Technical Memo

February 8, 2010

To: Bruce Reid, P.Eng. Director
Watershed Sciences and Engineering Services

From: Ferdous Ahmed, Ph.D., P.Eng.
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Subject: Rideau River Flood Risk Mapping – Poonamalie Dam to Smith Falls

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This is a technical report submitted in support of the completion of Flood Risk Mapping for the Rideau River reach running from the Poonamalie dam, at the outlet of the Rideau Lakes, to the water intake (Abbott St.) for the Separated Town of Smith Falls. The mapping was done in-house by Rideau Valley Conservation Authority staff and was undertaken in accordance with the technical guidelines set out under the Canada-Ontario Flood Damage Reduction Program (FDRP) (MNR, 1984), and the technical guide for flood hazard delineation in Ontario (MNR, 2002) as approved for use by the Ontario Ministry of Natural Resources. A separate "documentation folder", containing all pertinent background information, data, and analyses, is available at the RVCA offices.

Introduction

In general, Conservation Authorities are expected to have knowledge about the extent of flood hazard areas adjacent to rivers, streams and lakes throughout their areas of jurisdiction, and to use that knowledge to protect people and property from the adverse effects of natural hazards. One tool for exercising this protection is the establishment of development regulations made under Section 28 of the Conservation Authorities Act. As of 2009 flood hazard areas have been delineated for a relatively small percentage of the watercourses and waterbodies in the RVCA area of jurisdiction. The RVCA is making progress, however, on the expansion of its flood hazard knowledge-base, applying the available resources according to a set of priorities that have been identified under leadership from the RVCA Planning Advisory and Regulatory Services program, based generally on a sense of where development pressures are greatest.

The need to update and extend the flood lines in this particular study area (Rideau River-Poonamalie dam to Smiths Falls) arose out of a requirement to define 'intake protection zones' (IPZ's) for the municipal water supply system serving the Town of Smiths Falls, as part of the Mississippi-Rideau Drinking Water Source Protection Planning initiative. In accordance with the MOE technical guidance, the upstream limits of IPZ's were to be defined by the travel time of pollutants along watercourses from potential sources to the intake location, and the lateral extent of the IPZ's was to be based on Conservation Authority Section 28 regulation limits established in accordance with the 'generic regulation'. It was necessary to extend the regulations limits mapping to at least as far as the upstream limit of the IPZ.

In preparing updated and extended flood lines, use has been made of new topographic mapping and imagery that was acquired as part of the Drinking Water Source Protection Planning program. During the process, efforts have been made to refine the hydraulic modeling that is used for estimating water surface elevations.

Flood Risk maps have been created for several reaches of the Rideau River (Maclaren, 1976, 1979; Dillon, 1989; and Robinson, 1984, 2003), including the area from the Poonamalie dam to Smith Falls. This particular reach was mapped by J.F. MacLaren Ltd. in 1979 using Ortho-photo base coverage without topographic contours; consequently there was a need for a more up to date and comprehensive mapping study, using the current FDRP standards (MNR, 1984). This updated mapping also provides a more up to date point of reference for area landowners.

Aerial photographs were collected in 2006, at a scale of 1:2000, and used to generate a high quality Digital Terrain Model (DTM) by *Base Mapping Company Inc.*; see Figure 1 for the extent of the aerial photographs. Ground surveys were also completed in 2006 by RVCA staff to collect additional data on stream cross-sections and bridges and culverts. The design flow estimates for this study were compiled from different sources as shown in Table 1. For the mapping extent, as shown in Figure 1, there was sufficient data available to meet the standards for 'engineered' floodplain mapping, in accordance with the technical guidelines for flood hazard delineation in Ontario (MNR, 2002),

Study Area

Given that detailed topographic information is required to produce 'engineered floodplain lines', the study limits were determined by the extent of the aerial photography, as shown in Figure 1. The main study reach, along the Rideau River, runs from Poonamalie dam to the Smith Falls water intake, located just downstream of the Abbott Street Bridge. Tributaries that link to this particular section of the Rideau River were also considered. The following reaches were included in the study and are shown in Figure 2:

- Rideau River: from Poonamalie dam to approximately 300m downstream of the Abbott St. Bridge in Smith Falls.
- Black Creek: from the Poonamalie side Rd. culvert to the outlet at the Rideau River.
- Tributary 1: from the Highway 43 culvert to the outlet at the Rideau River.
- Tributary 2: from the Highway 43 culvert to the outlet at the Rideau River.
- Tributary 3 (also known as *Lousy Creek*): from the Lombard St. culvert to the outlet at the Rideau River.

Hydrological Analysis

The RVCA watershed is classified as a Zone-2 region under the 'Flood Hazard Criteria Zones' for Ontario and Conservation Authorities (MNR 2002); therefore the regulatory flood for the entire watershed is the 100-year return period flow. MacLaren (1979) estimated the 1:100 year design flow at 143 m^3/s, for the Rideau River between the Old Slys Lock and the Poonamalie dam. This value was determined using observed flow records from 1944 to 1975 at the Poonamalie control structure. To generate an updated value for the Rideau River 1:100 year flow in the study area requires a complex study involving conversion of the historical flow records to "natural" flows (i.e. not regulated by dams), taking into account the effect of reservoir operations on past events, and then considering how a 1:100 year event on the watershed would affected by present-day dam and reservoir operating procedures. As much as such a study should be undertake,, doing so was beyond the scope and budget for this assignment; so in the absence of an updated estimate, the previous estimate of 143 m^3/s, on the Rideau River, was used as the design flow for this study.

The design flows for Tributaries 1, 2, and 3 were determined using the regional frequency analysis method (MNR, 1984).

The design flow at the outlet of Black Creek was estimated two ways: (a) by using the regional frequency analysis; (b) by using the synthetic flow series generated by the Mike11 model (RVCA, 2007) and then performing the usual single station frequency analysis. The Mike11-based values were smaller than those obtained by the regional method. However, the Mike11-based values were judges to be more appropriate, because the Back Creek basin is very elongated in shape with substantial flood attenuation accumulating over the long channel reach, and the hydrodynamic module of Mike11 is capable of capturing such channel attenuation. The simulated peak flows were extracted from the Mike11 model and used as input in a 'Consolidated Frequency Analysis' (CFA) program – developed by Environment Canada (Pilon and Harvey, 1993). The drainage areas for all tributaries and resulting design flows are listed in Table 1, and shown in Figure 3.

Data Used for Flood Hazard Mapping

Design Flows: As discussed in the previous section, design flows were estimated in various ways for the different catchments (see Table 1).

Water Levels: The downstream boundary condition for the 1:100 year flow on the Rideau River was taken from the earlier flood mapping study (MacLaren, 1979). A water level of 119.12 m, at cross-section 5855 just downstream of Abbott St. Bridge, was used for the Rideau River.

For all other tributaries (Black Creek, Tributaries 1, 2 and 3) the following scenarios were considered:

1. The 1:2 yr flow on the tributaries and the 1:100 yr flow on Rideau River
2. The 1:100 yr flow on the tributaries and the Navigational Water Level (NWL) on Rideau River

The second scenario uses a NWL of 121.8 m (CHS, 2005) at the downstream cross-section of each tributary; whereas the first scenario extracts the water level from the Rideau River hydraulic model. In other words the 1: 100 year water level from the Rideau River is used as a boundary condition for the point at which each tributary meets the Rideau River. See the section on '**Hydraulic Modeling'** for further details and Table 2 for all water levels used.

Aerial Photo: The aerial photography was collected in May 2006 at a scale of 1:2000. This high quality black and white photography clearly shows the rivers, creeks, land use, houses, buildings, roads, infrastructure, vegetation and other details.

DTM: Aerial photography was used to derive a high quality digital terrain model (DTM) for flood mapping purposes. Contour lines were drawn at 1.0 m intervals with 0.5 m interpolated lines. The mapping procedures were in accordance with the FDRP program (MNR, 1984). Other standard layers showing houses, roads, depressions, etc. were also produced.

Cross-Sections: In general, cross sections were generated from the high quality DTM using standard GIS software; however along the Rideau River, cross sections were used from the previous study (Maclaren 1979). Due to the incomplete documentation by MacLaren at the time, the locations of the cross section cutlines on the map are approximate. The cross-sections were tied to the centre line of the Rideau River; yet the actual cross-sections may be shorter or longer than those depicted on the map (Figure 4). This is considered an acceptable approximation as it would not have an effect on the hydraulic computations. For the most part the above procedure captured the floodplain as well as most of the low flow channel in sufficient detail to be used for this floodplain mapping project. However, in the case of the tributaries, a ground survey was done to collect the stream thalweg or bottom definition to supplement the DTM-generated profile. The surveying was undertaken by appropriately qualified RVCA staff in July-August of 2006. Information on culverts and bridges was also collected at this time. In the lake area, cross sections were generated from nautical maps.

Channel Roughness: Following standard procedures (Chow, 1959), the surface roughness of the channel under possible high water conditions was estimated from aerial photos and occasional field inspections. The Manning's n was generally 0.035 in the main channel, and varied from 0.05 to 0.10 for the floodplains. The values of n for the tributaries were slightly higher due to the type of vegetation. These values were consistent with those found appropriate in earlier studies.

Bridges/Culverts: There are six bridge and culvert crossings within the study area (Table 3). These structures were included in the HEC-RAS model in order to account for the constriction of flow and the resulting change in water levels. The physical dimensions and other pertinent data of these structures were collected from various sources. For the culverts on *Tributaries 1, 2* and *3* and the bridge on *Black Creek* the dimensions were obtained from the 'IPZ Delineation Study' (RVCA, 2007). In 2006, during the IPZ study, RVCA staff conducted surveys of these structures.

The coefficients of contraction (C_c) and expansion (C_e) associated with bridges/culverts were estimated from available information using standard procedures (USACE, 1990, 2002).

Water Control Structures: The water level within the study area is controlled by a number of dams and locks for summer navigational purposes. Two in-line water control structures were incorporated into the HEC-RAS model. In particular, Poonamalie dam, operated by a vertical lifted gate section, and the Smith Falls detached dam, controlled by stop logs, were included. During periods of high flow, and obviously including the 100 yr event, all logs are taken out of the Smith Falls Detached dam. This is in compliance with the recommended procedures, as mentioned in the MacLaren study (1979). The Poonamalie dam gate is also kept fully open during high flows - Parks Canada officials confirmed this policy. See Table 4 for more details.

Hydraulic Modeling

A steady-state hydraulic model was created for the study area, in accordance with standard procedures (MNR, 1984; USACE, 1990, 2002). The model was produced using HEC-RAS software (version 3.1.1) developed by the US Corps of Engineers (USACE, 2002). This one dimensional steady-state model uses backwater computations, based on the energy equations.

Five separate hydraulic models were built for the five stream reaches within the study area. With reference to Figure 2, the modeled reaches are as follows:

- Rideau River: from Poonamalie dam to approximately 300m downstream of the Abbott St. Bridge in Smith Falls.
- Black Creek: from the Poonamalie side Rd. culvert to the outlet at the Rideau River.
- Tributary 1: from the Highway 43 culvert to the outlet at the Rideau River.
- Tributary 2: from the Highway 43 culvert to the outlet at the Rideau River.
- Tributary 3 (also known as *Lousy Creek*): from the Lombard St. culvert to the outlet at the Rideau River.

Along the Rideau River the existing model (MacLaren, 1979) was extended and updated. For Tributaries 1, 2, and 3 and Black creek, new hydraulic models were developed using the cross-sections developed from the DTM. Distances between cross-sections along the stream centerline and distances between left and right overbanks were calculated using GIS software and then added to the model. The bridges, culverts and control structures were also inserted in the HEC-RAS model at the appropriate locations. The ineffective flow areas surrounding these structures were defined. At each cross-section the appropriate Manning's n value and contraction and expansion coefficients were entered.

Two combinations of the 1:100 and 1:2 yr design flows (Table 1) in the main channel and tributaries were considered in the hydraulic model. The regulatory flood levels are defined by the maximum water levels produced by the two combinations. The two different flow scenarios considered in this study are as follows:

Scenario 1 - The 1:2 yr flow on the tributaries and the 1:100 yr flow on Rideau River

Scenario 2 - The 1:100 yr flow on the tributaries and the Navigational Water Level (NWL) on Rideau River (121.80 m)

For the second scenario listed above, the NWL was considered rather than the water levels produced from the 1:2 yr return period. This is because Parks Canada tries to maintain the NWL during the navigation season (May to October) and a slightly lower level during the rest of the year.

The downstream boundary conditions for each of the reaches, for both scenarios are listed in Table 2. For the first scenario the hydraulic model was set up and run for the Rideau River using the 1:100 yr boundary condition from MacLaren (1979). Next the 1:100 yr water levels were extracted from the Rideau River model at each of the junctions (i.e. where the tributaries connect to the main channel). These water levels were then used as downstream boundary conditions for the four tributaries. For the second scenario there was no need to build a HEC-RAS model for the Rideau River reach because the NWL was assumed throughout this reach. All boundary conditions were set with reference to accepted procedures (USACE, 1990, 2002).

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

Along the Rideau River, it was found that the flood level is governed by the 1: 100 year flow condition. Whereas in the tributaries, the governing event (producing the highest water levels) varies throughout each individual reach. For the tributaries, the first scenario is dominant near the confluences of the Rideau River and as one moves further upstream on the tributaries, the second scenario becomes the dominant event.

The 1:100 year computed water surface elevations and other parameters for the Rideau River are shown in Table 5. For the other four tributaries, Table 6 details the dominant flood levels resulting from a combination of flow simulations. Water surface profiles and all cross-sections, from the HEC-RAS model, are included in Appendix A.

Regulatory Flood Levels

As per Section 3 of the Provincial Policy Statement, under the Planning Act (MMAH, 2005), the regulatory flood for Zone 2 (including the RVCA watershed) is the 1:100 year flood event. Computed Water Surface Elevations (CWSEL) are therefore commonly used to determine the regulatory flood level (RFL).

Post-processing of the hydraulic model output was required because it is recognized that the numerical models can never be a perfect representation of real world hydraulic phenomena. To obtain the RFL, the following algorithm was used:

- By default, set RFL = CWSEL
- If the RFL at any location is lower than the RFL at the next downstream section, then set the RFL = downstream RFL

The above assures that the RFLs always decrease in the downstream direction. The flood levels for all cross-sections are presented in Table 5 and Table 6, along with the computed water surface elevations and energy grade lines.

When compared to the water levels computed during previous studies, the present water levels were in general agreement. It was found that the updated RFL varied slightly from the previous study (McLaren, 1979), which utilized an older version of HEC-2 software. The updated values varied by an amount ranging from + 7 cm to -35 cm, when compared to the previously generated output. Particularly in the vicinity of structures, the water levels differed because of constrictions and other perturbations. In general, the variation in water levels may be due to more accurate channel definition, channel roughness and due to the fact that additional structural information was included. In terms of flood prone area, this variation is not very significant because of the steep contours along the Rideau River.

Flood Line Delineation

Once the RFLs are established, the plotting of the flood risk area is relatively straightforward, using the new DTM and current FDRP standards. Given the topographical information, the inundated area below the RFLs can be easily delineated manually or by using automated computer programs. For this study the HEC-GeoRAS program version 4.0 (USACE, 2005) was used to delineate flood lines on topographical maps. The lines were then visually inspected to identify and correct any anomalies, and to ensure that the lines conformed to hydraulic engineering principles. The HEC-GeoRAS-generated flood lines also needed to be smoothed out using GIS software.

Flood Risk Maps

An overview of the resultant Flood maps is attached; see Figures 4, 4a, 4b, and 4c. More detailed digital maps are available on RVCA's GIS platform.

Public Consultation

There were three public consultations held on the following dates:

- September 29th, 2009 at the Smith Falls Legion,
- September 30th, 2009 at the municipal building in Oxford Mills and
- October 5th, 2009 at the RVCA offices in Manotick.

The flood mapping was presented and explained to those, approximately 30 people, who attended the meetings. Any questions were dealt with at the time and there were no outstanding issues that required follow-up, since all who attended the consultations were satisfied.

Project Deliverables

1. 'Rideau River Flood Risk Mapping – Poonamalie Dam to Smith Falls' Report – including a detailed description of the hydrology, modeling procedures, and flood risk mapping procedures (this memo)
2. Digital Flood Risk Maps – on RVCA's GIS platform
3. HEC-RAS model files
4. The "documentation folder"

Closure

The hydrotechnical and cartographic procedures used in this study conform to present day standards of flood hazard delineation, as per the MNR's Natural Hazard Technical Guide (MNR, 2002). The resulting regulatory flood lines are suitable for use in the RVCA's regulation limits mapping (referred to in Section 12 of Ontario regulation 174/06) and in municipal land use planning and development approval processes under the Planning Act. The water surface profiles will also be of valuable use in the flood forecasting and warning services of the RVCA.

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Table 1 - Drainage Area and Estimated Design Flows

Reach	Drainage Area	Design Flows		Method used to estimate Design Flow	Source
		1:100 yr	1:2 yr		
	km^2	m^3/s	m^3/s		
Rideau River (at Poonamalie Dam)	1290.00	143.00	-	Single Station Frequency Analysis	MacLaren, 1979
Black Creek*	143.4962	31.20	16.60	Mike11 Modeling + Frequency Analysis	RVCA, 2010
Tributary 1*	16.8506	8.10	2.36	Regional Frequency Analysis	RVCA, 2007
Tributary 2*	6.2483	3.50	0.93	Regional Frequency Analysis	RVCA, 2007
Tributary 3*	4.6363	2.60	0.66	Regional Frequency Analysis	RVCA, 2007

*Refer to Figure 2 for location of tributaries

Table 2 - Downstream Boundary Conditions for Each Scenario

	Scenario 1 - 2 yr flow in Tributaries and 100 yr flow in Rideau		**Scenario 2 -** 100 yr flow in Tributaries and Navigational WL in Rideau	
Reach	Water Level (m)	Source	Water Level (m)	Source
Rideau River (d/s of Abbott St. Bridge)	119.116	MacLaren, 1979	n/a	n/a
Black Creek	122.805	Extracted from the Rideau River Hydraulic model (developed for this report)	121.8	NWL (Parks Canada)
Tributary 1	122.575		121.8	
Tributary 2	122.59		121.8	
Tributary 3	122.615		121.8	

Table 3 - Bridges and Culverts

Reach	Name	Bridges/ Culverts	Chainage (m)	Bounding X-Secs (ID)	Deck Top (m)	Low chord (m)	Deck width (m)	Source
Rideau River	Abbott Street	B	373.0	47 & 50	123.51	121.70	7.316	Robinson, 1991*
Rideau River	CNR	B	530.0	40 & 42	123.21	122.68	2.70	MacLaren, 1979
Black Creek	Poonamalie Side Road	B	632.5	23 & 24	124.82	124.05	9.09	RVCA, 2006
Tributary 1	HWY 43	C	1170.0	58 & 59	128.24	123.80	26.20	
Tributary 2	HWY 43	C	1475.0	40 & 41	124.00	123.84	30.80	
Tributary 3	Lombard Street	C	1015.0	64 & 65	122.55	122.35	16.20	

*Engineering Drawing (available in "Documentation Folder")

Notation: B - Bridge, C - Culvert

Table 4 - Water Control Structures

Reach	Name	Chainage (m)	Bounding X-Secs (ID)	Source
Rideau River	Poonamalie Dam	5355	5890 & 5895	Acres, 1994
Rideau River	Smith Falls Detached Dam	491	U/s of 5985	Parks Canada, 1982*

*Engineering Drawing (available in "Documentation Folder")

Table 5 - Regulatory Flood Levels for 1:100 Year Flood Event - Rideau River Reach

River	Cross section ID (GIS)	Cross section ID (HEC RAS)	Chainage (m)	Q Total (m^3/s)	Min Ch El (m)	CWSEL (m)	EGL (m)	RFL (m)
Rideau River	5855	33	0	143.00	115.40	119.12	119.16	119.12
	5860	34	114	143.00	115.40	119.16	119.17	119.16
	5865	35	184	143.00	117.53	119.05	119.23	119.16
	5870	36	284	143.00	118.54	120.49	121.47	120.49
	5875	37	313	143.00	118.69	121.50	121.60	121.50
	5880	40	363	143.00	119.45	121.52	121.72	121.52
		40.75		CNR Bridge				
	5885	42	383	143.00	118.87	121.86	121.96	121.86
	5890	43	426	143.00	119.66	121.70	122.11	121.86
		44.5		Smith Falls Detached Dam				
	5895	46	487	143.00	120.09	122.42	122.47	122.42
	5900	47	515	143.00	119.88	122.45	122.48	122.45
		48.5		Abbott St. Bridge				
	5905	50	545	143.00	119.88	122.54	122.57	122.54
	5910	51	560	143.00	114.45	122.57	122.57	122.57
	5915	52	670	143.00	120.06	122.57	122.57	122.57
	5920	53	1170	143.00	119.24	122.58	122.58	122.58
	5925	54	1560	143.00	119.24	122.60	122.61	122.60
	5930	55	2000	143.00	118.93	122.63	122.63	122.63
	5935	56	2220	143.00	119.24	122.63	122.65	122.63
	5940	57	2800	143.00	118.93	122.68	122.68	122.68
	5945	58	3188	143.00	119.24	122.69	122.70	122.69
	5950	59	3528	143.00	120.15	122.73	122.74	122.73
	5955	60	3868	143.00	119.24	122.77	122.78	122.77
	5960	61	4163	143.00	119.54	122.79	122.81	122.79
	5965	62	4398	143.00	119.85	122.82	122.84	122.82
	5970	63	4660	143.00	120.43	122.87	122.93	122.87
	5975	64	4820	143.00	120.15	122.95	122.99	122.95
	5980	65	5115	143.00	120.46	123.04	123.10	123.04
	5985	66	5323	143.00	120.73	123.16	123.20	123.16
				Poonamalie Dam				

Notation: Min Ch El – Minimum Channel Elevation; CWSEL – Computed water surface elevation; EGL – Energy grade line; RFL – Regulatory Flood Level

Table 6 - Regulatory Flood Levels for Tributaries

Reach	Cross section ID (GIS)	Chainage (m)	Min Ch El (m)	Scenarios: 1) 2 yr flow in Tributaries and 100 yr flow in Rideau (Q2 RR 100) Q Total (m^3/s)	CWSEL (m)	EGL (m)	Corrected WL (m)	Scenarios: 2) 100 yr flow in Tributaries and Navigable WL in Rideau (Q100 RR NWL) Q Total (m3/s)	CWSEL (m)	EGL (m)	Corrected WL (m)	Scenario with Max WL	RFL* (m)
Black Creek				Poonamalie Side Road Bridge									
	24	816	121.5	16.6	122.8	122.91	122.81	31.2	122.97	123.23	122.97	1:100	122.97
	25	459	121	16.6	122.81	122.81	122.81	31.2	121.81	121.85	121.81	1:2	122.81
	26	130	119.8	16.6	122.81	122.81	122.81	31.2	121.8	121.8	121.8	1:2	122.81
Tributary 1				HWY 43 Culvert									
	59	1150	121.41	2.36	122.57	122.58	122.58	8.1	121.9	122.15	121.9	1:2	122.58
	60	810	121.29	2.36	122.58	122.58	122.58	8.1	121.82	121.82	121.82	1:2	122.58
	61	450	121.29	2.36	122.58	122.58	122.58	8.1	121.79	121.8	121.8	1:2	122.58
Tributary 2				HWY 43 Culvert									
	41	1450	122.32	0.93	123.63	123.65	123.63	3.50	123.95	124.11	123.95	1:100	123.95
	42	1100	123.00	0.93	123.08	123.11	123.08	3.50	123.27	123.28	123.27	1:100	123.27
	43	800	121.90	0.93	122.59	122.59	122.59	3.50	121.95	121.97	121.95	1:2	122.59
Tributary 3	71	1925	123.25	0.66	123.32	123.32	123.32	2.6	123.37	123.37	123.37	1:100	123.37
	70	1675	123.25	0.66	123.26	123.26	123.26	2.6	123.33	123.33	123.33	1:100	123.33
	69	1515	122.96	0.66	123.12	123.12	123.12	2.6	123.27	123.27	123.27	1:100	123.27
	68	1315	122.93	0.66	122.95	122.96	122.95	2.6	122.97	122.98	122.97	1:100	122.97
	67	1290	122.42	0.66	122.65	122.65	122.65	2.6	122.89	122.89	122.89	1:100	122.89
	66	1150	122.38	0.66	122.64	122.65	122.64	2.6	122.89	122.89	122.89	1:100	122.89
	65	1030	121.9	0.66	122.62	122.63	122.62	2.6	122.71	122.84	122.71	1:100	122.71
		1015		Lombard St. Culvert									
	64	1000	121.9	0.66	122.61	122.62	122.61	2.6	122.48	122.77	122.48	1:2	122.61
	63	750	121.9	0.66	122.61	122.61	122.61	2.6	122.04	122.04	122.04	1:2	122.61
	62	250	121.9	0.66	122.61	122.61	122.61	2.6	121.93	121.93	121.93	1:2	122.61

*The Regulatory Flood Level (RFL) is the maximum of the two scenarios

Notation:

Min Ch El – Minimum Channel Elevation
EGL – Energy grade line
CWSEL – Computed water surface elevation
RFL – Regulatory Flood Level

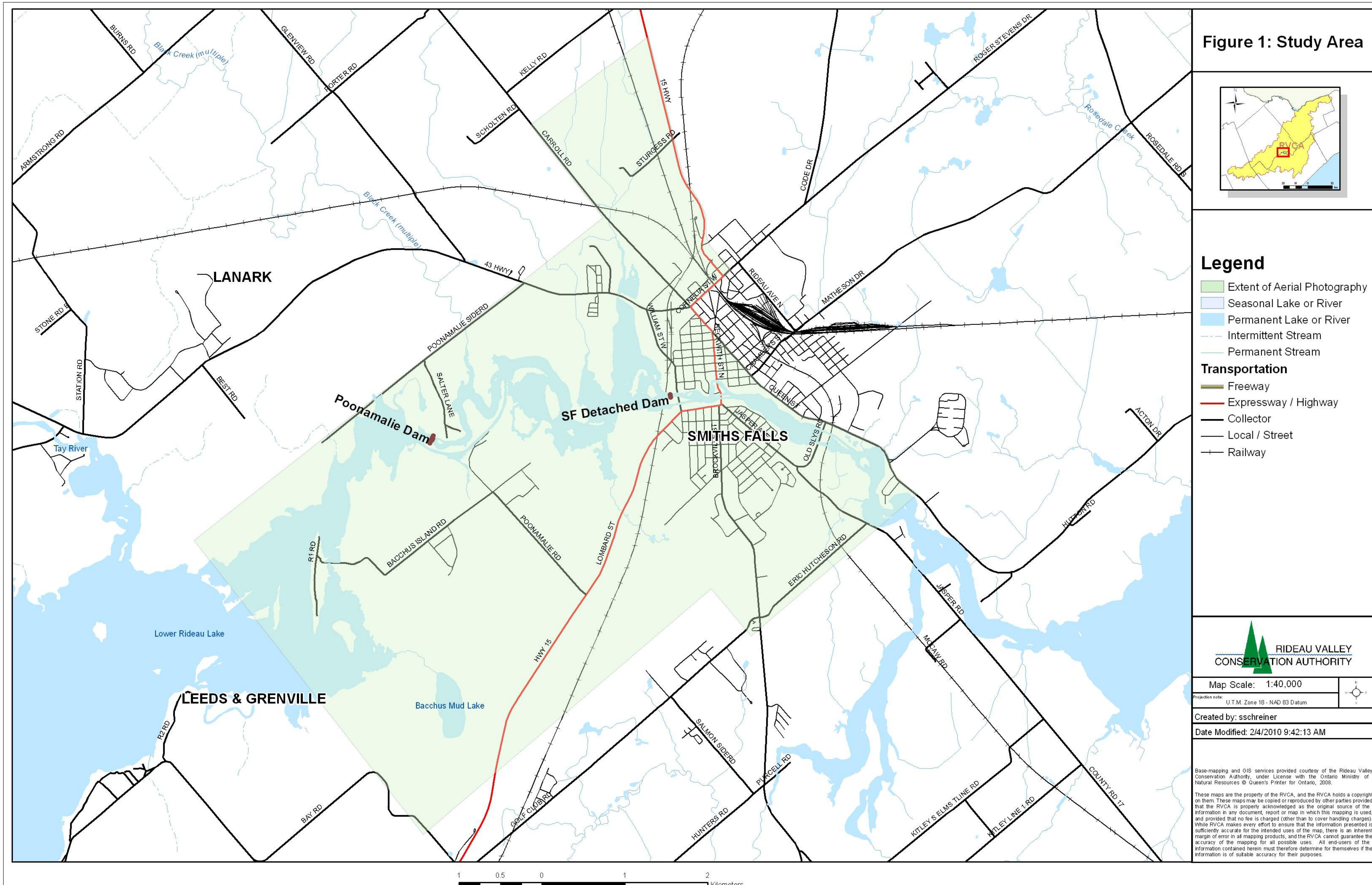
Figure 1: Study Area
Legend
Extent of Aerial Photography
Seasonal Lake or River
Permanent Lake or River
Intermittent Stream
Permanent Stream
Transportation
Freeway
Expressway / Highway
Collector
Local / Street
Railway
RIDEAU VALLEY CONSERVATION AUTHORITY
Map Scale: 1:40,000
Projection note: U.T.M. Zone 18 - NAD 83 Datum
Created by: sschreiner
Date Modified: 2/4/2010 9:42:13 AM
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RVCA
LANARK
LEEDS & GRENVILLE
SMITHS FALLS
Poonamalie Dam
SF Detached Dam
Lower Rideau Lake
Bacchus Mud Lake
Tay River
Black Creek (multiple)
Rosedale Creek
BURNS RD
GLENVIEW RD
PORTER RD
KELLY RD
SCHOLTEN RD
CARROLL RD
STURGESS RD
15 HWY
ROGER STEVENS DR
ROSEDALE RD S
CODE DR
ARMSTRONG RD
43 HWY
RIDEAU AVE N
MATHESON DR
CORNELIA ST W
WILLIAM ST W
BECKWITH ST N
STONE RD E
STATION RD
BEST RD
POONAMALIE SIDERD
SALTER LANE
QUEEN ST
OLD SLYS RD
BROCKVILLE ST
ACTON DR
HUTTON RD
BACCHUS ISLAND RD
POONAMALIE RD
LOMBARD ST
R1 RD
ERIC HUTCHESON RD
JASPER RD
MCCAW RD
HWY 15
R2 RD
BAY RD
GOLF CLUB RD
SALMON SIDERD
PURCELL RD
HUNTERS RD
KITLEY S ELMS TLINE RD
KITLEY LINE 1 RD
COUNTY RD 17
1 0.5 0 1 2
Kilometers

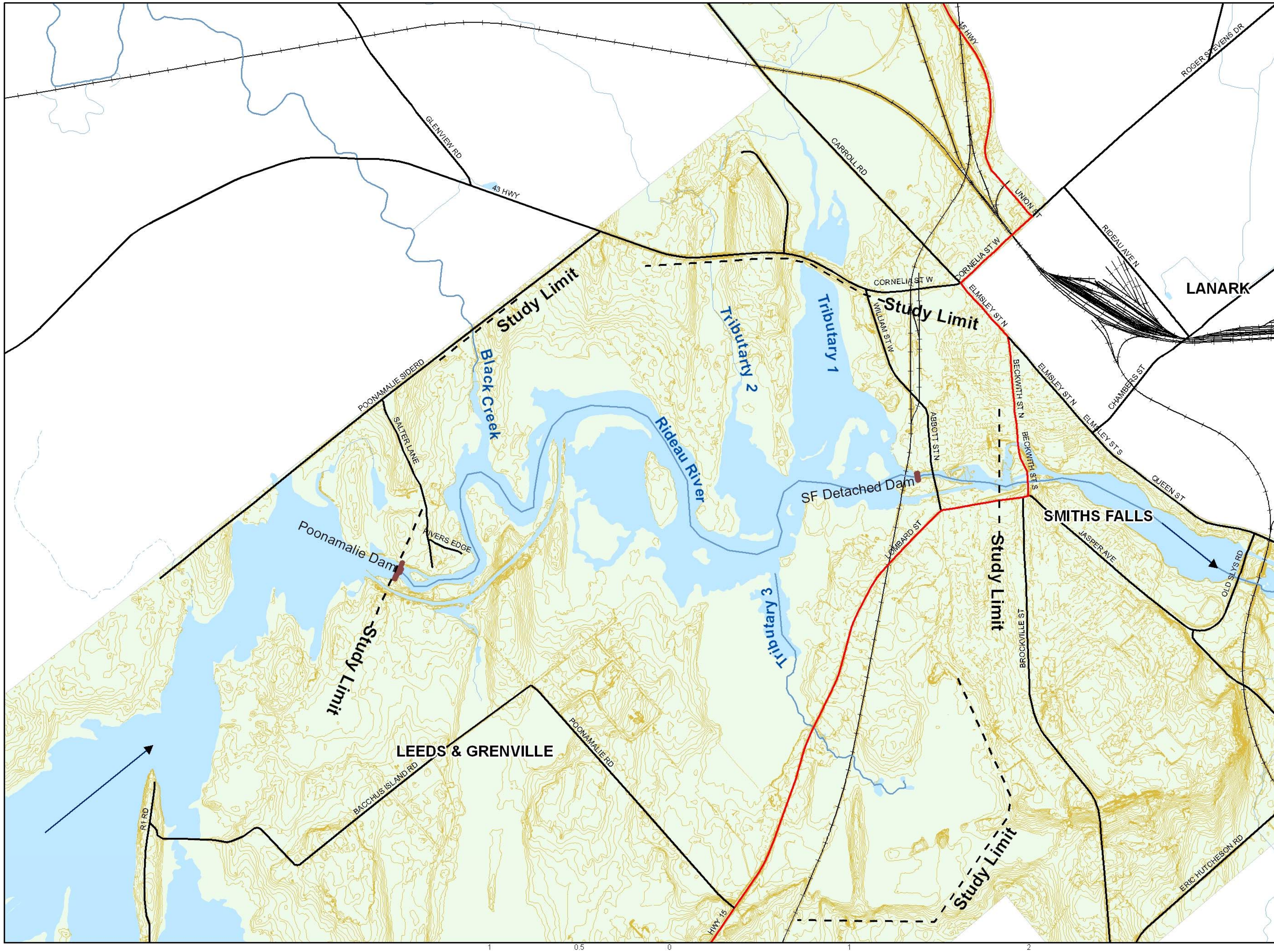

Figure 2: Rideau River and Tributaries

Legend

- Extent of Aerial Photography
- Intermittent Stream
- Permanent Stream
- Seasonal Lake or River
- Permanent Lake or River
- Contours

Transportation

- Freeway
- Expressway / Highway
- Collector
- Railway

RIDEAU VALLEY CONSERVATION AUTHORITY

Map Scale: 1:20,000

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

Created by: sschreiner

Date Modified: 2/4/2010 5:06:47 PM

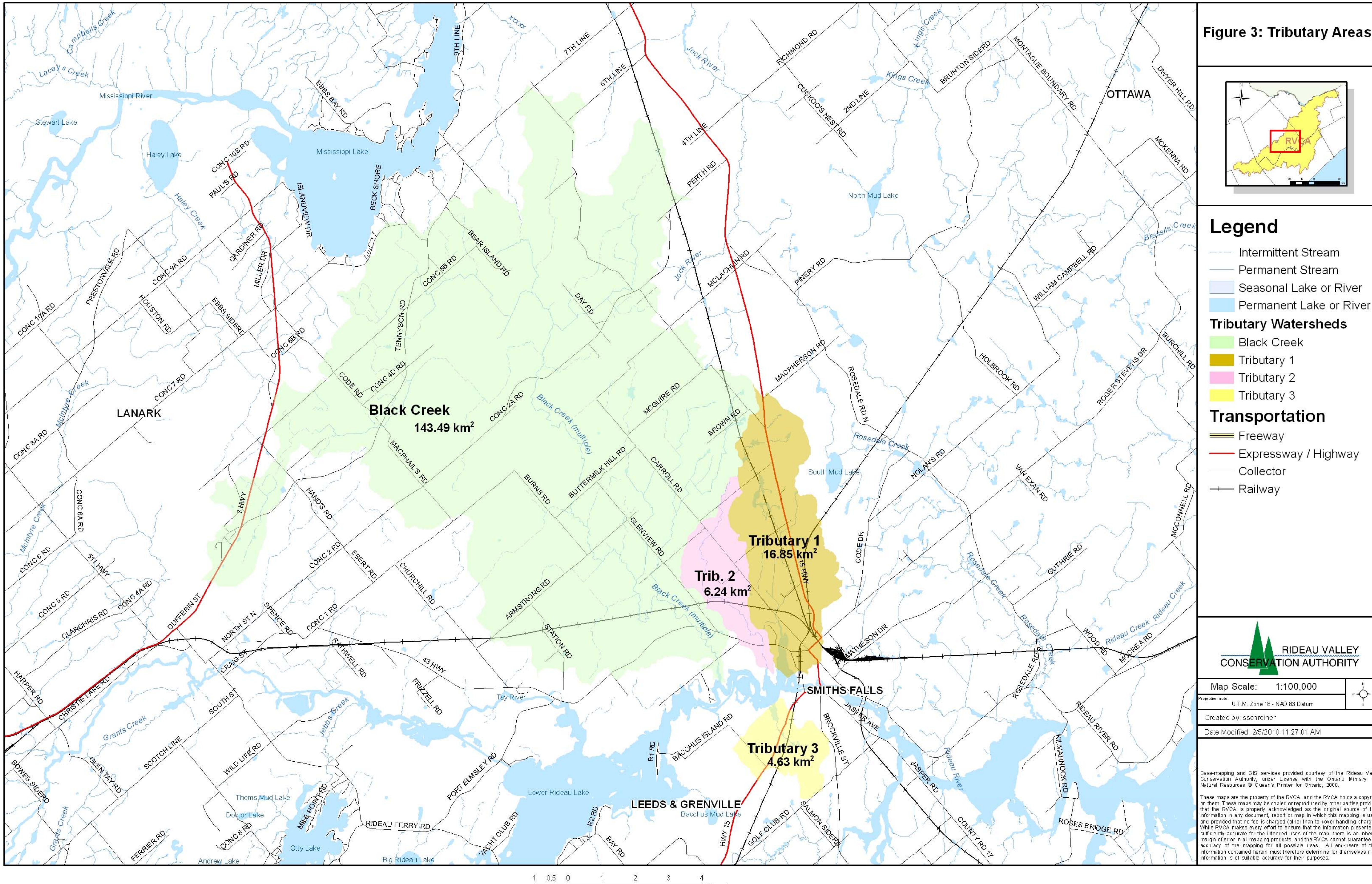
Figure 3: Tributary Areas
Legend
Intermittent Stream
Permanent Stream
Seasonal Lake or River
Permanent Lake or River
Tributary Watersheds
Black Creek
Tributary 1
Tributary 2
Tributary 3
Transportation
Freeway
Expressway / Highway
Collector
Railway
Black Creek
143.49 km²
Tributary 1
16.85 km²
Trib. 2
6.24 km²
Tributary 3
4.63 km²
LANARK
OTTAWA
SMITHS FALLS
LEEDS & GRENVILLE
Mississippi Lake
Mississippi River
Haley Lake
Stewart Lake
North Mud Lake
South Mud Lake
Lower Rideau Lake
Big Rideau Lake
Bacchus Mud Lake
Thoms Mud Lake
Doctor Lake
Otty Lake
Andrew Lake
Tay River
Jock River
Rosedale Creek
Rideau Creek
Rideau River
Kings Creek
Grants Creek
Black Creek (multiple)
RIDEAU VALLEY CONSERVATION AUTHORITY
Map Scale: 1:100,000
Projection note:
U.T.M. Zone 18 - NAD 83 Datum
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Date Modified: 2/5/2010 11:27:01 AM
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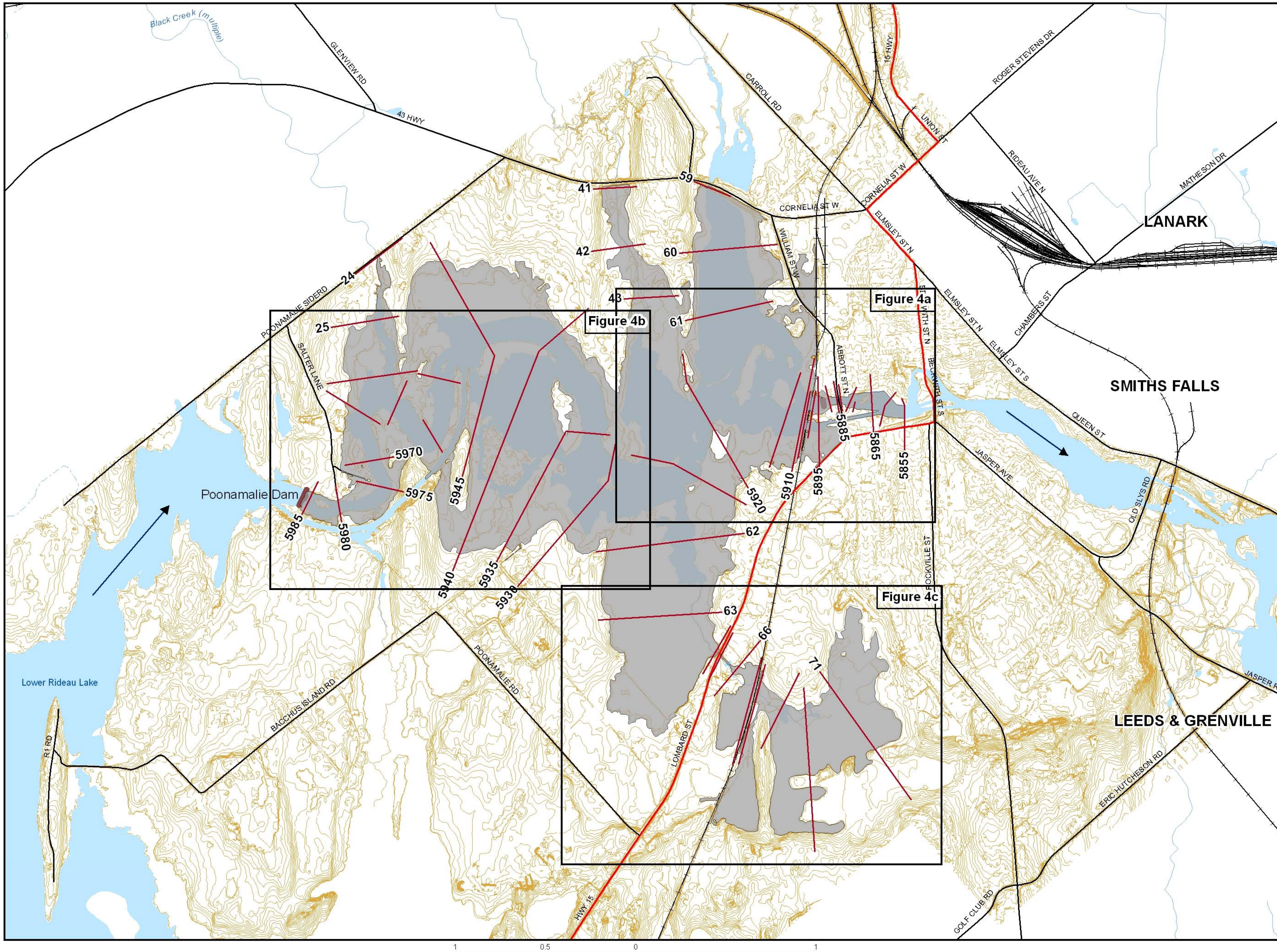
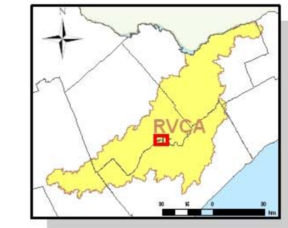
1 0.5 0 1 2 3 4
Kilometers

Figure 4: Summary Flood Risk Map





Legend

- Flood Plain
- Cross Sections
- Seasonal Lake or River
- Permanent Lake or River
- Intermittent Stream
- Permanent Stream
- Contours

Transportation

- Freeway
- Expressway / Highway
- Collector
- Railway

RIDEAU VALLEY CONSERVATION AUTHORITY

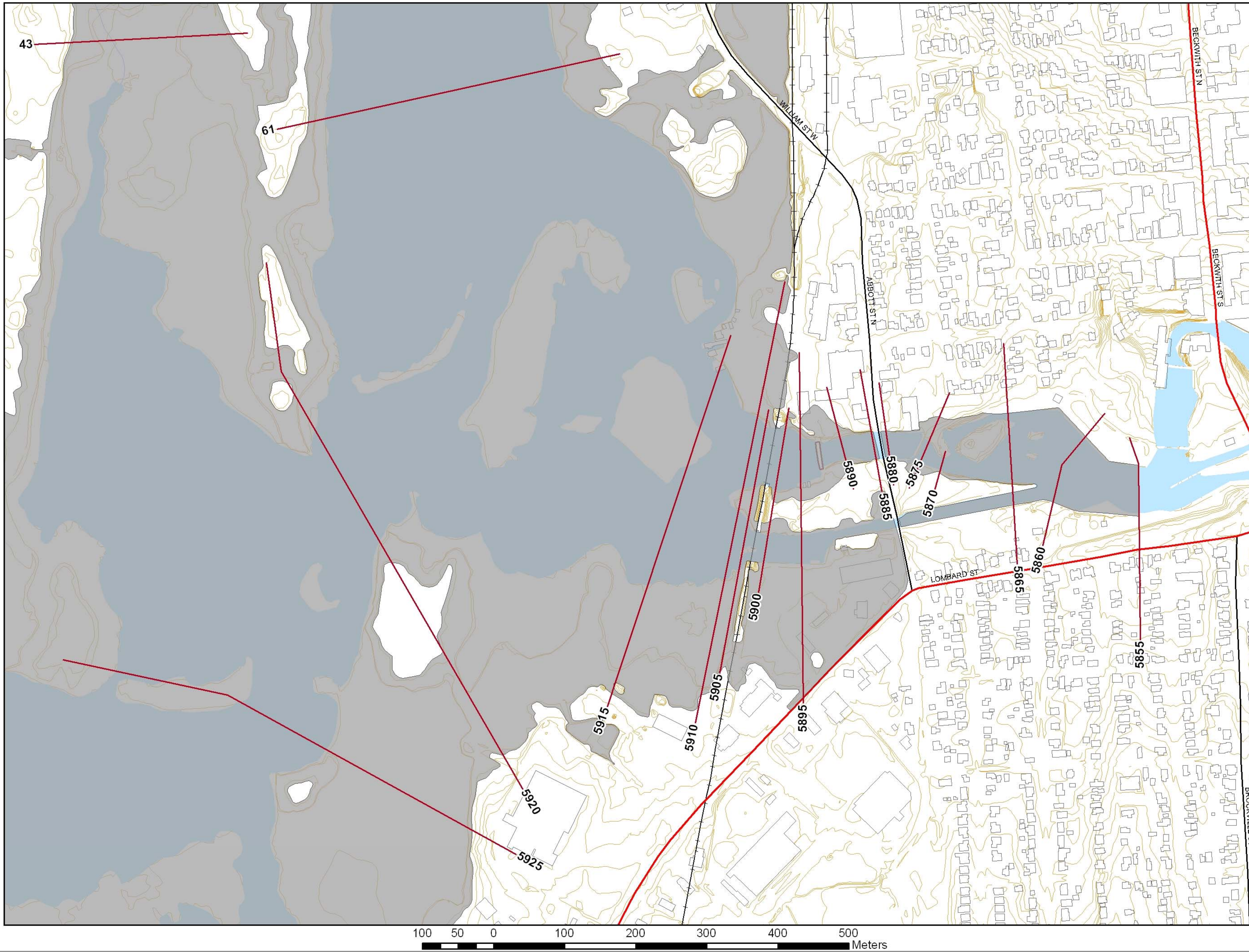
Map Scale: 1:20,000

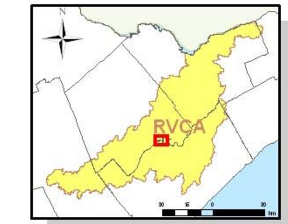
Projection note: U.T.M. Zone 18 - NAD 83 Datum

Created by: sschreiner

Date Modified: 2/5/2010 1:31:15 PM

Figure 4a: Summary Flood Risk Map





Legend

- Flood Plain
- Cross Sections
- Seasonal Lake or River
- Permanent Lake or River
- Intermittent Stream
- Permanent Stream
- Building
- Contours

Transportation

- Freeway
- Expressway / Highway
- Collector
- Railway

RIDEAU VALLEY CONSERVATION AUTHORITY

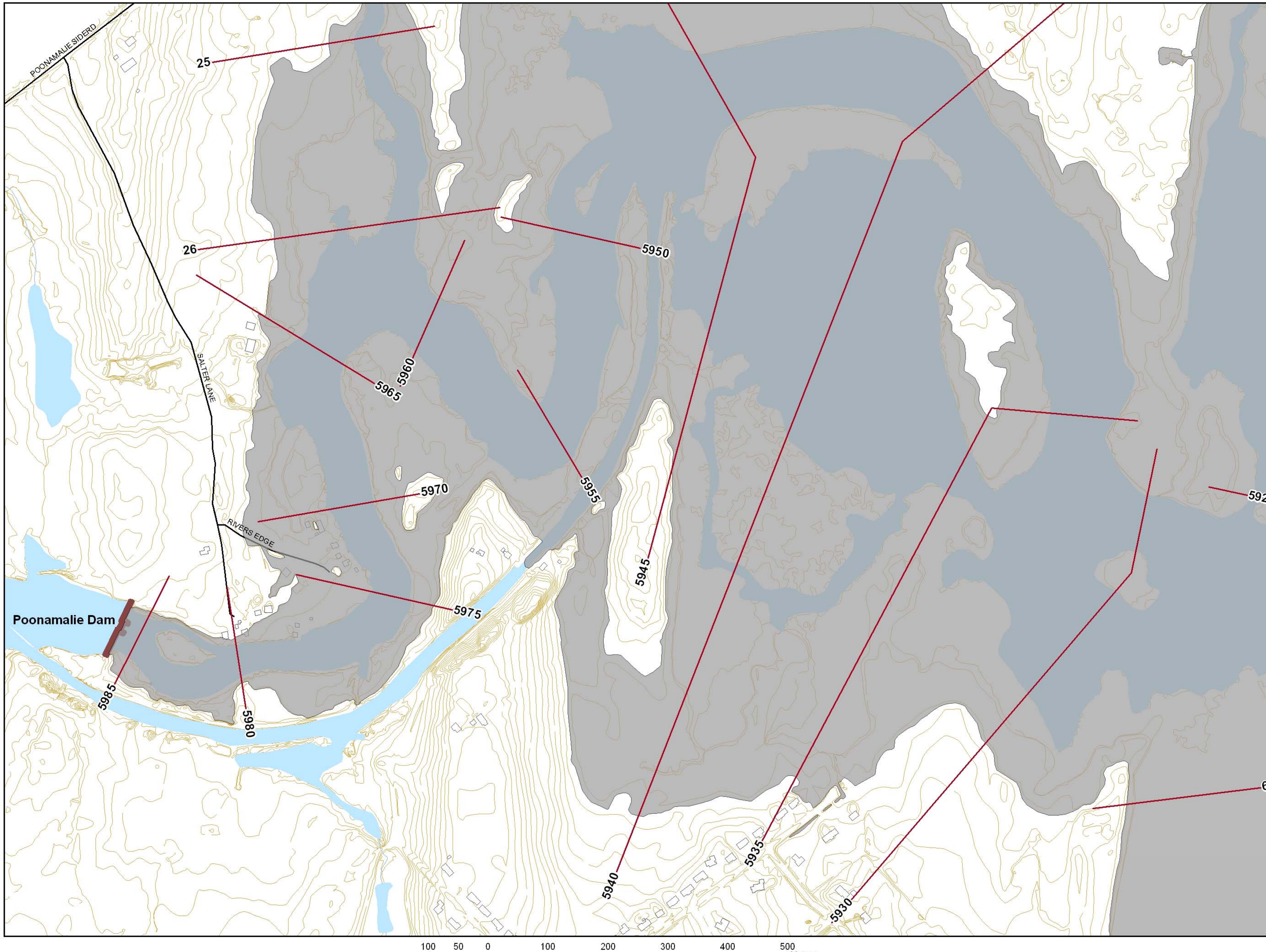
Map Scale: 1:5,000

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

Created by: sschreiner

Date Modified: 2/5/2010 1:31:15 PM

Figure 4b: Summary Flood Risk Map



Legend

- Flood Plain
- Cross Sections
- Seasonal Lake or River
- Permanent Lake or River
- Intermittent Stream
- Permanent Stream
- Building
- Contours

Transportation

- Freeway
- Expressway / Highway
- Collector
- Railway

RIDEAU VALLEY CONSERVATION AUTHORITY

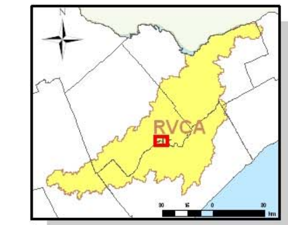
Map Scale: 1:6,000

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

Created by: sschreiner

Date Modified: 2/5/2010 1:31:15 PM

Figure 4c: Summary Flood Risk Map



Legend

- Flood Plain
- Cross Sections
- Seasonal Lake or River
- Permanent Lake or River
- Intermittent Stream
- Permanent Stream
- Building
- Contours

Transportation

- Freeway
- Expressway / Highway
- Collector
- Railway

100 50 0 100 200 300 400 500 Meters

RIDEAU VALLEY CONSERVATION AUTHORITY

Map Scale: 1:6,000

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

Created by: sschreiner

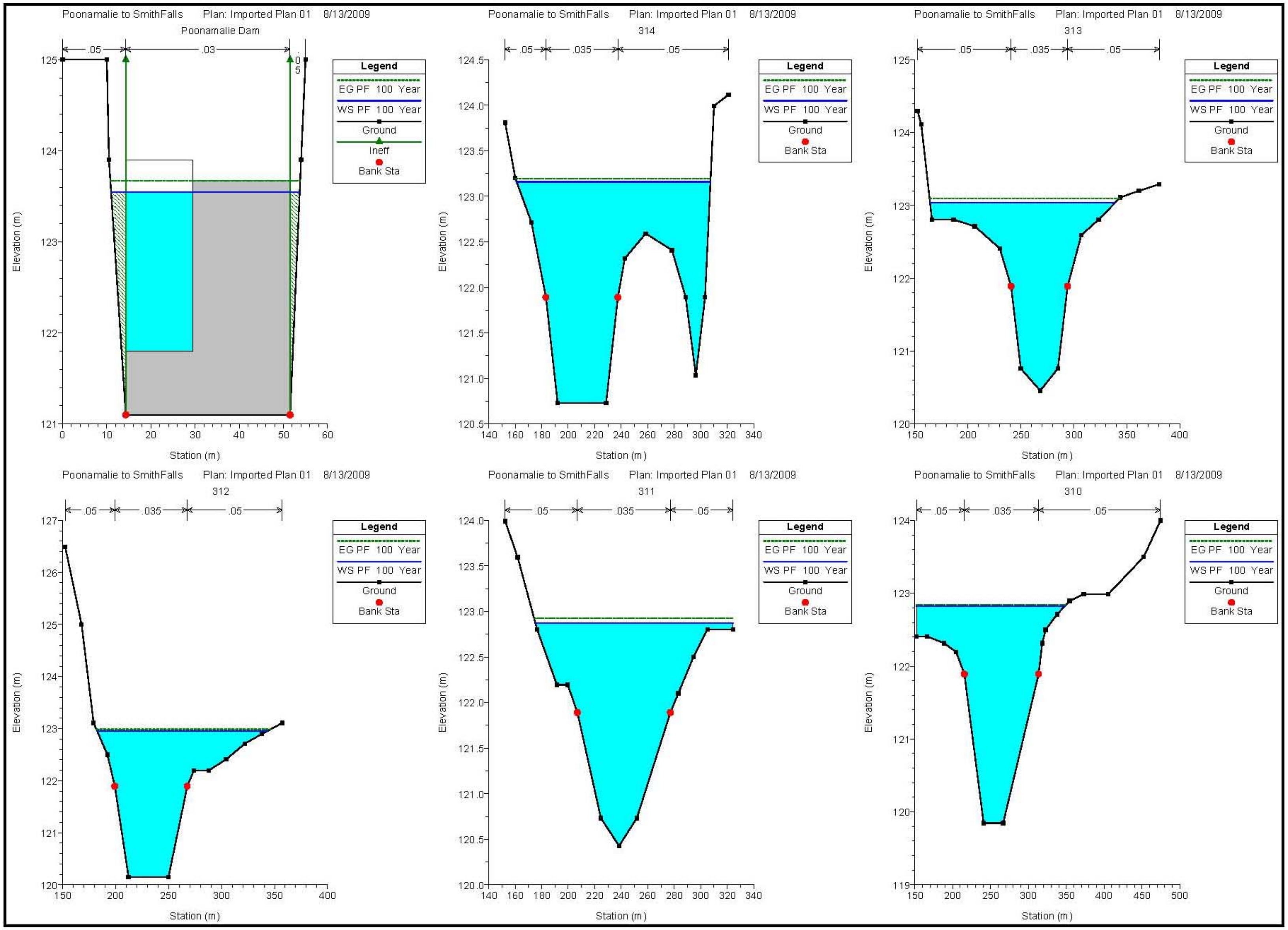
Date Modified: 2/5/2010 1:31:15 PM

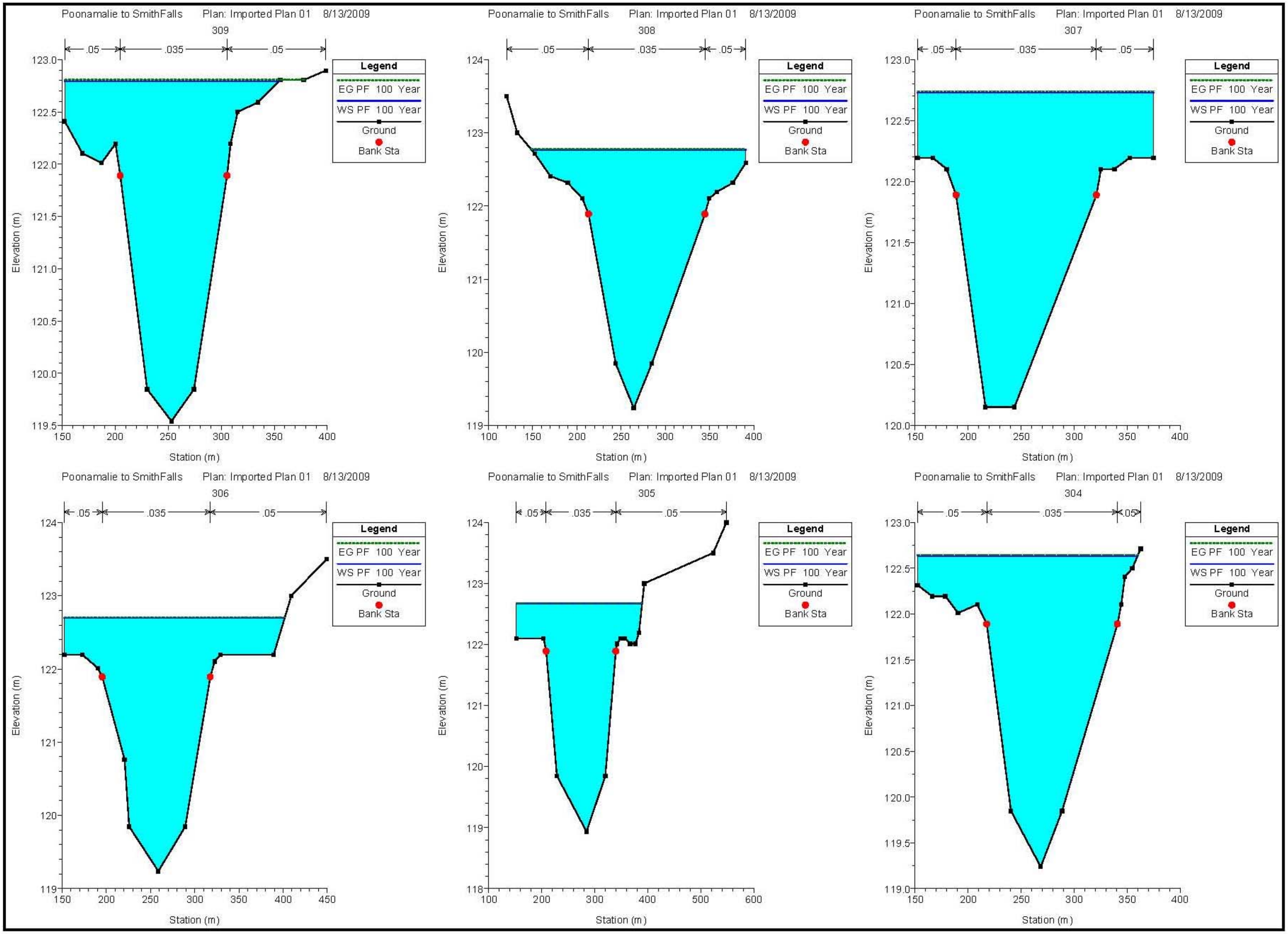
Appendix A

HEC-RAS Cross-sections and Longitudinal Profiles

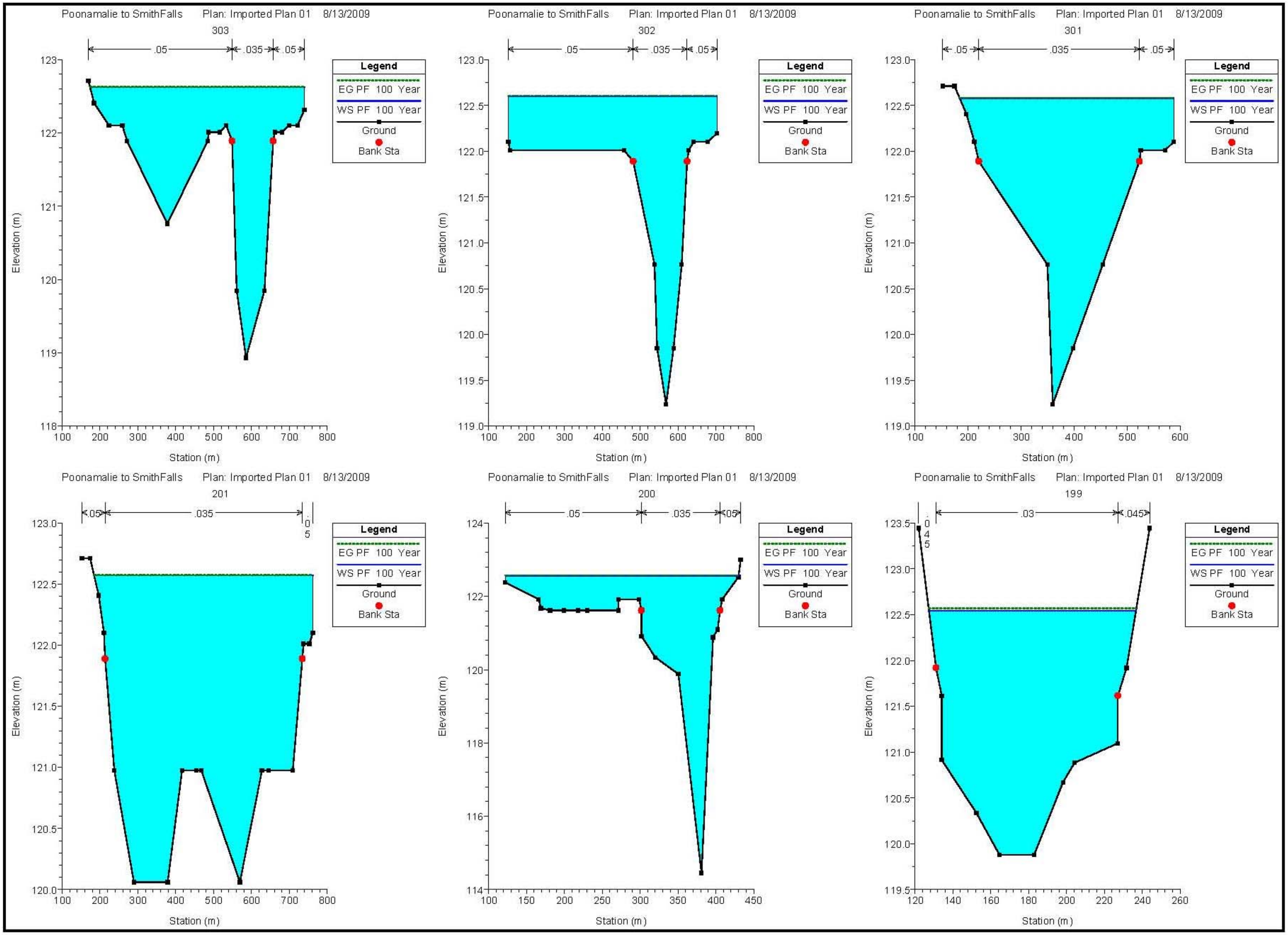
Scenario 1 - The 1:2 yr flow on the tributaries and the 1:100 yr flow on Rideau River

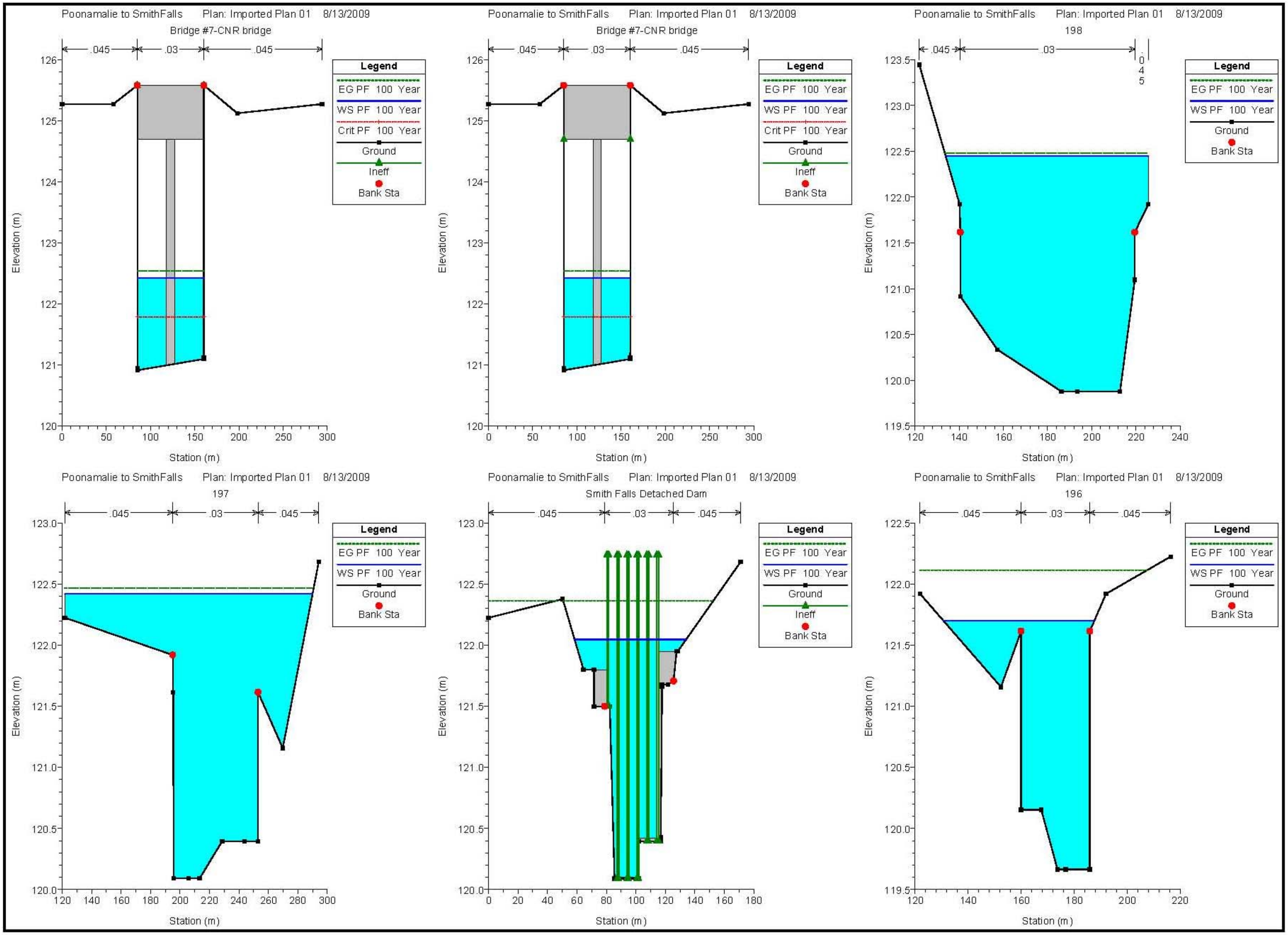
Rideau River

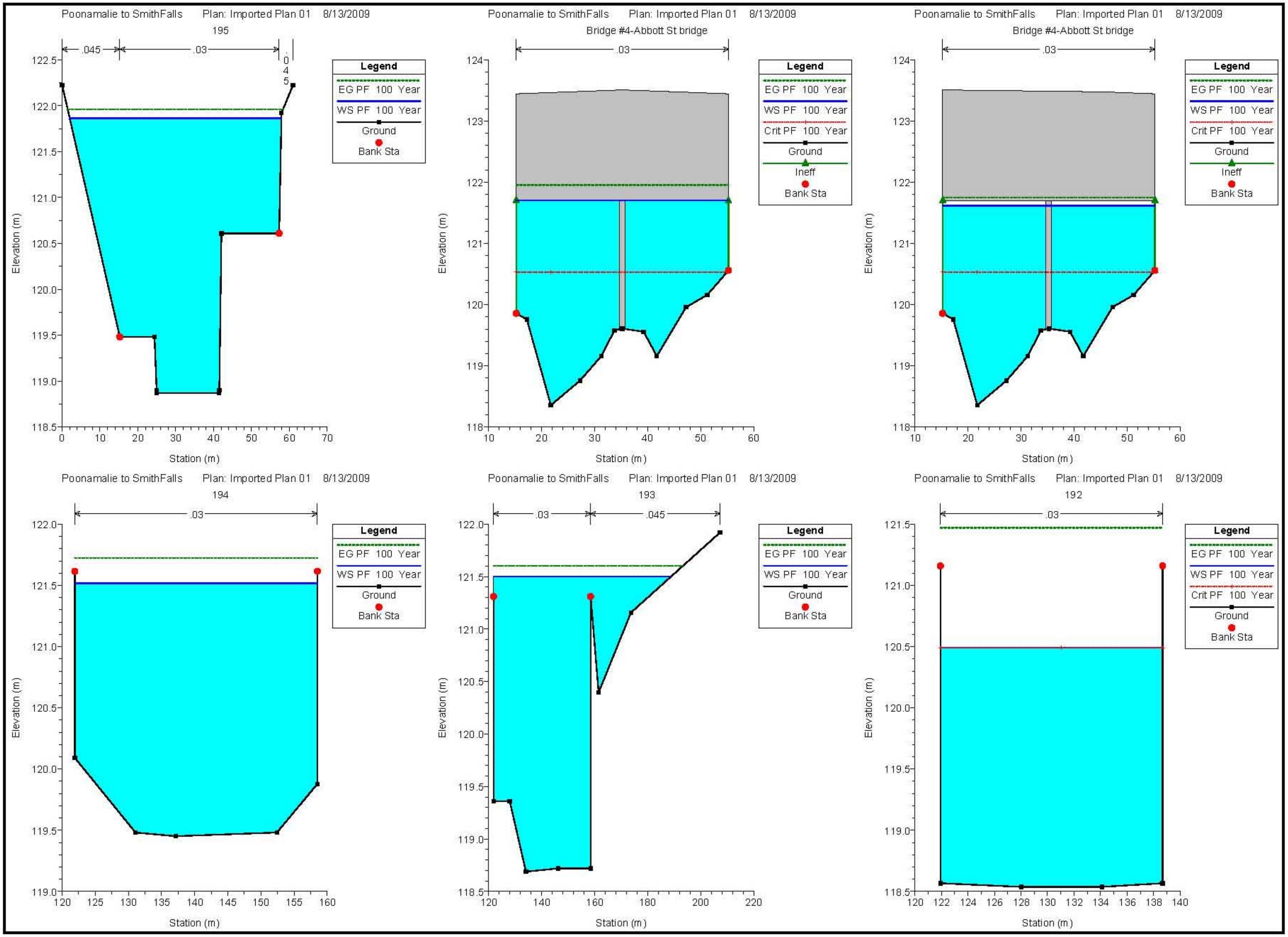


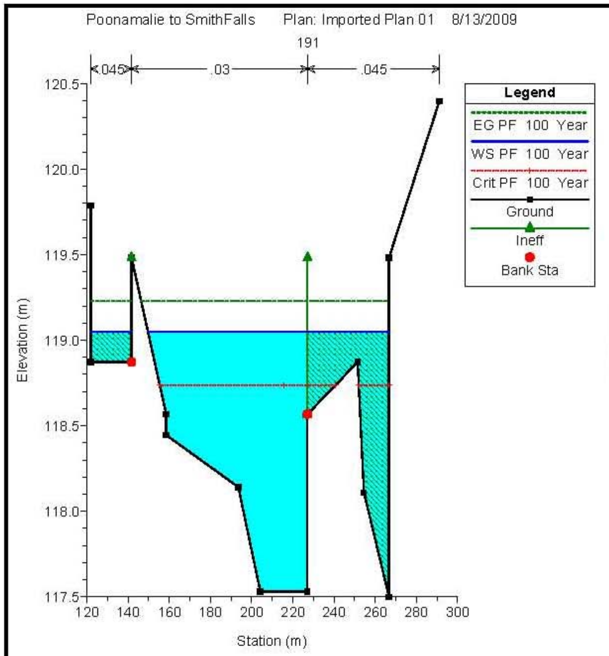


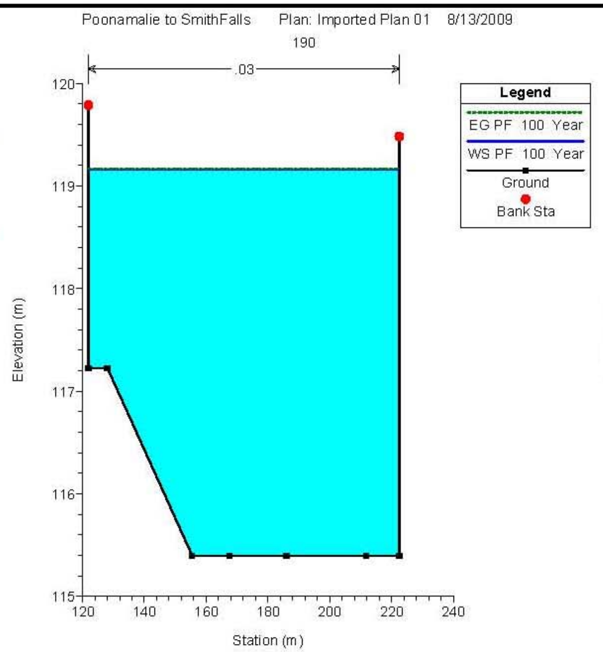
Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
309
.05 .035 .05
Legend
EG PF 100 Year
WS PF 100 Year
Ground
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
308
.05 .035 .05
Legend
EG PF 100 Year
WS PF 100 Year
Ground
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
307
.05 .035 .05
Legend
EG PF 100 Year
WS PF 100 Year
Ground
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
306
.05 .035 .05
Legend
EG PF 100 Year
WS PF 100 Year
Ground
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
305
.05 .035 .05
Legend
EG PF 100 Year
WS PF 100 Year
Ground
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
304
.05 .035 .05
Legend
EG PF 100 Year
WS PF 100 Year
Ground
Bank Sta
Elevation (m)
Station (m)

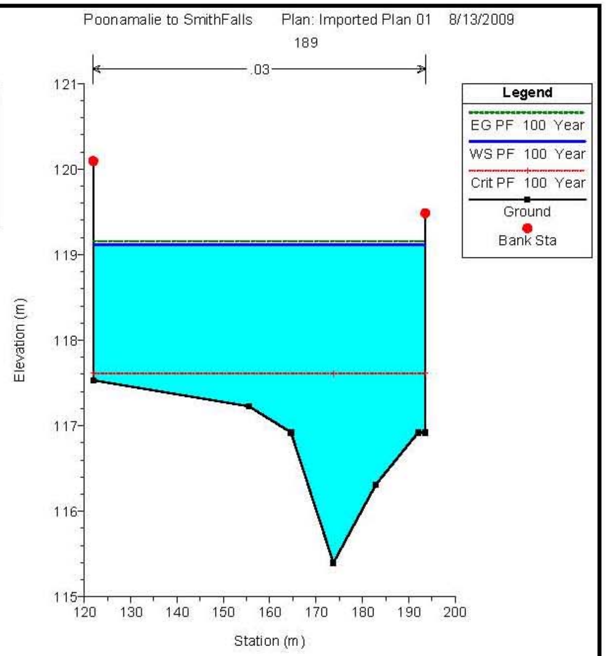

Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
303
.05
.035
.05
Legend
EG PF 100 Year
WS PF 100 Year
Ground
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
302
.05
.035
.05
Legend
EG PF 100 Year
WS PF 100 Year
Ground
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
301
.05
.035
.05
Legend
EG PF 100 Year
WS PF 100 Year
Ground
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
201
.05
.035
Legend
EG PF 100 Year
WS PF 100 Year
Ground
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
200
.05
.035
.05
Legend
EG PF 100 Year
WS PF 100 Year
Ground
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
199
.03
.045
Legend
EG PF 100 Year
WS PF 100 Year
Ground
Bank Sta
Elevation (m)
Station (m)

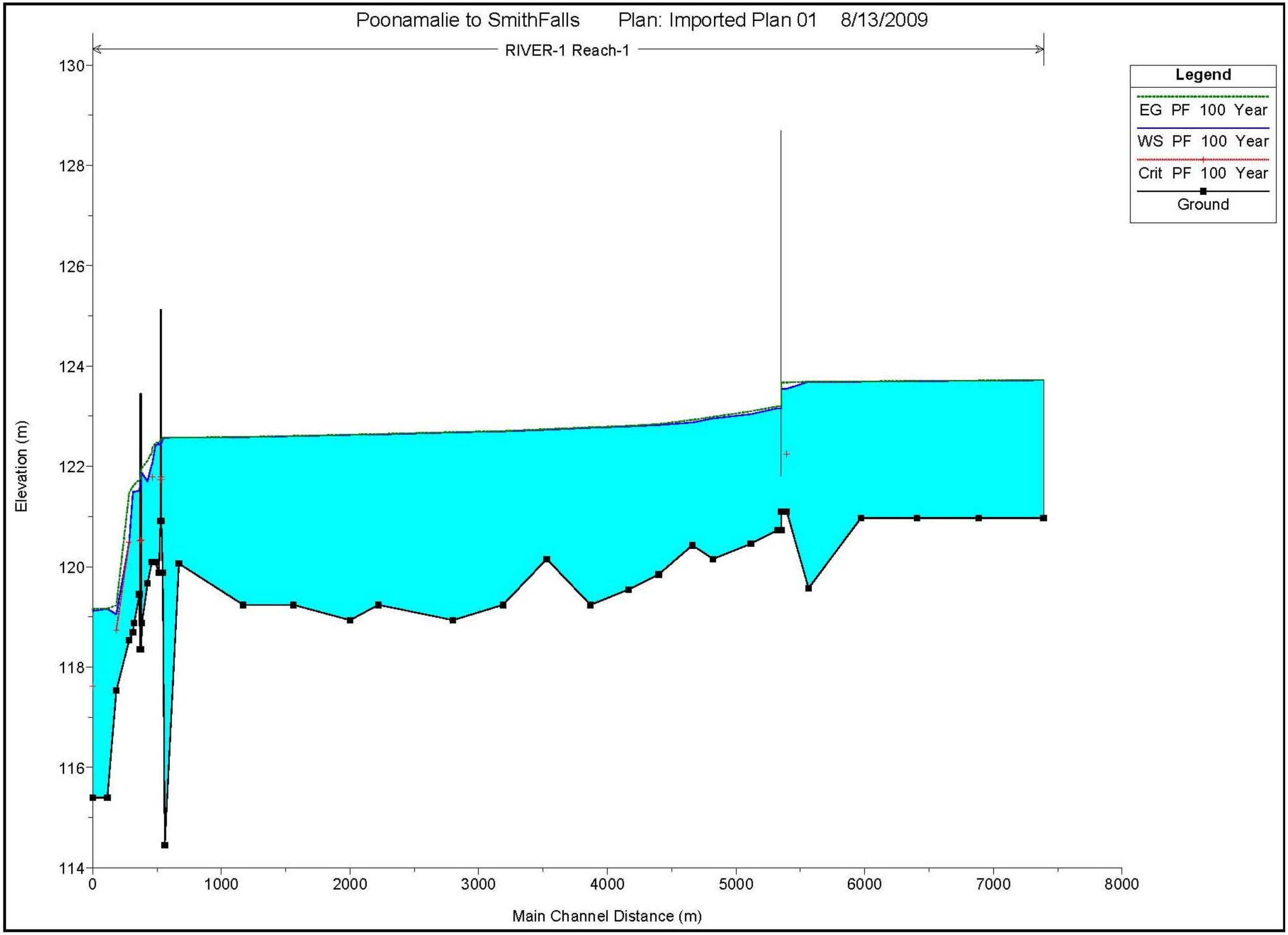

Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
Bridge #7-CNR bridge
.045
.03
.045
Legend
EG PF 100 Year
WS PF 100 Year
Crit PF 100 Year
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
Bridge #7-CNR bridge
.045
.03
.045
Legend
EG PF 100 Year
WS PF 100 Year
Crit PF 100 Year
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
198
.045
.03
.045
Legend
EG PF 100 Year
WS PF 100 Year
Ground
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
197
.045
.03
.045
Legend
EG PF 100 Year
WS PF 100 Year
Ground
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
Smith Falls Detached Dam
.045
.03
.045
Legend
EG PF 100 Year
WS PF 100 Year
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
196
.045
.03
.045
Legend
EG PF 100 Year
WS PF 100 Year
Ground
Bank Sta
Elevation (m)
Station (m)


Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
195
.045
.03
0
4
5
Legend
EG PF 100 Year
WS PF 100 Year
Ground
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
Bridge #4-Abbott St bridge
.03
Legend
EG PF 100 Year
WS PF 100 Year
Crit PF 100 Year
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
Bridge #4-Abbott St bridge
.03
Legend
EG PF 100 Year
WS PF 100 Year
Crit PF 100 Year
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
194
.03
Legend
EG PF 100 Year
WS PF 100 Year
Ground
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
193
.03
.045
Legend
EG PF 100 Year
WS PF 100 Year
Ground
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
192
.03
Legend
EG PF 100 Year
WS PF 100 Year
Crit PF 100 Year
Ground
Bank Sta
Elevation (m)
Station (m)

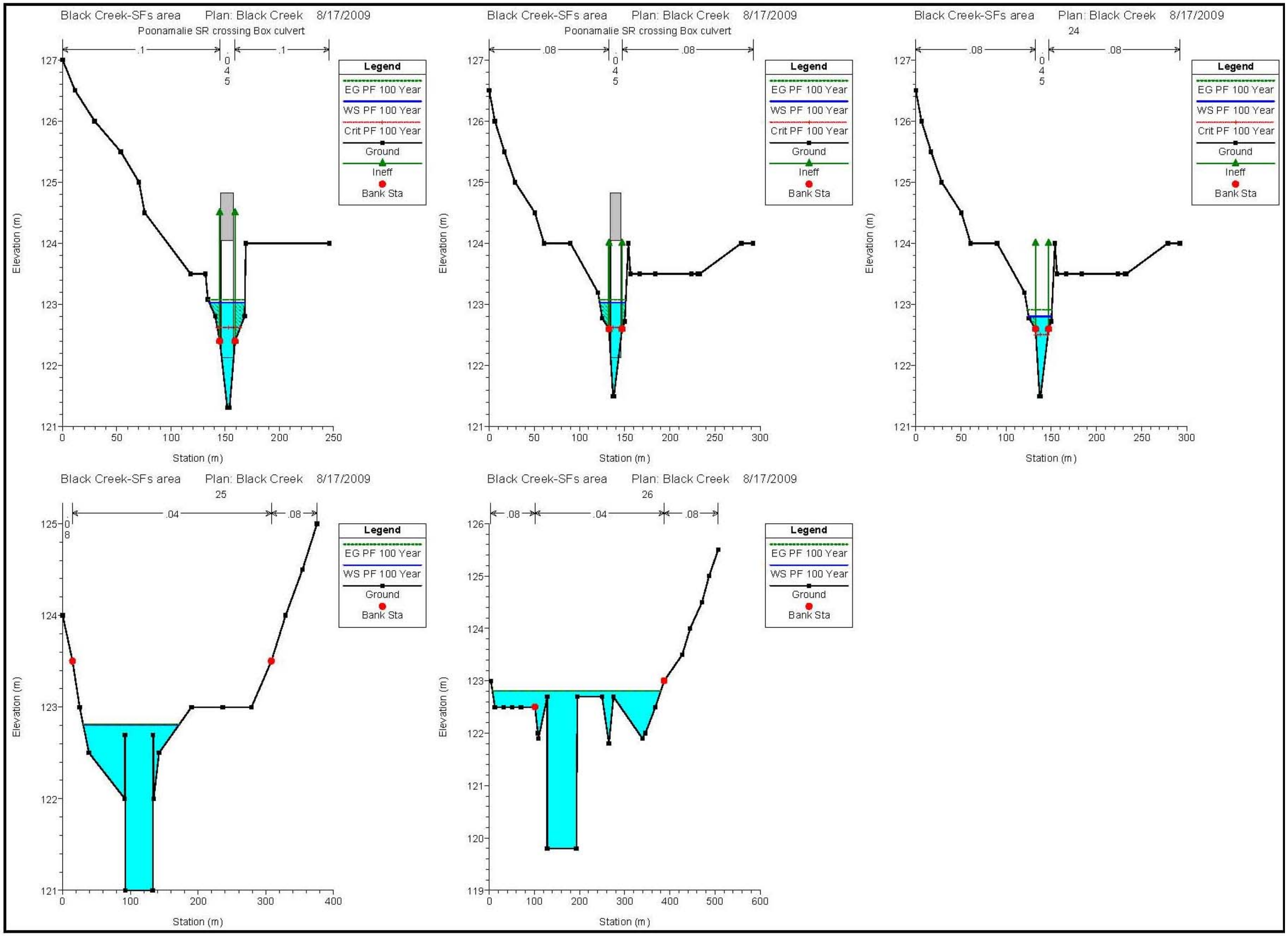

Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
191
.045
.03
.045
Legend
EG PF 100 Year
WS PF 100 Year
Crit PF 100 Year
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)

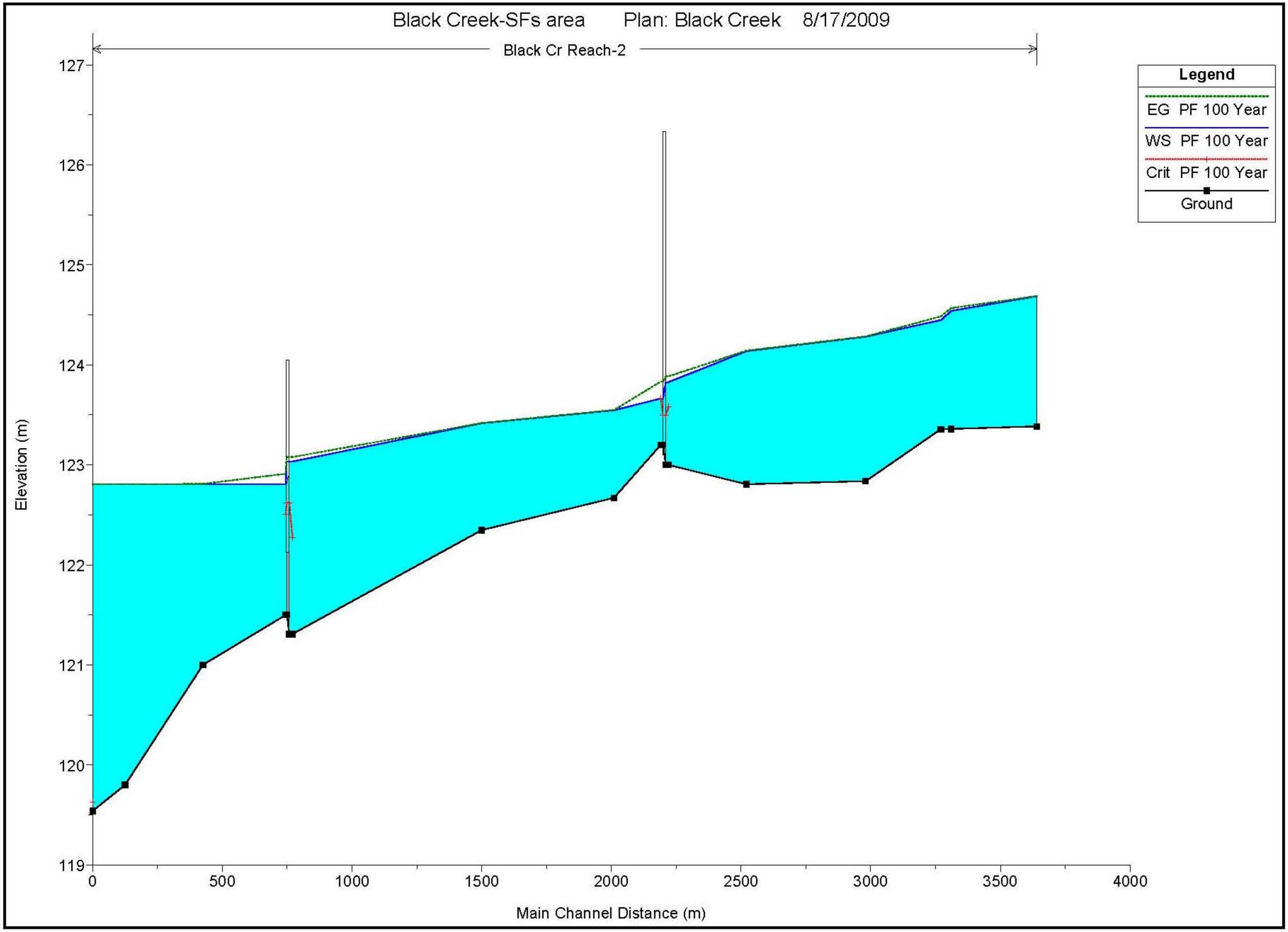

Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
190
.03
Legend
EG PF 100 Year
WS PF 100 Year
Ground
Bank Sta
Elevation (m)
Station (m)


Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
189
.03
Legend
EG PF 100 Year
WS PF 100 Year
Crit PF 100 Year
Ground
Bank Sta
Elevation (m)
Station (m)


Poonamalie to SmithFalls Plan: Imported Plan 01 8/13/2009
RIVER-1 Reach-1
Legend
EG PF 100 Year
WS PF 100 Year
Crit PF 100 Year
Ground
Elevation (m)
Main Channel Distance (m)
130
128
126
124
122
120
118
116
114
0
1000
2000
3000
4000
5000
6000
7000
8000

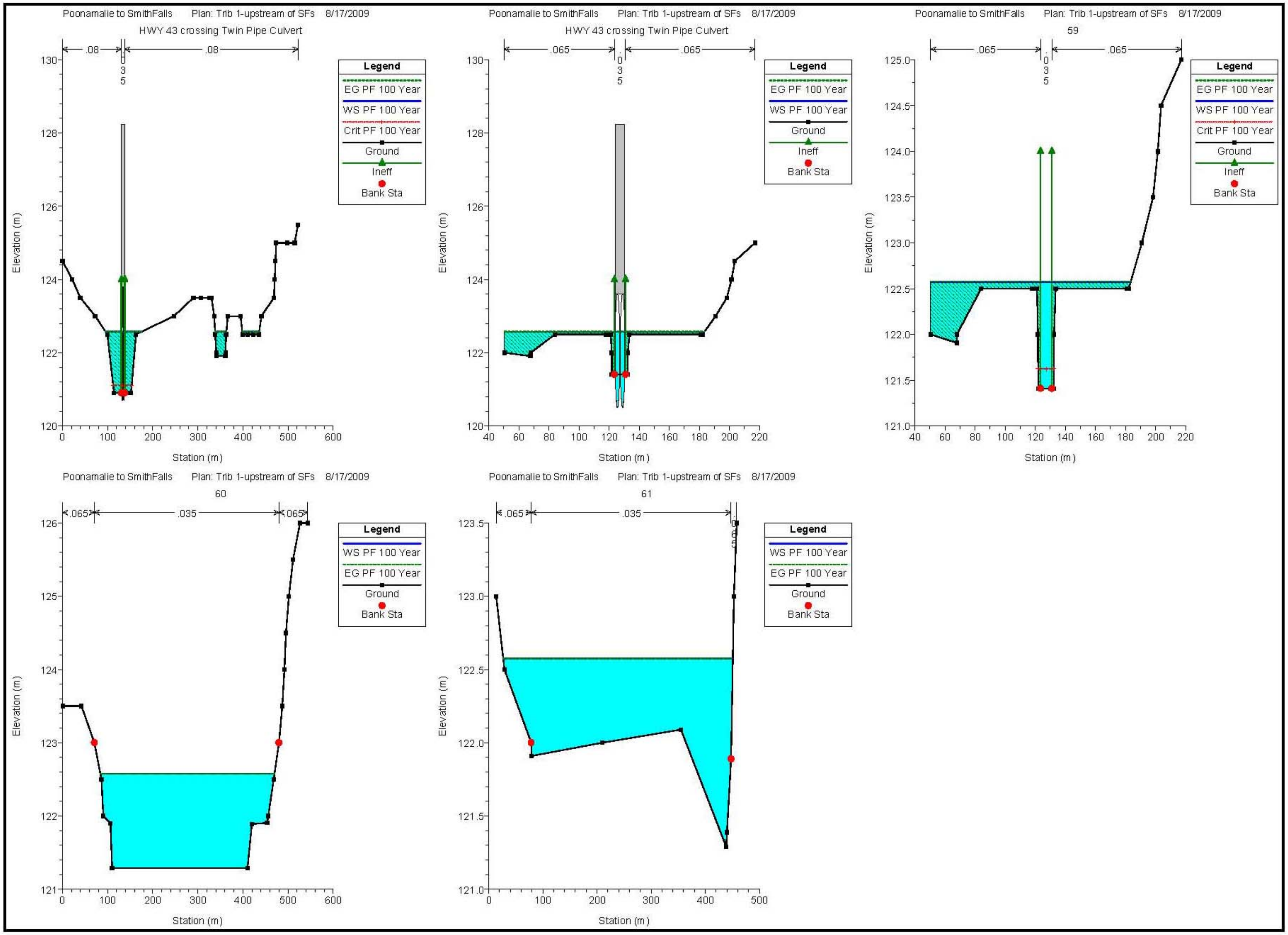
Black Creek

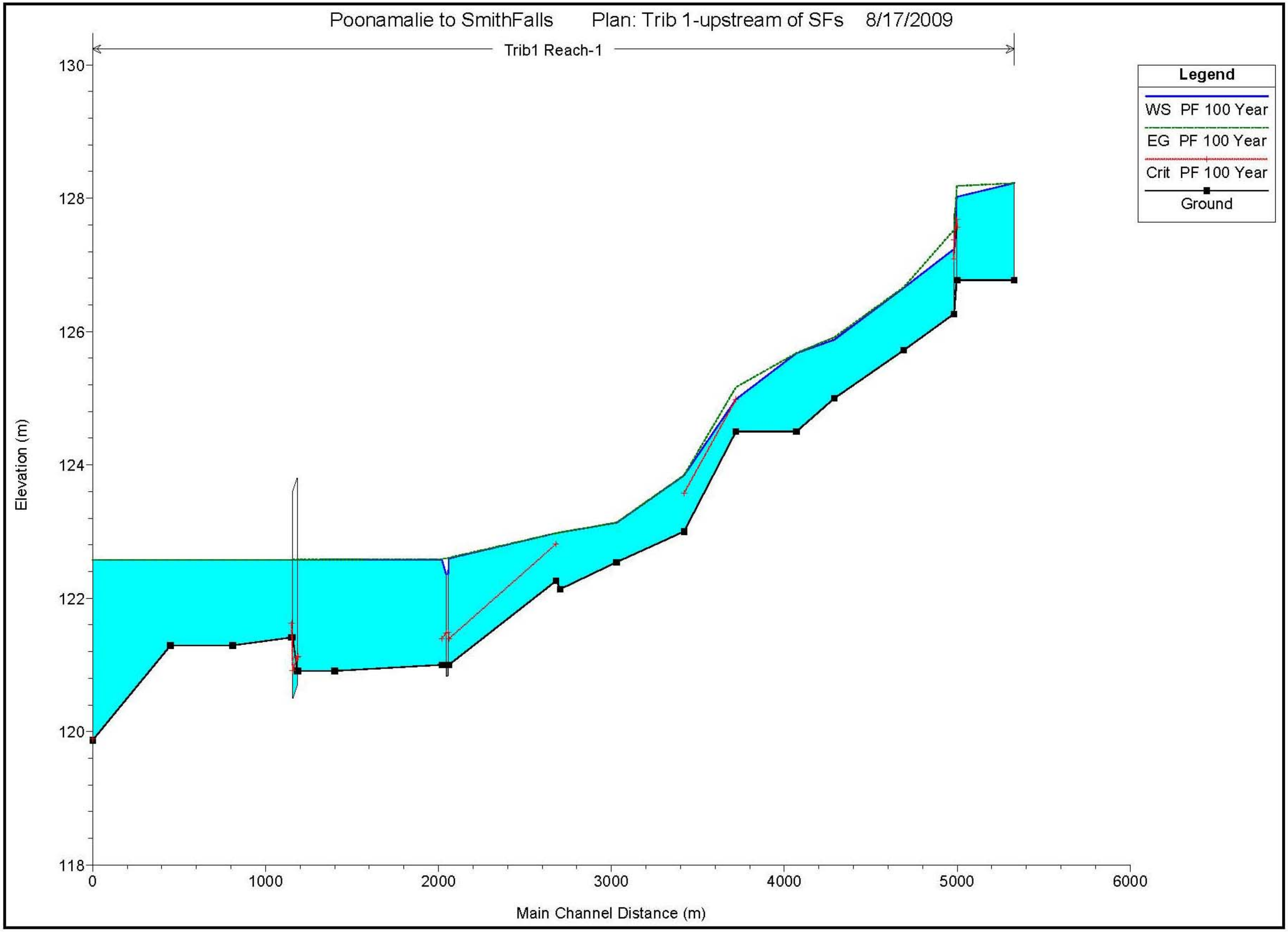

Black Creek-SFs area Plan: Black Creek 8/17/2009
Poonamalie SR crossing Box culvert
Legend
EG PF 100 Year
WS PF 100 Year
Crit PF 100 Year
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Black Creek-SFs area Plan: Black Creek 8/17/2009
Poonamalie SR crossing Box culvert
Black Creek-SFs area Plan: Black Creek 8/17/2009
24
Black Creek-SFs area Plan: Black Creek 8/17/2009
25
Black Creek-SFs area Plan: Black Creek 8/17/2009
26



Black Creek-SFs area Plan: Black Creek 8/17/2009
Black Cr Reach-2
Legend
EG PF 100 Year
WS PF 100 Year
Crit PF 100 Year
Ground
Elevation (m)
127
126
125
124
123
122
121
120
119
0
500
1000
1500
2000
2500
3000
3500
4000
Main Channel Distance (m)

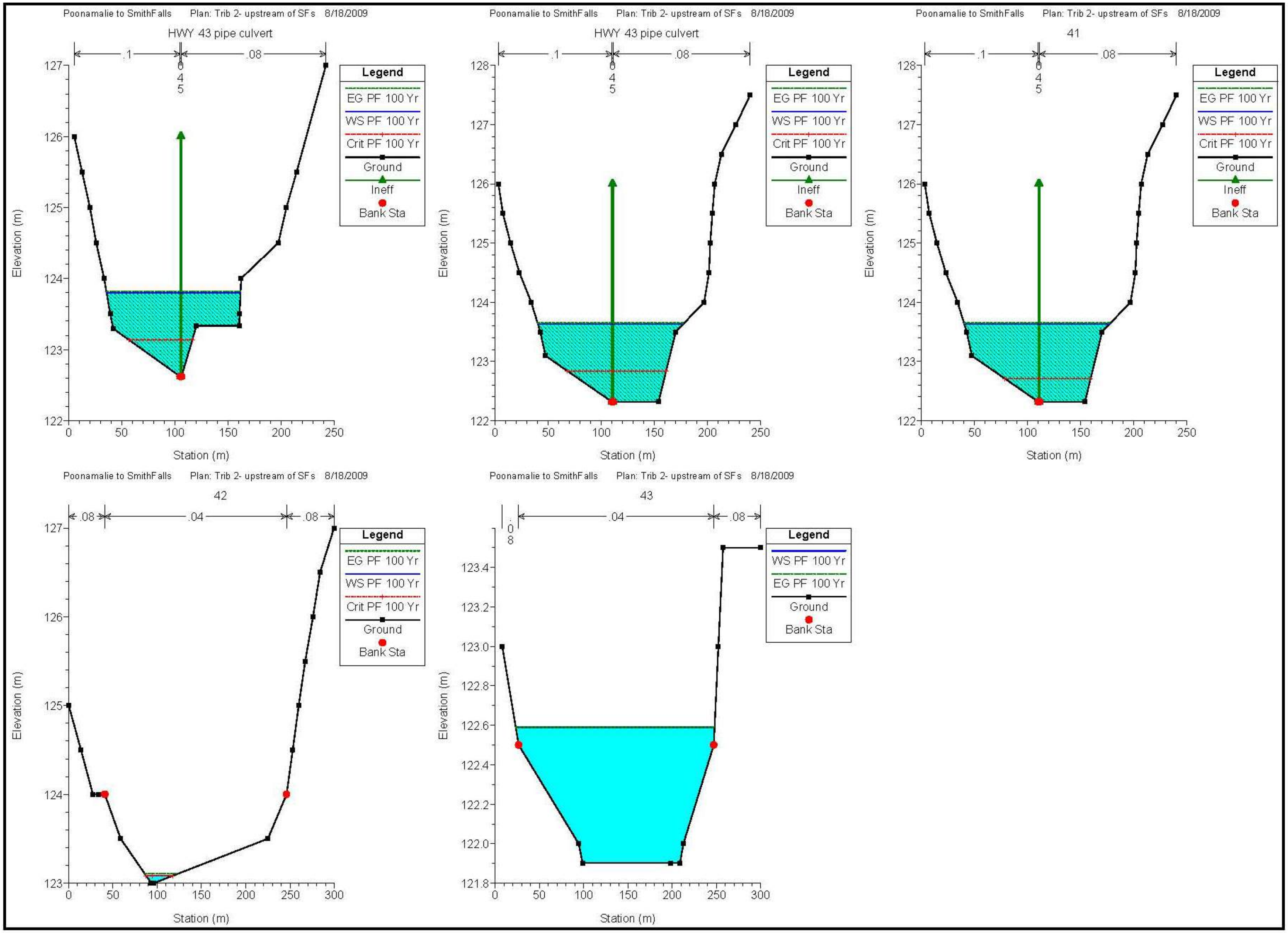
Tributary 1

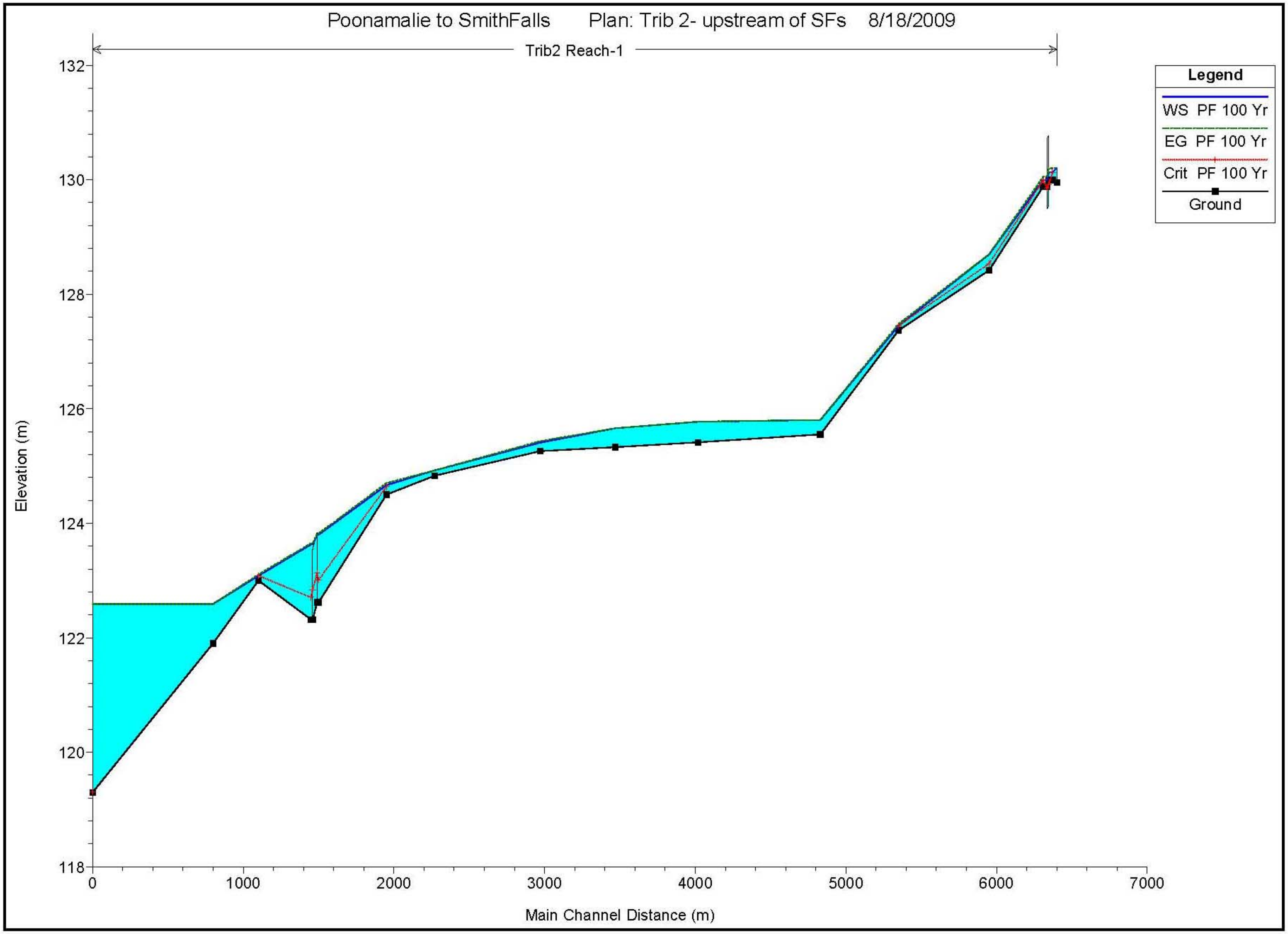

Poonamalie to SmithFalls Plan: Trib 1-upstream of SFs 8/17/2009
HWY 43 crossing Twin Pipe Culvert
.08
.08
Legend
EG PF 100 Year
WS PF 100 Year
Crit PF 100 Year
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Trib 1-upstream of SFs 8/17/2009
HWY 43 crossing Twin Pipe Culvert
.065
.065
Legend
EG PF 100 Year
WS PF 100 Year
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Trib 1-upstream of SFs 8/17/2009
59
.065
.065
Legend
EG PF 100 Year
WS PF 100 Year
Crit PF 100 Year
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Trib 1-upstream of SFs 8/17/2009
60
.065
.035
.065
Legend
WS PF 100 Year
EG PF 100 Year
Ground
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Trib 1-upstream of SFs 8/17/2009
61
.065
.035
Legend
WS PF 100 Year
EG PF 100 Year
Ground
Bank Sta
Elevation (m)
Station (m)



Poonamalie to SmithFalls Plan: Trib 1-upstream of SFs 8/17/2009
Trib1 Reach-1
Legend
WS PF 100 Year
EG PF 100 Year
Crit PF 100 Year
Ground
Elevation (m)
130
128
126
124
122
120
118
0
1000
2000
3000
4000
5000
6000
Main Channel Distance (m)

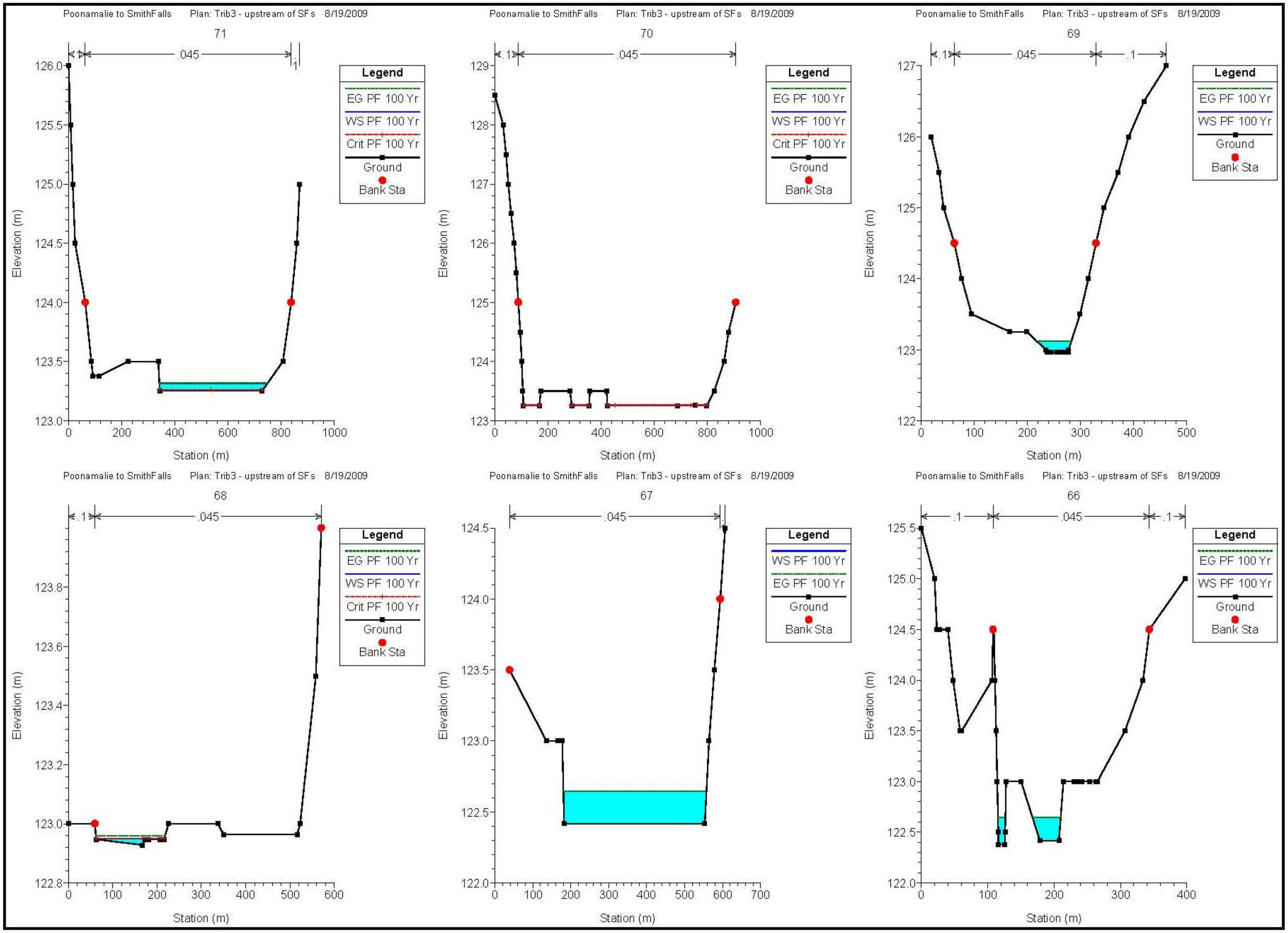
Tributary 2


Poonamalie to SmithFalls Plan: Trib 2- upstream of SFs 8/18/2009
HWY 43 pipe culvert
Legend
EG PF 100 Yr
WS PF 100 Yr
Crit PF 100 Yr
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
41
42
43

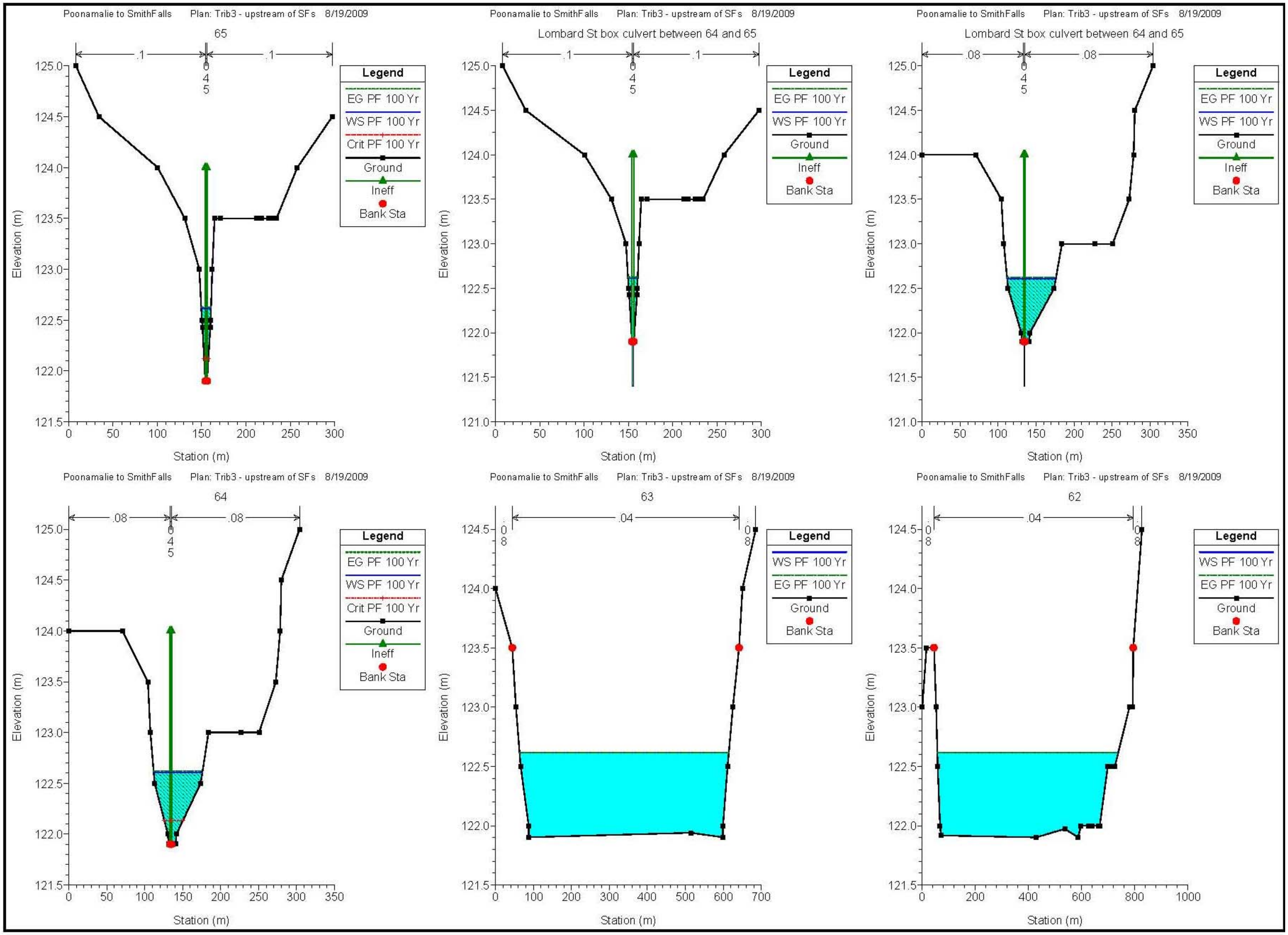


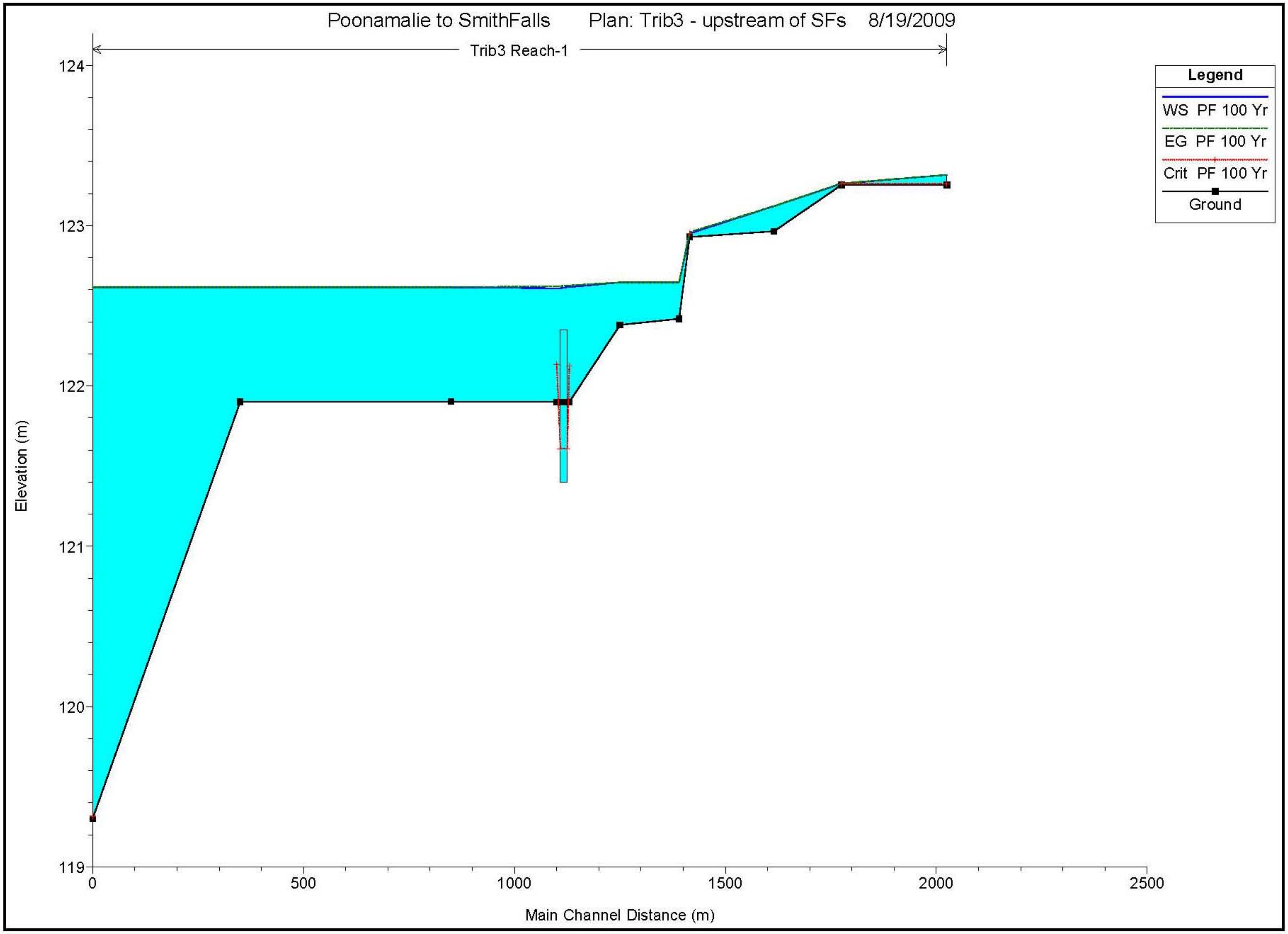
Poonamalie to SmithFalls   Plan: Trib 2- upstream of SFs   8/18/2009
Trib2 Reach-1
Legend
WS PF 100 Yr
EG PF 100 Yr
Crit PF 100 Yr
Ground
Elevation (m)
132
130
128
126
124
122
120
118
0
1000
2000
3000
4000
5000
6000
7000
Main Channel Distance (m)

Tributary 3



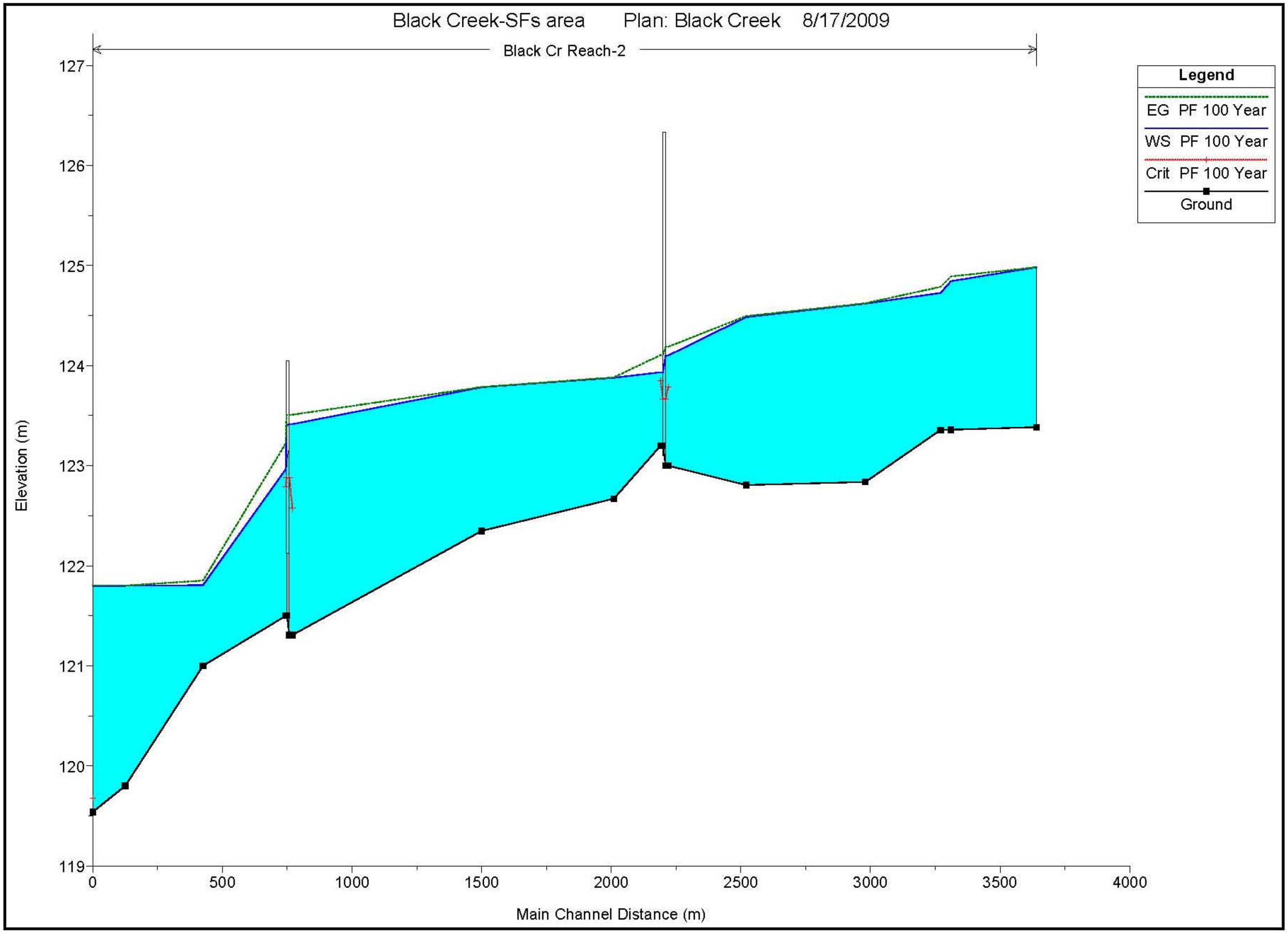
Poonamalie to SmithFalls Plan: Trib3 - upstream of SFs 8/19/2009
71
Legend
EG PF 100 Yr
WS PF 100 Yr
Crit PF 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Trib3 - upstream of SFs 8/19/2009
70
Legend
EG PF 100 Yr
WS PF 100 Yr
Crit PF 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Trib3 - upstream of SFs 8/19/2009
69
Legend
EG PF 100 Yr
WS PF 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Trib3 - upstream of SFs 8/19/2009
68
Legend
EG PF 100 Yr
WS PF 100 Yr
Crit PF 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Trib3 - upstream of SFs 8/19/2009
67
Legend
WS PF 100 Yr
EG PF 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Trib3 - upstream of SFs 8/19/2009
66
Legend
EG PF 100 Yr
WS PF 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)


Poonamalie to SmithFalls Plan: Trib3 - upstream of SFs 8/19/2009
65
Legend
EG PF 100 Yr
WS PF 100 Yr
Crit PF 100 Yr
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Trib3 - upstream of SFs 8/19/2009
Lombard St box culvert between 64 and 65
Legend
EG PF 100 Yr
WS PF 100 Yr
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Trib3 - upstream of SFs 8/19/2009
Lombard St box culvert between 64 and 65
Legend
EG PF 100 Yr
WS PF 100 Yr
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Trib3 - upstream of SFs 8/19/2009
64
Legend
EG PF 100 Yr
WS PF 100 Yr
Crit PF 100 Yr
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Trib3 - upstream of SFs 8/19/2009
63
Legend
WS PF 100 Yr
EG PF 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)
Poonamalie to SmithFalls Plan: Trib3 - upstream of SFs 8/19/2009
62
Legend
WS PF 100 Yr
EG PF 100 Yr
Ground
Bank Sta
Elevation (m)
Station (m)

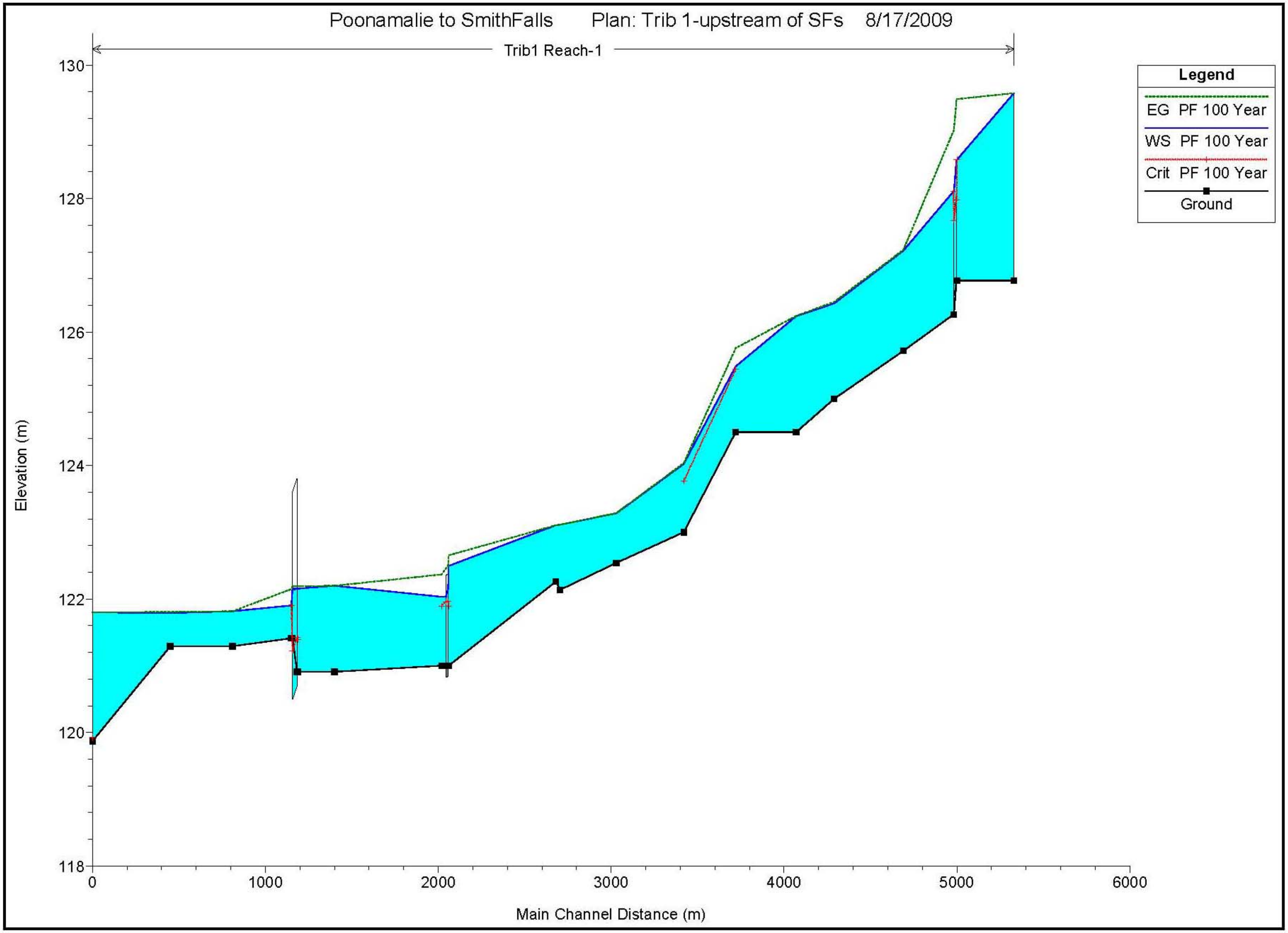

Poonamalie to SmithFalls Plan: Trib3 - upstream of SFs 8/19/2009
Trib3 Reach-1
Legend
WS PF 100 Yr
EG PF 100 Yr
Crit PF 100 Yr
Ground
Elevation (m)
124
123
122
121
120
119
0
500
1000
1500
2000
2500
Main Channel Distance (m)

Scenario 2 - The 1:100 yr flow on the tributaries and the Navigational Water Level (NWL) on Rideau River (121.80 m)

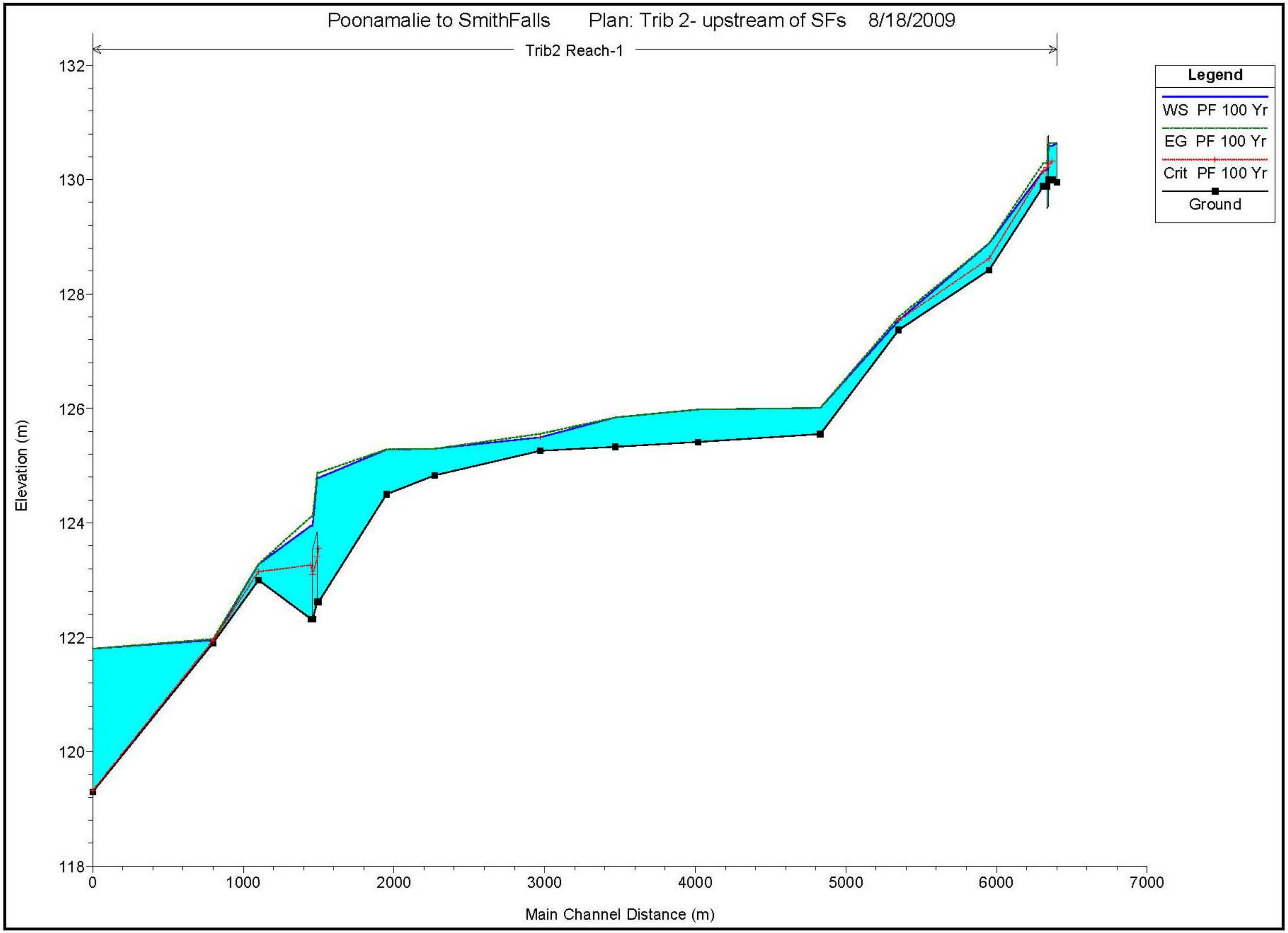
Black Creek


Black Creek-SFs area Plan: Black Creek 8/17/2009
Black Cr Reach-2
Legend
EG PF 100 Year
WS PF 100 Year
Crit PF 100 Year
Ground
Elevation (m)
127
126
125
124
123
122
121
120
119
0
500
1000
1500
2000
2500
3000
3500
4000
Main Channel Distance (m)

Tributary 1

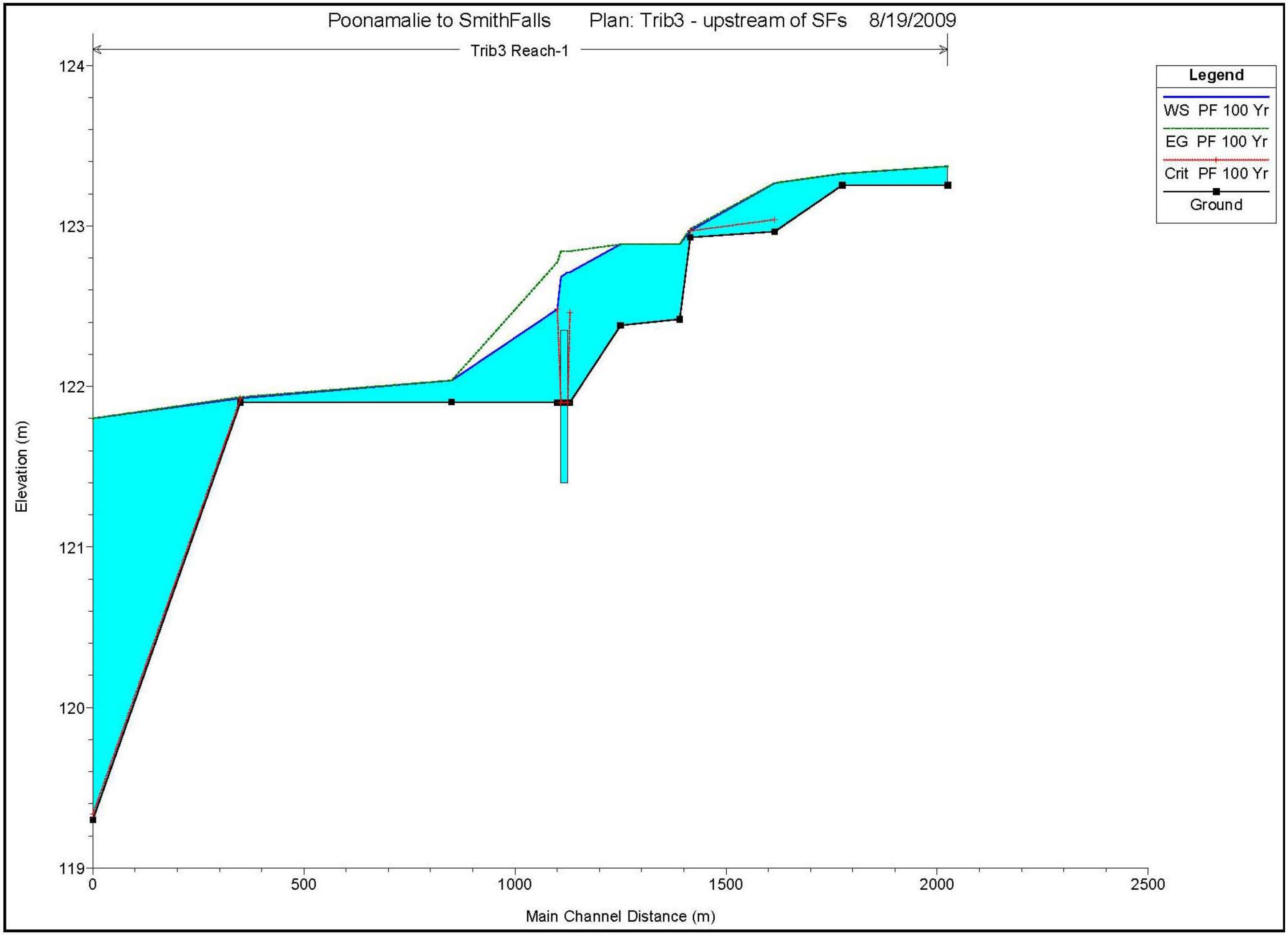

Poonamalie to SmithFalls Plan: Trib 1-upstream of SFs 8/17/2009
Trib1 Reach-1
Legend
EG PF 100 Year
WS PF 100 Year
Crit PF 100 Year
Ground
Elevation (m)
130
128
126
124
122
120
118
0
1000
2000
3000
4000
5000
6000
Main Channel Distance (m)

Tributary 2



Poonamalie to SmithFalls Plan: Trib 2- upstream of SFs 8/18/2009
Trib2 Reach-1
Legend
WS PF 100 Yr
EG PF 100 Yr
Crit PF 100 Yr
Ground
Elevation (m)
132
130
128
126
124
122
120
118
0
1000
2000
3000
4000
5000
6000
7000
Main Channel Distance (m)

Tributary 3



Poonamalie to SmithFalls Plan: Trib3 - upstream of SFs 8/19/2009
Trib3 Reach-1
Legend
WS PF 100 Yr
EG PF 100 Yr
Crit PF 100 Yr
Ground
Elevation (m)
Main Channel Distance (m)
124
123
122
121
120
119
0
500
1000
1500
2000
2500