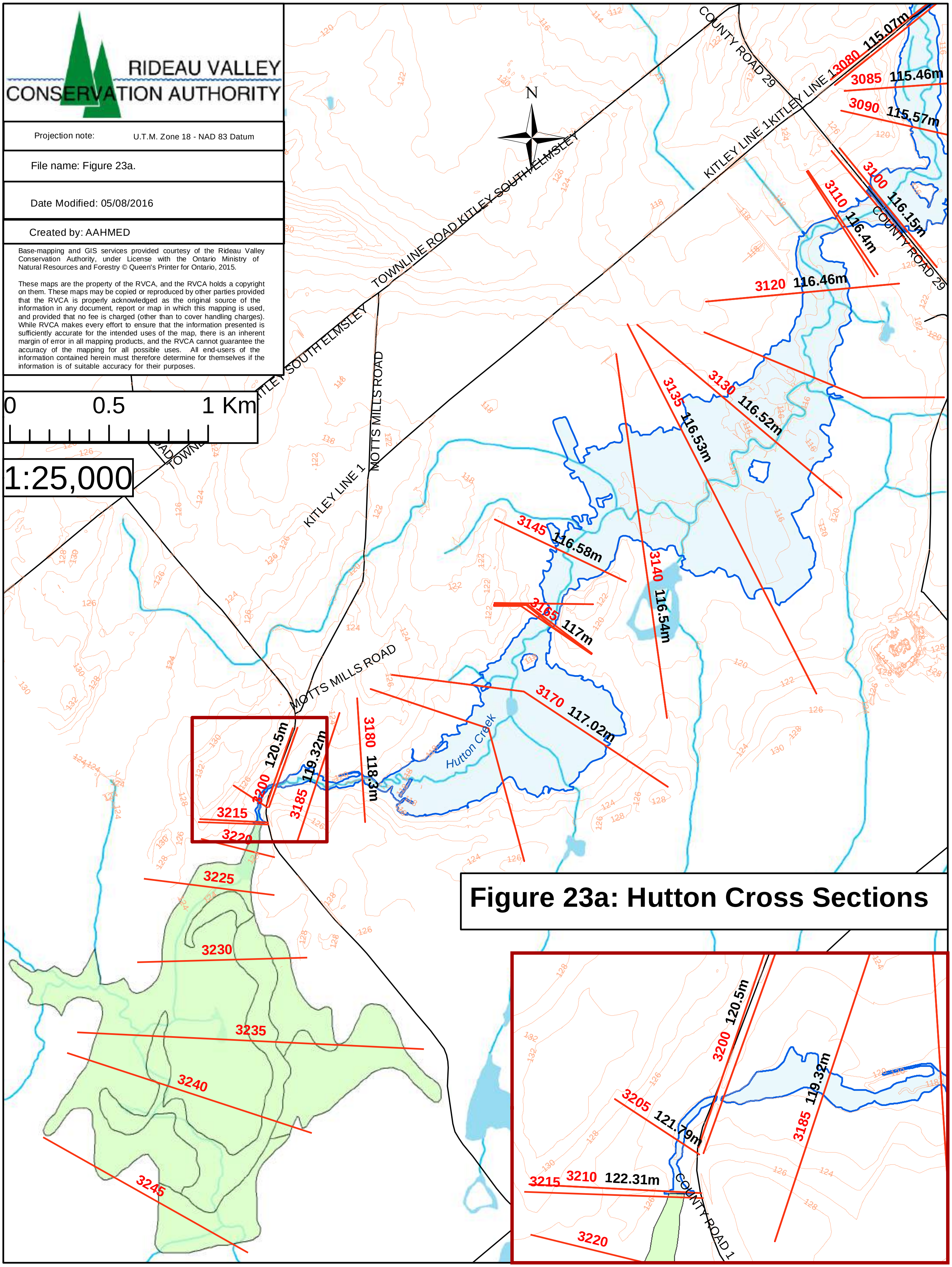
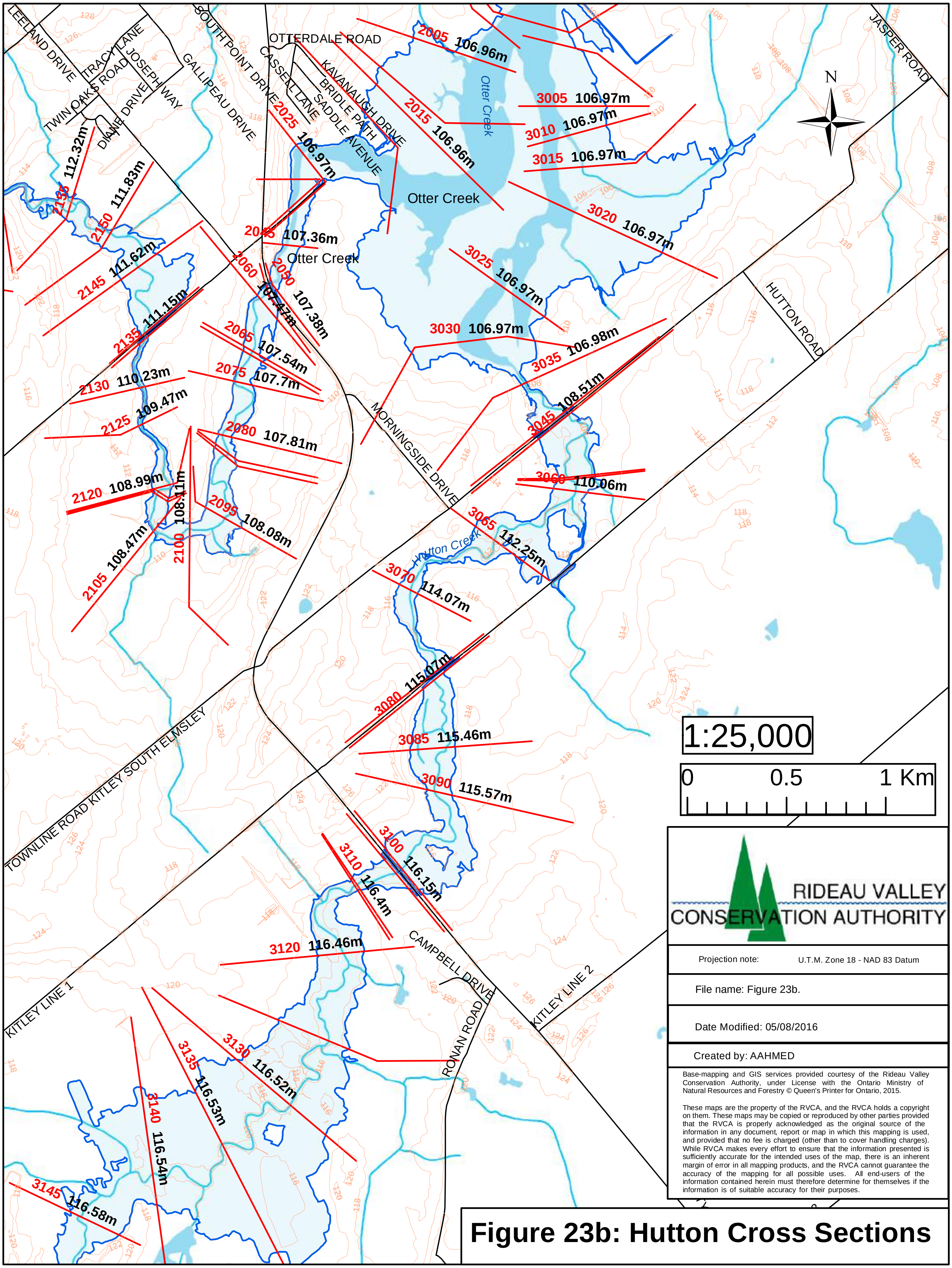


Figure 23a: Hutton Cross Sections



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

File name: Figure 23b.

Date Modified: 05/08/2016

Created by: AAHMED

Figure 23b: Hutton Cross Sections

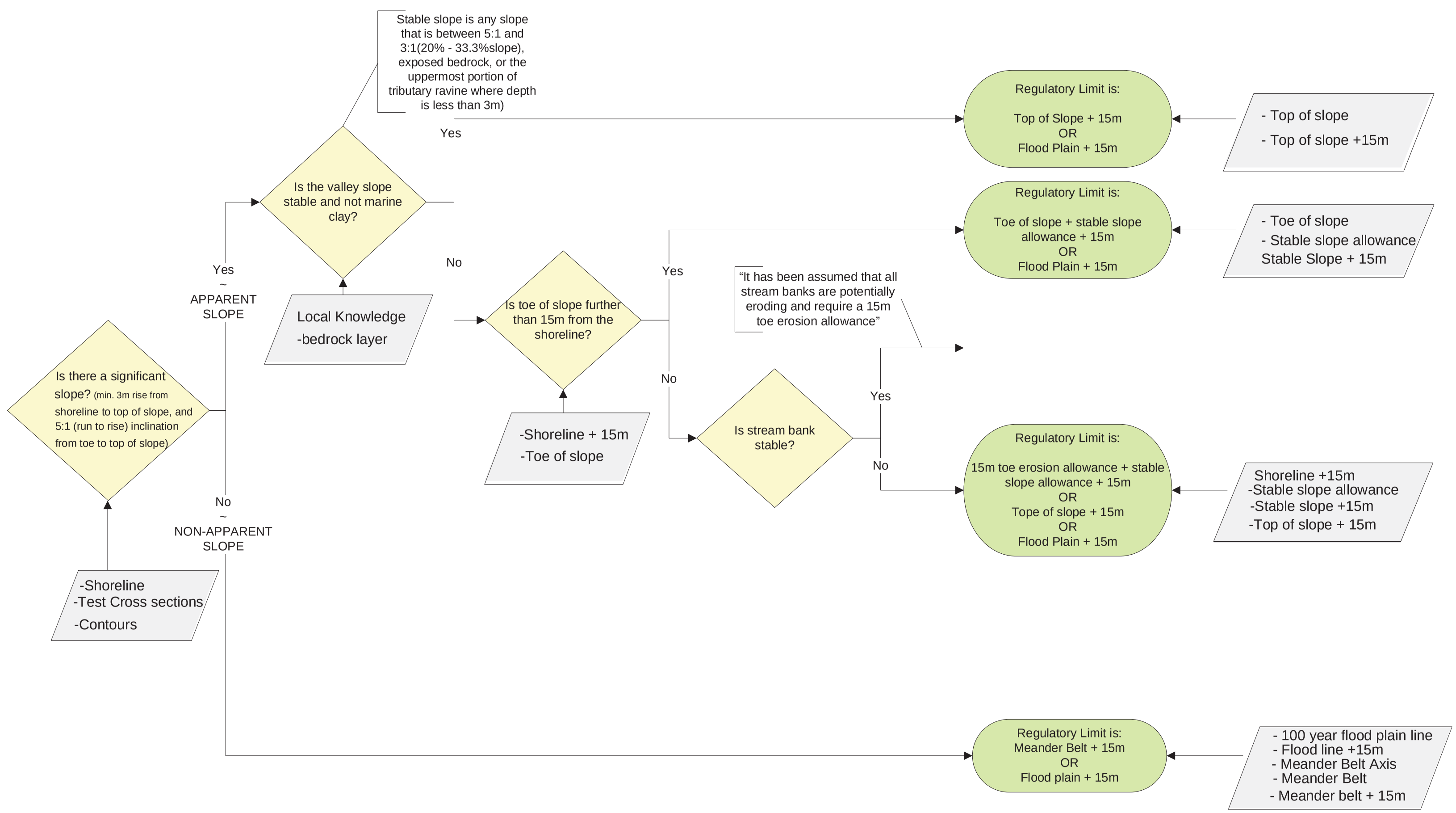


Figure 24: Generic Regulation Limit Delineation: Decision Tree

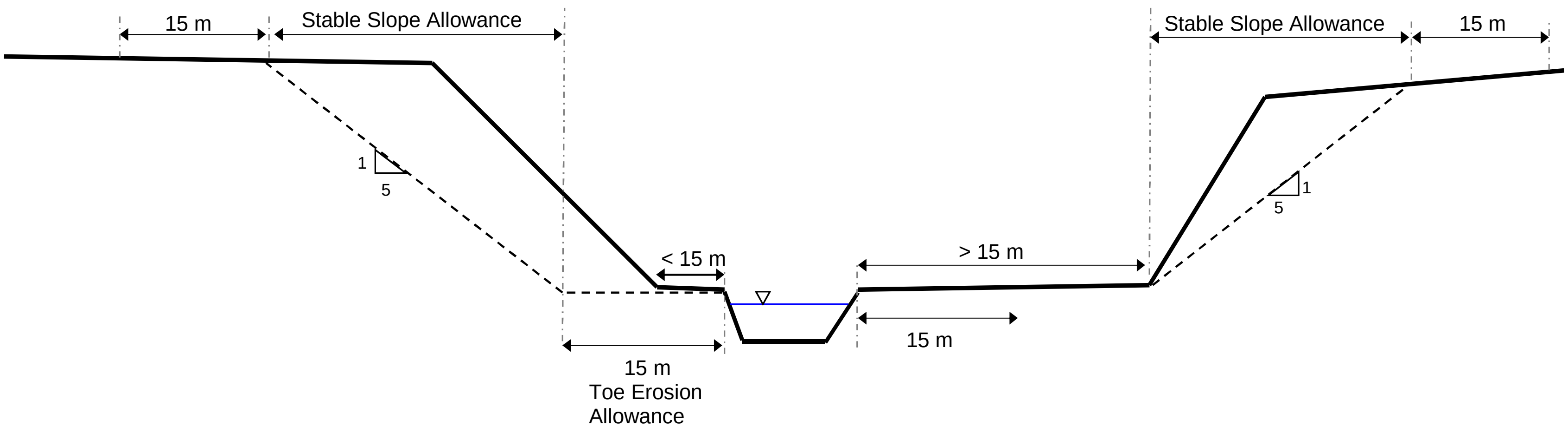
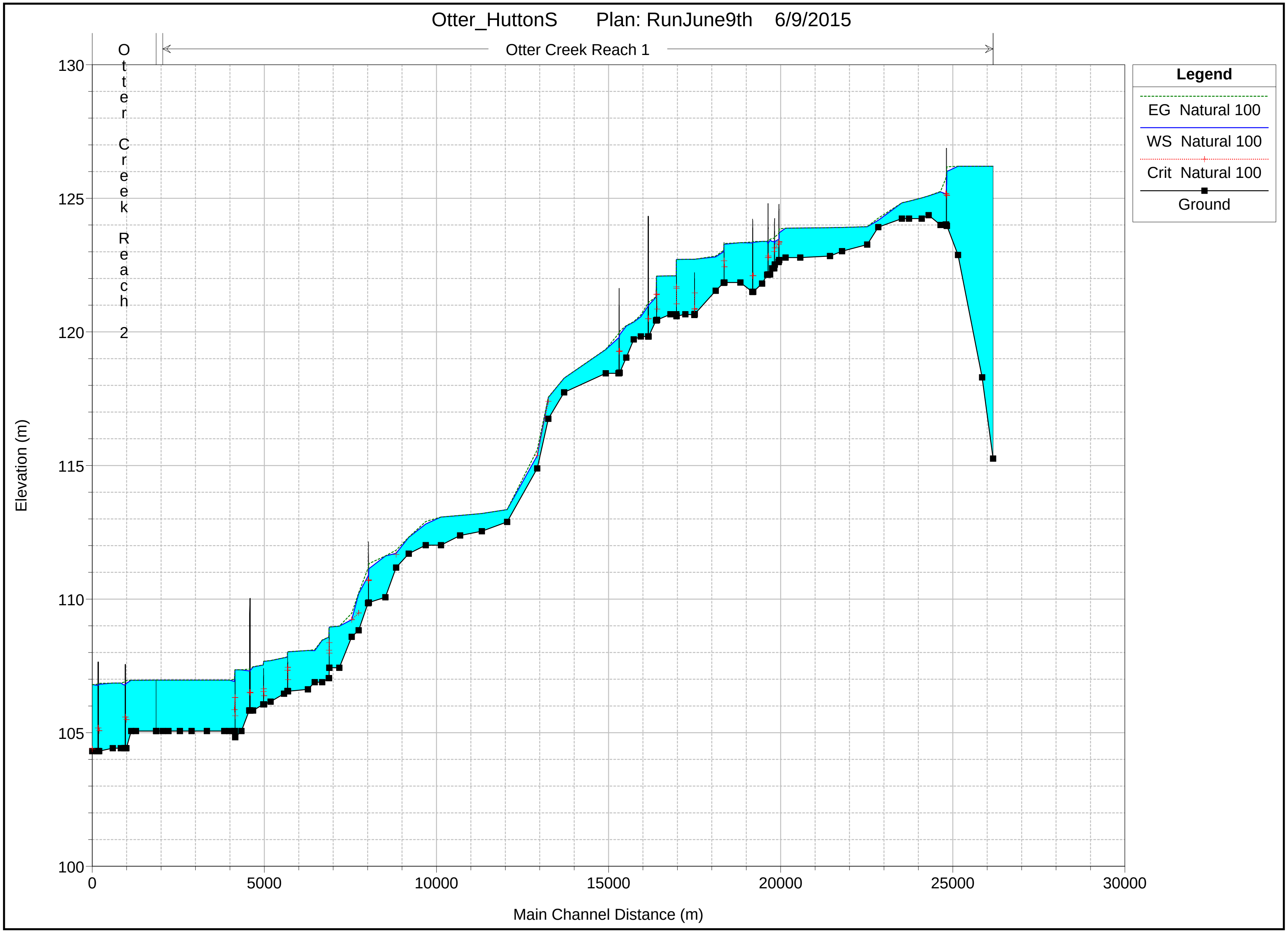


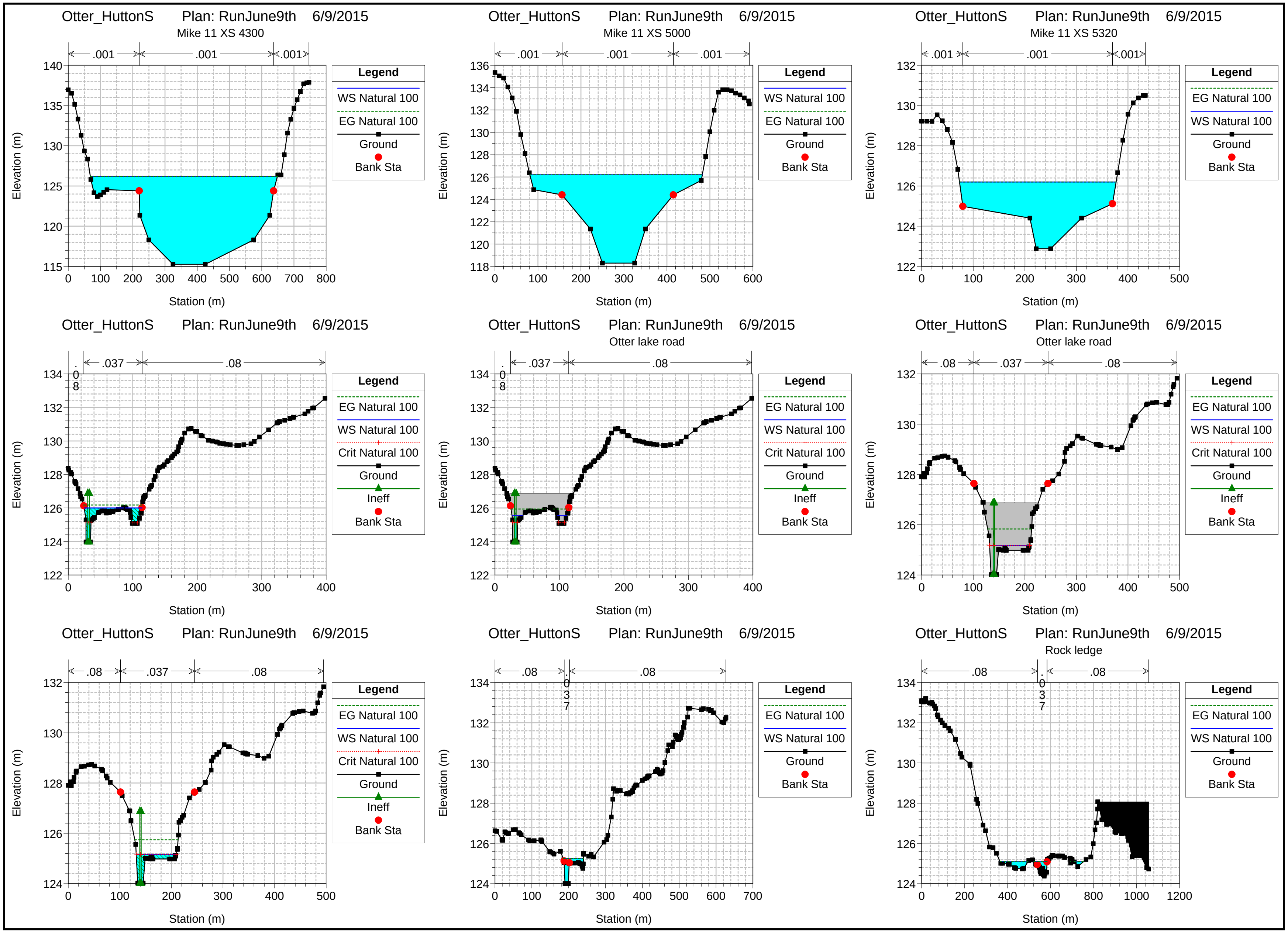
Figure 25 Erosion and Slope Stability Allowance (RVCA 2005)

Appendix A

HEC-RAS Profiles and Cross-Sections – Otter Creek



Otter_HuttonS Plan: RunJune9th 6/9/2015
Otter Creek Reach 1
Otter Creek Reach 2
Legend
EG Natural 100
WS Natural 100
Crit Natural 100
Ground
Elevation (m)
130
125
120
115
110
105
100
0
5000
10000
15000
20000
25000
30000
Main Channel Distance (m)



Otter_HuttonS Plan: RunJune9th 6/9/2015
Mike 11 XS 4300
.001 .001 .001
Elevation (m)
Station (m)
Legend
WS Natural 100
EG Natural 100
Ground
Bank Sta
Otter_HuttonS Plan: RunJune9th 6/9/2015
Mike 11 XS 5000
.001 .001 .001
Elevation (m)
Station (m)
Legend
WS Natural 100
EG Natural 100
Ground
Bank Sta
Otter_HuttonS Plan: RunJune9th 6/9/2015
Mike 11 XS 5320
.001 .001 .001
Elevation (m)
Station (m)
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta
Otter_HuttonS Plan: RunJune9th 6/9/2015
.08 .037 .08
Elevation (m)
Station (m)
Legend
EG Natural 100
WS Natural 100
Crit Natural 100
Ground
Ineff
Bank Sta
Otter_HuttonS Plan: RunJune9th 6/9/2015
Otter lake road
.08 .037 .08
Elevation (m)
Station (m)
Legend
EG Natural 100
WS Natural 100
Crit Natural 100
Ground
Ineff
Bank Sta
Otter_HuttonS Plan: RunJune9th 6/9/2015
Otter lake road
.08 .037 .08
Elevation (m)
Station (m)
Legend
EG Natural 100
WS Natural 100
Crit Natural 100
Ground
Ineff
Bank Sta
Otter_HuttonS Plan: RunJune9th 6/9/2015
.08 .037 .08
Elevation (m)
Station (m)
Legend
EG Natural 100
WS Natural 100
Crit Natural 100
Ground
Ineff
Bank Sta
Otter_HuttonS Plan: RunJune9th 6/9/2015
.08 .037 .08
Elevation (m)
Station (m)
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta
Otter_HuttonS Plan: RunJune9th 6/9/2015
Rock ledge
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Elevation (m)
Station (m)
Legend
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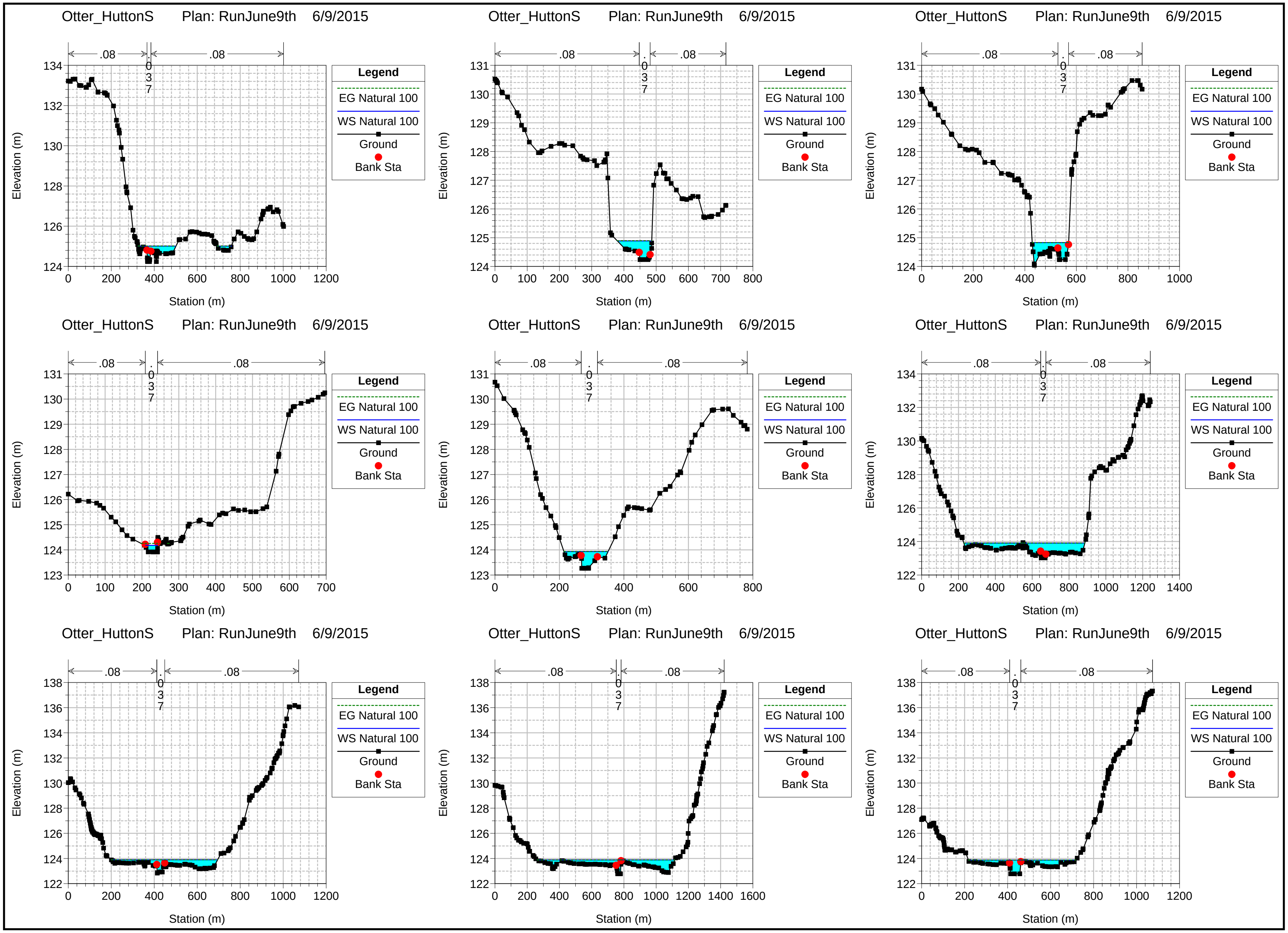
WS Natural 100
Ground
Bank Sta



Otter_HuttonS Plan: RunJune9th 6/9/2015
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Legend
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Ground
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
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Legend
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Ground
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Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
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Legend
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Elevation (m)
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Otter_HuttonS Plan: RunJune9th 6/9/2015
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Legend
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Ground
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
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Ground
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Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
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Ground
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Otter_HuttonS Plan: RunJune9th 6/9/2015
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Otter_HuttonS Plan: RunJune9th 6/9/2015
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Otter_HuttonS Plan: RunJune9th 6/9/2015
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Legend
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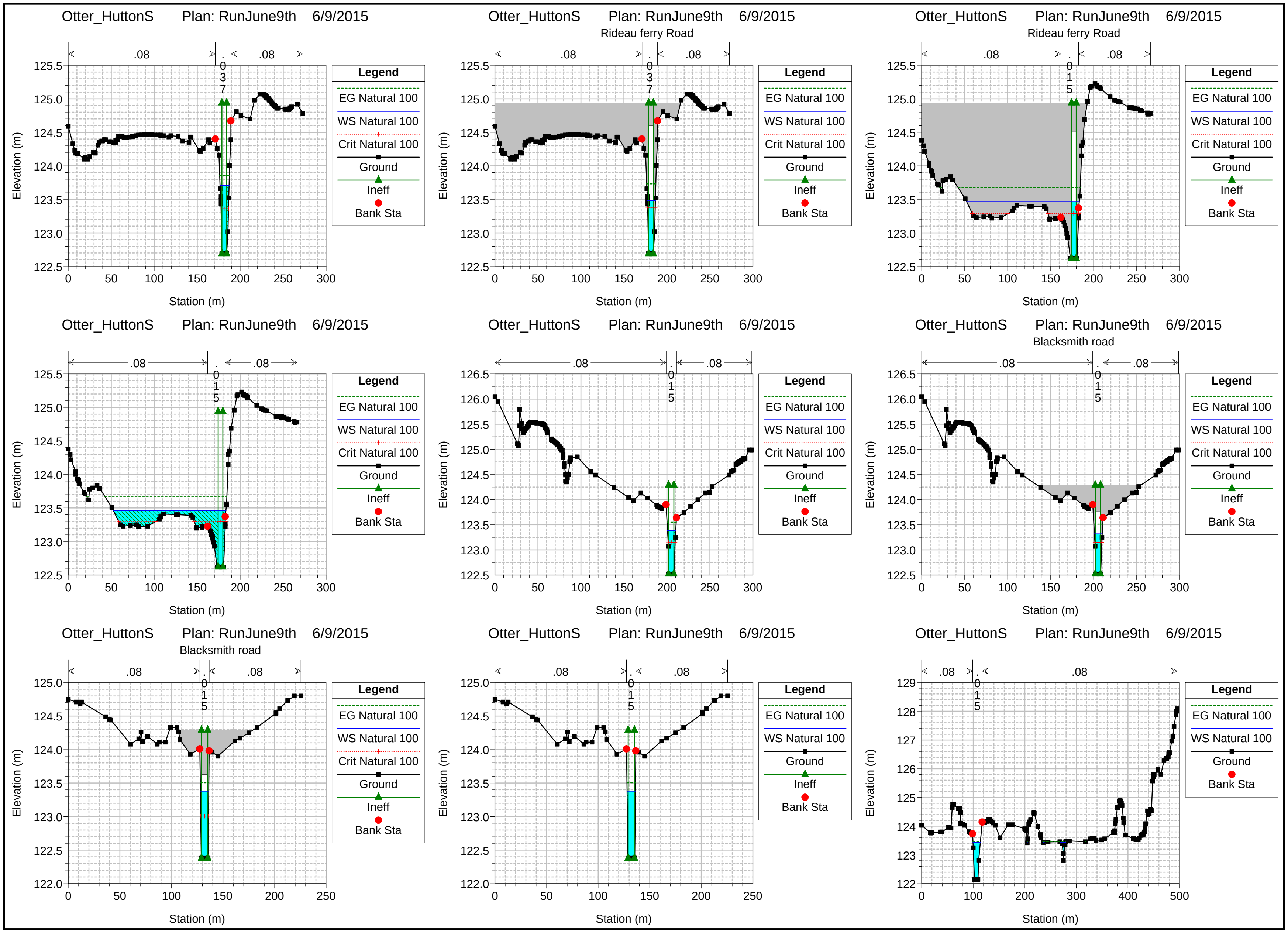
Bank Sta
Elevation (m)
Station (m)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Legend
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Bank Sta
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Rideau ferry Road
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Station (m)
Legend
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Crit Natural 100
Ground
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Bank Sta
Otter_HuttonS Plan: RunJune9th 6/9/2015
Rideau ferry Road
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Elevation (m)
Station (m)
Legend
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Crit Natural 100
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Bank Sta
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Elevation (m)
Station (m)
Legend
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Crit Natural 100
Ground
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Bank Sta
Otter_HuttonS Plan: RunJune9th 6/9/2015
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Elevation (m)
Station (m)
Legend
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Crit Natural 100
Ground
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Bank Sta
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Blacksmith road
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Station (m)
Legend
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Crit Natural 100
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Bank Sta
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Blacksmith road
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Elevation (m)
Station (m)
Legend
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Crit Natural 100
Ground
Ineff
Bank Sta
Otter_HuttonS Plan: RunJune9th 6/9/2015
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Elevation (m)
Station (m)
Legend
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WS Natural 100
Ground
Ineff
Bank Sta
Otter_HuttonS Plan: RunJune9th 6/9/2015
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Station (m)
Legend
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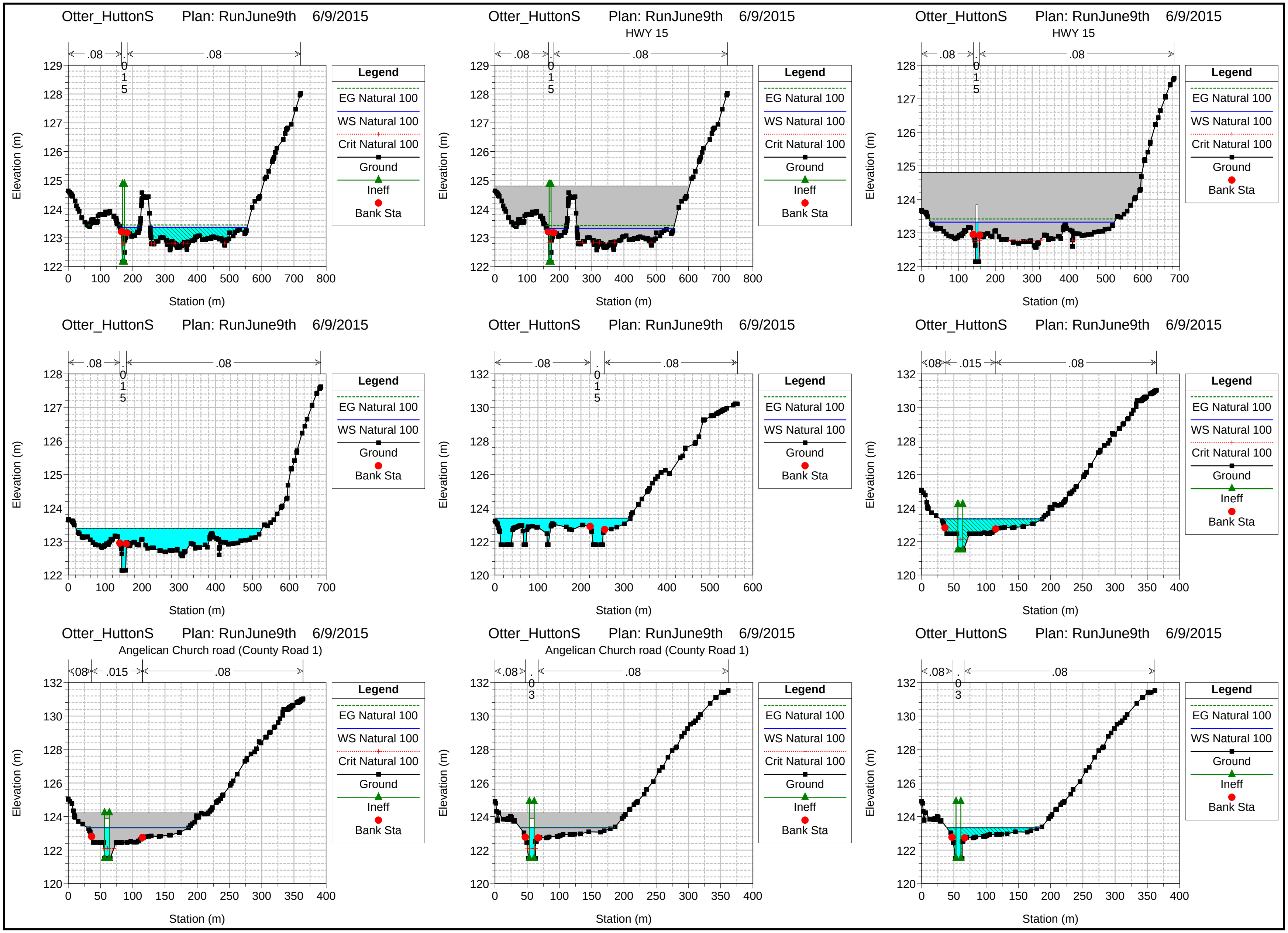
Bank Sta



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Bank Sta
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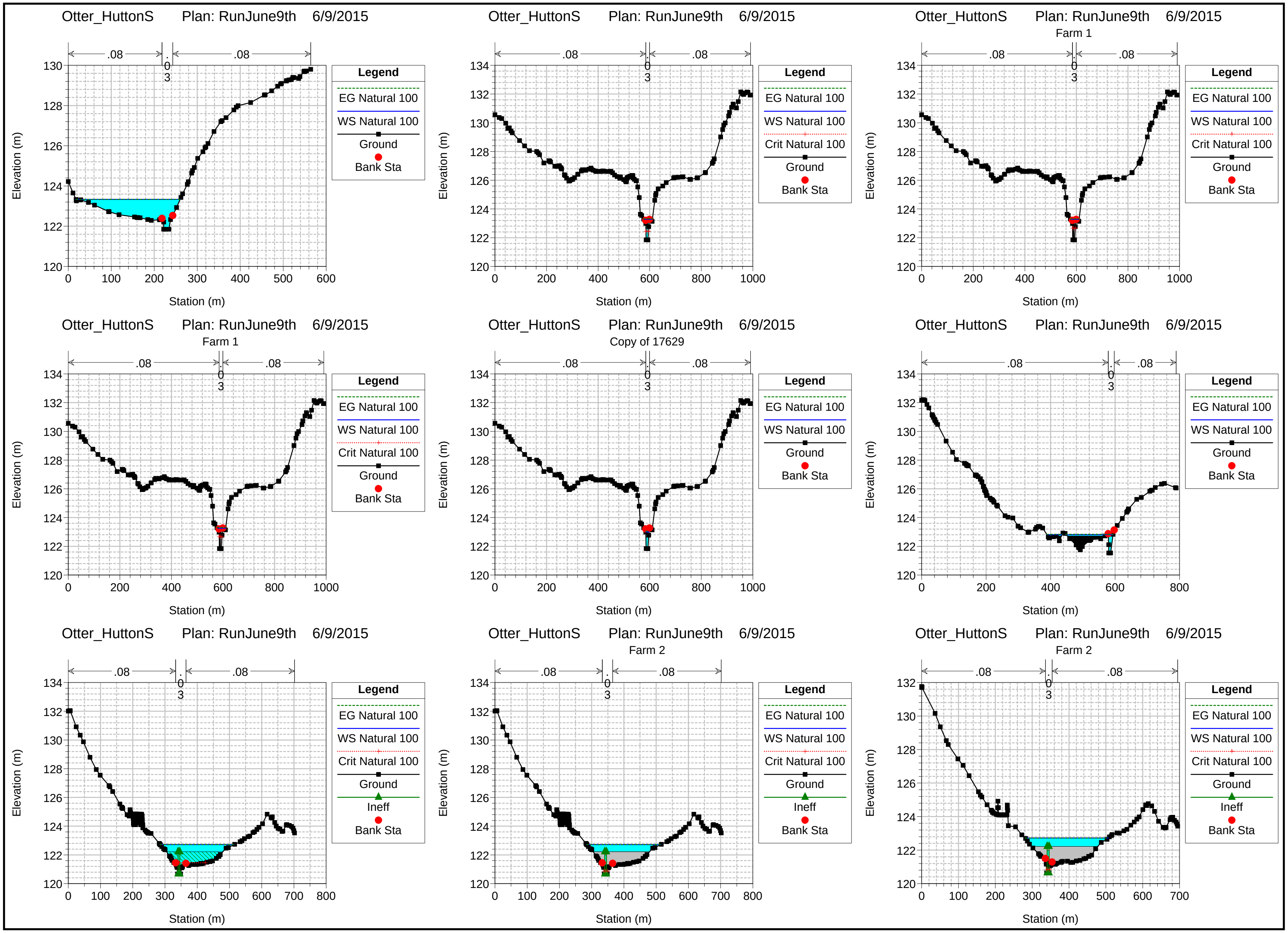
Otter_HuttonS Plan: RunJune9th 6/9/2015
HWY 15
Otter_HuttonS Plan: RunJune9th 6/9/2015
Otter_HuttonS Plan: RunJune9th 6/9/2015
Otter_HuttonS Plan: RunJune9th 6/9/2015
Otter_HuttonS Plan: RunJune9th 6/9/2015
Angelican Church road (County Road 1)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Angelican Church road (County Road 1)
Otter_HuttonS Plan: RunJune9th 6/9/2015



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Station (m)
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Bank Sta
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Farm 1
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Elevation (m)
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Station (m)
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Farm 2
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Station (m)
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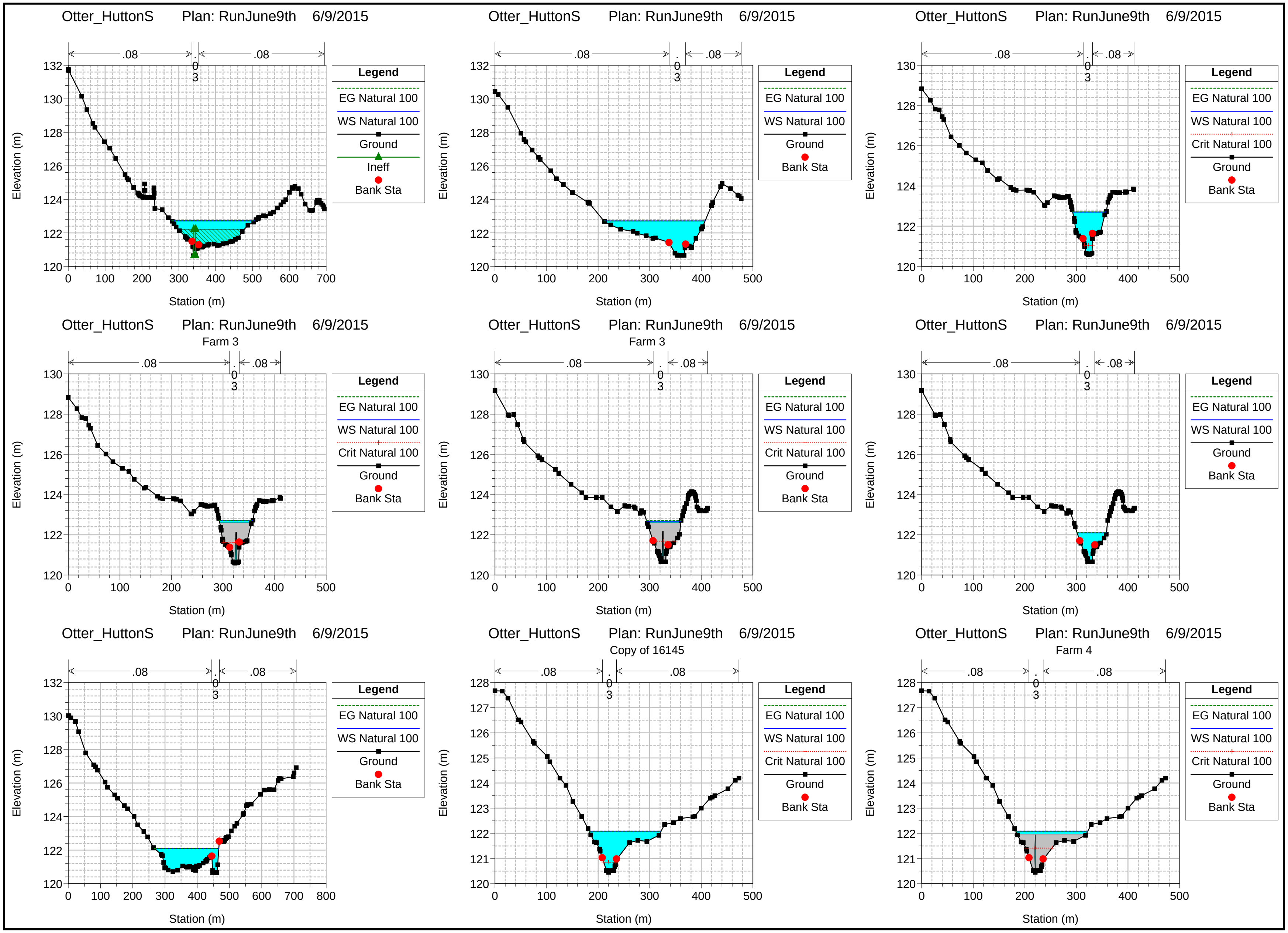
Station (m)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Station (m)
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Legend
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Crit Natural 100
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Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Farm 3
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Legend
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Crit Natural 100
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Station (m)
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Farm 3
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Crit Natural 100
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Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
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Legend
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Ground
Bank Sta
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Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
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Legend
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Station (m)
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Legend
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Crit Natural 100
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Bank Sta
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Station (m)
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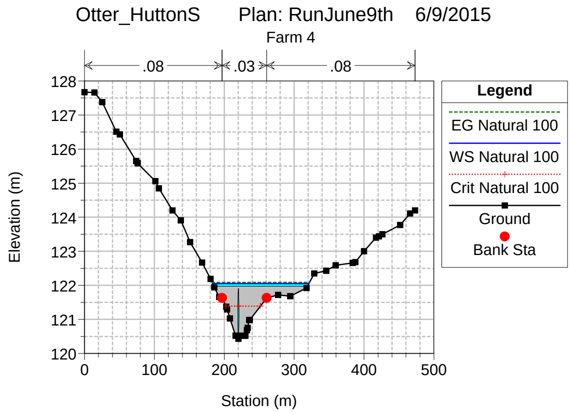
Station (m)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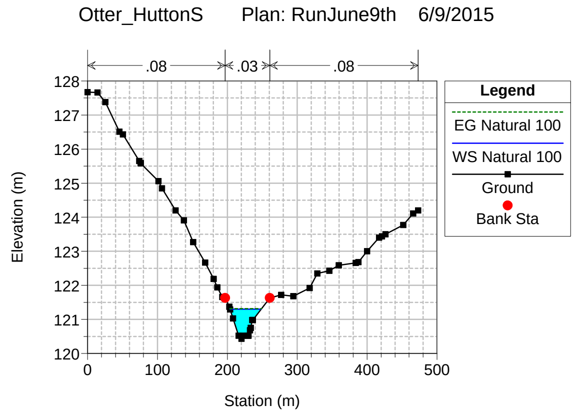
Station (m)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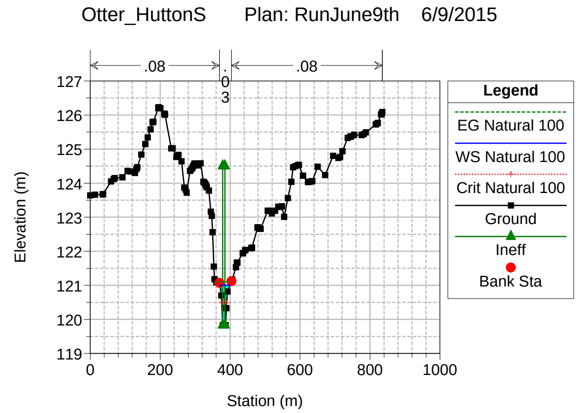
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Legend
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WS Natural 100
Crit Natural 100
Ground
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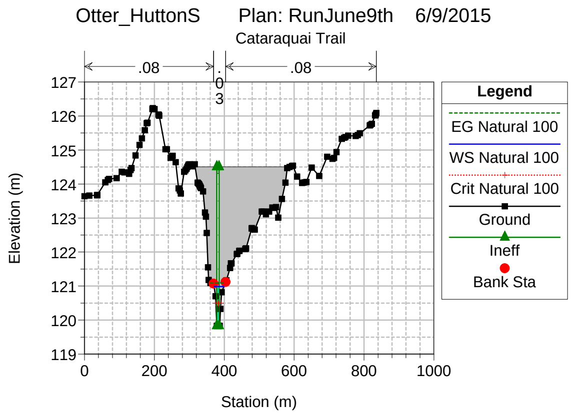
Bank Sta
Elevation (m)
Station (m)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Cataraquai Trail
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Legend
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Crit Natural 100
Ground
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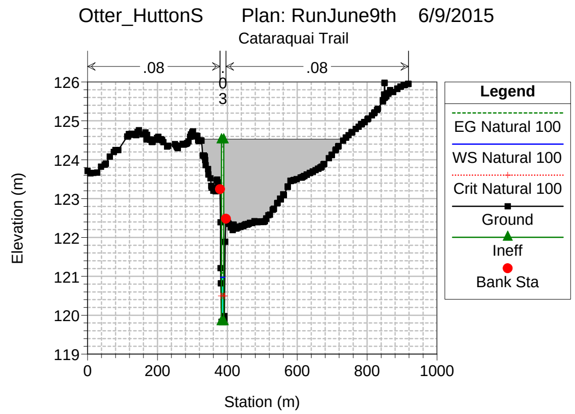
Elevation (m)
Station (m)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Cataraquai Trail
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Legend
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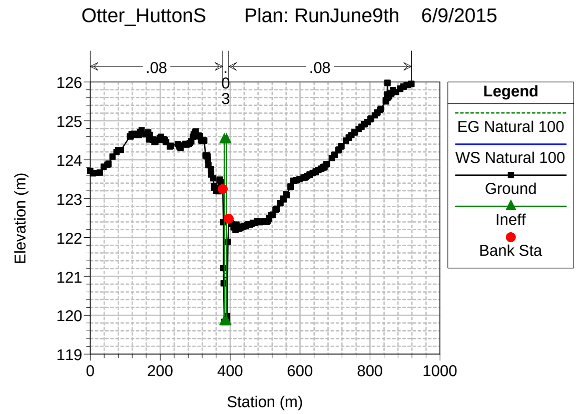
Elevation (m)
Station (m)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Legend
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Bank Sta
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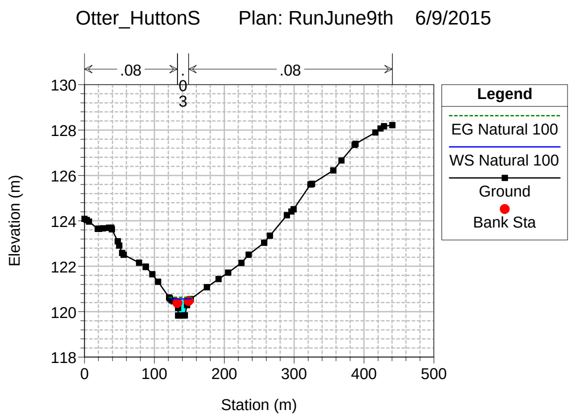
Station (m)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Legend
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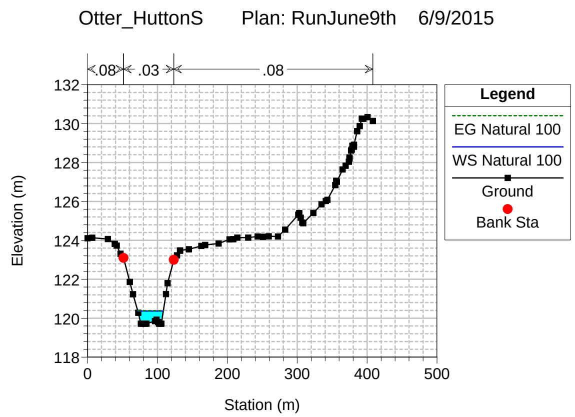
Elevation (m)
Station (m)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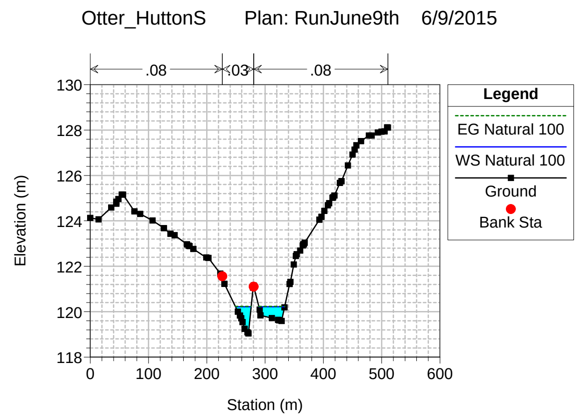
Bank Sta
Elevation (m)
Station (m)


Otter_HuttonS Plan: RunJune9th 6/9/2015
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Legend
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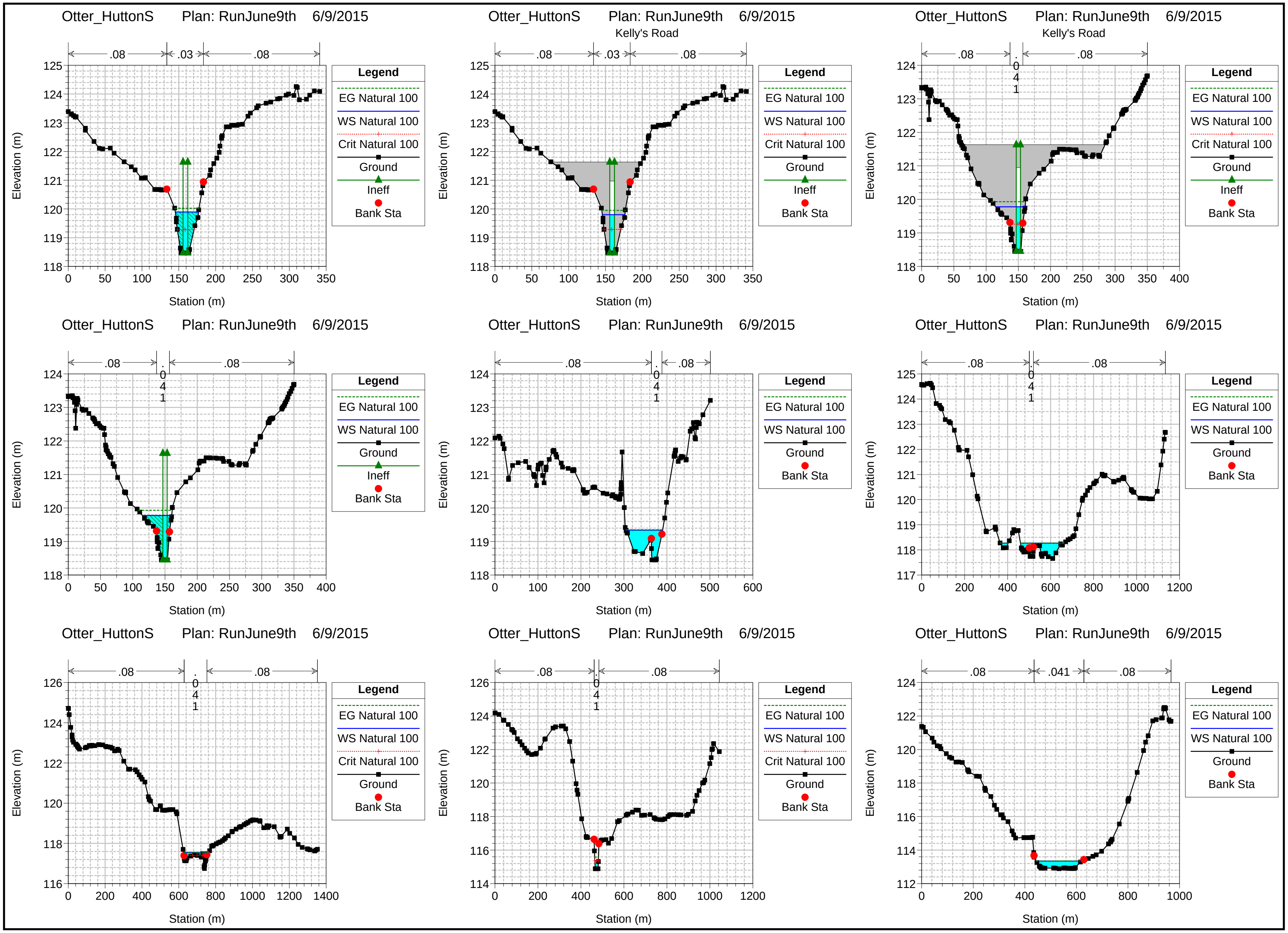
Bank Sta
Elevation (m)
Station (m)



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Crit Natural 100
Ground
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Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Kelly's Road
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Legend
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Crit Natural 100
Ground
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Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Kelly's Road
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Legend
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Crit Natural 100
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Bank Sta
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Station (m)
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Legend
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Ground
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Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
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Legend
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Elevation (m)
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Legend
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Otter_HuttonS Plan: RunJune9th 6/9/2015
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Legend
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Ground
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Elevation (m)
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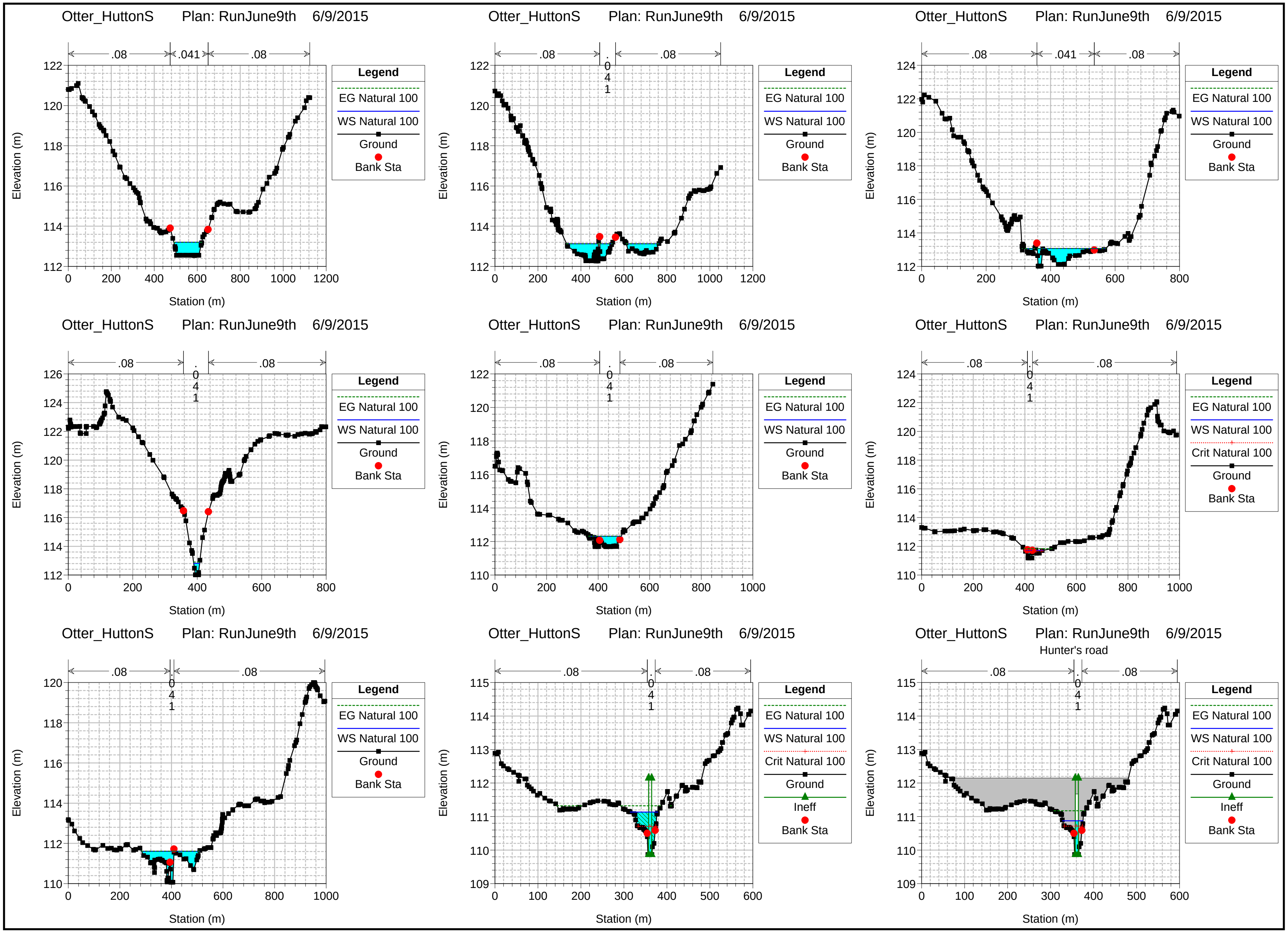
Ground
Bank Sta
Elevation (m)
Station (m)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Otter_HuttonS Plan: RunJune9th 6/9/2015
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Elevation (m)
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Otter_HuttonS Plan: RunJune9th 6/9/2015
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Legend
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Ground
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Elevation (m)
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Otter_HuttonS Plan: RunJune9th 6/9/2015
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Legend
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WS Natural 100
Ground
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
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Legend
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Ground
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Elevation (m)
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Otter_HuttonS Plan: RunJune9th 6/9/2015
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Legend
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Crit Natural 100
Ground
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Otter_HuttonS Plan: RunJune9th 6/9/2015
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Legend
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Ground
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Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
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Legend
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Crit Natural 100
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Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Hunter's road
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Legend
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Elevation (m)
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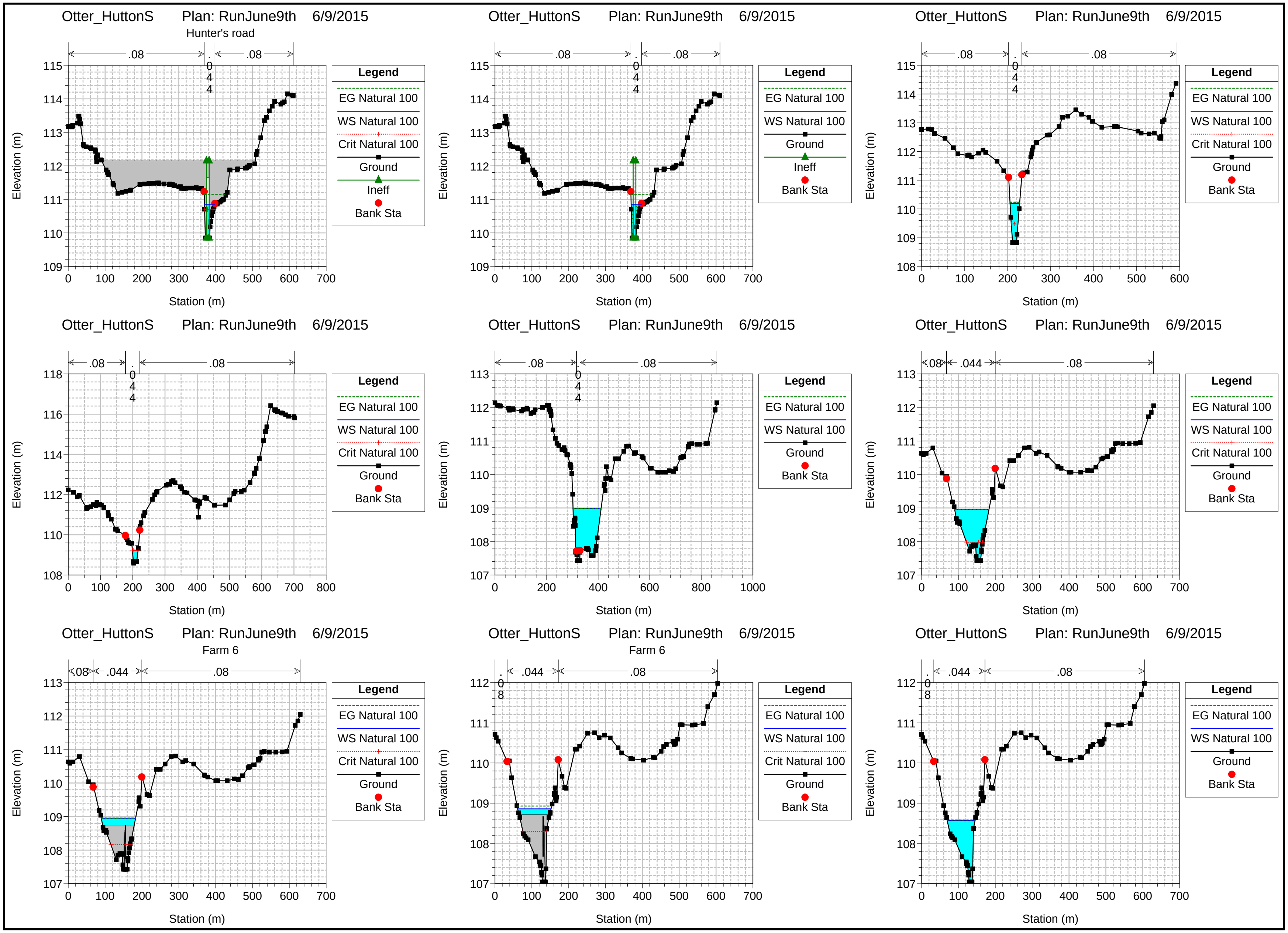
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Hunter's road
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Ground
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Bank Sta
Elevation (m)
Station (m)
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Legend
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Legend
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Otter_HuttonS Plan: RunJune9th 6/9/2015
Otter_HuttonS Plan: RunJune9th 6/9/2015
Otter_HuttonS Plan: RunJune9th 6/9/2015
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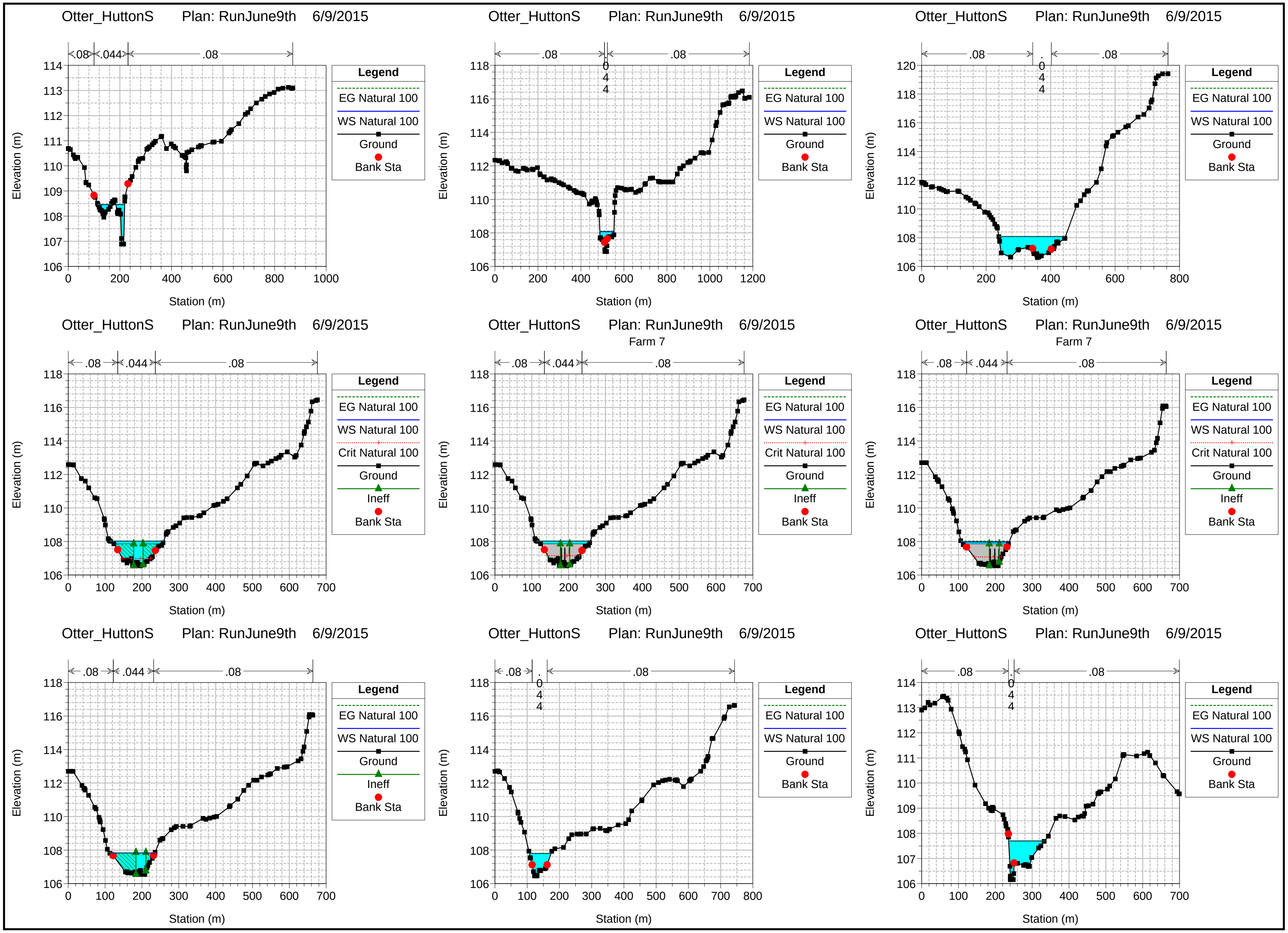
Farm 6
Otter_HuttonS Plan: RunJune9th 6/9/2015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Farm 7
Otter_HuttonS Plan: RunJune9th 6/9/2015
Farm 7
Otter_HuttonS Plan: RunJune9th 6/9/2015
Otter_HuttonS Plan: RunJune9th 6/9/2015
Otter_HuttonS Plan: RunJune9th 6/9/2015
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Station (m)
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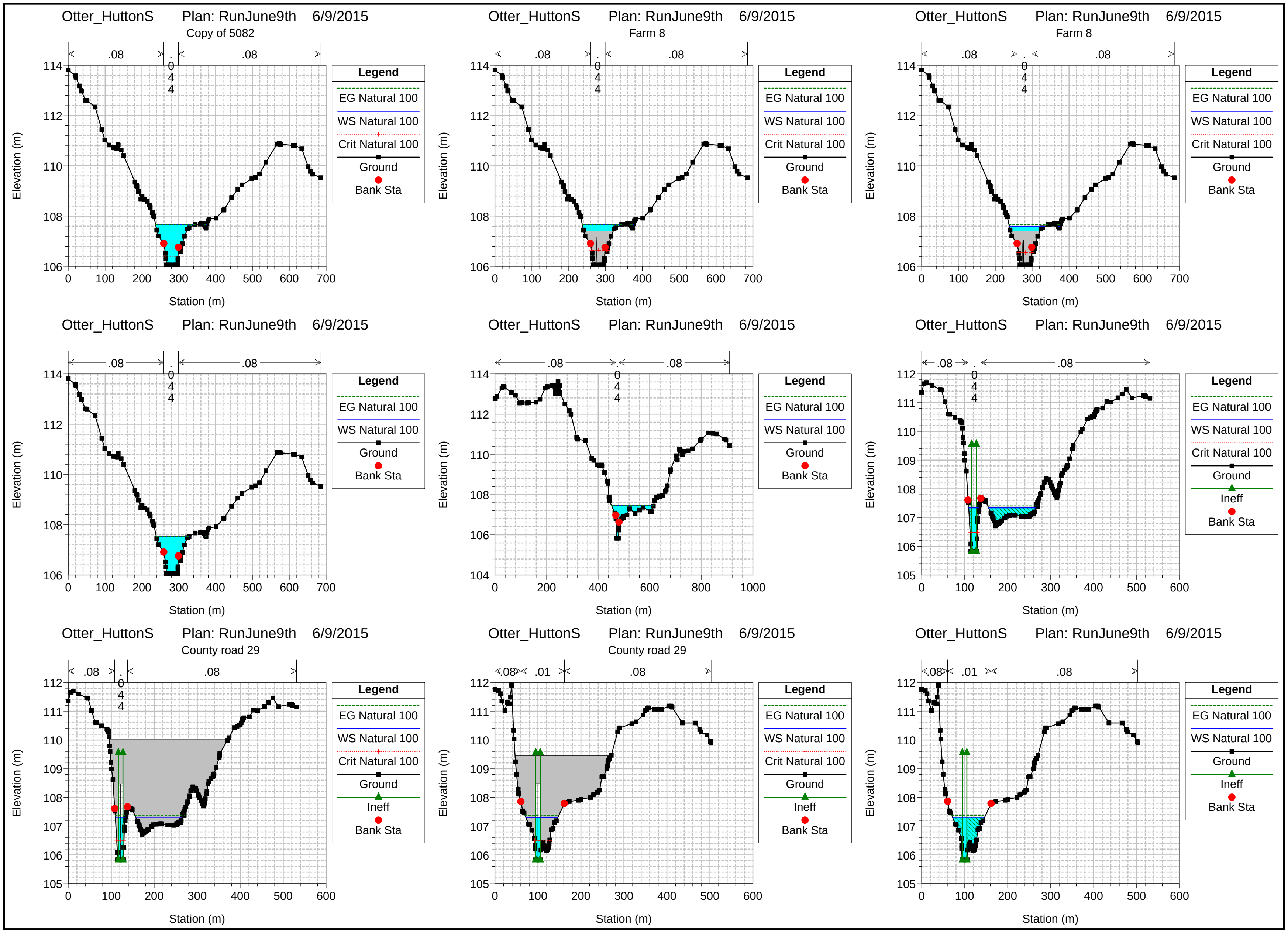
Bank Sta



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Legend
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Otter_HuttonS Plan: RunJune9th 6/9/2015
Farm 8
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Elevation (m)
Station (m)
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Bank Sta
Otter_HuttonS Plan: RunJune9th 6/9/2015
Farm 8
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Elevation (m)
Station (m)
Legend
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Crit Natural 100
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Otter_HuttonS Plan: RunJune9th 6/9/2015
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Station (m)
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Legend
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Ground
Bank Sta
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County road 29
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Bank Sta
Otter_HuttonS Plan: RunJune9th 6/9/2015
County road 29
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Station (m)
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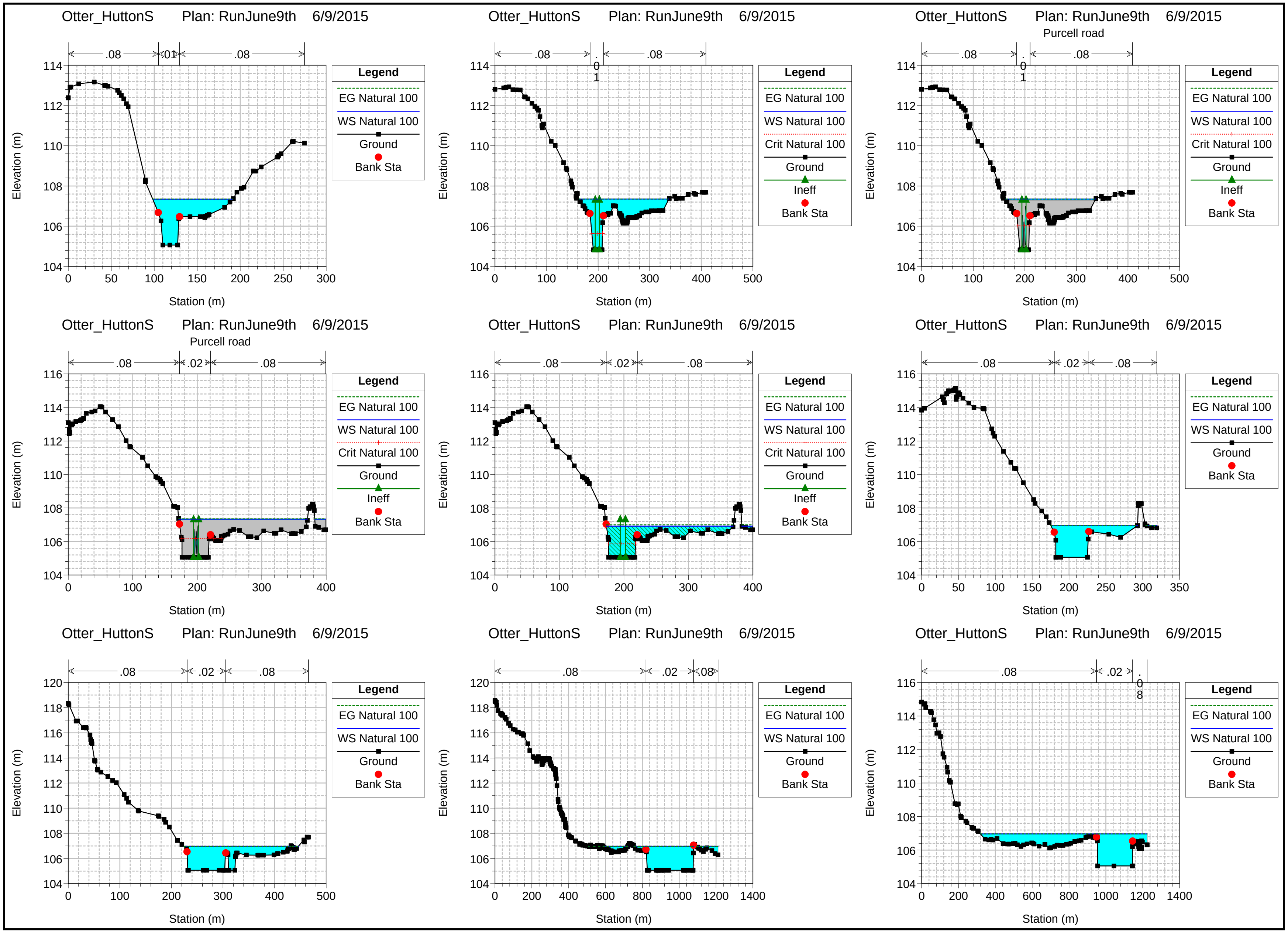
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Station (m)
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Crit Natural 100
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Ineff
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Purcell road
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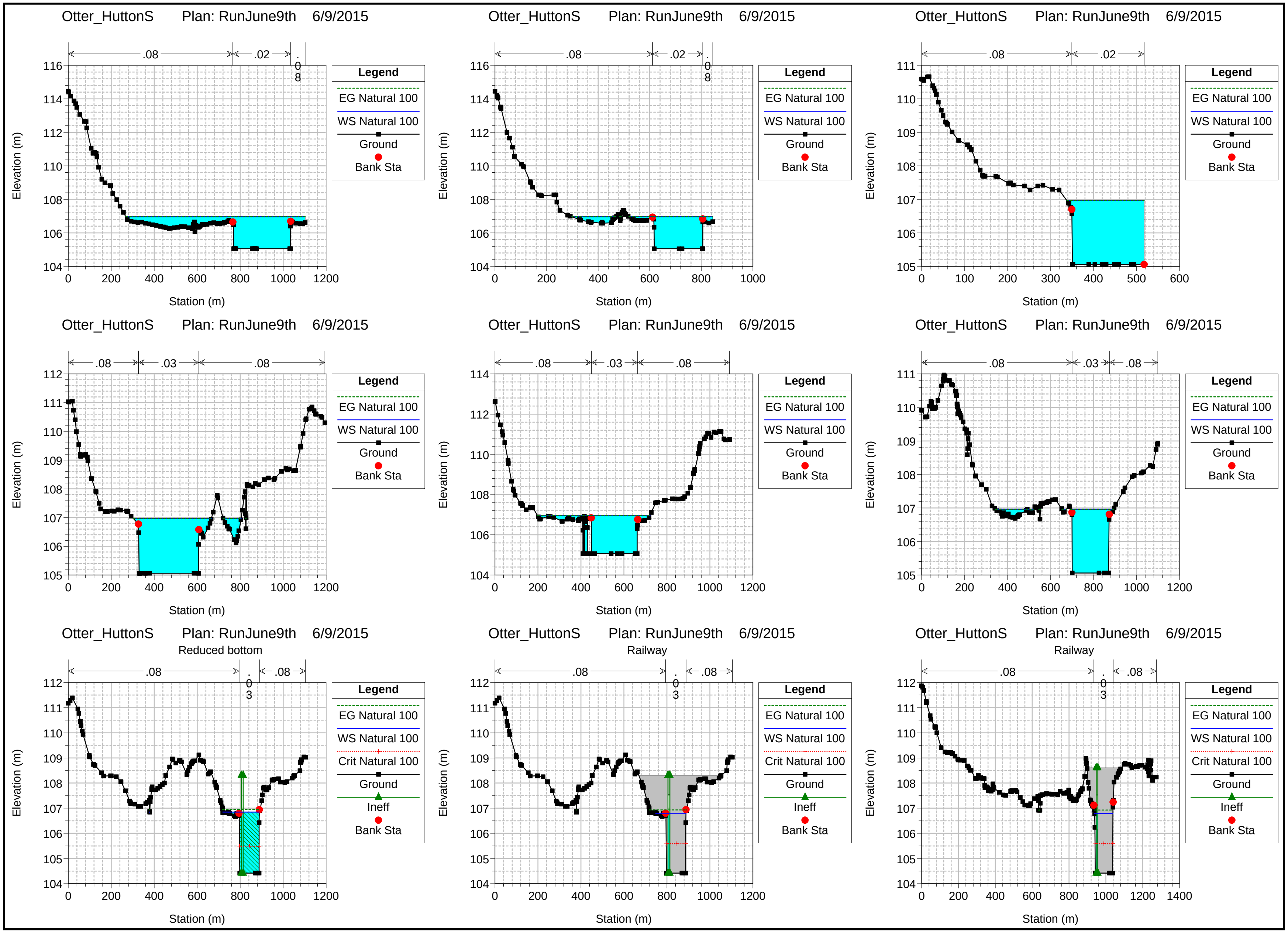
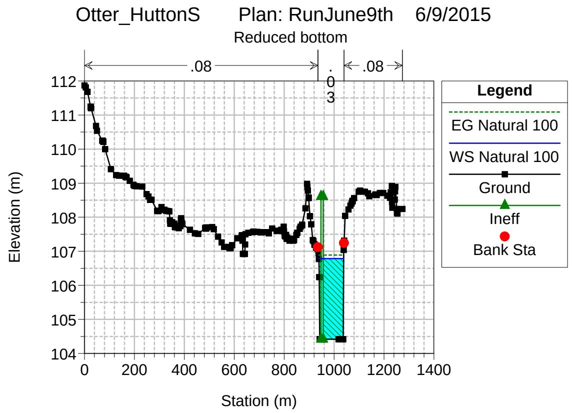
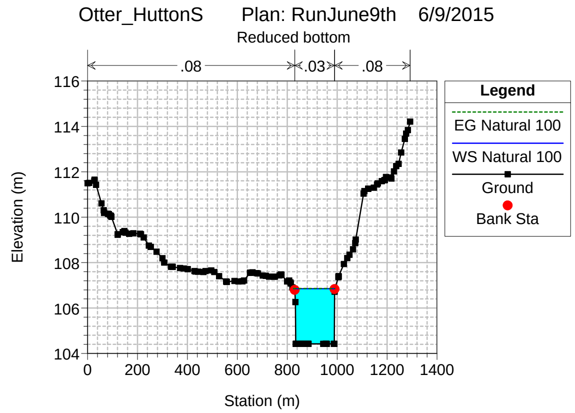
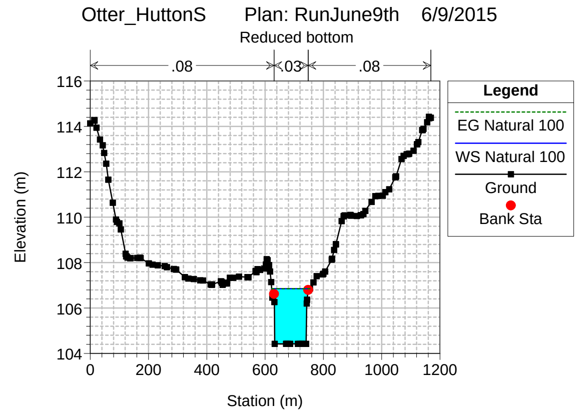
Ineff
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Purcell road
.08
.02
.08
Legend
EG Natural 100
WS Natural 100
Crit Natural 100
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
.08
.02
.08
Legend
EG Natural 100
WS Natural 100
Crit Natural 100
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
.08
.02
.08
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
.08
.02
.08
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
.08
.02
.08
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
.08
.02
.0 8
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta
Elevation (m)
Station (m)

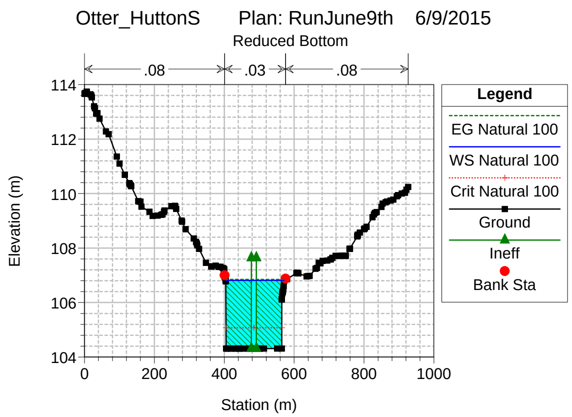


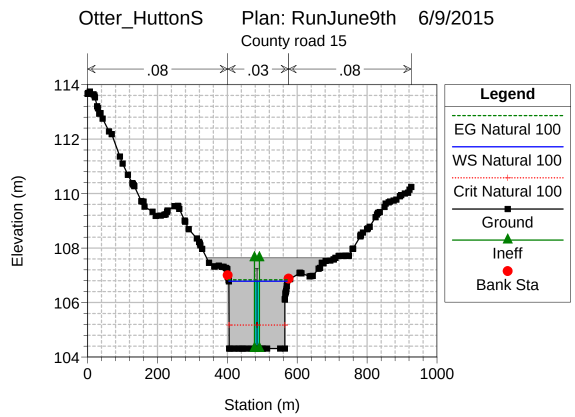
Otter_HuttonS Plan: RunJune9th 6/9/2015
.08
.02
.08
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
.08
.02
.08
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
.08
.02
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
.08
.03
.08
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
.08
.03
.08
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
.08
.03
.08
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Reduced bottom
.08
.03
.08
Legend
EG Natural 100
WS Natural 100
Crit Natural 100
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Railway
.08
.03
.08
Legend
EG Natural 100
WS Natural 100
Crit Natural 100
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Railway
.08
.03
.08
Legend
EG Natural 100
WS Natural 100
Crit Natural 100
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)

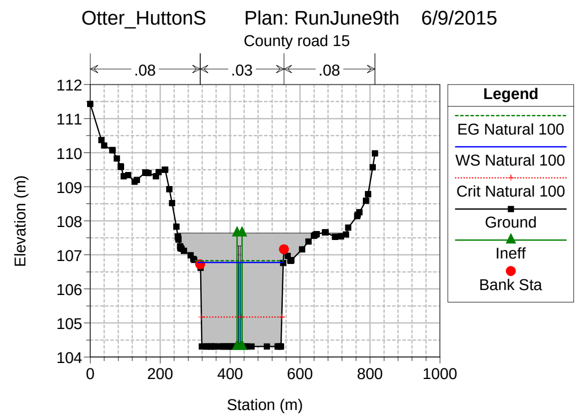

Otter_HuttonS Plan: RunJune9th 6/9/2015
Reduced bottom
.08
.03
.08
Elevation (m)
Station (m)
Legend
EG Natural 100
WS Natural 100
Ground
Ineff
Bank Sta

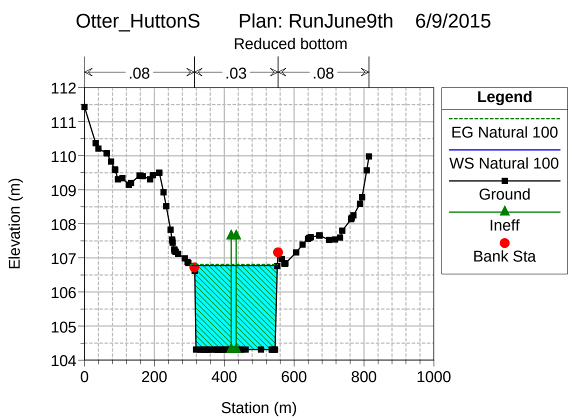

Otter_HuttonS Plan: RunJune9th 6/9/2015
Reduced bottom
.08
.03
.08
Elevation (m)
Station (m)
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta

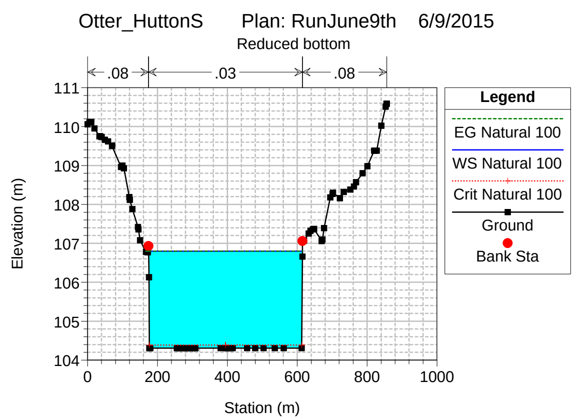

Otter_HuttonS Plan: RunJune9th 6/9/2015
Reduced bottom
.08
.03
.08
Elevation (m)
Station (m)
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta


Otter_HuttonS Plan: RunJune9th 6/9/2015
Reduced Bottom
.08
.03
.08
Elevation (m)
Station (m)
Legend
EG Natural 100
WS Natural 100
Crit Natural 100
Ground
Ineff
Bank Sta


Otter_HuttonS Plan: RunJune9th 6/9/2015
County road 15
.08
.03
.08
Elevation (m)
Station (m)
Legend
EG Natural 100
WS Natural 100
Crit Natural 100
Ground
Ineff
Bank Sta

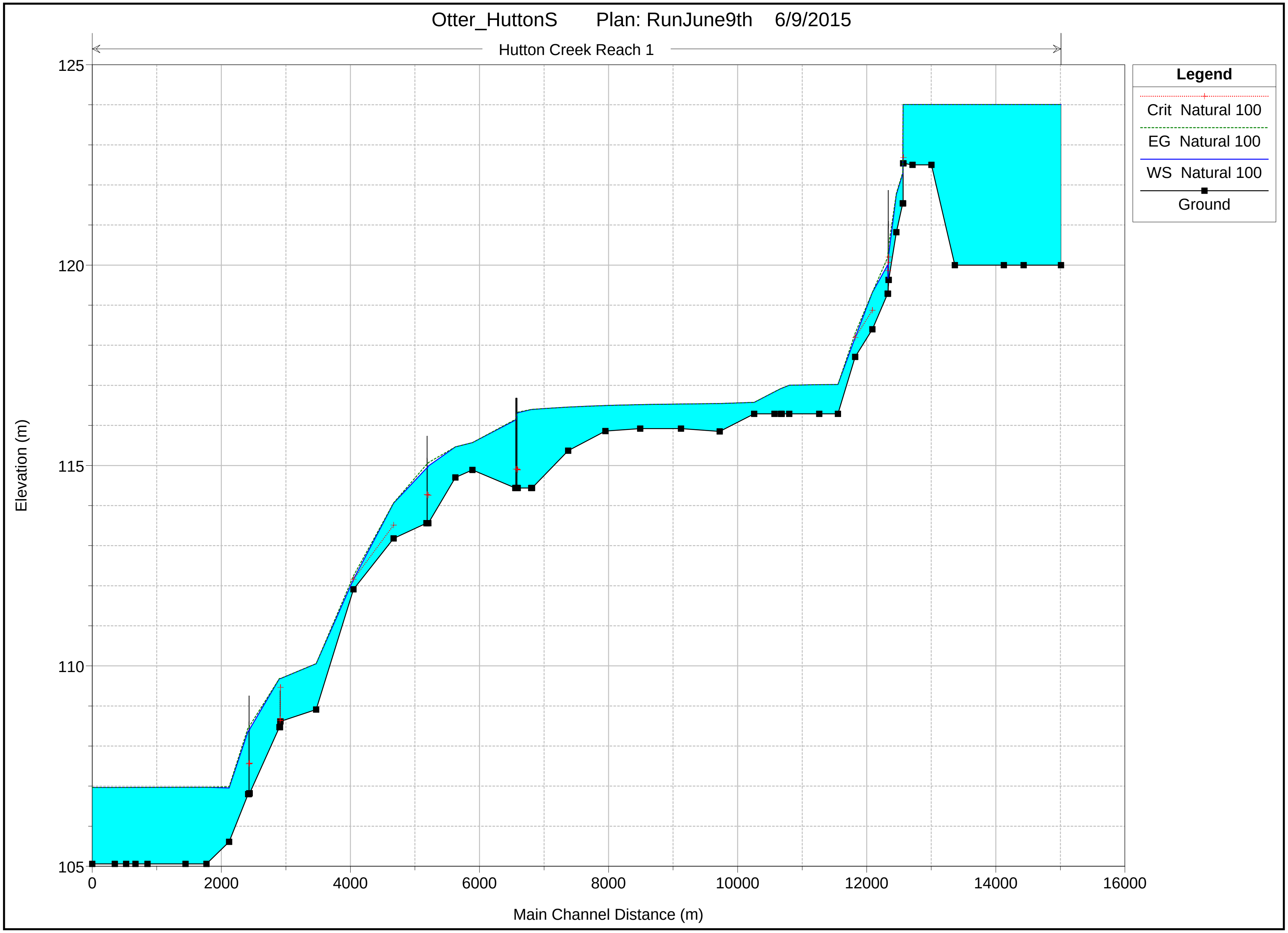

Otter_HuttonS Plan: RunJune9th 6/9/2015
County road 15
.08
.03
.08
Elevation (m)
Station (m)
Legend
EG Natural 100
WS Natural 100
Crit Natural 100
Ground
Ineff
Bank Sta


Otter_HuttonS Plan: RunJune9th 6/9/2015
Reduced bottom
.08
.03
.08
Elevation (m)
Station (m)
Legend
EG Natural 100
WS Natural 100
Ground
Ineff
Bank Sta

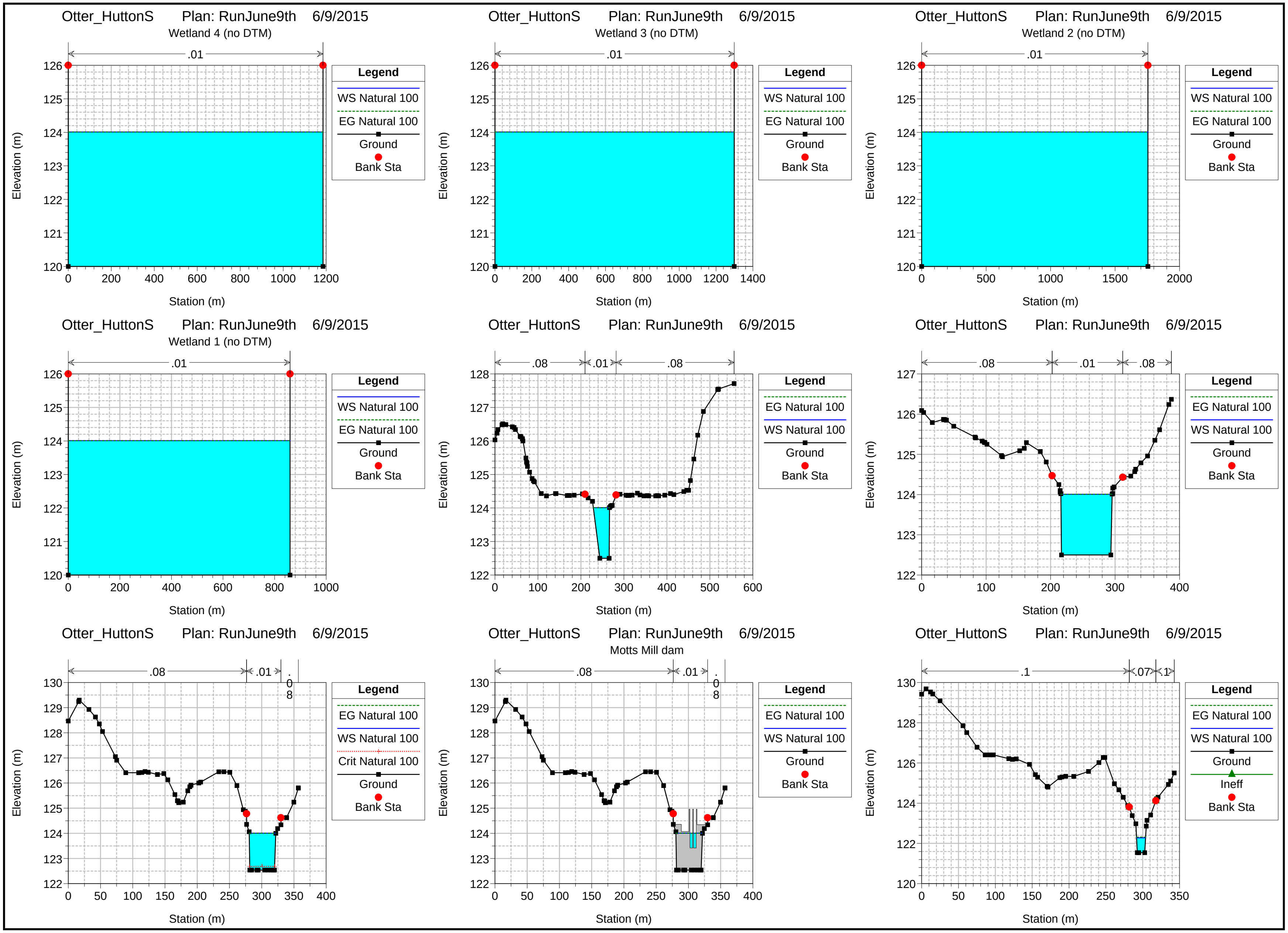

Otter_HuttonS Plan: RunJune9th 6/9/2015
Reduced bottom
.08
.03
.08
Elevation (m)
Station (m)
Legend
EG Natural 100
WS Natural 100
Crit Natural 100
Ground
Bank Sta

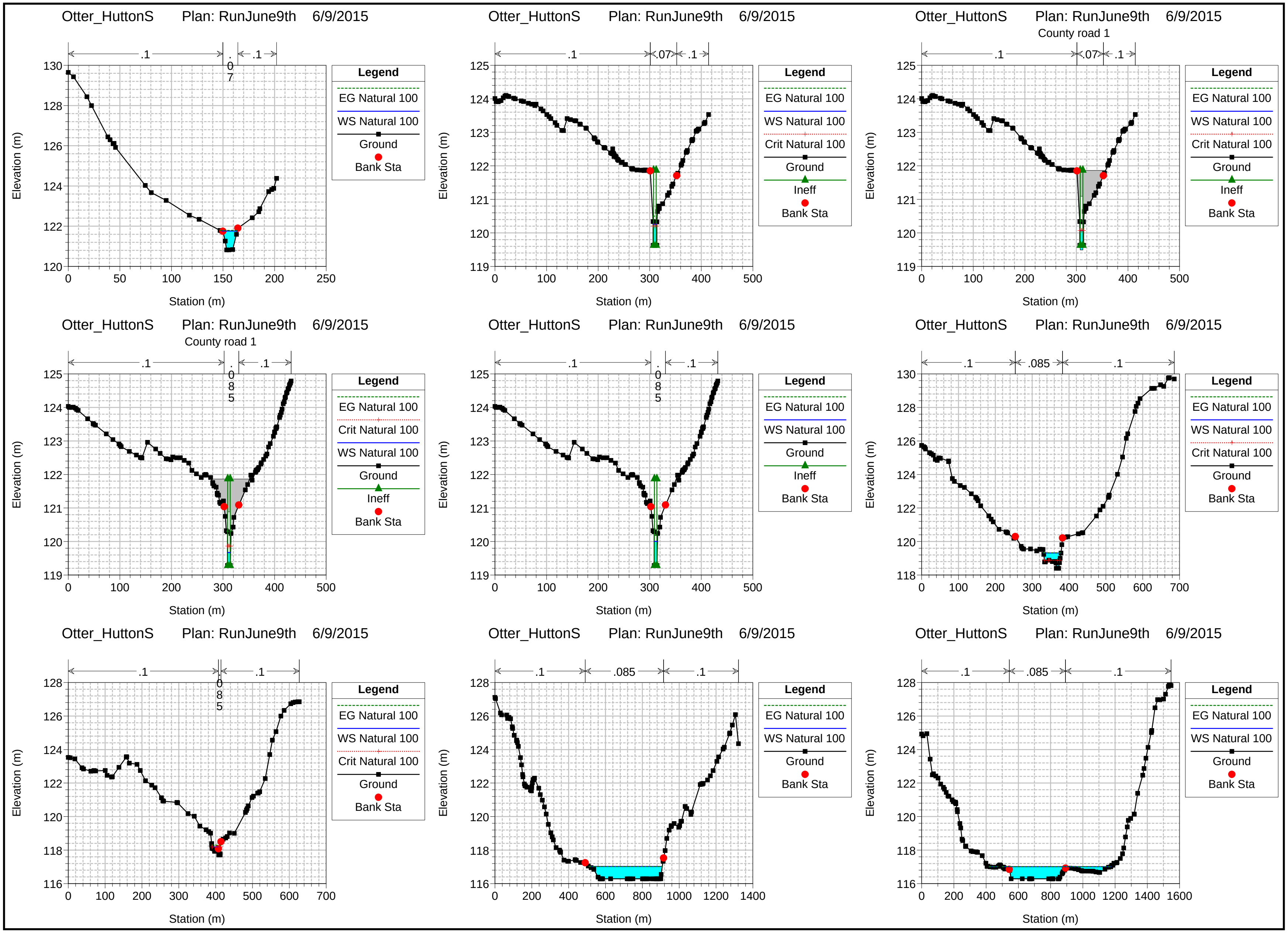
Appendix B

HEC-RAS Profiles and Cross-Sections – Hutton Creek

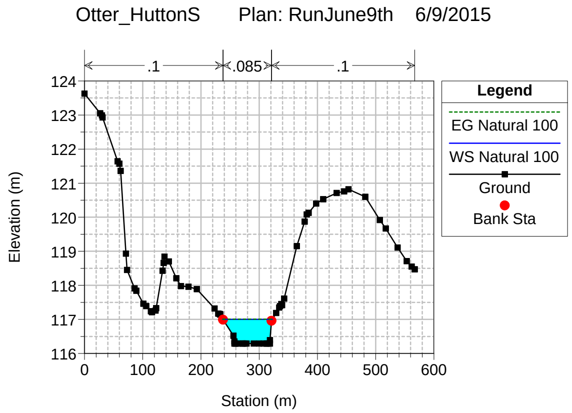


Otter_HuttonS   Plan: RunJune9th   6/9/2015
Hutton Creek Reach 1
Legend
Crit Natural 100
EG Natural 100
WS Natural 100
Ground
Elevation (m)
125
120
115
110
105
0
2000
4000
6000
8000
10000
12000
14000
16000
Main Channel Distance (m)

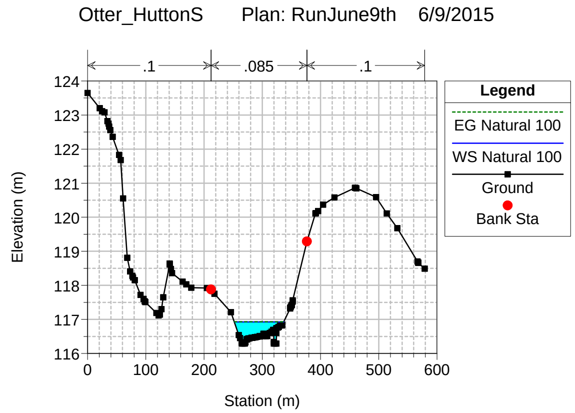

Otter_HuttonS Plan: RunJune9th 6/9/2015
Wetland 4 (no DTM)
.01
Legend
WS Natural 100
EG Natural 100
Ground
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Wetland 3 (no DTM)
.01
Legend
WS Natural 100
EG Natural 100
Ground
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Wetland 2 (no DTM)
.01
Legend
WS Natural 100
EG Natural 100
Ground
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Wetland 1 (no DTM)
.01
Legend
WS Natural 100
EG Natural 100
Ground
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
.08 .01 .08
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
.08 .01 .08
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
.08 .01 .08
Legend
EG Natural 100
WS Natural 100
Crit Natural 100
Ground
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Motts Mill dam
.08 .01 .08
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
.1 .07 .1
Legend
EG Natural 100
WS Natural 100
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)



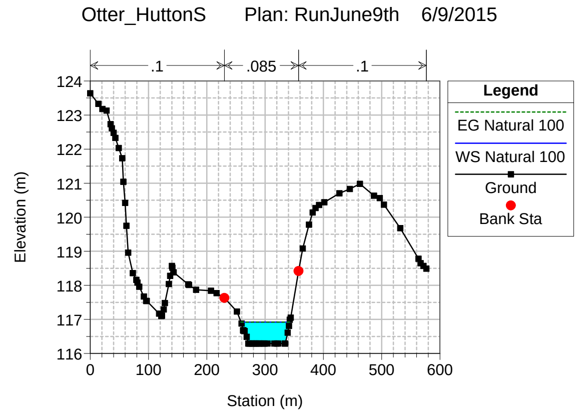
Otter_HuttonS Plan: RunJune9th 6/9/2015
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta
Otter_HuttonS Plan: RunJune9th 6/9/2015
Legend
EG Natural 100
WS Natural 100
Crit Natural 100
Ground
Ineff
Bank Sta
Otter_HuttonS Plan: RunJune9th 6/9/2015
County road 1
Legend
EG Natural 100
WS Natural 100
Crit Natural 100
Ground
Ineff
Bank Sta
Otter_HuttonS Plan: RunJune9th 6/9/2015
County road 1
Legend
EG Natural 100
Crit Natural 100
WS Natural 100
Ground
Ineff
Bank Sta
Otter_HuttonS Plan: RunJune9th 6/9/2015
Legend
EG Natural 100
WS Natural 100
Ground
Ineff
Bank Sta
Otter_HuttonS Plan: RunJune9th 6/9/2015
Legend
EG Natural 100
WS Natural 100
Crit Natural 100
Ground
Bank Sta
Otter_HuttonS Plan: RunJune9th 6/9/2015
Legend
EG Natural 100
WS Natural 100
Crit Natural 100
Ground
Bank Sta
Otter_HuttonS Plan: RunJune9th 6/9/2015
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta
Otter_HuttonS Plan: RunJune9th 6/9/2015
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta
Elevation (m)
Station (m)



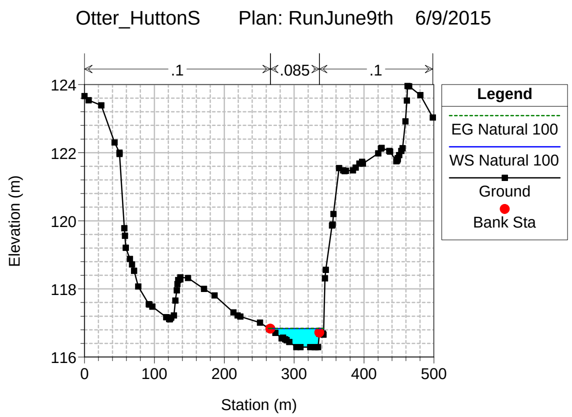
Otter_HuttonS Plan: RunJune9th 6/9/2015
.1 .085 .1
Elevation (m)
124 123 122 121 120 119 118 117 116
0 100 200 300 400 500 600
Station (m)
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta



Otter_HuttonS Plan: RunJune9th 6/9/2015
.1 .085 .1
Elevation (m)
124 123 122 121 120 119 118 117 116
0 100 200 300 400 500 600
Station (m)
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta



Otter_HuttonS Plan: RunJune9th 6/9/2015
.1 .085 .1
Elevation (m)
124 123 122 121 120 119 118 117 116
0 100 200 300 400 500 600
Station (m)
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta



Otter_HuttonS Plan: RunJune9th 6/9/2015
.1 .085 .1
Elevation (m)
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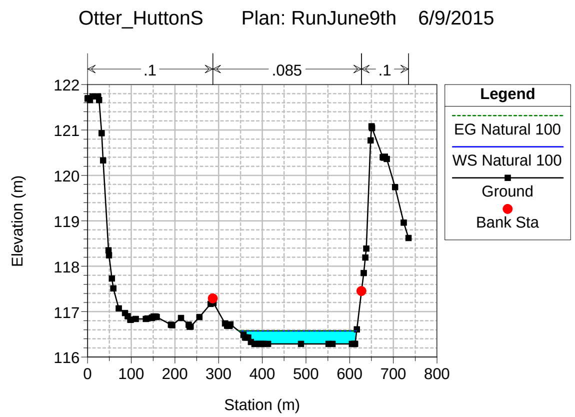
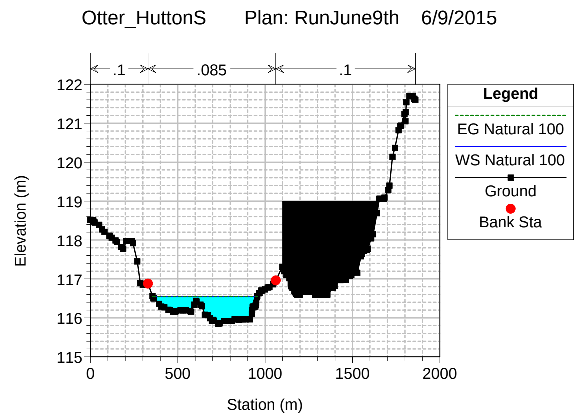
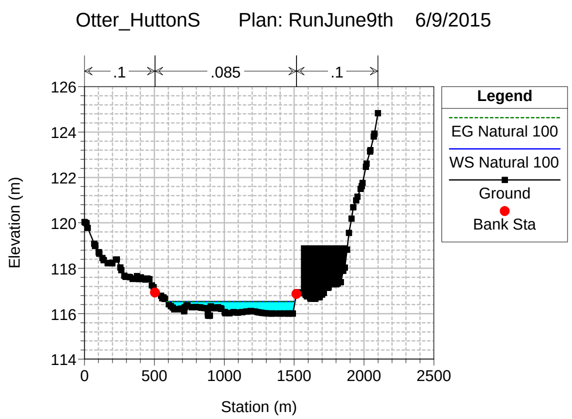
0 100 200 300 400 500
Station (m)
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta



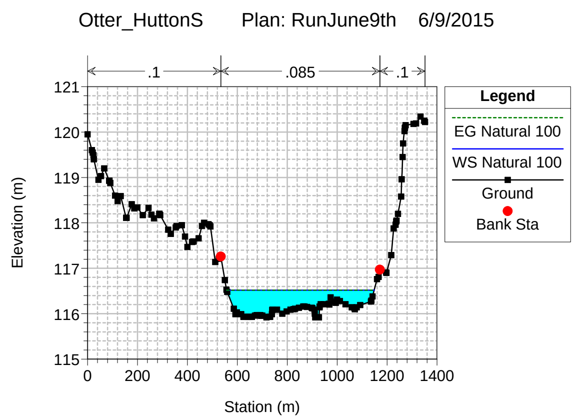
Otter_HuttonS Plan: RunJune9th 6/9/2015
.1 .085 .1
Elevation (m)
122 121 120 119 118 117 116
0 100 200 300 400 500 600 700 800
Station (m)
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta



Otter_HuttonS Plan: RunJune9th 6/9/2015
.1 .085 .1
Elevation (m)
122 121 120 119 118 117 116 115
0 500 1000 1500 2000
Station (m)
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta



Otter_HuttonS Plan: RunJune9th 6/9/2015
.1 .085 .1
Elevation (m)
126 124 122 120 118 116 114
0 500 1000 1500 2000 2500
Station (m)
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta



Otter_HuttonS Plan: RunJune9th 6/9/2015
.1 .085 .1
Elevation (m)
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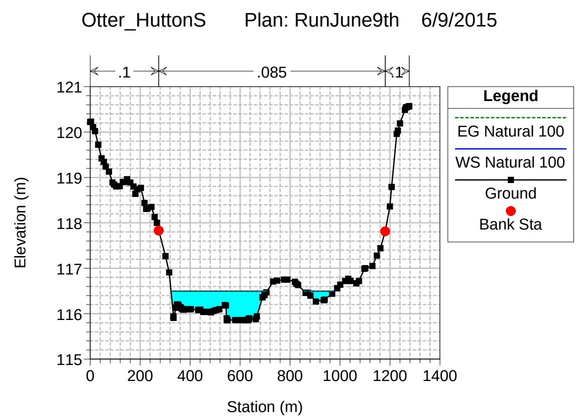
0 200 400 600 800 1000 1200 1400
Station (m)
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta



Otter_HuttonS Plan: RunJune9th 6/9/2015
.1 .085 .1
Elevation (m)
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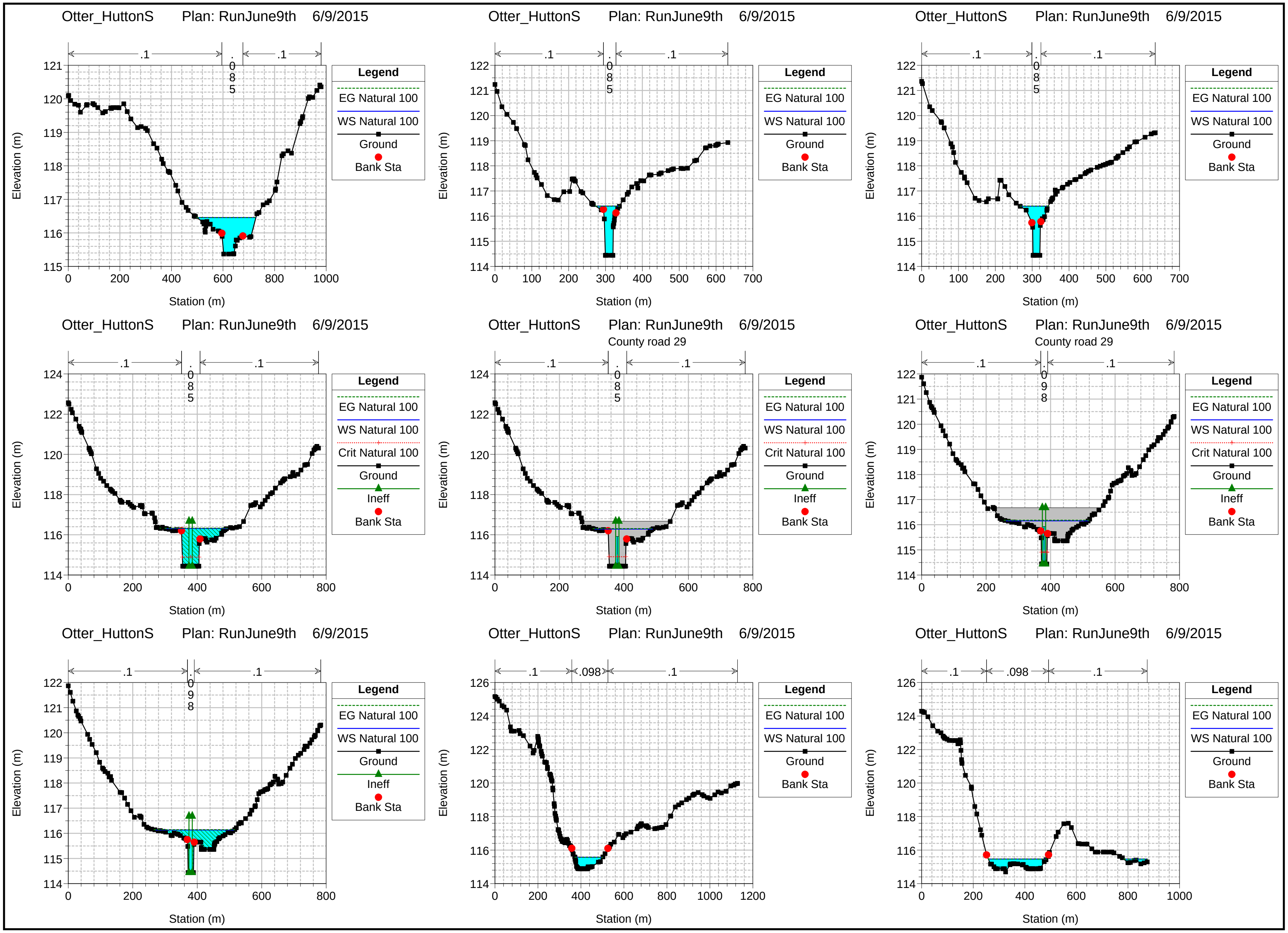
0 200 400 600 800 1000 1200 1400
Station (m)
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta



Otter_HuttonS Plan: RunJune9th 6/9/2015
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Legend
EG Natural 100
WS Natural 100
Crit Natural 100
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
County road 29
Legend
EG Natural 100
WS Natural 100
Crit Natural 100
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
County road 29
Legend
EG Natural 100
WS Natural 100
Crit Natural 100
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Legend
EG Natural 100
WS Natural 100
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta
Elevation (m)
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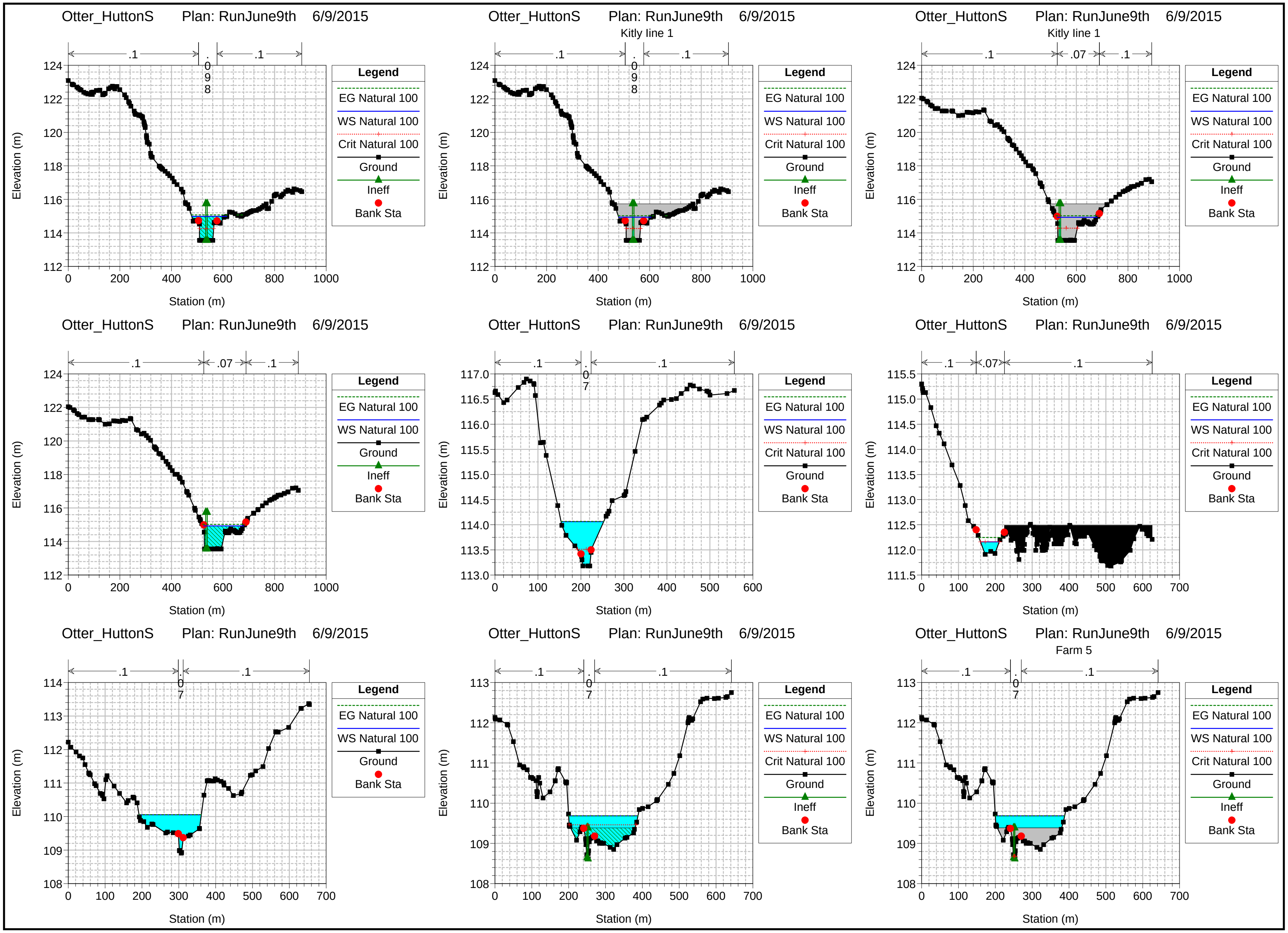
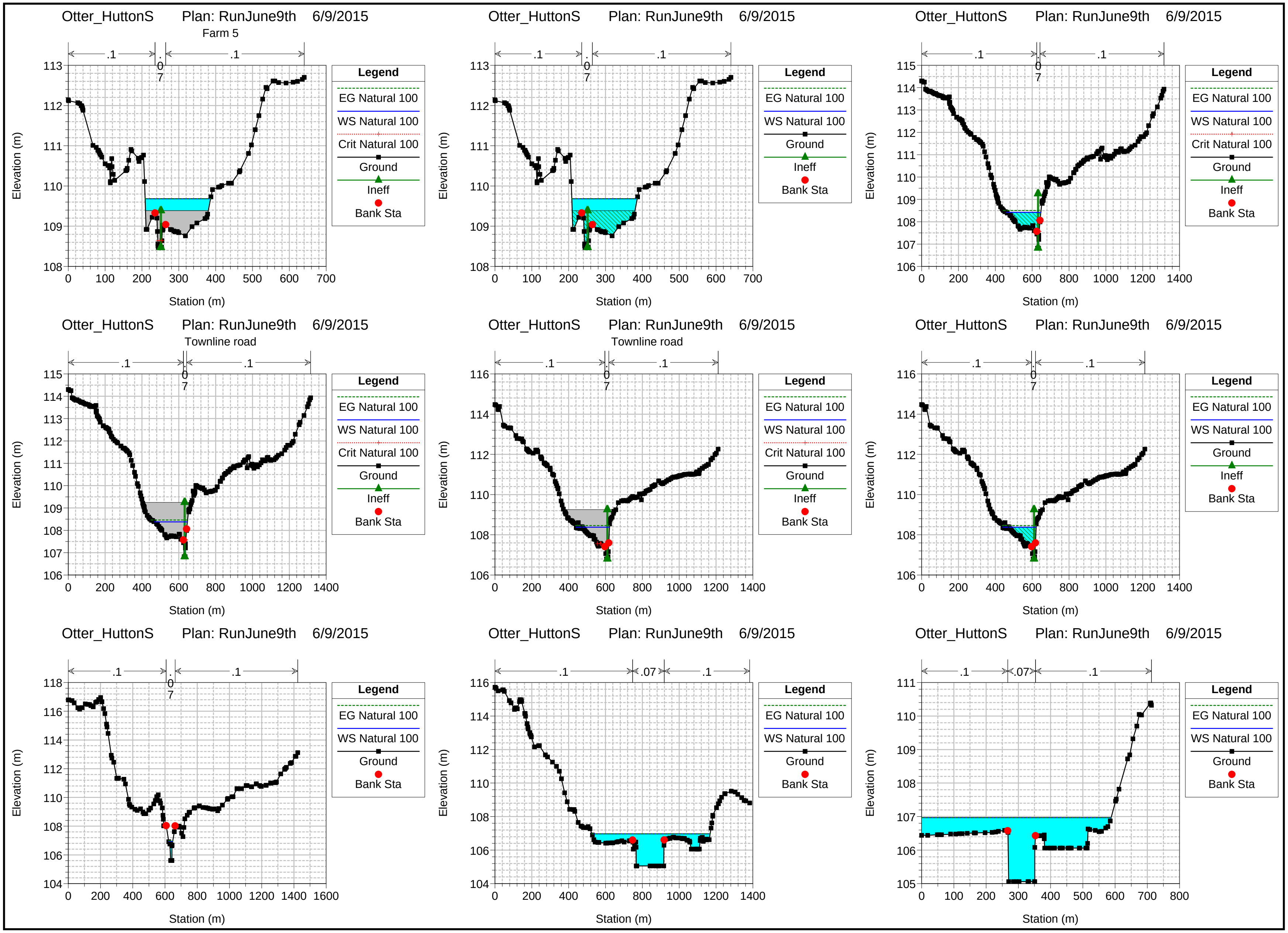
Bank Sta
Elevation (m)
Station (m)



Otter_HuttonS Plan: RunJune9th 6/9/2015
.1
.098
.1
Legend
EG Natural 100
WS Natural 100
Crit Natural 100
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Kitly line 1
Otter_HuttonS Plan: RunJune9th 6/9/2015
Kitly line 1
.07
Otter_HuttonS Plan: RunJune9th 6/9/2015
Otter_HuttonS Plan: RunJune9th 6/9/2015
Otter_HuttonS Plan: RunJune9th 6/9/2015
Otter_HuttonS Plan: RunJune9th 6/9/2015
Otter_HuttonS Plan: RunJune9th 6/9/2015
Otter_HuttonS Plan: RunJune9th 6/9/2015
Farm 5


Otter_HuttonS Plan: RunJune9th 6/9/2015
Farm 5
Legend
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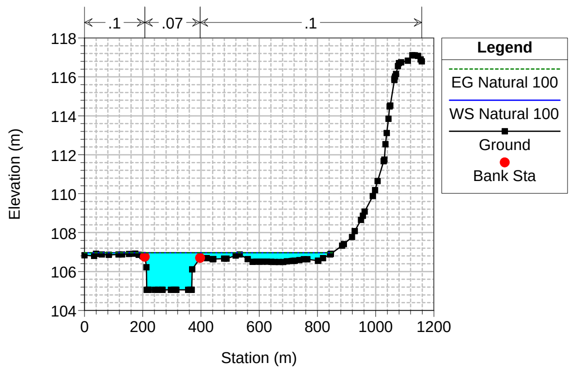
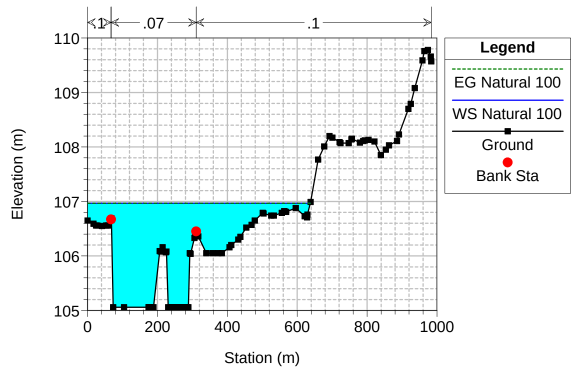
WS Natural 100
Crit Natural 100
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Legend
EG Natural 100
WS Natural 100
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Legend
EG Natural 100
WS Natural 100
Crit Natural 100
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Townline road
Legend
EG Natural 100
WS Natural 100
Crit Natural 100
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Townline road
Legend
EG Natural 100
WS Natural 100
Crit Natural 100
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Legend
EG Natural 100
WS Natural 100
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta
Elevation (m)
Station (m)
Otter_HuttonS Plan: RunJune9th 6/9/2015
Legend
EG Natural 100
WS Natural 100
Ground
Bank Sta
Elevation (m)
Station (m)

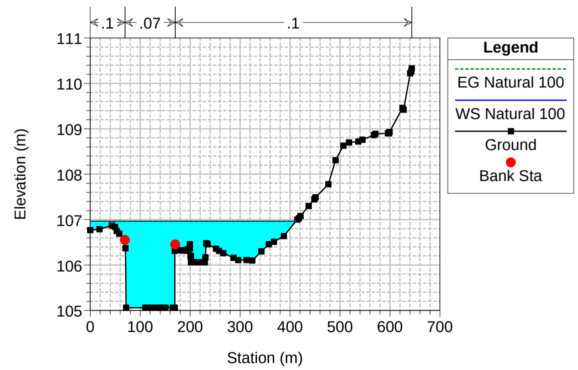
Otter_HuttonS Plan: RunJune9th 6/9/2015



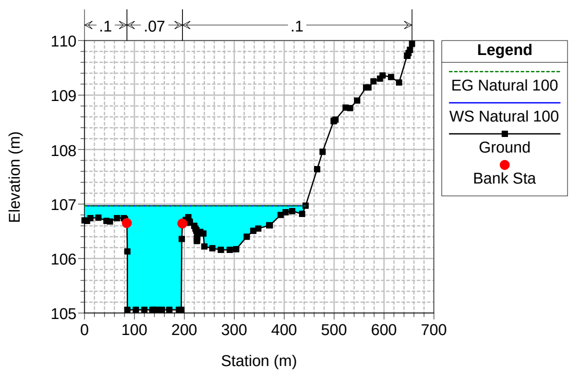
Otter_HuttonS Plan: RunJune9th 6/9/2015



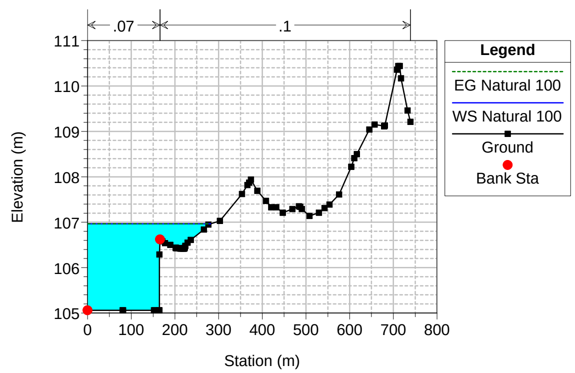
Otter_HuttonS Plan: RunJune9th 6/9/2015



Otter_HuttonS Plan: RunJune9th 6/9/2015



Otter_HuttonS Plan: RunJune9th 6/9/2015



Appendix C

Structures and Road Crossings – Photographs


Otter Lake Road Upstream


Otter Lake Road Downstream


Rideau Ferry Road Upstream


Rideau Ferry Road Downstream

Blacksmith Road Upstream

Highway 15 Upstream

Blacksmith Road Downstream

Highway 15 Downstream

Anglican Church Road Upstream

Kelly’s Road Upstream

Anglican Church Road Downstream

Kelly’s Road Downstream

Hunters Road Upstream

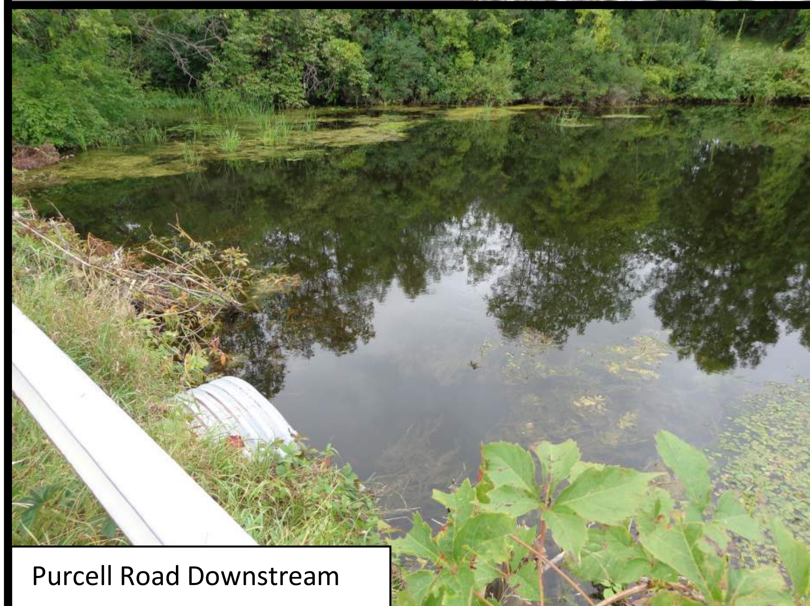
County Road 29 (Otter) Upstream

Hunters Road Downstream

County Road 29 (Otter) Downstream

Purcell Road Upstream

County Road 17 Upstream



Purcell Road Downstream

County Road 17 Downstream

Motts Mill Dam


Motts Mill Dam


County Road 1 Upstream


County Road 1 Downstream

County Road 29 (Hutton) Upstream

Kitley Line 1 Road Upstream

County Road 29 (Hutton) Downstream

Kitley Line 1 Road Downstream

Townline Road Upstream

Townline Road Downstream

Appendix D

Motts Mills Dam – Flow Computation

Excerpts from:

RVCA (2009). Motts Mills Dam Operational Review, Final Report. Rideau Valley Conservation Authority, Manotick, Ontario, Canada, September 2009.

During final design of any selected arrangement, the hydrologic analysis can be revisited if the selection of structure dimensions and operating levels (and hence the anticipated cost of completing the dam's rehabilitation) is found to vary significantly depending on the assumed value of the 1:100 year outflow that needs to be accommodated by it.

5.2 The Dam Rating Curves

The physical dimensions of the dam were taken from the Trow (2005) report. Additional measurements were taken in May 2007 since all the dimensions necessary for hydraulic computation were not available in this report. In April 2008, a geodetic survey was conducted and the operating deck of the dam was found to be at 124.96 m (Figure 5.3). The structure has four and a half stop logs in each of its two dam bays. The full size logs are 25 by 30 centimeters in dimension (at butt end); the half logs are 25 by 15 centimeters (at butt end).

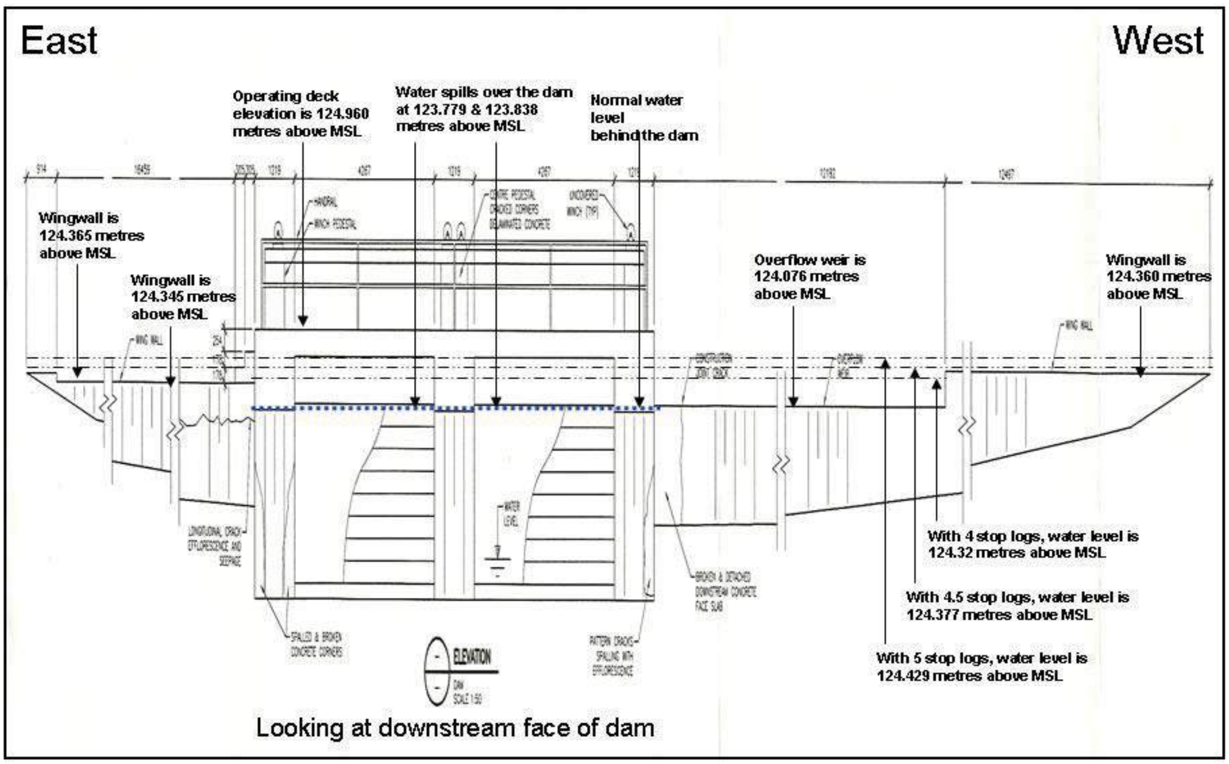


Figure 5.3. Motts Mills Dam Physical Dimensions

The rating curve of the dam, i.e., the relationship between the upstream water level and the flow passing through the dam, was constructed using the physical dimensions of the dam and standard weir flow equations as described by Bos (1990)[6].

The sharp-crested weir formula for the flow rate Q is

$$Q = \frac{2}{3} C_e \sqrt{2g} b h^{1.5}$$

[6] M. G. Bos (1990). Discharge Measurement Structures. ILRI Publication 20.

where C_e is a coefficient, found to be 0.59 based on the weir configuration; g is the acceleration due to gravity (9.81 m2/s); b is the width of the weir; and h is the height of upstream water level above the weir crest level. This formula applies to the stop-log bays.

The broad-crested weir formula is

$$Q = \frac{2}{3} C_d C_v \sqrt{\frac{2}{3} g} b h^{1.5}$$

where the coefficients C_d and C_v were estimated to be 0.93 and 1.1 based on the weir configuration. This formula was applied to the side weirs.

Figure 5.4 shows the rating curves for the entire structure as well as for the two bays and three weirs. In these calculations, it was assumed that all logs (4 and a half) are in place, which is the worst case scenario (yielding higher, conservative flood levels). This also represents the existing condition, since all logs have been in place for the last 20 years.

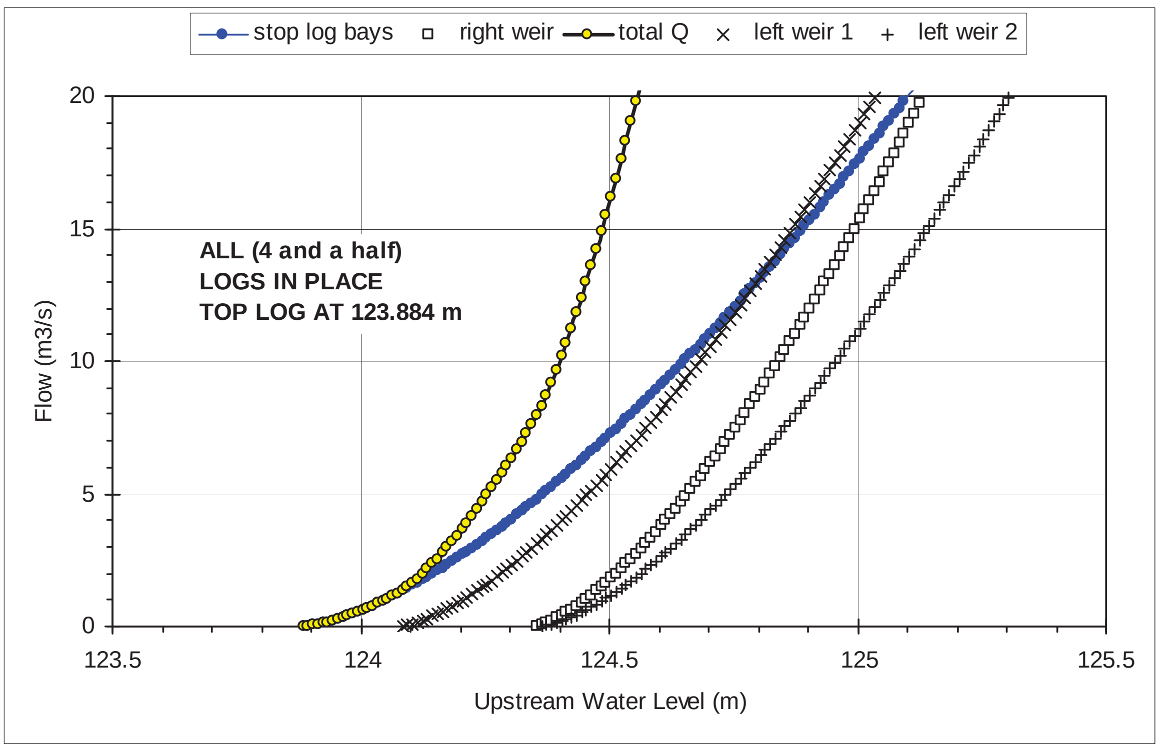


Figure 5.4. Rating Curve at the Motts Mills Dam

5.3 Upstream Flood Elevation

The flood elevation in the wetland upstream of Motts Mills can be readily estimated from the rating curve. They are shown in Table 5.3. It should be kept in mind that these flood elevations

Appendix E

Buildings 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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