QUINTE CONSERVATION

Salmon River Upper Lakes Flood Hazard Mapping
Hydraulics Report

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STATEMENT OF LIMITATIONS AND CONDITIONS

Limitations

This report has been prepared for Quinte Conservation in accordance with the agreement between KGS Group and Quinte Conservation (the "Agreement"). This report represents KGS Group's professional judgment and exercising due care consistent with the preparation of similar reports. The information, data, recommendations and conclusions in this report are subject to the constraints and limitations in the Agreement and the qualifications in this report. This report must be read as a whole, and sections or parts should not be read out of context.

This report is based on information made available to KGS Group by Quinte Conservation. Unless stated otherwise, KGS Group has not verified the accuracy, completeness or validity of such information, makes no representation regarding its accuracy and hereby disclaims any liability in connection therewith. KGS Group shall not be responsible for conditions/issues it was not authorized or able to investigate or which were beyond the scope of its work. The information and conclusions provided in this report apply only as they existed at the time of KGS Group's work.

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1.0 INTRODUCTION

1.1 Objectives of the Study

KGS Group was retained by Quinte Conservation (QC) to update the regulatory floodplain for the Salmon River Upper Lakes Watershed, from Kennebec Lake to the outlet of Crotch Lake (Figure 1-1). The study includes collection of topographic data through site inspection and surveying, hydrologic assessments, hydraulic modeling and analysis, and mapping of the Regulatory Floodplain.

The study was conducted in accordance with the requirements outlined in the Ontario Ministry of Natural Resources and Forestry (MNRF), and the Flood Hazard Identification and Mapping Program (FHIMP) – Project Eligibility and Requirements. The technical guidelines used were the following:

- Natural Resources Canada Federal Flood Mapping Guidelines Series
- OMNR (2011) Technical Bulletins associated with the Lakes and Rivers Improvement Act (LRIA)
- OMNR Technical Guide – River & Stream Systems: Flooding Hazard Limit (2002)
- OMNR Technical Guide – River & Stream Systems: Erosion Hazard Limit (2002)
- USACE HEC-HMS and HEC-RAS User's Manual and Technical Reference Manual

Following guidance from Environment and Climate Change Canada (ECCC), in this study, recurrent events are referred to as both return periods and AEPs. This is to provide clarity to users of the report, and to the public, regarding the likelihood of a flood event happening in any given year. It highlights the fact that the event referred to as the 100-year flood has a 1% probability of occurring or being exceeded in any given year. The correspondence between return period and Annual Exceedance Probability (AEP) is provided in Table 1-1. The two nomenclatures are interchangeable in this report. This report describes the hydraulic analyses and modeling conducted as part of the study.

TABLE 1-1: RETURN PERIODS AND AEPS

Return Period	Annual Exceedance Probability (AEP)
2 years	50%
5 years	20%
10 years	10%
20 years	5%
25 years	4%
50 years	2%
100 years	1%
200 years	0.5%
500 years	0.2%

1.2 Criteria for Flood Hazard Limit

The study area is located within Zone 2, in Ontario. Based on the "Technical Guide – River and Stream Systems: Flood Hazard Limit" (MNRF, 2002), the Regulatory Flood for this watershed is the 100-year Flood (*i.e.* the flood with 1% AEP).

1.3 General Description of the Study Area

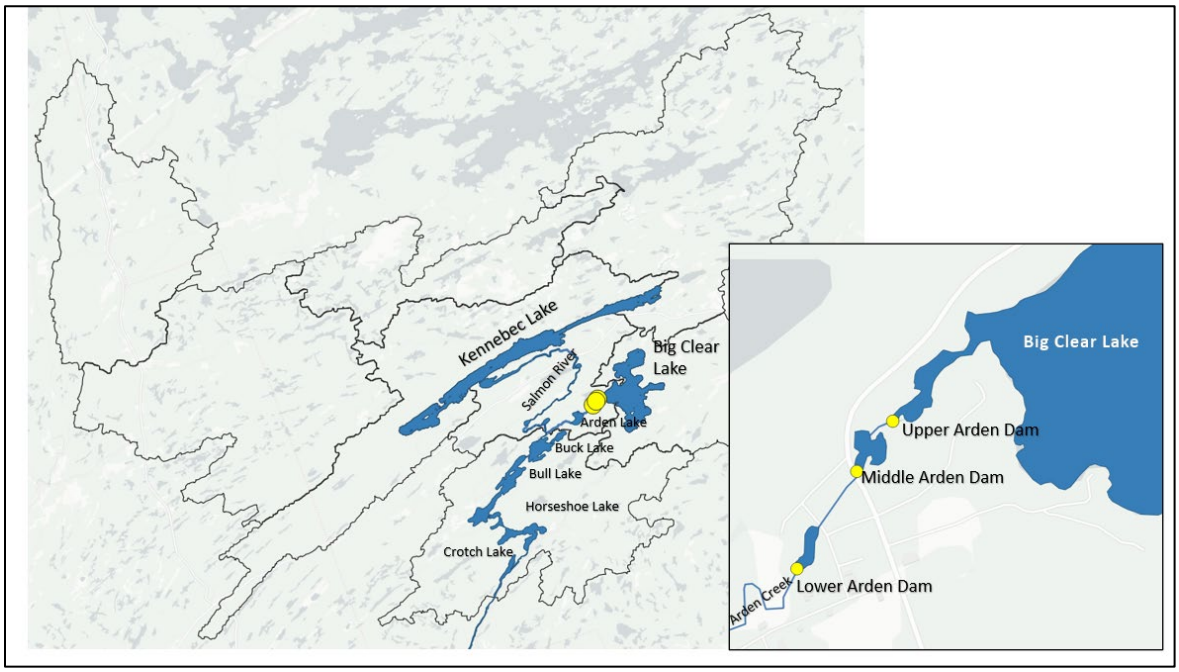
The Salmon River Upper Lakes are situated in the Township of Central Frontenac, including Kennebec Lake, Big Clear Lake, Arden Lake, Buck Lake, Bull Lake, Horseshoe Lake, Crotch Lake, and several other smaller lakes. The study area watershed (404 km^2) is shown in Figure 1-1.

The Kennebec Lake (to the north of the study area) receives runoff from the upstream most portion of the watershed, approximately half of the watershed's area (297 km^2). It drains through the Salmon River, which generally runs to the south, through flat terrain and into Buck Lake, Bull Lake, Horseshoe Lake, and Crotch Lake.

The Big Clear Lake receives the runoff from an eastern portion of the watershed (approximately 33 km^2 of drainage area) and drains through Arden Creek, a tributary of the Salmon River. The outflows from the Big Clear Lake are controlled at the Upper Arden Dam. From there, Arden Creek flows towards the west, passing through the Middle Arden Dam, the Lower Arden Dam, and Arden Lake, to join the Salmon River (from the east) at Buck Lake.

The study area for this floodplain mapping project is from the shores of Kennebeck Lake and Big Clear Lake, along the Salmon River and Arden Creek, to the outlet of Crotch Lake.

FIGURE 1-1: STUDY AREA



1.4 Previous Studies

Previous hydraulic studies that were identified in this project are:

- CCL (1981), Floodplain maps for certain lakes within the study area were created by Cumming-Cockburn & Associates Limited (CCL) in 1981; however, the associated studies or reports for these maps are currently unavailable.
- HATCH (2009), Dam Safety Reports (DSRs) for Upper Arden, Middle Arden, and Lower Arden Dams. As part of the study, the flood flows for the 100-year recurrent event (1% AEP) and other recurrent events were developed.
- AHYDTECH Geomorphic (2017), Upper Arden Dam Break Analysis. In this study 100-year flood and other recurrent events were simulated and included in an inundation map, for dam safety analysis.

2.0 BACKGROUND DATA REVIEW

2.1 Coordinate System and Vertical Datums

The coordinate system used is the Universal Transverse Mercator (UTM) NAD83 CSRS Zone 18. The elevations are based on the Canadian Geodetic Vertical Datum 2013 (CGVD2013). The elevations at the Upper Arden Dam and Lower Arden Dam, based on information provided in the Dam Operations Manual (NRCA, 1994), were corrected to represent the elevations obtained during the survey. Table 2-1 shows the conversion factors utilized in transforming the local datums for the Upper Arden Dam and Lower Upper Dam to CGVD2013.

TABLE 2-1: VERTICAL DATUMS CONVERSIONS

Datum	Conversion to CGVD2013
Upper Arden Dam Local Datum	- 0.6 m
Lower Arden Dam Local Datum	-0.4 m

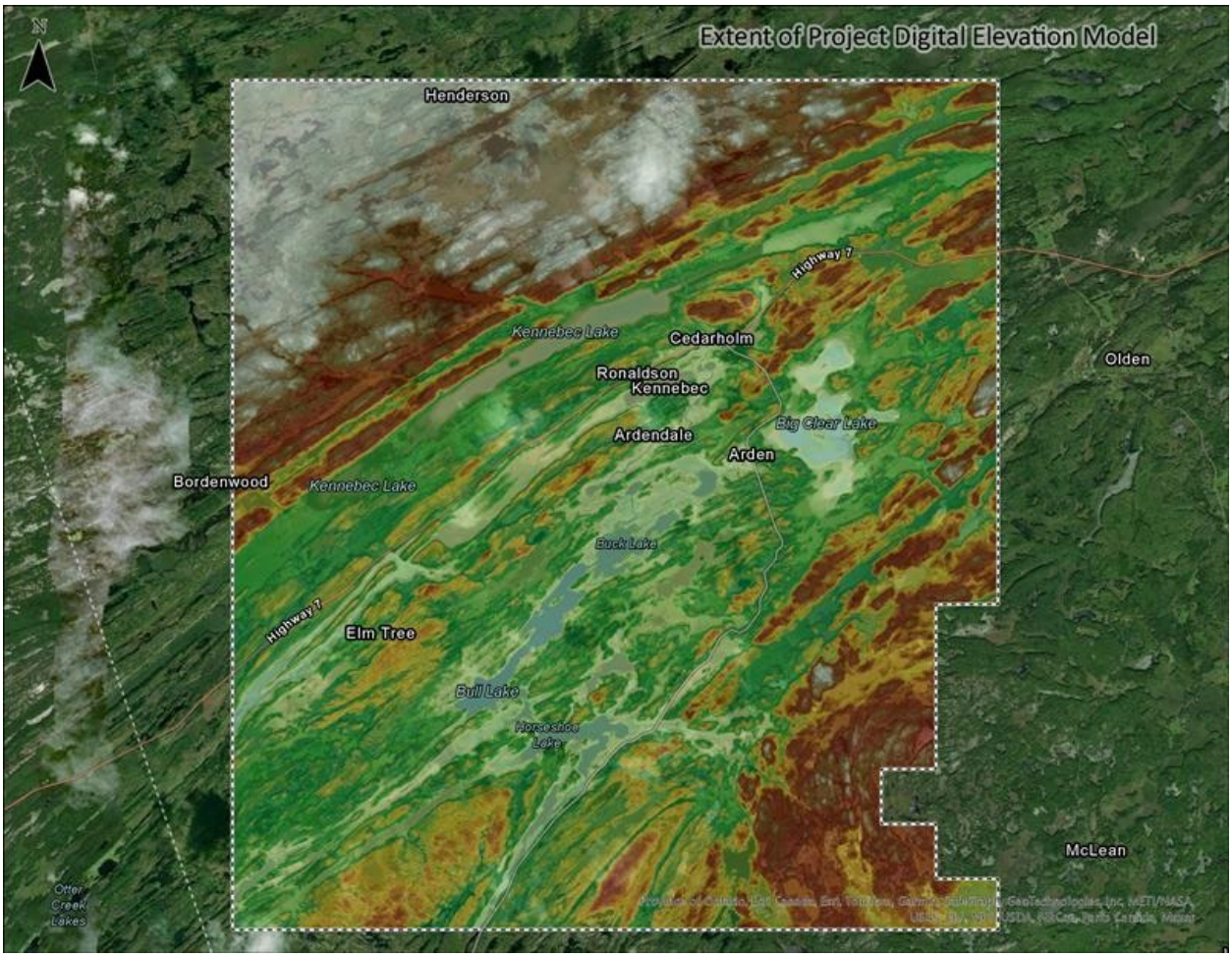
2.2 Topographic and Bathymetric Data

The project floodplain Digital Terrain Model DTM (Figure 2-1) that served as the basis for the study was developed based on the HRDEM (High Resolution Digital Elevation Model), from LiDAR acquire as part of the Eastern Ontario LiDAR Acquisition Project of 2022, It was supplemented with bathymetric data at structures and crossings, collected by KGS Group, as well as information obtained from available Nautical Charts. The vertical datum of the DTM is CGVD2013.

The bathymetric survey was carried out by KGS Group in August 2023, as part of the Salmon River Upper Lakes Flood Hazard Mapping project. The survey focused on collecting bed elevation data at crossings and structures. Only a few other locations along the lake system were surveyed. At the crossings, the dimensions of the structures and the road elevations were also surveyed. A total of 10 locations were surveyed including 5 bridges, 2 culverts and 3 dam structures. Crossing data sheets are included in Appendix A.

The Nautical Charts for the lakes were obtained from the i-Boating website and were only available in image format. The depth data was extracted from the Nautical Charts at multiple locations within the lakes to create depth contours. The depth contours were subtracted from the water surface to map the bottom of the lakes in the DTM. For sections of overlap between bathymetric data and nautical charts data, the bathymetric data was integrated and also used to verify the depths from the Nautical Charts matched.

FIGURE 2-1: EXTENT OF THE PROJECT DIGITAL TERRAIN MODEL



2.3 Land Cover Data

Land cover data was used to define the Manning's roughness coefficient for open water, forest, grass, among others. The Ontario Land Cover Compilation (OLCC version 2.0) was used to determine land use. OLCC is a compilation of three separate land cover sources across Ontario. The data source that covers this study is in the compilation is the Provincial Land Cover 2000 Edition (Land Information Ontario, 2014).

2.4 Hydrologic Data

As part of the floodplain mapping study, a hydrologic analysis of the Salmon River Upper Lakes Watershed was conducted by KGS (KGS, 2024) to determine the hydrologic conditions at the study area. The hydrologic analysis included a regional flood frequency analysis and hydrologic modelling of the watershed.

As part of that analysis, the following inflows, as shown in Table 2-2, were determined for the hydraulic modelling of the regulatory flood (100 -year flood, 1% AEP). To assess the potential effects of climate change,

as required by QC, a sensitivity analysis was carried out by simulating the flows that correspond to the 200-year flood (0.5% AEP) and the 500-year flood (0.2% AEP).

TABLE 2-2: ADOPTED FLOWS FOR HYDRAULIC MODEL

Hydrologic Model Output Location	Hydraulic Model Input Location	Peak Flow (m^3/s) 100-Year (1% AEP)
Junction 05	Inflows to Kennebec Lake from Cox's Lake (East of Kennebec)	20.5
Junction 03 and Subbasin Kennebec Lake	Inflows to Kennebec Lake from Beaver Creek (North of Kennebec)	31.1
Junction 07	Inflows to Big Clear Lake	8
Subbasin B11	Inflows to Horseshoe Lake	4.5
Subbasin B12	Inflows to Horseshoe Lake	2.4
Subbasin B08	Inflows to Buck Lake	7.2
Subbasin B09	Inflows to Arden Creek	1.6
Subbasin B06	Inflows to Salmon River at Garrison Lake	4.7

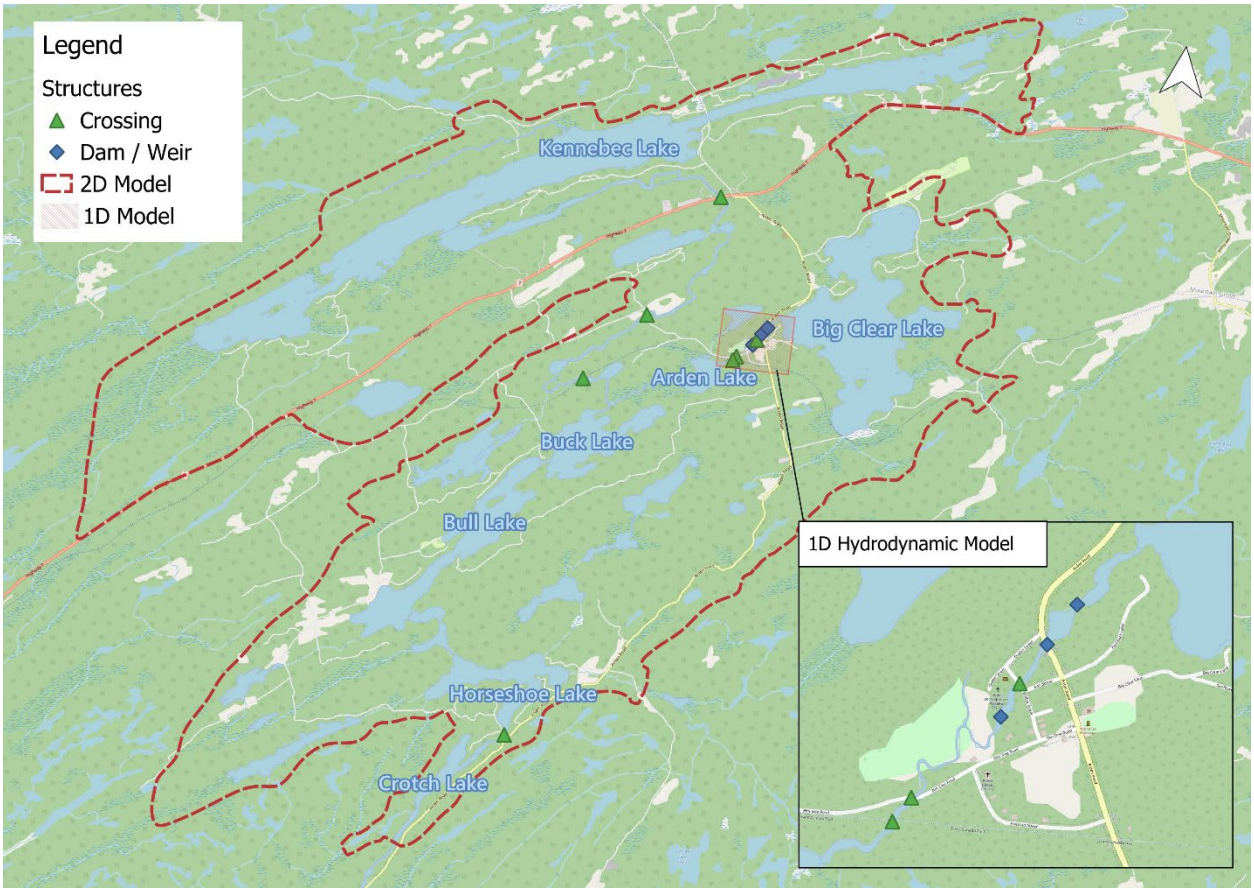
3.0 HYDRAULIC MODEL

3.1 Model Selection

The computer program HEC RAS, Version 6.4.1, was used in this study to define the hydraulics of the system. HEC RAS, developed by the USACE, is widely used in the water resources engineering industry for modeling open channel and river hydraulics.

Due to the complexity of the Salmon River system, it was recommended to simulate the area in two-dimensions (2D) as it can have a better representation of the flow patterns between interlinked watercourses and lakes. The 2D model covers a large area that forced the model to run over long periods of time. A separate one-dimensional (1D) model was developed to simulate the flow between Big Clear Lake and Arden Creek, which included the three dams along Arden Creek namely, Upper Arden Dam, Middle Arden Dam, and Lower Arden Dam. The sections of the models are shown in Figure 3-1. This reach, that was simulated in 1-D and unsteady state, was also part of the overall 2D model.

FIGURE 3-1: SALMON RIVER MODEL SECTIONS



3.2 Structures

For the study area there are ten structures located along Salmon River and Arden Creek. On Arden Creek, from Big Clear Lake to the point where Arden Creek reaches to Salmon River, there exist three dams and three bridges. On Salmon River, from Kennebec Lake to the mouth of Crotch Lake, there are four bridges. The summary of the structures is provided in Table 3-1. As part of the study, KGS Group carried out a field survey of the dams and bridges and prepared the crossing data sheets that will be available in the floodplain mapping report.

There is also a wooden pedestrian crossing located in Arden, close to 1054 Elm Tree Road. This wooden pedestrian crossing was not included in the hydraulic model. These slender structures are often not included in floodplain mapping studies because they can be washed out by the force of the flood currents and even when they withstand those events, they do not cause flow restriction as other structures that are more robust and supported with abutments.

TABLE 3-1: LIST OF STRUCTURES

Structure	Location
1. Road Bridge #1	Highway 7
2. Road Bridge #2	Cranberry Lake Road crossing Salmon River
3. Road Bridge #3	Elm Tree Road, near Fire Station
4. Road Bridge #4	Bridge St, near Post Office
5. Road Bridge #5	Elm Tree Road, near Garrison Lake Road
6. Rail Bridge #6	Trans-Canada Trail, North of Buck Lake
7. Rail Bridge #7	Trans-Canada near Arden Lake
8. Upper Arden Dam	Upstream Arden Pond
9. Middle Arden Dam	Arden Road
10. Lower Arden Dam	Church St

3.3 Dams

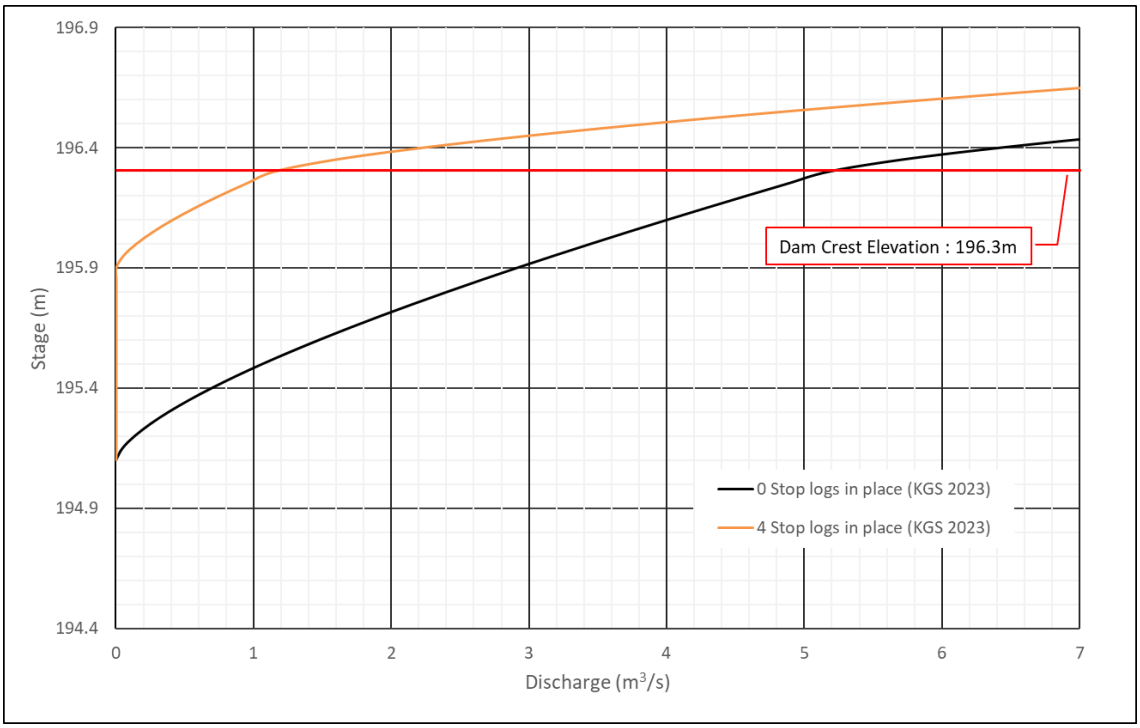
There are three dams along Arden Creek, Upper Arden Dam, Middle Arden Dam, and Lower Arden Dam. The three dams were simulated in the 1D model as in-line structures and as 2D connections in the 2D model. It must be noted that the results from the 1D model were used for floodplain mapping purposes along Arden Creek, up to just upstream of the Lower Arden Dam.

Geometric data was obtained from previous drawings and reports provided by Quinte Conservation and as well as the field survey data carried out by KGS Group. It must be noted that the vertical datum adopted on those reports was a local datum and was converted into CGVD2013 before integration (see Section 2.1).

The Upper Arden Dam is shown in Figure 3-2 . The dam has six stop logs. As indicated by Quinte Conservation, the winter setting for the dam is with four stoplogs in place, and it might not be possible to timely respond to high water levels during the freshet, by removing more stoplogs. The condition with four stoplogs in place was, therefore, adopted for the assessment of flood conditions and preparation of floodplain maps. Figure 3-3 shows the adopted rating curve for the Upper Arden Dam. The rating curve with all stoplogs removed is included in the figure for reference. Quinte Conservation has indicated that this dam has been overtopped in the past.

FIGURE 3-2: UPPER ARDEN DAM

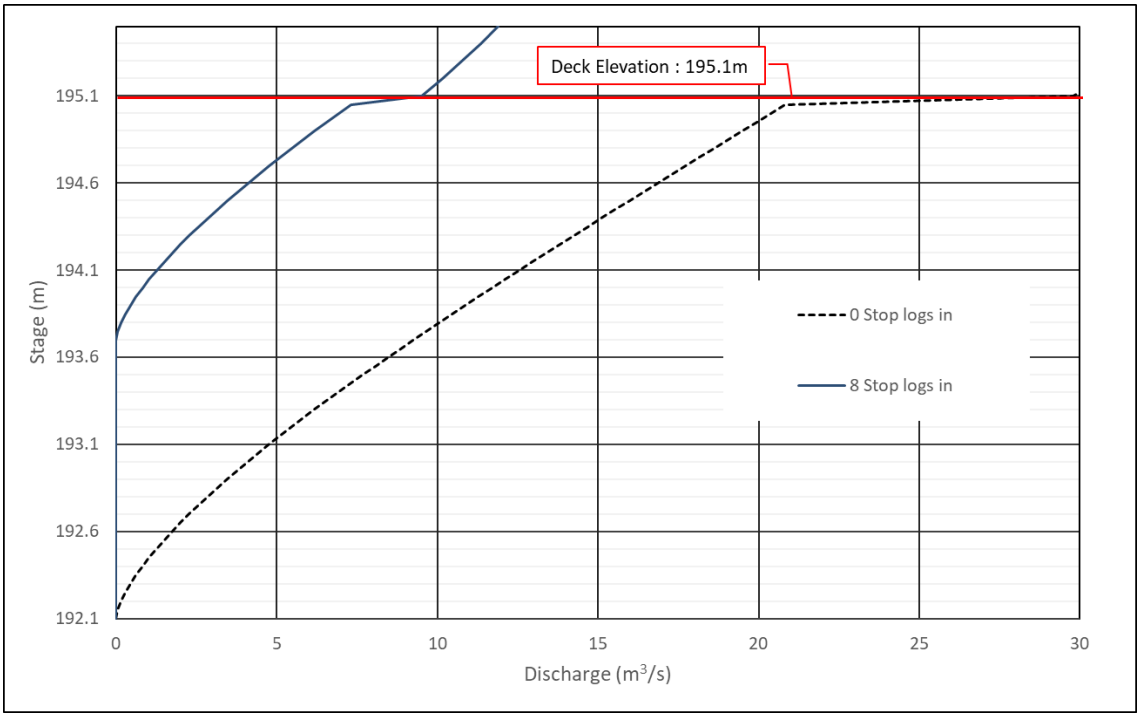
FIGURE 3-3: UPPER ARDEN DAM RATING CURVE



The Middle Arden Dam, shown in Figure 3-4, is a culvert (3 m wide, 3 m high and 8 m long) equipped with 12 stop logs on its upstream side. Quinte Conservation indicated that the winter setting for this dam, with eight stoplogs in place, is the most likely scenario during a flood, and, therefore, the dam was modelled using a rating curve representing those conditions, as shown in Figure 3-5. The rating curve with all stoplogs removed is included in the figure for reference.

FIGURE 3-4: MIDDLE ARDEN DAM

FIGURE 3-5: MIDDLE ARDEN DAM RATING CURVE



The Lower Arden Dam is shown in Figure 3-6. It is an overflow structure with no stop logs.

FIGURE 3-6: LOWER ARDEN DAM

3.4 Bridges

Bridges were included in the 1D model and in the 2D model based on the data obtained from field survey, elevation maps and aerial imagery. The elevation of the top of the deck, bridge span, width and piers dimensions were input to the model based on field survey data. The location of the bridges was determined based on elevation maps, aerial imagery and field photos.

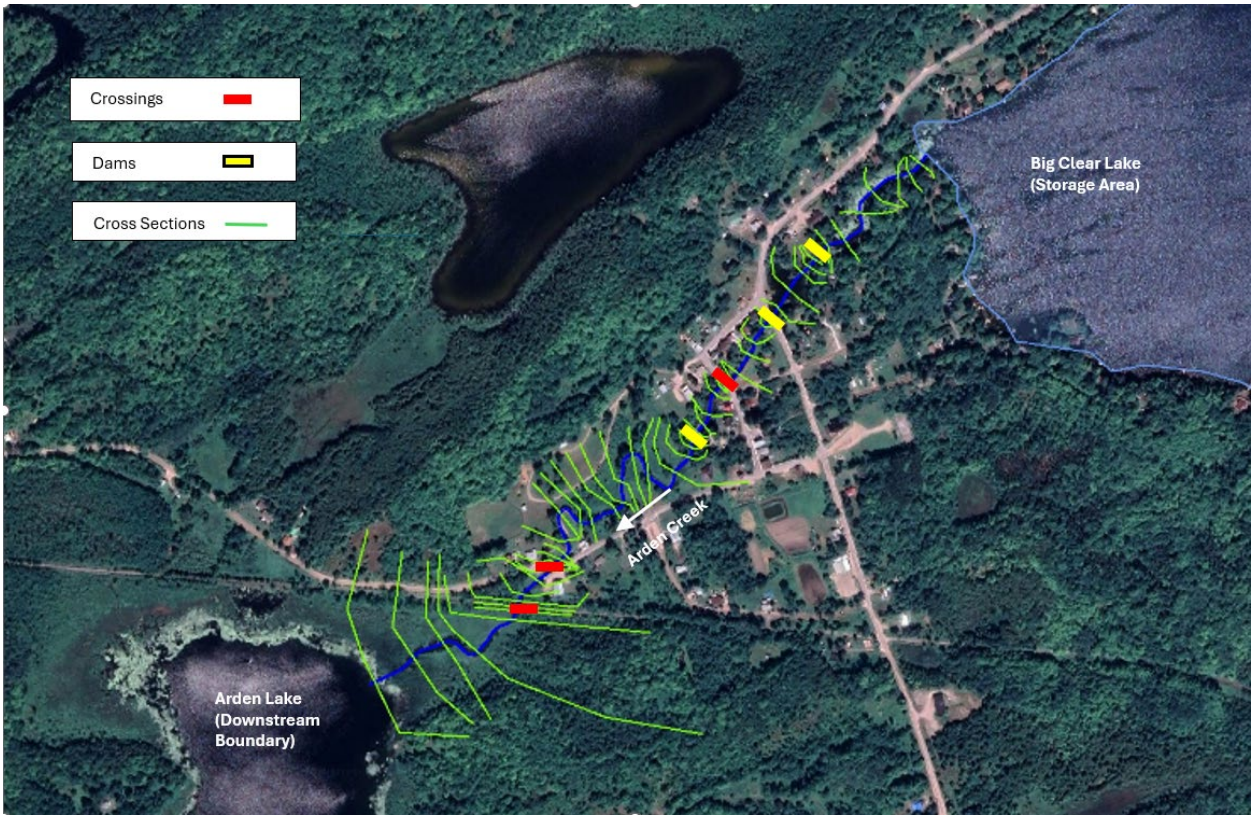
3.5 1D Model Development

The extent of the 1D model prepared as part of this study includes Big Clear Lake and Arden Creek. The model components and their connectivity are listed in Table 3-2. The extent of the 1D modelling is shown in Figure 3-8.

TABLE 3-2: COMPONENTS OF THE 1D MODEL AND THEIR CONNECTIVITY

River	Reach	Storage Area	Upstream Feature	Downstream Feature
Salmon	Arden	Big Clear Lake	Big Clear Lake	Arden Lake water level was set as boundary condition

FIGURE 3-7: EXTENT OF THE 1D MODEL

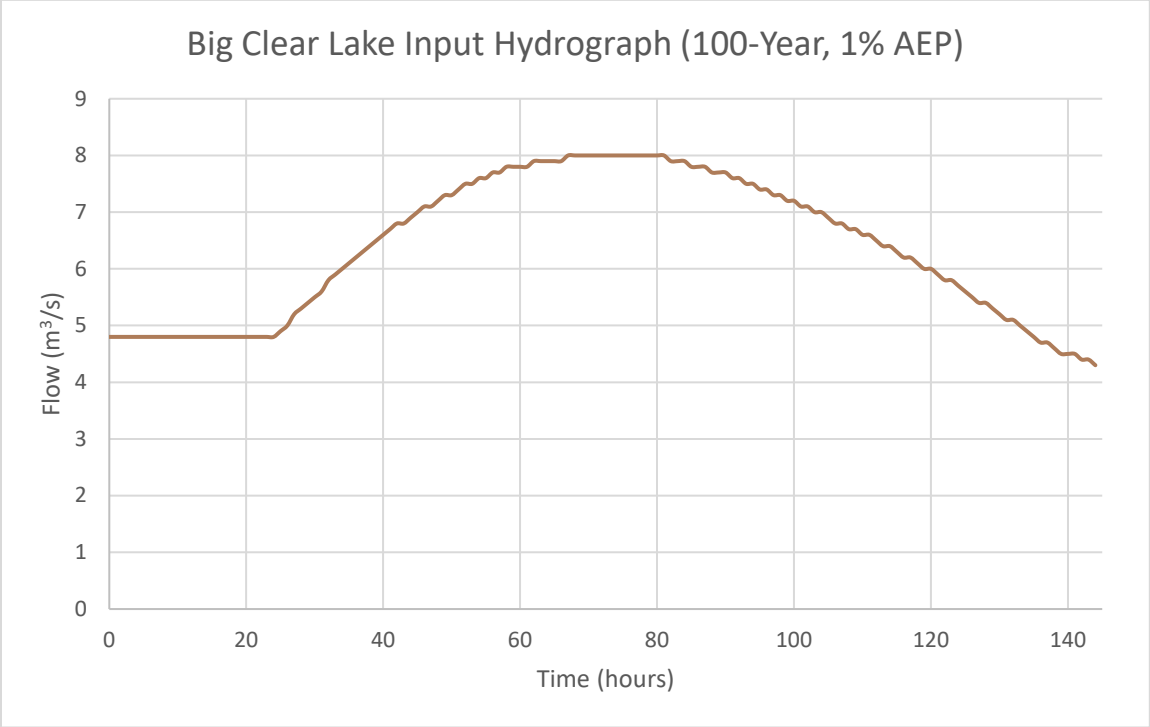


3.5.1 BOUNDARY CONDITIONS

The upstream boundary condition consisted of the inflows to Big Clear Lake which was modelled as a storage area connected to the Arden reach in the 1D model. The model includes the stage-storage curve for Big Clear

Lake, which was used to perform flood routing of those inflows (Section 3.5.4). Figure 3-8 shows the input hydrograph for Big Clear Lake, used to simulate the 100-year flood event (1% AEP).

FIGURE 3-8: INFLOWS TO BIG CLEAR LAKE



The downstream boundary condition for the 1D model was the water level at Arden Lake, which was assumed to be constant, independently of the flows in Salmon River. The water level assigned at the downstream end of the model was 186.2 m, which is representative of average water levels of Arden Lake. The accuracy of this downstream boundary condition is not important because the results in the lower reach of the 1D model, downstream of the Lower Arden Dam, were not used for the floodplain maps. Instead, the floodplain for this area was defined with the results from the 2D model, that includes any backwater effects from the Salmon River and lakes downstream of Arden. These effects, at least for the floods included in this study, do not propagate upstream of the Lower Arden Dam, into the domain represented with the 1D model.

3.5.2 MANNING'S N-VALUES

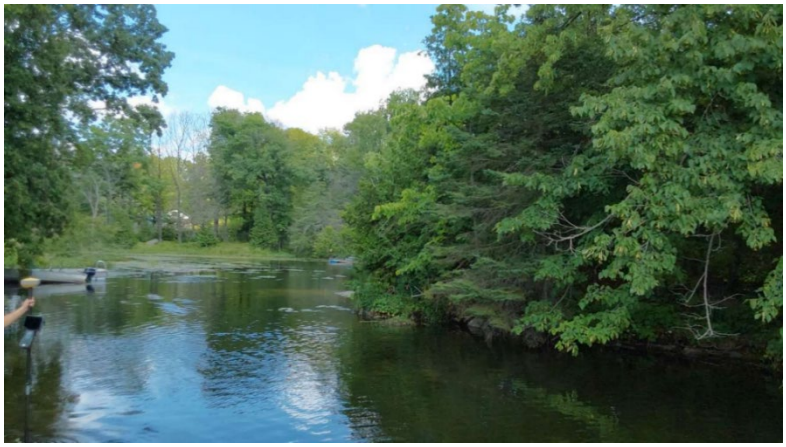
The Manning's n-values were selected based on photos of the study area obtained from the field survey conducted by KGS Group in 2023. Figure 3-9 and Figure 3-10 show photos taken at the Middle Arden Dam and Upper Arden Dam, respectively. Table 3-3 shows the Manning's n values selected for the 1D hydraulic model. For areas with steep streams such as downstream of Middle Arden Dam, the Manning's value was set slightly higher than the rest of the reach. It is common to have pool and riffle sequences in steep streams and Manning's values are typically higher in the riffle areas and lower in the pool areas.

TABLE 3-3: MANNING'S N-VALUES FOR 1D MODEL

Reach	River Station	n Channel	n Overbanks
Arden	**RS_1353 to RS_1284**	0.05	0.06
Arden	**RS_1262 to RS_1007**	0.03	0.06
Arden	**RS_996 to RS_965**	0.04	0.06
Arden	**RS_939 to RS_8**	0.03	0.06

FIGURE 3-9: DOWNSTREAM OF MIDDLE ARDEN DAM

FIGURE 3-10: UPSTREAM OF UPPER ARDEN DAM



3.5.3 CONTRACTION AND EXPANSION COEFFICIENTS

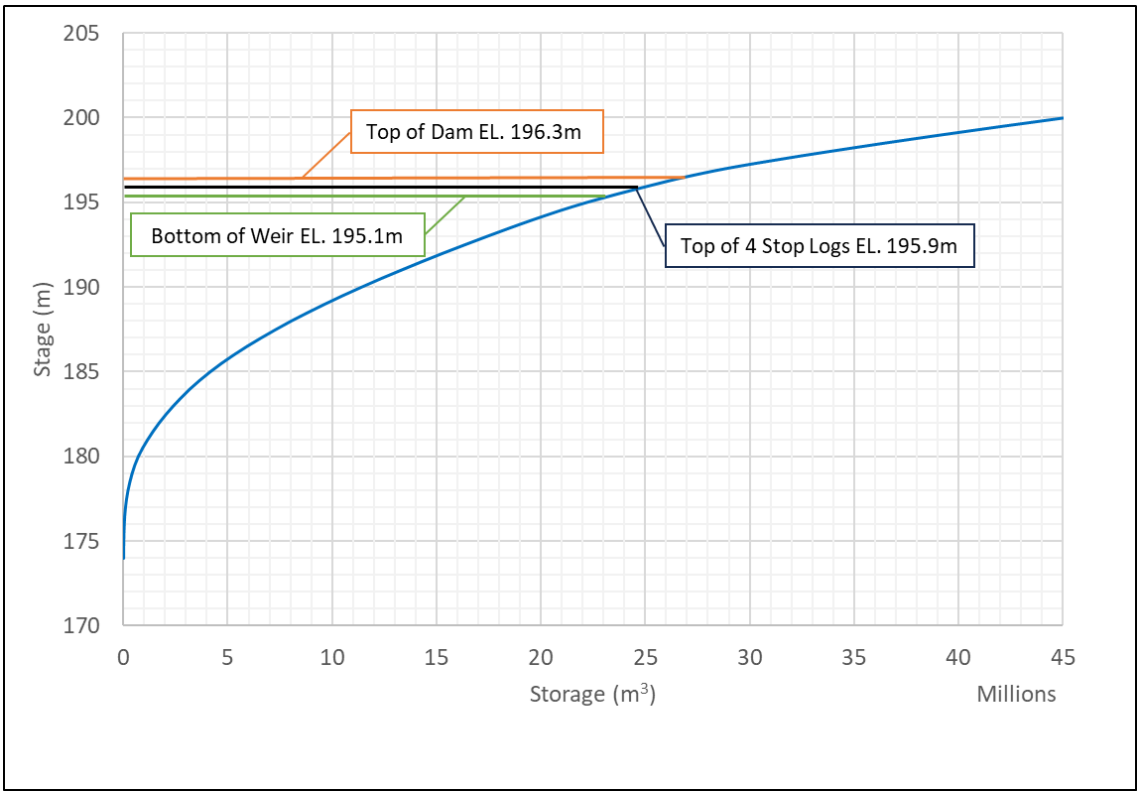
Contraction and expansion coefficients used in the 1D model were based on typical values recommended in the HEC-RAS manual and used in other similar studies by KGS Group. The contraction coefficients used in the

model were 0.1 for general cross sections and 0.3 for bridge/dam crossings. The expansion coefficients were 0.3 for general cross sections and 0.5 for bridge/dam crossings.

3.5.4 STORAGE AREAS

The main storage feature present in the 1D model is Big Clear Lake, which provides the flows to the river reach passing through the village of Arden which then drains into Arden Lake. Figure 3-11 shows the stage storage relationship for Big Clear Lake. It was prepared with the information listed in Section 2.2: DEM obtained from LiDAR data, and bathymetric contours delineated from Nautical Charts for the lakes that were obtained from the i-Boating website.

FIGURE 3-11: BIG CLEAR LAKE STORAGE CURVE



3.6 2D Model Development

The extent of the model is from Kennebec Lake to the mouth of Crotch Lake downstream of the crossing at Cranberry Lake Road. The model included the structures that were surveyed by KGS Group in 2023. The list of components included in the model is summarized in Table 3-4.

TABLE 3-4: COMPONENTS OF THE 2D MODEL

Lakes	Structures
Kennebec Lake	Bridge #1 at Highway 7
Garrison Lake	Bridge #2 at Elm Tree Road, near Garrison Lake Road
Buck Lake	Bridge #3 at Trans-Canada, North of Buck Lake
Big Clear Lake	Arden Upper Dam
Arden Lake	Middle Arden Dam
Bull Lake	Bridge #4 at Bridge St, near Post Office
Horseshoe Lake	Arden Lower Dam
Crotch Lake	Bridge #5 at Elm Tree Road, near Fire Station
	Bridge #6 at Trans-Canada, near Arden Lake
	Bridge #7 at Cranberry Lake Road crossing Salmon River

3.6.1 COMPUTATIONAL MESH

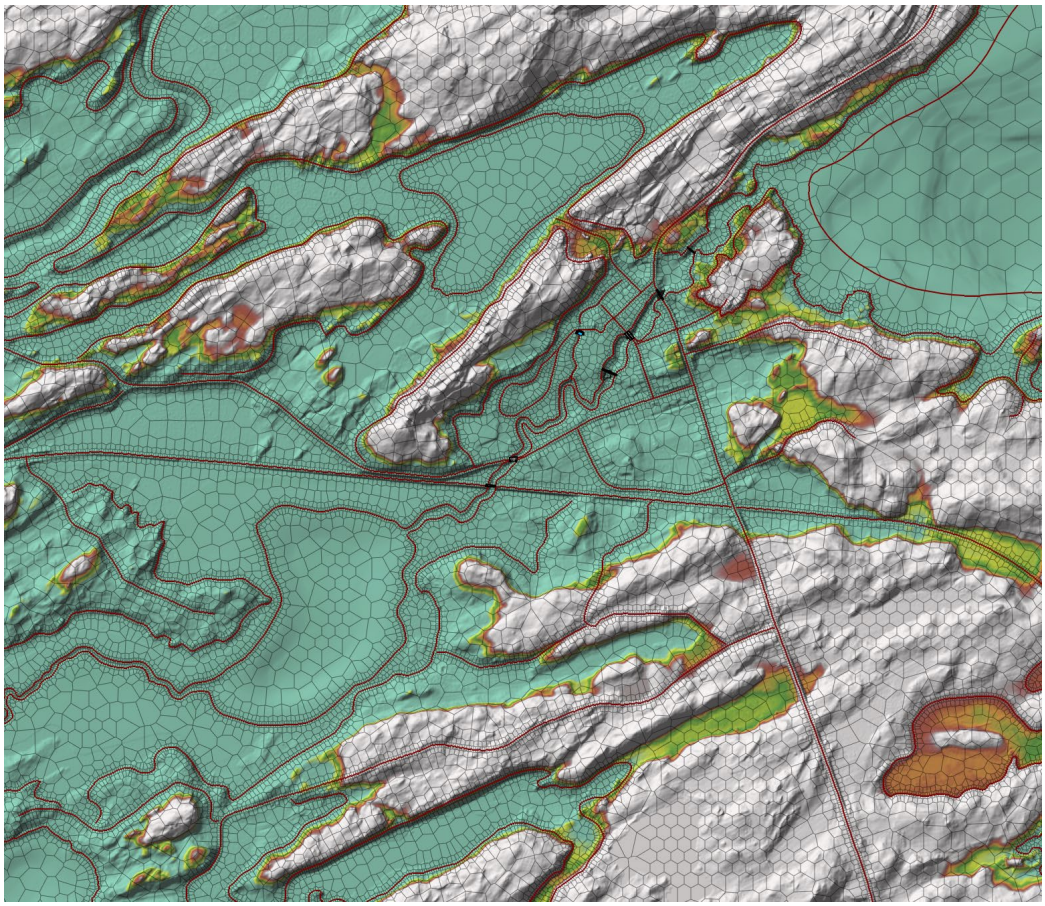
The computational mesh for the 2D model was created using the parameters shown in Table 3-5. Break lines were used extensively to align the configuration of the mesh with the overall elevation surface and to better define longitudinal and salient features of the terrain. Break lines were placed on (but not limited to) roadways, banks, cliffs, hills and structures (embankments, dams, bridges). An example of the mesh configuration is provided in Figure 3-12. This figure shows how the mesh elements (using break lines and flexible element sizes) were used to capture the terrain features affecting flow conditions. The light gray areas in the figure correspond to high terrain elevations and the green areas correspond to low terrain elevations.

The time step adopted in the 2D model was defined for a Courant Number ranging between 0.4 and 0.9 to maintain the stability of the numerical model. The time step that the model used during simulations ranged from 1 minute to 0.5 seconds.

TABLE 3-5: 2D COMPUTATIONAL MESH PARAMETERS

Parameter	Value
2D Meshing Scheme	Hexagonal grid elements of variable size
Element Size	Ranged from 5 m to 30 m for overland ground locations and up to 60 m within lakes, to balance proper definition of key features with size of the mesh
Breakline Cell Spacing	Structures: 2 m Channel banks, roads, shorelines and other longitudinal features: 5 m

FIGURE 3-12: COMPUTATIONAL MESH AROUND ARDEN



3.6.2 INITIAL CONDITIONS

The initial conditions were defined at 10 locations based on either measured water levels obtained during the survey or water levels obtained from the original DTM. Table 3-6 shows the initial water levels used for the various lakes in the 2D model. The model also included initial levels for the Big Clear Lake and the dams in Arden Creek but those are not listed because they were adjusted in the 1D model with updated conditions based on the operation of the dams.

TABLE 3-6: INITIAL CONDITIONS FOR 2D MODEL

Location	Initial Water Level (m)
1. Kennebec Lake [1]	197.7
6. Arden Lake [2]	185.8
7. Bull Lake [2]	185.5
8. Horseshoe Lake [2]	185.5
9. Buck Lake [2]	185.5
10. Crotch Lake [2]	185.5

Notes: 1) From LiDAR data 5) from KGS Group 2023 Survey

3.6.3 BOUNDARY CONDITIONS

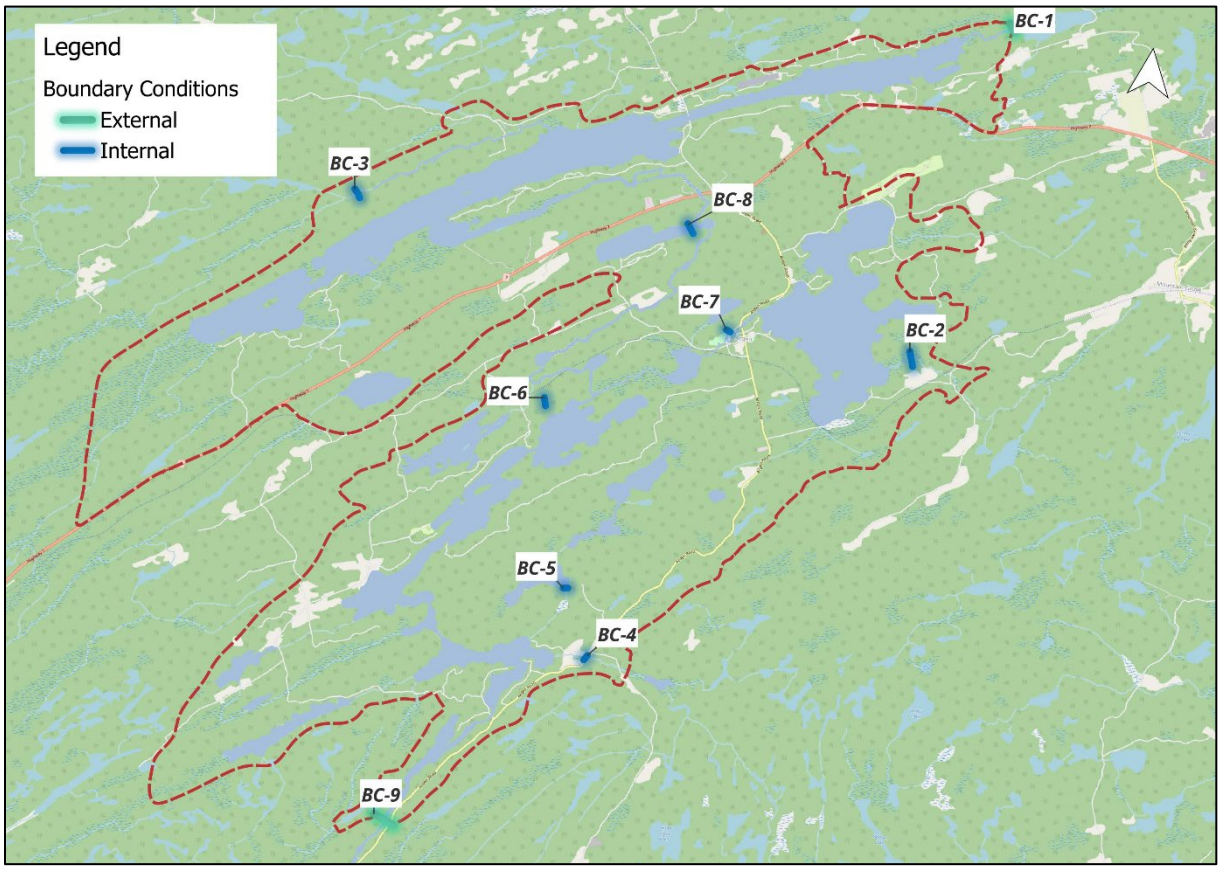
The locations of the boundary conditions used in the model are shown in Figure 3-13 with their corresponding type summarized in Table 3-7. As shown in this table, hydrographs were assigned to denote the inflows to the model and a stage-discharge rating curve was used to define the water levels at Crotch Lake. Hydrographs for the internal and external boundary conditions can be found in Appendix B.

TABLE 3-7: BOUNDARY CONDITIONS FOR 2D MODEL

No.	Location	Name	Type
1	External	Kennebec Lake East	Hydrograph
2	Internal	Big Clear Lake	Hydrograph (1)
3	Internal	Kennebec Lake North	Hydrograph
4	Internal	B11	Hydrograph
5	Internal	B12	Hydrograph
6	Internal	B08	Hydrograph
7	Internal	B09	Hydrograph
8	Internal	B06	Hydrograph
9	External	DS_BC	Rating Curve

(1) similar hydrograph to that used in the 1D model

FIGURE 3-13: BOUNDARY CONDITIONS FOR 2D MODEL



3.6.3.1 DOWNSTREAM BOUNDARY CONDITION

The downstream boundary condition for this model is critical because the model ends at Crotch Lake. Downstream of the downstream boundary, there were no evident locations of controls that would allow establishing a boundary condition purely based on the river geometry. The water levels captured in the LiDAR DEM are the same for a long distance downstream of the location where the model ends.

It was therefore determined that a downstream boundary at the selected location would have to rely on the available information from past events. The nearest documented location upstream of the model boundary is at the crossing on Cranberry Lake Road, near the intersection with Arden Road. There is a staff gauge on the upstream-north abutment of the bridge but there were no measurements available there. It was clear, though that during two visits to the site, in the fall of 2023 and the winter of 2024, the water level without the influence of high flows was at El. 185.5 m. There were also photos and field notes from the flood of 2014. That information was used to set a stage-discharge rating curve at the downstream boundary, and to adjust that stage-discharge rating curve so that the level at the Cranberry Lake Road crossing matched the available data:

- Water level @ El. 185.5 m, which denotes the conditions at the lake during the survey on August 23, 2023; Figure 3-14 shows a photo taken at Cranberry Lake Road during the survey. This level was associated with an estimated low flow of 3 m^3/s, which was also used as initial flow condition there.
- Water level @ El. 186 m, which denotes the flooding conditions of an area, downstream of the Cranberry Lake Road crossing, that people from the area indicated as exposed to frequent flooding. Figure 3-15 shows the area of frequent flooding. The 2-year peak flow of 18 m^3/s was assigned to this water level.
- Water level @ El. 187.30 m, which corresponds to the field notes by Quinte Conservation staff during the record flood event in 2014; Figure 3-16, Figure 3-17, Figure 3-18 and Figure 3-19 show photos taken at Cranberry Lake Road during that flood. The flood of 2014 closely matches the 100-year peak flow magnitude at the nearest Water Survey of Canada Station (02HM010-Salmon River at Tamworth). This water level was, therefore, associated with the 100-year flood peak (approximately 50 m^3/s at the Cranberry Lake Road crossing).

FIGURE 3-14: PHOTO TAKEN AT CRANBERRY LAKE ROAD CROSSING ON AUGUST 23, 2023

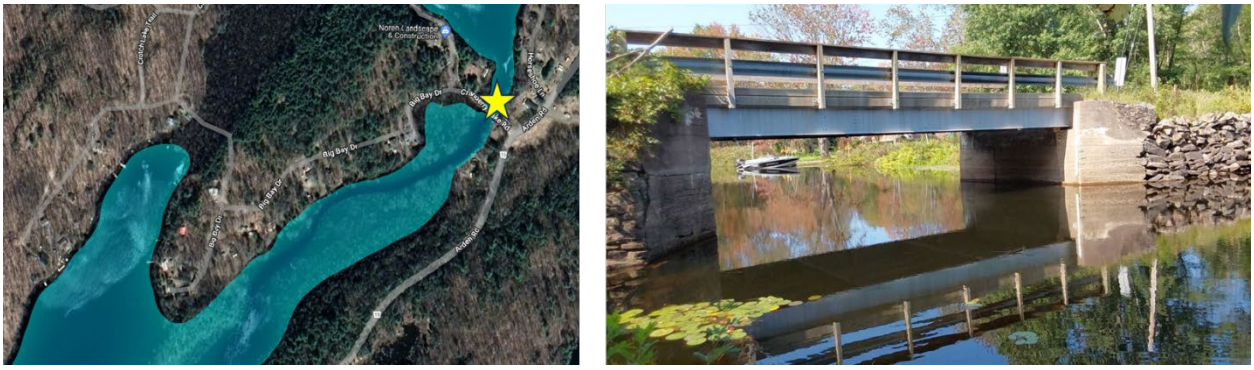


FIGURE 3-15: AREA WITH FREQUENT FLOODING

FIGURE 3-16: PHOTO #1 TAKEN AT CRANBERRY LAKE ROAD CROSSING ON APRIL 15, 2014

FIGURE 3-17: PHOTO #2 TAKEN AT CRANBERRY LAKE ROAD CROSSING ON APRIL 15, 2014

FIGURE 3-18: PHOTO #3 TAKEN AT CRANBERRY LAKE ROAD CROSSING ON APRIL 15, 2014

FIGURE 3-19: PHOTO TAKEN DOWNSTREAM OF CRANBERRY LAKE ROAD CROSSING ON APRIL 15, 2014

3.6.4 MANNING ROUGHNESS COEFFICIENT

The Manning Roughness Coefficient is used in the 2D model to represent the surface roughness. The adopted values were based on typical values obtained in the literature for rivers and floodplains with similar descriptions to those classified in the Ontario Land Cover Compilation (OLCC) dataset. The values used for each OLC class used in the OLCC dataset are provided in Table 3-8. The landcover primarily consists of forests with bogs along the lakes and watercourses.

TABLE 3-8: MANNING'S N VALUES

Raster Value	OLC Class	OLC Description	Assigned Mannings
1	Clear Open Water	This class is characterized by water with minimal or no evidence of turbidity or sediment. There is also an absence of macrophyte vegetation, tree or shrub cover	0.03
7	Fen	Fens generally lacking tree cover that may support some shrub cover and tamarack.	0.1
8	Bog	Open, shrub and treed communities - water table seasonally or permanently at, near, or above substrate surface - tree cover (trees > 2m high) ≤ 25%	0.1
11	Sparse Treed	Sparse Treed: Treed (> two metres in height) area containing coniferous or deciduous species or a combination of the two.	0.06
13	Deciduous Treed	Deciduous Treed: Predominately deciduous tree cover situated on varying soil depths having dry, fresh and sometimes moist conditions.	0.12
14	Mixed Treed	A mixture of deciduous and coniferous tree cover situated on varying soil depths that can have dry, fresh and sometimes moist conditions.	0.12
15	Coniferous Treed	Predominately coniferous tree cover situated on varying soil depths that can have dry, fresh and sometimes moist conditions.	0.12
26	Bedrock	Exposed bedrock, lacking vegetation cover	0.04
28	Agriculture and Undifferentiated Rural Land Use	Includes all agricultural features (e.g. field and forage crops and rural properties) as well as urban brown fields, and openings within forests	0.1

4.0 MODEL RESULTS

This section provides the results of the hydraulic model simulations for the Regulatory Flood (100-year or 1% AEP Flood) as well as for two scenarios (10 year or 10% AEP and 200-year or 0.5 % AEP) that were completed as a sensitivity analysis to assess potential changes due to climate change. Additional results for other flood scenarios discussed with Quinte Conservation are not included in this report.

- Table 4-1 shows the result of the flood routing of the inflows for the various events through Big Clear Lake, obtained with the 1D HEC-RAS model.
- Table 4-2 shows a summary of the results obtained with the 1D HEC-RAS model, along Arden Creek. More detailed model results are provided in Appendix C.
- Table 4-3 shows a summary of the results obtained with the 2D HEC-RAS model from Kennebec Lake to Crotch Lake.

TABLE 4-1: TIMING AND PEAK FLOW OUT OF BIG CLEAR LAKE

Scenario	Peak Flow (m^3/s)	Time to Peak (hours after peak inflow)
10YR (10% AEP)	3.5	50
100YR (1% AEP)	5.6	51
200YR (0.5% AEP)	6.1	52

TABLE 4-2: SUMMARY OF RESULTS FROM THE 1D HYDRAULIC MODEL

Structure/Lake	Headwater Elevation (m, CGVD2013)			Overtopping Elevations (m, CGVD2013)
	10YR	100YR	200YR	
Big Clear Lake	196.53	196.67	196.70	
Upper Arden Dam	**196.48**	**196.58**	**196.61**	**196.30**
Middle Arden Dam	194.50	194.82	194.89	**195.50**
Post Office Bridge	190.36	190.74	190.83	**192.15**
Lower Arden Dam	189.71	189.87	189.91	**190.10**

Note: **Red** Highlighted Values indicate overtopping.

TABLE 4-3: SUMMARY OF RESULTS FROM THE 2D HYDRAULIC MODEL

Structure/Lake	Headwater Elevation (m, CGVD2013)			Overtopping Elevations (m, CGVD2013)
	10YR	100YR	200YR	
Fire Station Bridge	186.8	187.6	187.8	**188.1**
Railway Bridge (North of Arden Lake)	186.8	187.6	187.8	**189.0**
Garrison Bridge	189.8	190.4	190.5	**191.3**
Highway 7 Bridge	189.9	190.5	190.7	**192.2**
Trans-Canada Bridge (North of Buck Lake)	187.8	188.2	188.3	**192.4**
Cranberry Lake Bridge	186.5	187.3	187.5	**188.2**
Kennebec Lake	198.8	199.3	199.4	
Garrison Lake	189.8	190.5	190.6	
Buck Lake	186.8	187.6	187.8	
Bull Lake	186.8	187.6	187.8	
Horseshoe Lake	186.6	187.4	187.5	
Crotch Lake	186.5	187.2	187.4	

Note: **Red** Highlighted Values indicate overtopping.

5.0 REFERENCES

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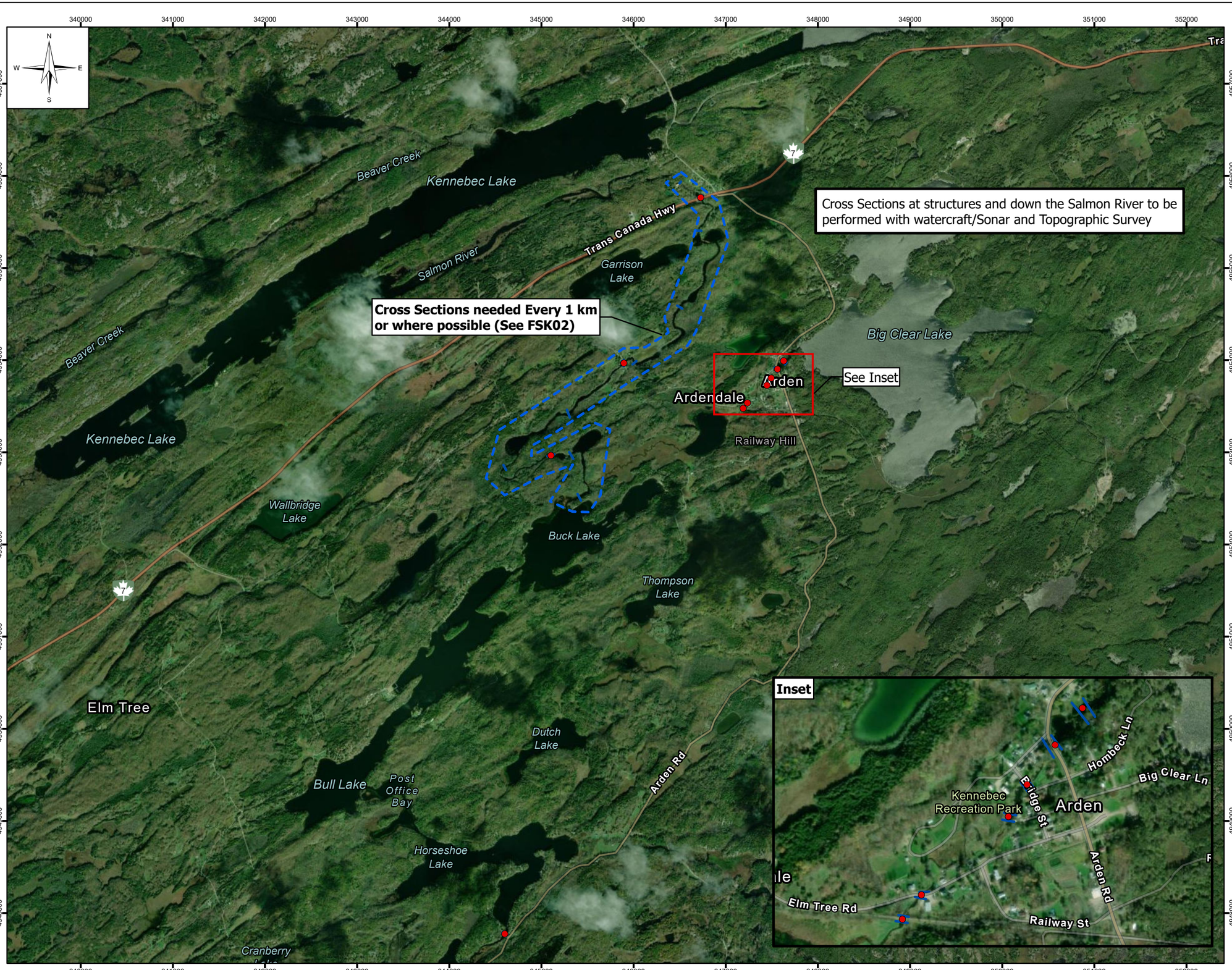
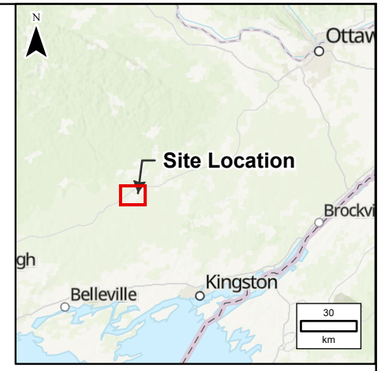
APPENDIX A

Field Survey Crossing Data Sheets





LEGEND:

- Structures
- Propose Cross Sections

NOTES:

1. Base Imagery by ESRI/MAXAR, dated 2022.
2. All units are metric and in metres unless otherwise specified. Transverse Mercator Projection, NAD 1983, CSRS Zone 18 Elevations are in metres above sea level (MSL).

DRAFT

500 0 500 1,000 1,500

Metres

SCALE: 1:40,000 METRIC 11"x17"

NO.	YY/MM/DD	DESCRIPTION	ISSUED BY	CHECK BY
A	23/07/26	FOR INFORMATION ONLY	FGC	MSW

REVISIONS / ISSUE

KGS GROUP

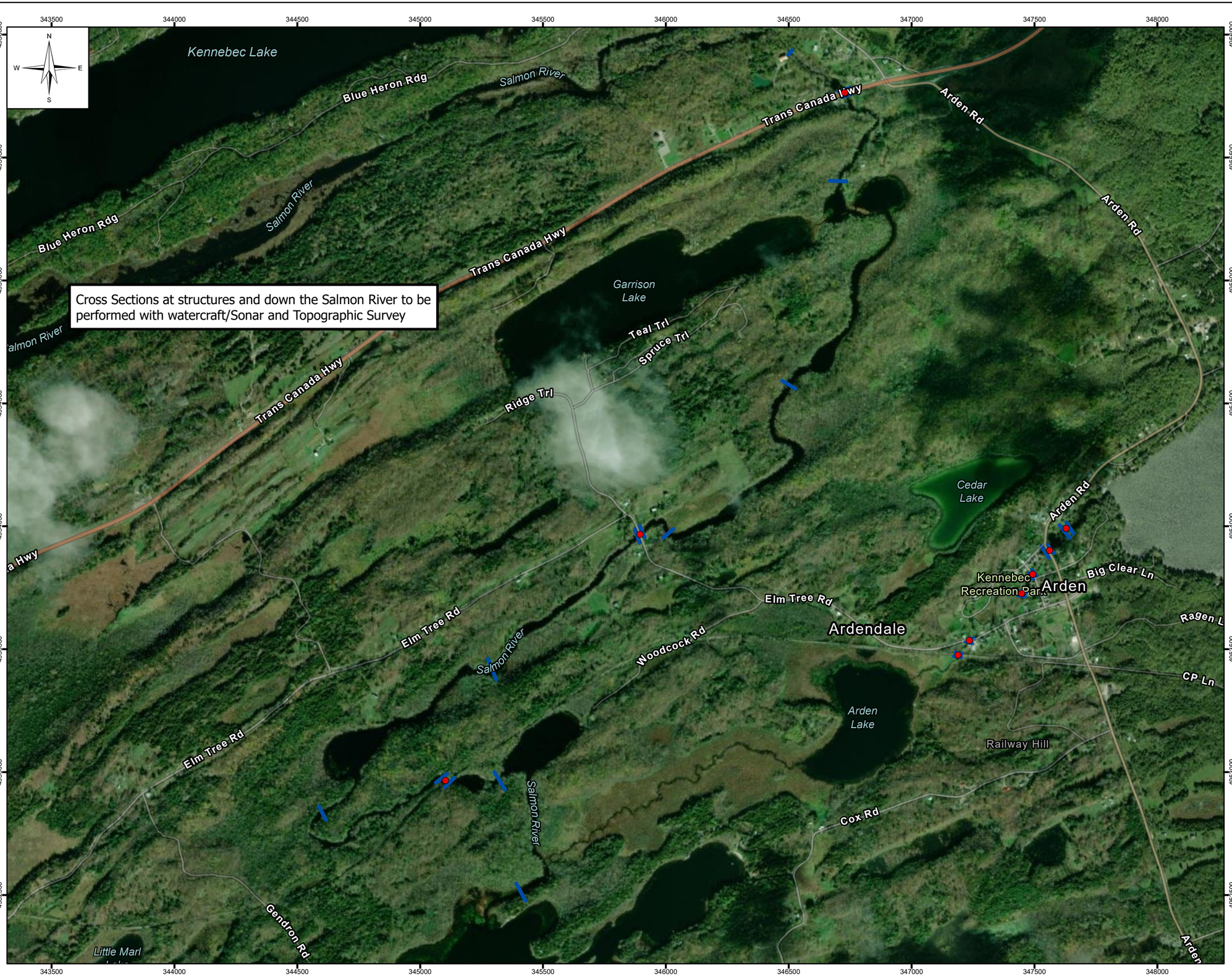
Quinte CONSERVATION

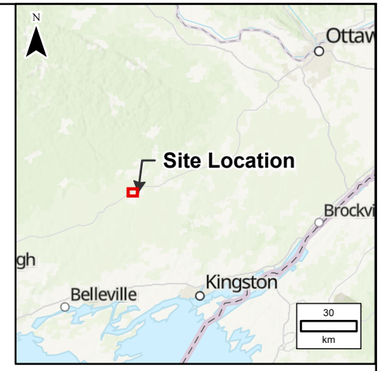
SALMON RIVER FLOODPLAIN MAPPING AND DSR

FIELD PLANNING
STRUCTURES AND PROPOSED CROSS SECTIONS

JULY 2023	FSK01	REV: A

Portions of data Produced by KGS Group, under Licence with the Ontario Ministry of Natural Resources © Queen's Printer for Ontario, 2023.





LEGEND:

- Structures
- Propose Cross Sections

NOTES:

1. Base Imagery by ESRI/MAXAR, dated 2022.
2. All units are metric and in metres unless otherwise specified. Transverse Mercator Projection, NAD 1983, CSRS Zone 18 Elevations are in metres above sea level (MSL).

DRAFT

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Metres

SCALE: 1:15,000 METRIC 11"x17"

NO.	YY/MM/DD	DESCRIPTION	ISSUED BY	CHECK BY
A	23/07/26	FOR INFORMATION ONLY	FGC	MSW

REVISIONS / ISSUE

KGS GROUP

Quinte CONSERVATION

SALMON RIVER FLOODPLAIN MAPPING AND DSR

FIELD PLANNING
STRUCTURES AND PROPOSED CROSS SECTIONS

JULY 2023	FSK02	REV: A

FileName: C:\Users\cswain\Desktop\Scratch\Upper_Salmon_Conseccon_Field_Planning\Field_Planning_July_2023.aprx Upper Salmon_FSK02
11"x17" PLOT SCALE 1:1

Crossing Data Sheet

Project: Salmon River Flood Mapping

Site Visit Date: August 22, 2023 **Crew:** Jamie Childs & Ethan Bowers

Structure Name: Culvert by Fire Station

Structure Type: Culvert

Location: UTM Grid (CSRS Zone 18, N: 4953541.7, E: 347236.3) – Arden Creek

Coordinates: [44.718967, -76.928839]

Field Notes: Culvert with two openings.

Structure Data:

- Structure Material: Concrete
- Number of Culvert Openings: 2
- Culvert Type: Box Culvert
- Gated Culvert: No
- Trash Rack: No
- Culvert Measurement – Vertical: 1.51m
- Culvert Measurement – Horizontal: 3.54m
- Distance Between Culverts: 0.523m

Elevation Data (obtained from GIS survey data points):

- Top of deck elevation: 188.057m
- Culvert Invert: 185.676m
- Culvert Obvert: 187.885m
- Stream Invert: 185.547m

Photo 1: Upstream End of Structure

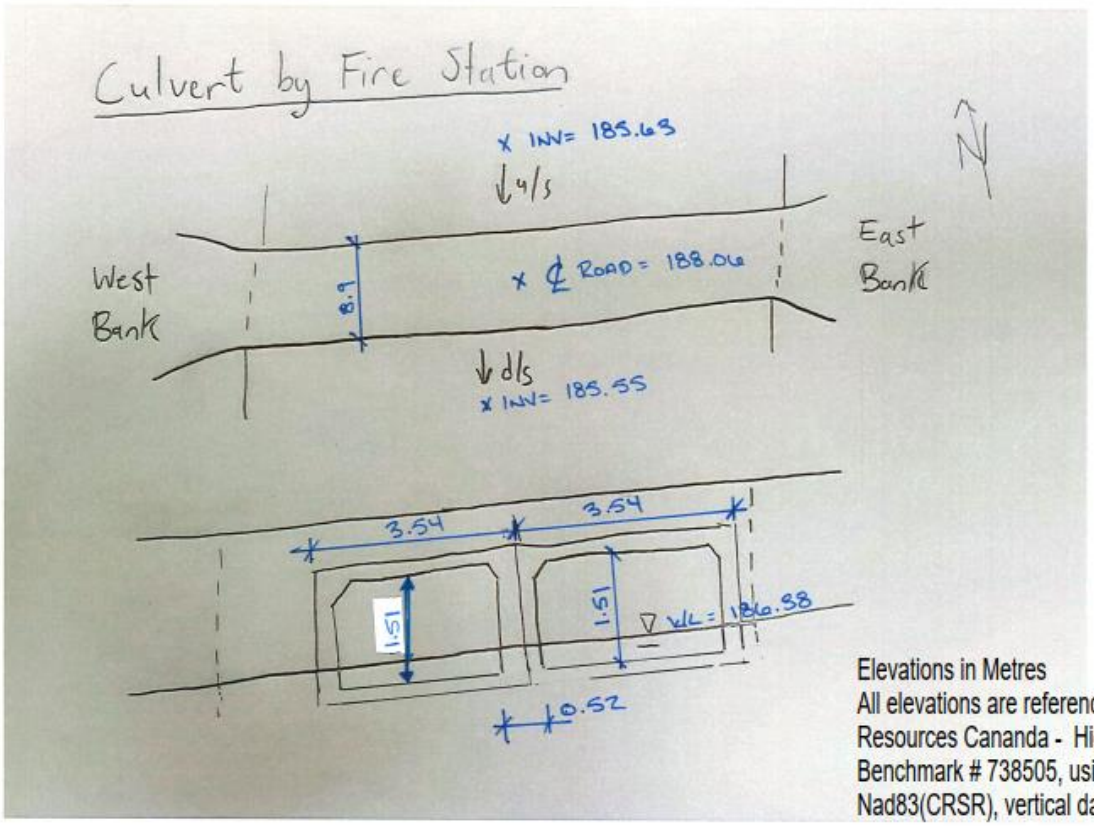
Photo 2: Downstream End of Structure

Photo 3: Looking Upstream from Structure

Photo 4: Looking Downstream from Structure

Additional Photos

Site Sketch



Elevations in Metres
All elevations are referenced to Natural Resources Cananda - High Precision 3D Benchmark # 738505, using UTM18, Nad83(CRSR), vertical datum CGVD2013

Crossing Data Sheet

Project: Salmon River Flood Mapping

Site Visit Date: August 22, 2023 **Crew:** Jamie Childs & Ethan Bowers

Structure Name: Culvert by Post Office

Structure Type: Culvert

Location: UTM Grid (CSRS Zone 18, N: 4953807.4, E: 347504.7) – Arden Creek

Coordinates: [44.721416, -76.925532]

Field Notes: Culvert with one opening.

Structure Data:

- Structure Material: Concrete
- Culvert Material: Corrugated Steel Pipe
- Culvert Type: Circular Culvert
- Gated Culvert: No
- Trash Rack: No
- Culvert Measurement - Vertical: 2.9m
- Culvert Measurement - Horizontal: 2.2m

Elevations (obtained from GIS survey data points in CGVD 2013):

- Top of deck elevation: 192.15m
- Culvert Invert: 188.807m
- Culvert Obvert: 192.056m
- Stream Invert: 188.632m

Photo 1: Upstream End of Structure

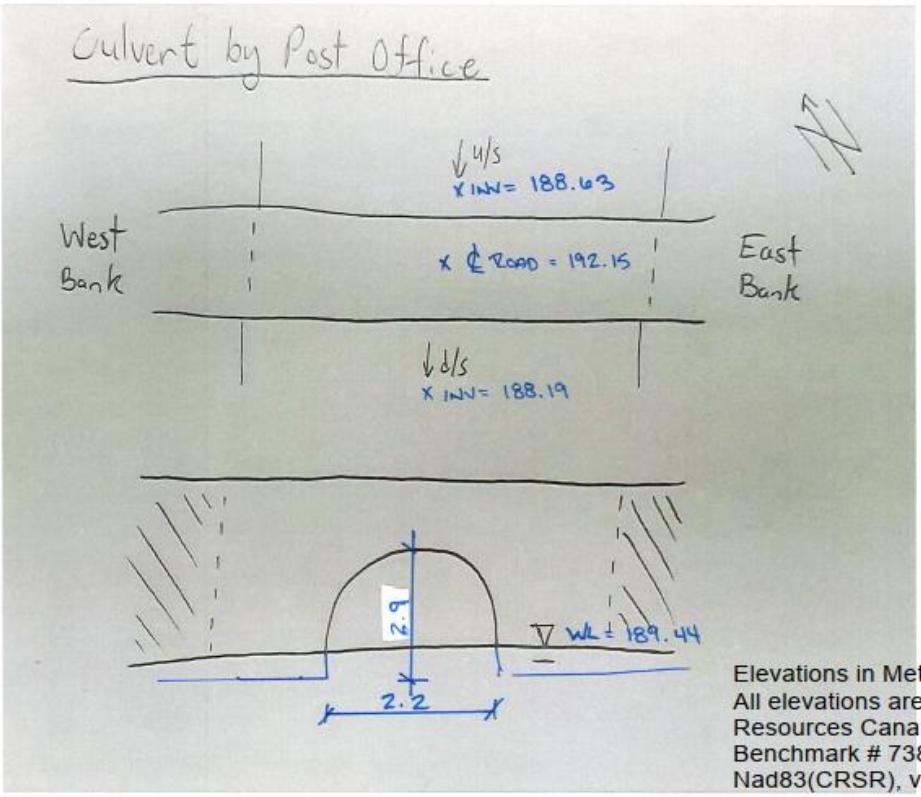
Photo 2: Downstream End of Structure

Photo 3: Looking Upstream from Structure

Photo 4: Looking Downstream from Structure

Additional Photos

Site Sketch



Elevations in Metres
All elevations are referenced to Natural Resources Cananda - High Precision 3D Benchmark # 738505, using UTM18, Nad83(CRSR), vertical datum CGVD2013

Crossing Data Sheet

Project: Salmon River Flood Mapping

Site Visit Date: August 24, 2023 **Crew:** Jamie Childs & Ethan Bowers

Structure Name: Bridge on Elm/Garrison Lake Rd

Structure Type: Vehicular Bridge

Location: UTM Grid (CSRS Zone 18, N: 4953952.0, E: 345902.6) – Salmon River

Coordinates: [44.722374, -76.945794]

Field Notes: Have to pull elevations from processed survey points. Units in meters.

Structure Data:

- Shape of abutments: Rectangular
- Width of abutments: 8.531m

Office Notes:
Top of deck elevation (obtained from survey data points): 191.249m

Bridge Material	Total Bridge Span	Deck Width	Number of Spans	Number of Piers	Measurement to Bottom of Girder
Concrete	17.657	8.531	1	0	1.33

Photo 1: Upstream End of Structure

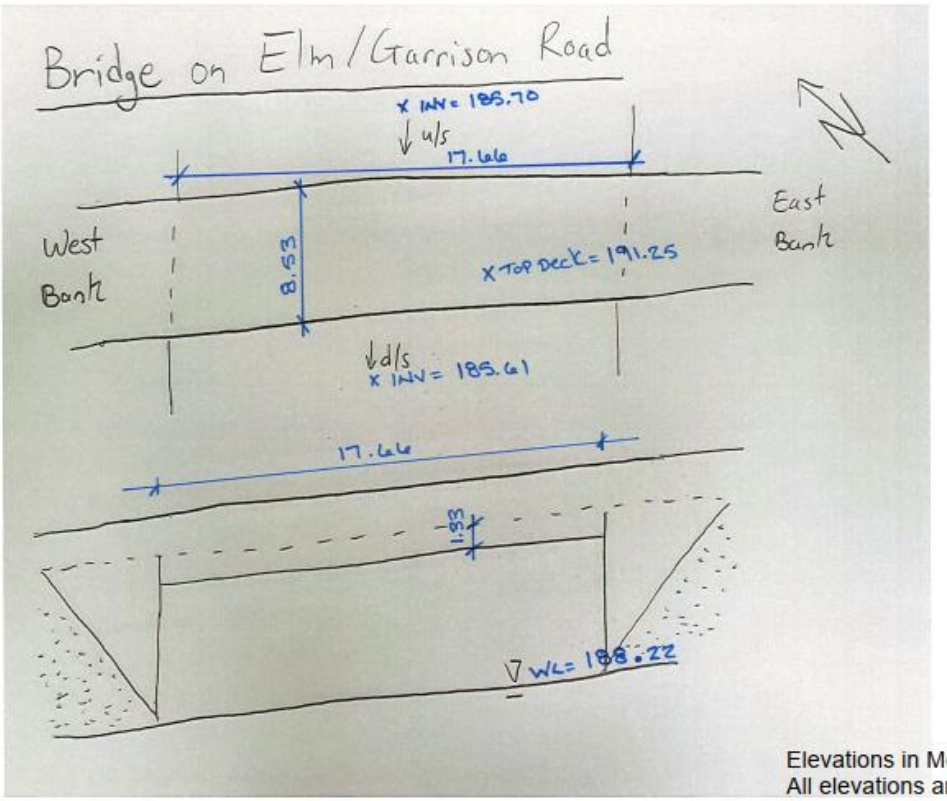
Photo 2: Downstream End of Structure

Photo 3: Looking Upstream from Structure

Photo 4: Looking Downstream from Structure

Additional Photos

Site Sketch



Elevations in Metres
All elevations are referenced to Natural Resources Cananda - High Precision 3D Benchmark # 738505, using UTM18, Nad83(CRSR), vertical datum CGVD2013

Crossing Data Sheet

Project: Salmon River Flood Mapping

Site Visit Date: August 22, 2023 **Crew:** Jamie Childs & Ethan Bowers

Structure Name: Old Railway Bridge

Structure Type: Vehicular Bridge

Location: UTM Grid (CSRS Zone 18, N: 4953481.6, E: 347191.8) – Arden Creek

Coordinates: [44.718418, -76.929383]

Field Notes:
Was an old railway bridge. Currently a vehicular bridge. Units in metres.

Additional Structure Data:

- Abutment Material: Stone
- Width of Abutments: 4.84m
- Pier Material: Wood
- Shape of Piers: Rectangular

Office Notes:
Elevations (from processed survey points):

- Top of Deck Elevation: 189.174m
- Stream Invert Elevation: 185.1m

Bridge Material	Total Bridge Span	Deck Width	Number of Spans	Number of Piers	Measurement to Bottom of Girder
Metal	5.78	3.76	1	2	0.8

Photo 1: Upstream End of Structure

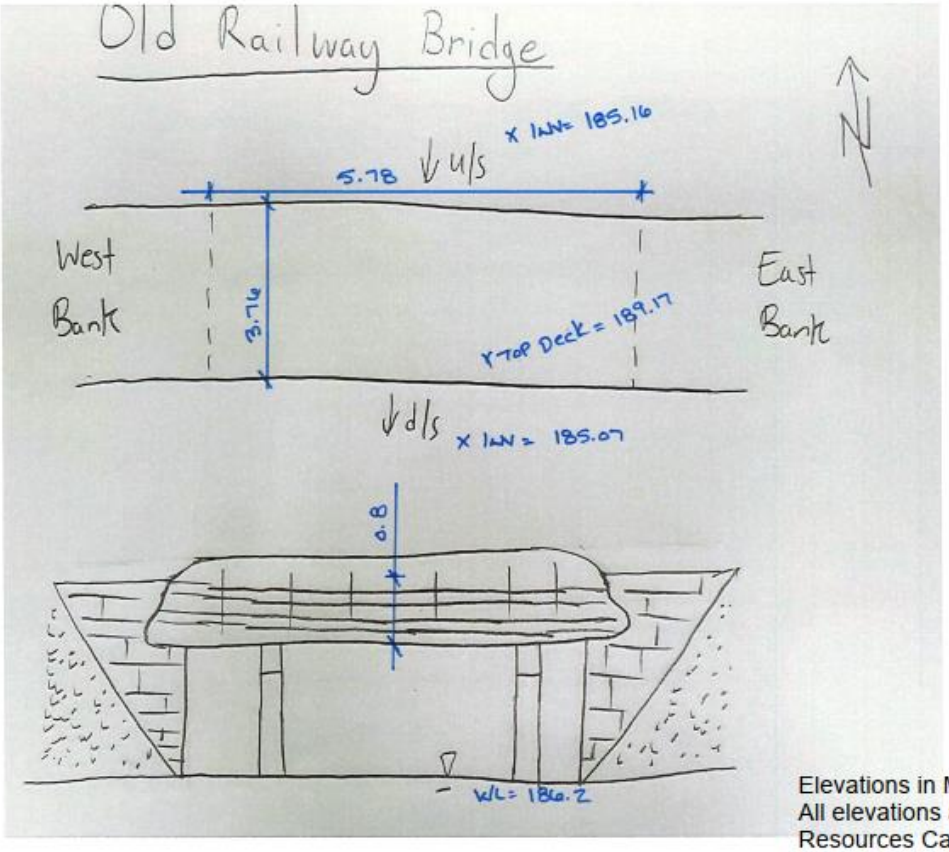
Photo 2: Downstream End of Structure

Photo 3: Looking Upstream from Structure

Photo 4: Looking Downstream from Structure

Additional Photo

Site Sketch



Elevations in Metres
All elevations are referenced to Natural Resources Cananda - High Precision 3D Benchmark # 738505, using UTM18, Nad83(CRSR), vertical datum CGVD2013

Crossing Data Sheet

Project: Salmon River Flood Mapping

Site Visit Date: August 22, 2023 **Crew:** Jamie Childs & Ethan Bowers

Structure Name: Middle Arden Dam

Structure Type: Control Structure

Location: UTM Grid (CSRS Zone 18, N: 4953926.6, E: 347549.5) – Arden Creek

Coordinates: [44.722498, -76.925002]

Field Notes: Concrete dam with stop logs. Units in metres.

Office Notes:
The dam consists of a culvert and the stoplogs are placed on its upstream face. The dam is equipped with 12 stoplogs. The culvert is 3m high, 3m wide, and 8m long.

Dimensions (obtained from GIS field survey points):

- The top of deck elevation is 195.5m (CGVD 2013).
- Width of the opening: 3.0m
- Height of the opening: 1.0m (From elevation 195.1m to 194.1m)
- Height of Dam: 3.8m
- Length of Dam: 3m

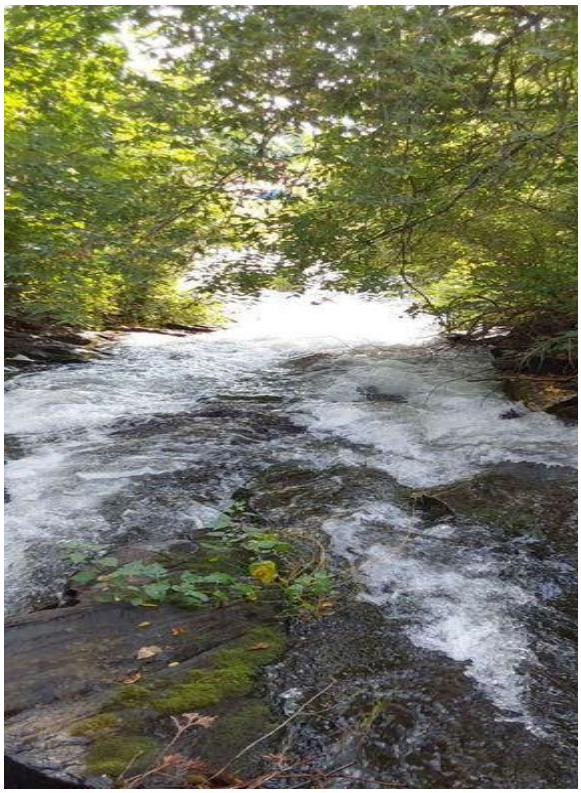
Photo 1: Upstream End of Structure

Photo 2: Downstream End of Structure

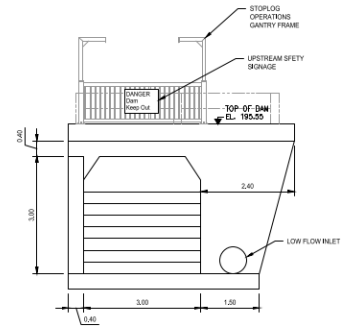
Photo 3: Looking Upstream from Structure

Photo 4: Looking Downstream from Structure

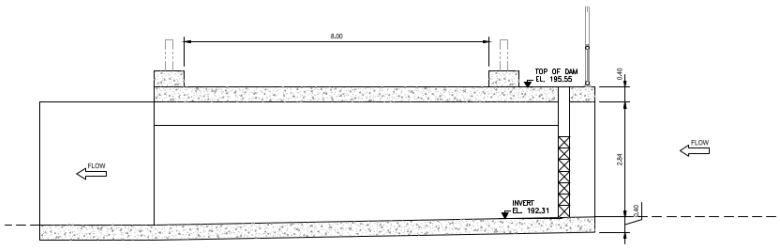
Additional Photos



Drawings



MIDDLE ARDEN DAM DOWNSTREAM ELEVATION
1:50



SECTION A–A
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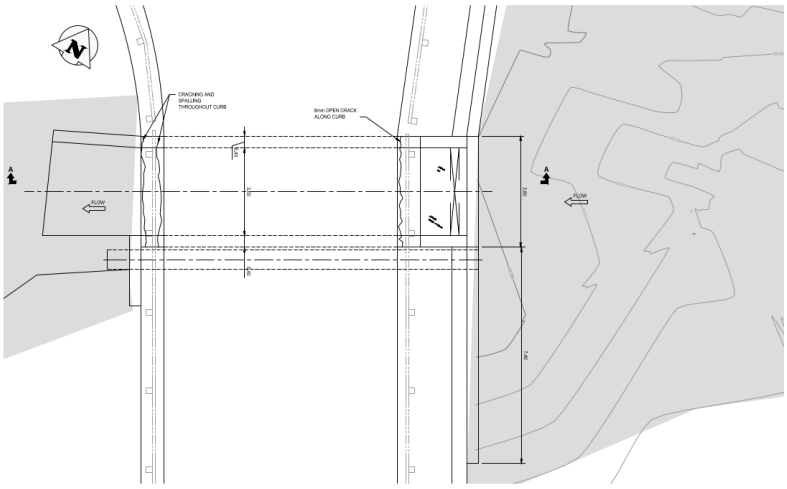


MIDDLE ARDEN DAM GENERAL ARRANGEMENT PLAN
1:50

Crossing Data Sheet

Project: Salmon River Flood Mapping

Site Visit Date: August 22, 2023 **Crew:** Jamie Childs & Ethan Bowers

Structure Name: Lower Arden Dam

Structure Type: Control Structure

Location: UTM Grid (CSRS Zone 18, N: 4953728.4, E: 347442.2) – Arden Creek

Coordinates: [44.720692, -76.926297]

Field Notes: Concrete control structure.

Office Notes:
The dam consists of a concrete weir and spillway.

Dimensions (obtained from GIS field survey points):

- The top of deck elevation is 190.1m (CGVD 2013).
- Width of the opening: 7.75m
- Height of the opening: 0.8m (From elevation 190.1m to 189.3m)
- Length of Dam: 25.5m
- Height of Dam: 2.75m

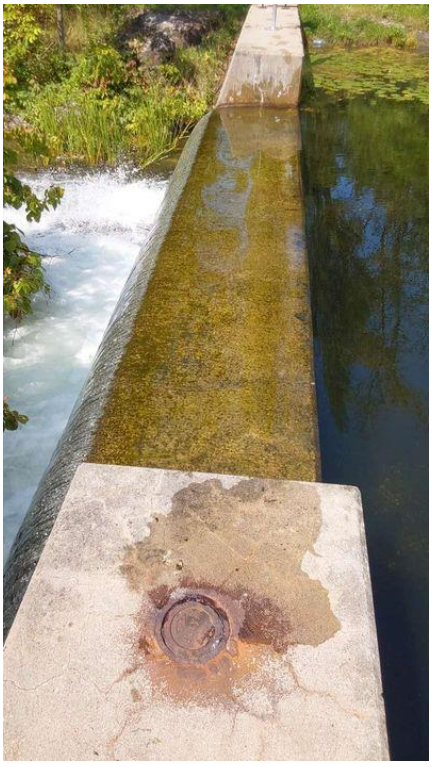
Photo 1: Upstream End of Structure

Photo 2: Downstream End of Structure

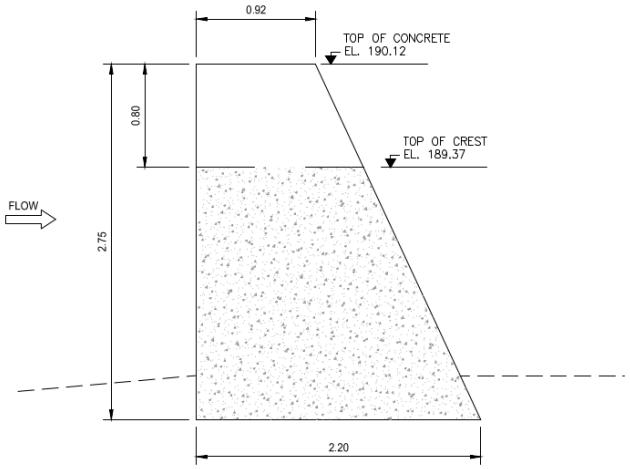
Photo 3: Looking Upstream from Structure

Photo 4: Looking Downstream from Structure

Additional Photos



Drawings



SECTION A–A
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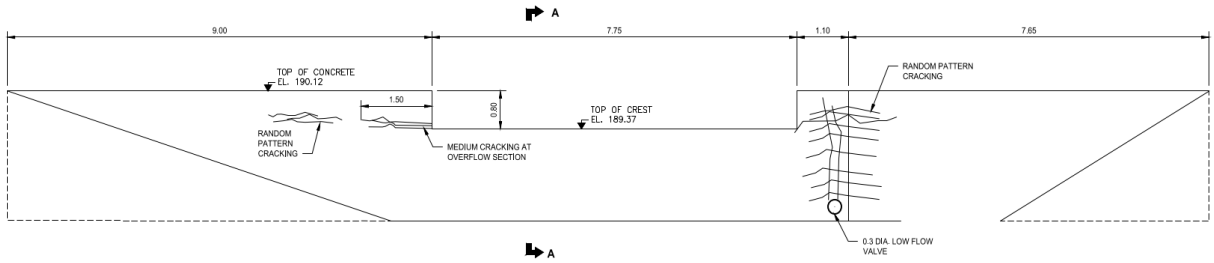
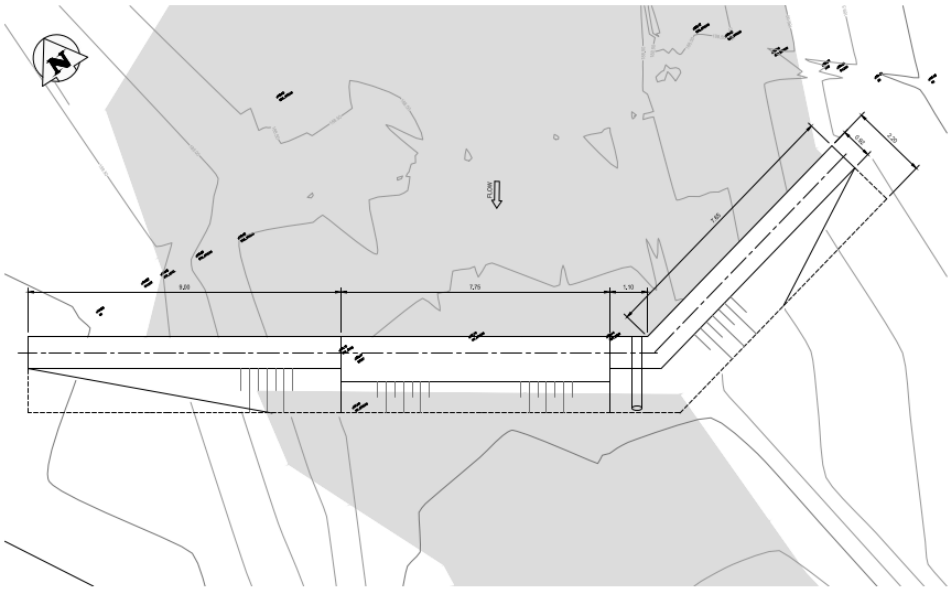


LOWER ARDEN DAM DOWNSTREAM ELEVATION
1:50



LOWER ARDEN DAM GENERAL ARRANGEMENT PLAN
1:50

Crossing Data Sheet

Project: Salmon River Flood Mapping

Site Visit Date: August 22, 2023 **Crew:** Jamie Childs & Ethan Bowers

Structure Name: Upper Arden Dam

Structure Type: Control Structure

Location: UTM Grid (CSRS Zone 18, N: 4953996.9, E: 347622.7) – Arden Creek

Coordinates: [44.723147, -76.9241]

Field Notes:
Concrete dam with stop logs. Has trash rack installed. Units in meters.

Office Notes:
The dam consists of a spillway with retaining walls.

Dimensions (obtained from GIS field survey points):

- The top of deck elevation is 196.3 (CGVD 2013).
- Width of the opening: 2.55m
- Height of the opening: 1.2m (From elevation 196.3m to 195.1m)
- Height of Dam: 1.8m
- Length of Dam: 12.1m

Photo 1: Upstream End of Structure

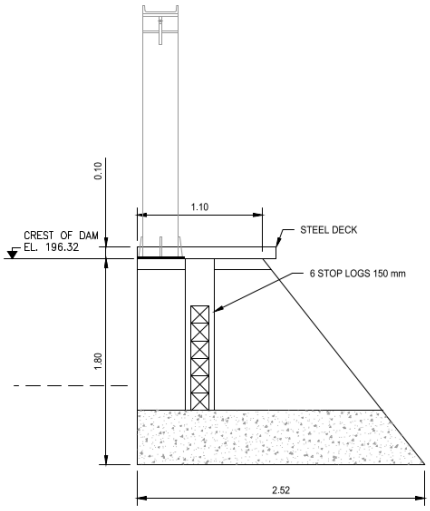
Photo 2: Downstream End of Structure

Photo 3: Looking Upstream from Structure

Photo 4: Looking Downstream from Structure

Additional Photos

Drawings



SECTION A–A
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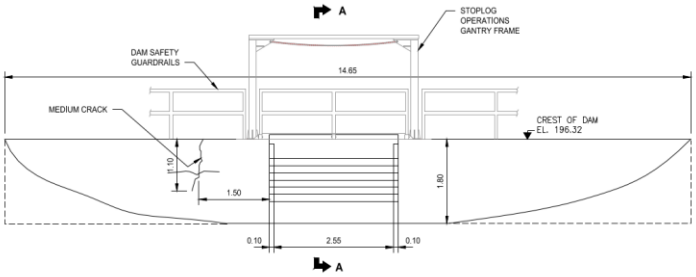
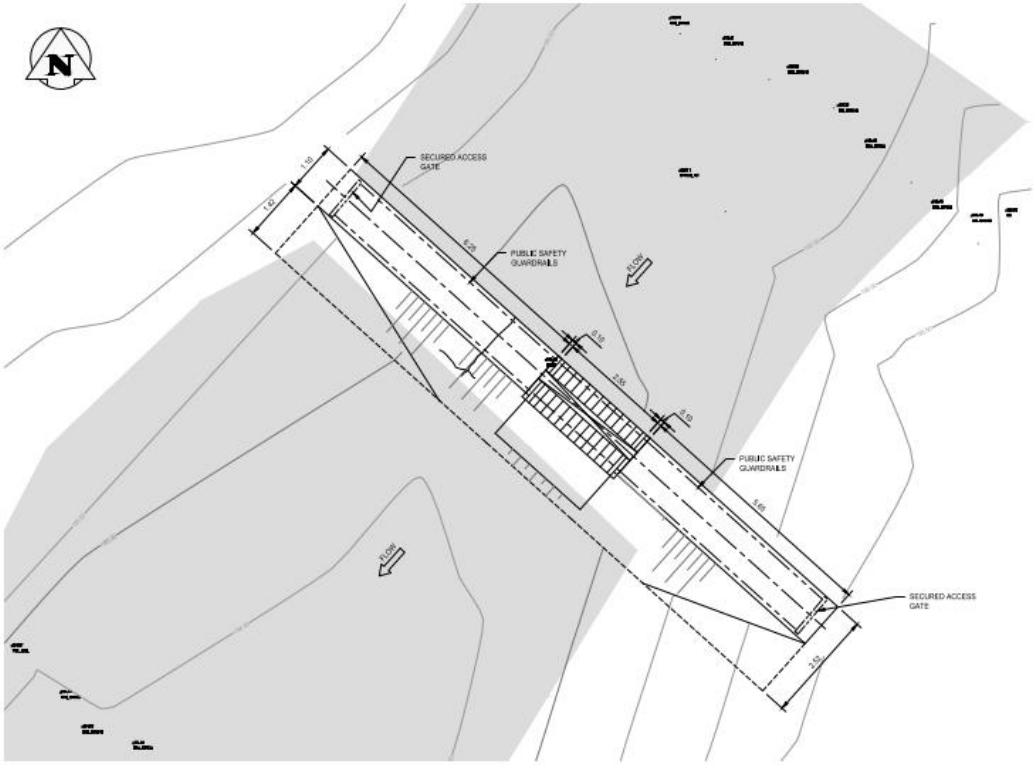


UPPER ARDEN DAM DOWNSTREAM ELEVATION
1:50



UPPER ARDEN DAM GENERAL ARRANGEMENT PLAN
1:50

Crossing Data Sheet

Project: Salmon River Flood Mapping

Site Visit Date: August 23, 2023 **Crew:** Jamie Childs & Ethan Bowers

Structure Name: Trans Canada Trail Bridge

Structure Type: Pedestrian Bridge

Location: UTM Grid (CSRS Zone 18, N: 4952969.8, E: 345108.1) – Salmon River

Coordinates: [44.713365, -76.955522]

Field Notes:
Cannot safely get cross sections. Water level shot on upstream and downstream side. Units in metres.

Structure Data:

- Width of Abutments: 7.266m
- Shape of Abutments: Rectangular
- Abutment Material: Concrete

Office Notes:
Top of Deck Elevation (from processed survey data points): 192.429m

Bridge Material	Total Bridge Span	Deck Width	Number of Spans	Number of Piers	Measurement to Bottom of Girder
Metal	24.71	4.00	1	0	2.54

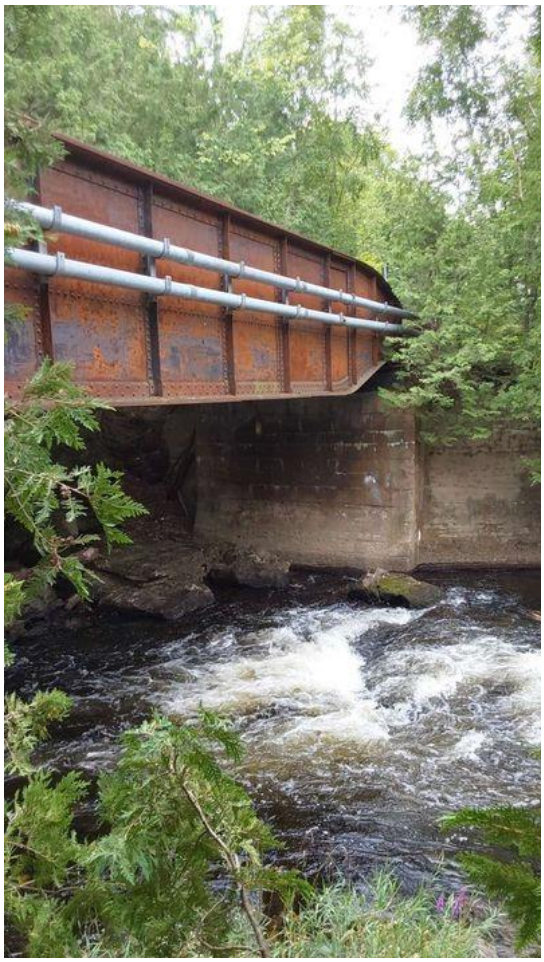
Photo 1: Upstream End of Structure

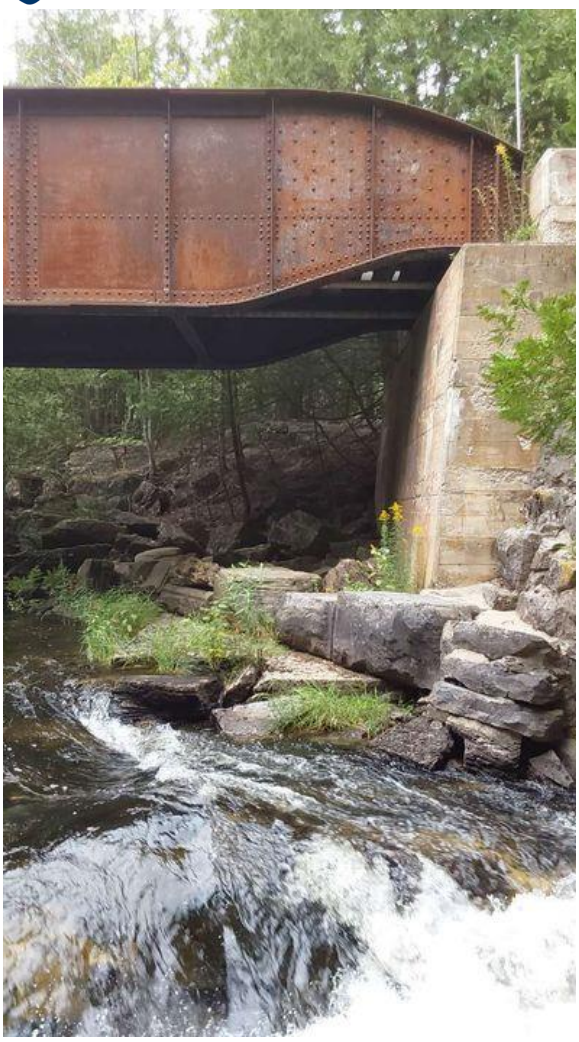
Photo 2: Downstream End of Structure

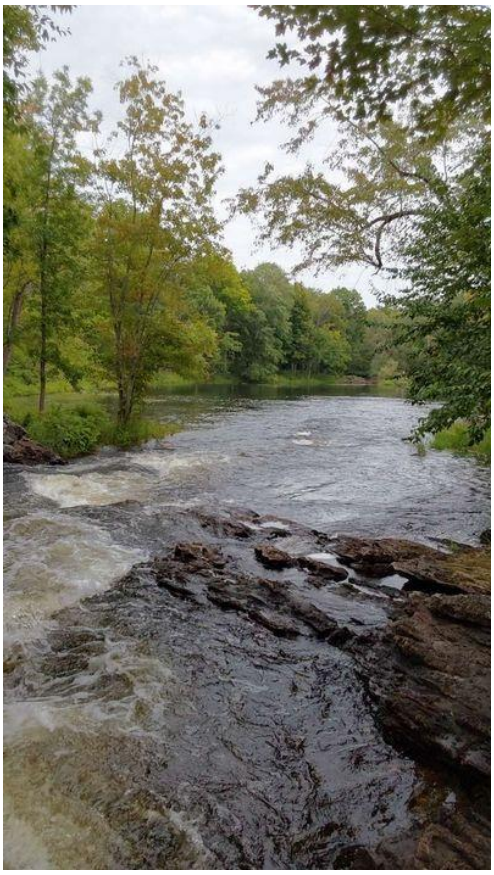
Photo 3: Looking Upstream from Structure

Photo 4: Looking Downstream from Structure

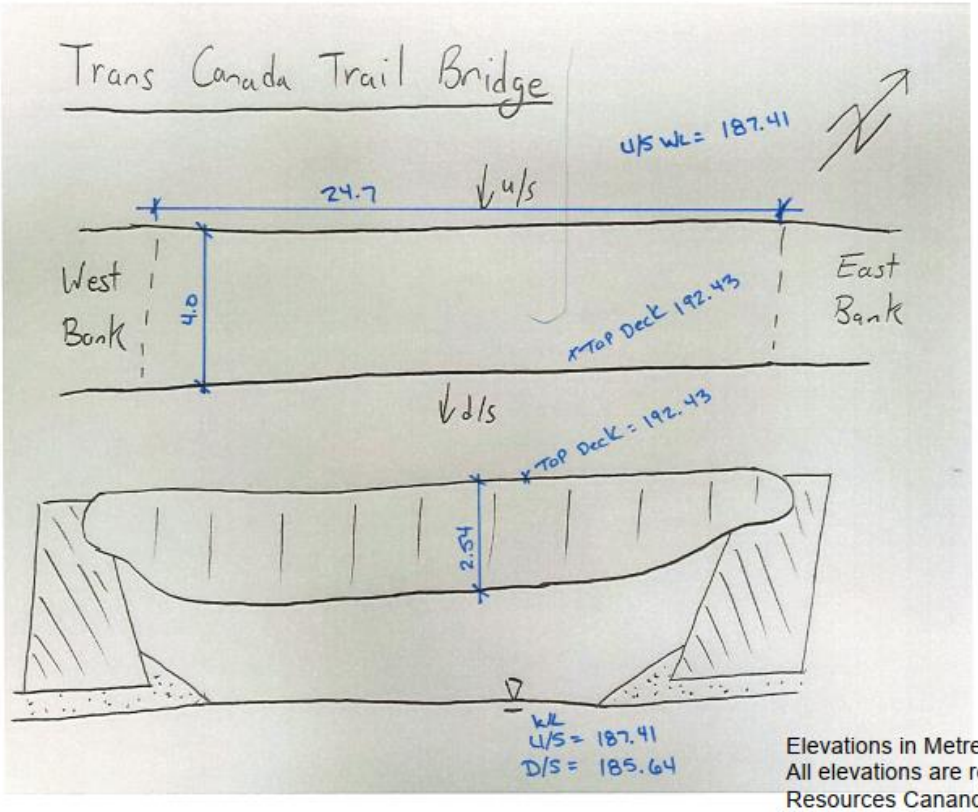
Additional Photos







Site Sketch



Elevations in Metres
All elevations are referenced to Natural Resources Cananda - High Precision 3D Benchmark # 738505, using UTM18, Nad83(CRSR), vertical datum CGVD2013

Crossing Data Sheet

Project: Salmon River Flood Mapping

Site Visit Date: August 24, 2023 **Crew:** Jamie Childs & Ethan Bowers

Structure Name: Highway 7 Bridge

Structure Type: Vehicular Bridge

Location: UTM Grid (CSRS Zone 18, N: 4955751.1, E: 346731.3) – Salmon River

Coordinates: [44.738738, -76.935875]

Field Notes: Hwy 7 Bridge crossing Upper Salmon River. Units in metres.

Structure Data:

- Width of Abutments: 11.74
- Shape of Abutments: Rectangular

Office Notes:
Top of Deck Elevation (from processed survey points): 192.216m

Bridge Material	Total Bridge Span	Deck Width	Number of Spans	Number of Piers	Measurement to Bottom of Girder
Concrete	30.97	11.74	1	0	1.30

Photo 1: Upstream End of Structure

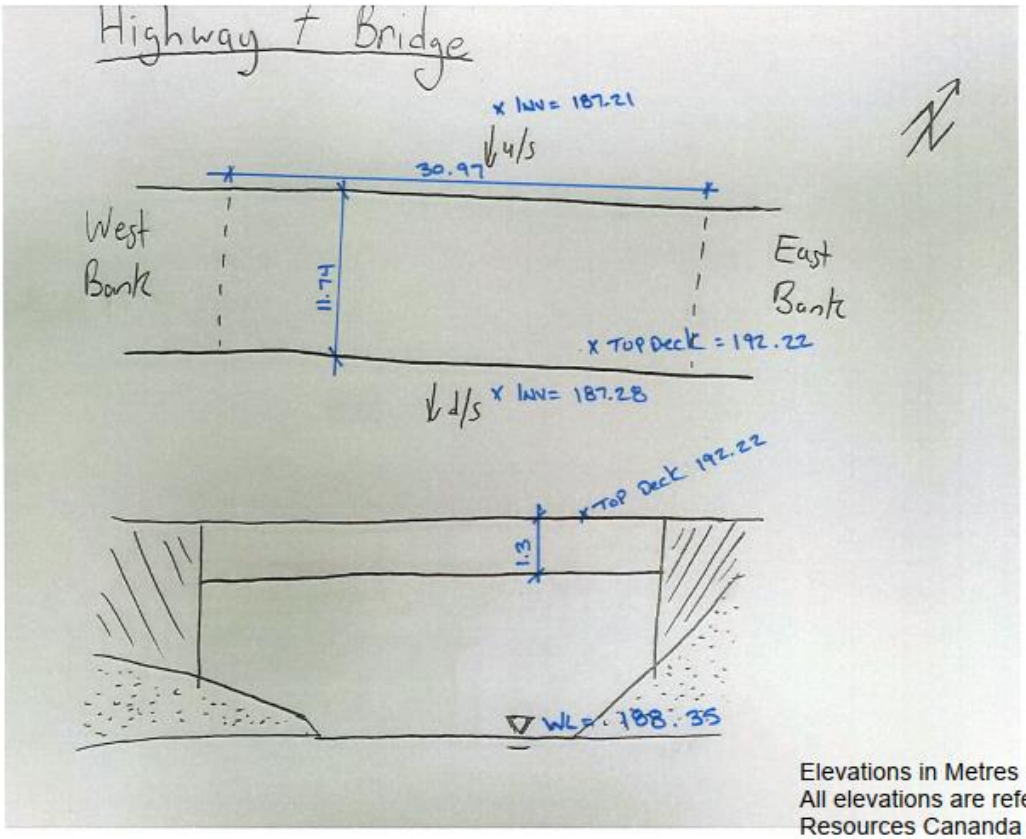
Photo 2: Downstream End of Structure

Photo 3: Looking Upstream from Structure

Photo 4: Looking Downstream from Structure

Additional Photos

Site Sketch



Elevations in Metres
All elevations are referenced to Natural Resources Cananda - High Precision 3D Benchmark # 738505, using UTM18, Nad83(CRSR), vertical datum CGVD2013

Crossing Data Sheet

Project: Salmon River Flood Mapping

Site Visit Date: August 23, 2023 **Crew:** Jamie Childs & Ethan Bowers

Structure Name: Bridge on Cranberry Lake Rd

Structure Type: Vehicular Bridge

Location: UTM Grid (CSRS Zone 18, N: 4947776.9, E: 344597.5) – Salmon River

Coordinates: [44.666534, -76.960388]

Field Notes:
Units in meters.
Width of abutments: 5.493m
Shape of abutments: Rectangular

Top of deck elevation (from GIS survey points): 188.197m

Bridge Material	Total Bridge Span	Deck Width	Number of Spans	Number of Piers	Measurement to Bottom of Girder
Concrete	11.992	4.548	1	0	0

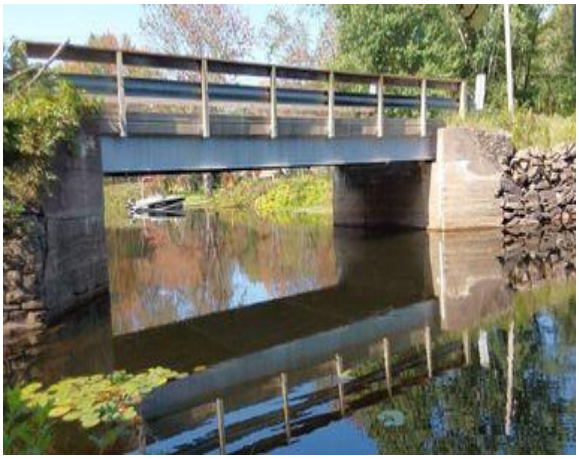


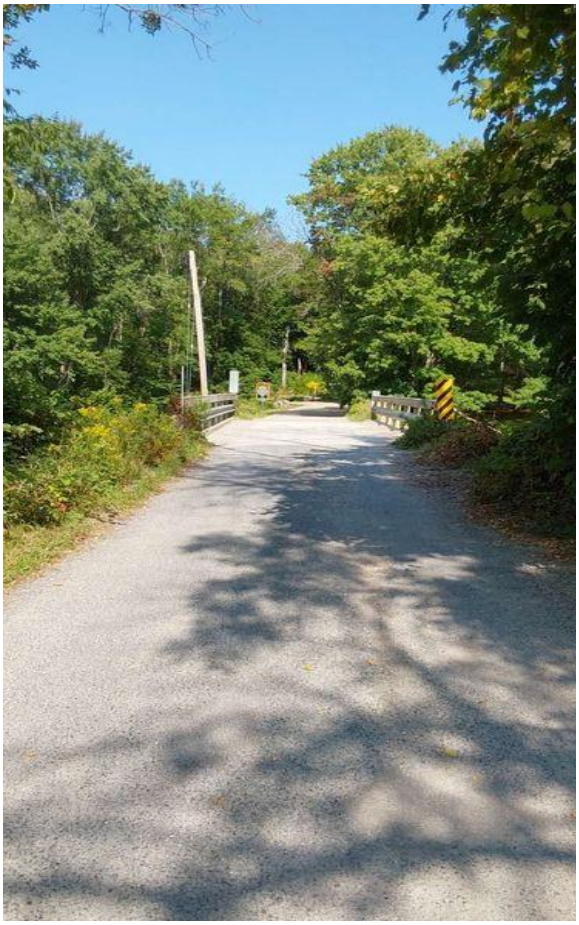
Photo 1: Upstream End of Structure

Photo 2: Downstream End of Structure

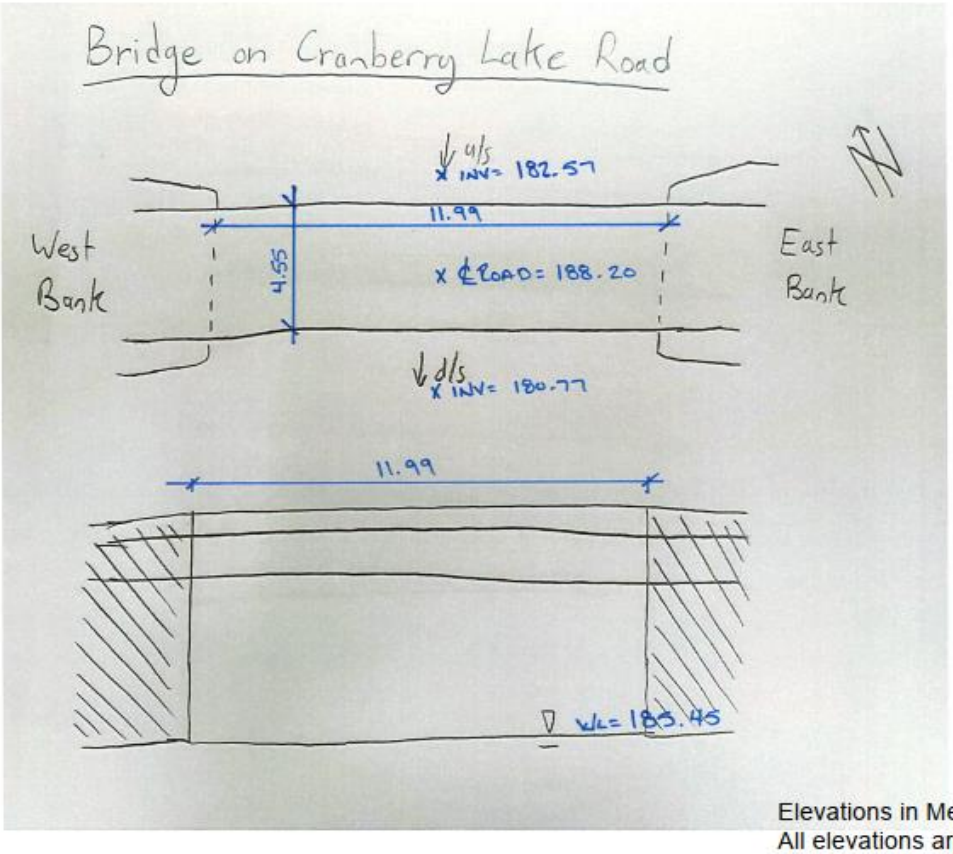
Photo 3: Looking Upstream from Structure

Photo 4: Looking Downstream from Structure

Additional Photos



Site Sketch

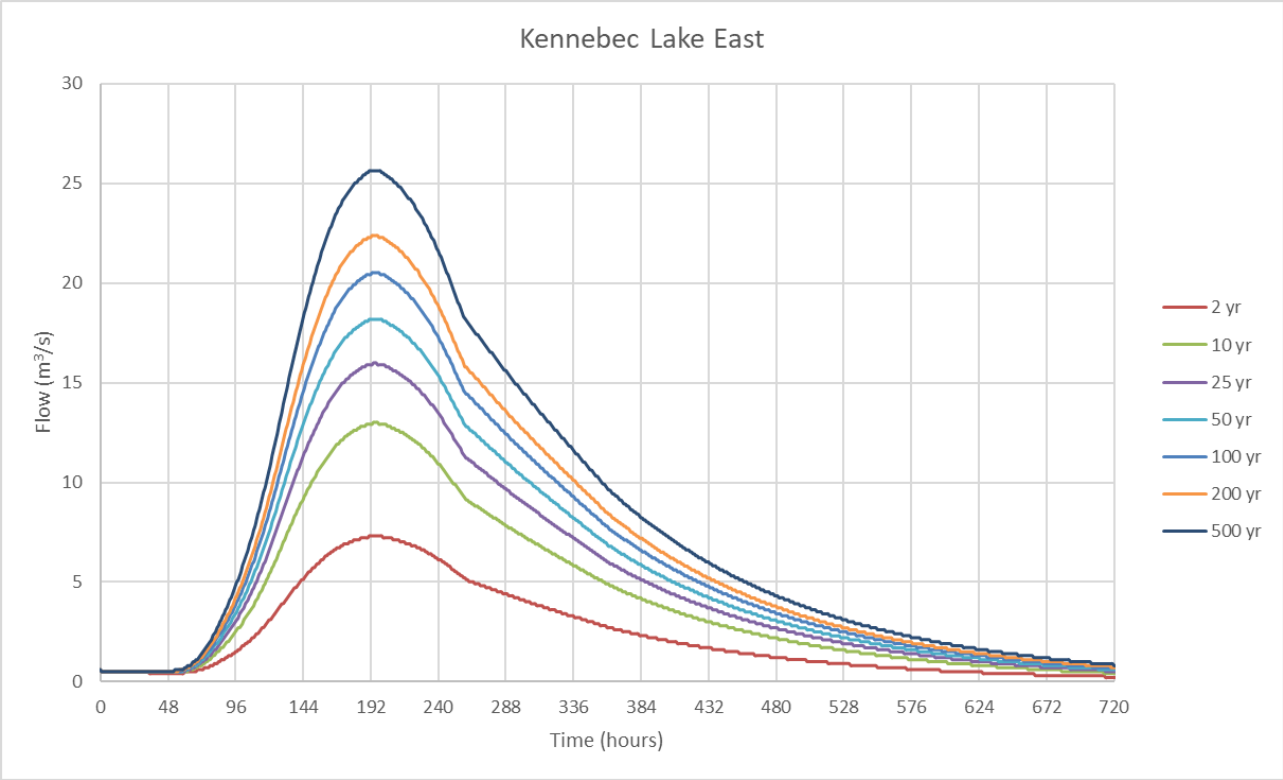


Elevations in Metres
All elevations are referenced to Natural Resources Cananda - High Precision 3D Benchmark # 738505, using UTM18, Nad83(CRSR), vertical datum CGVD2013

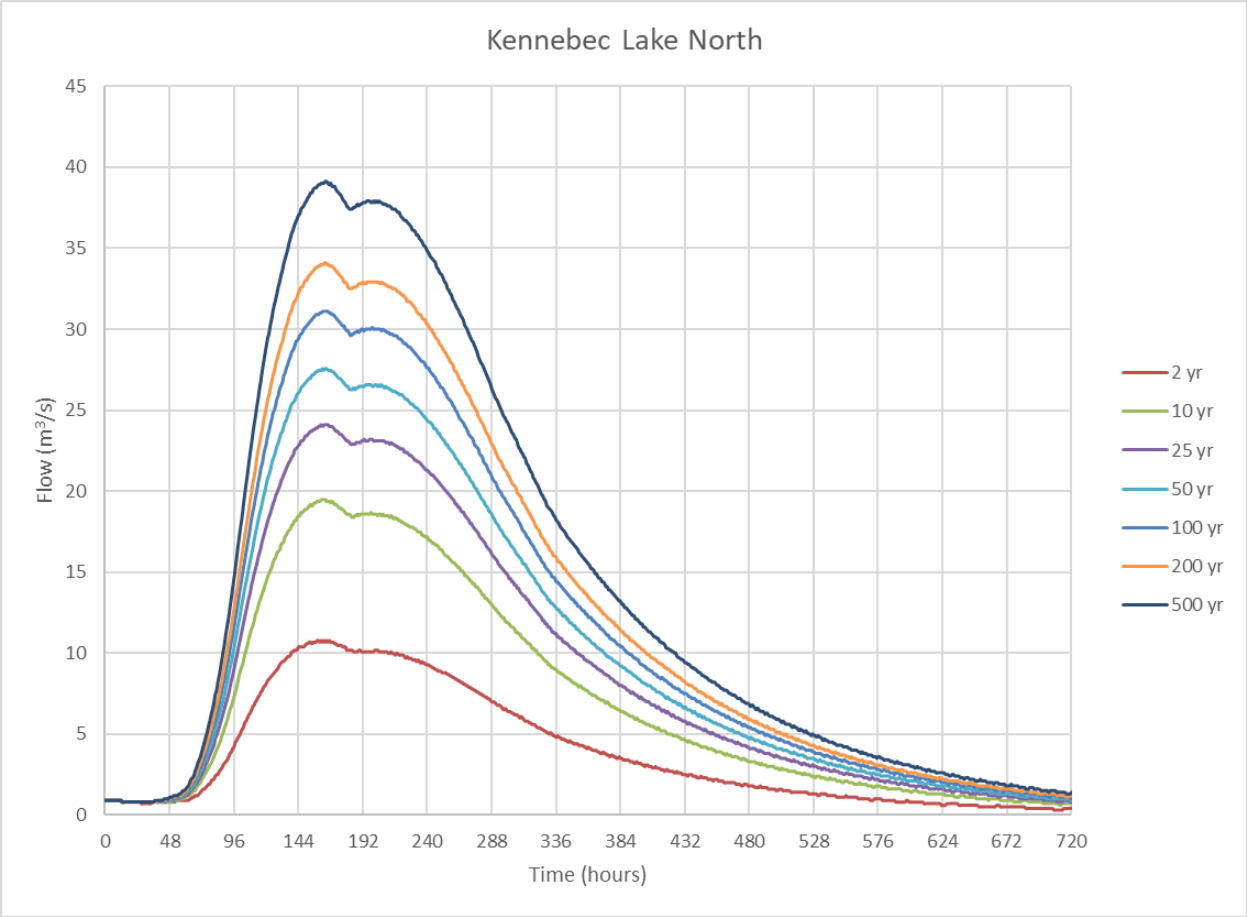
APPENDIX B

Inflow Hydrographs

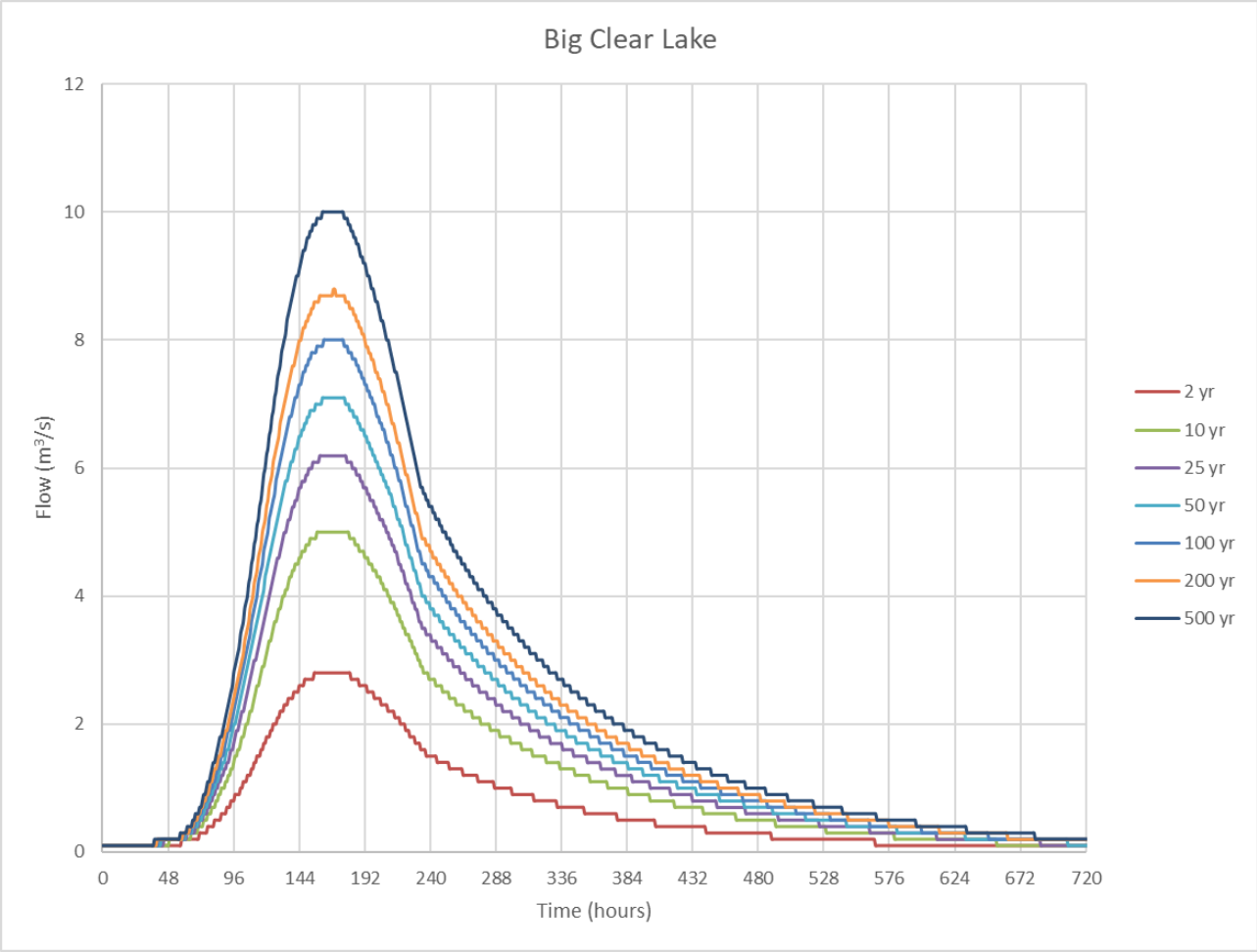
Hydrographs for Kennebec Lake East



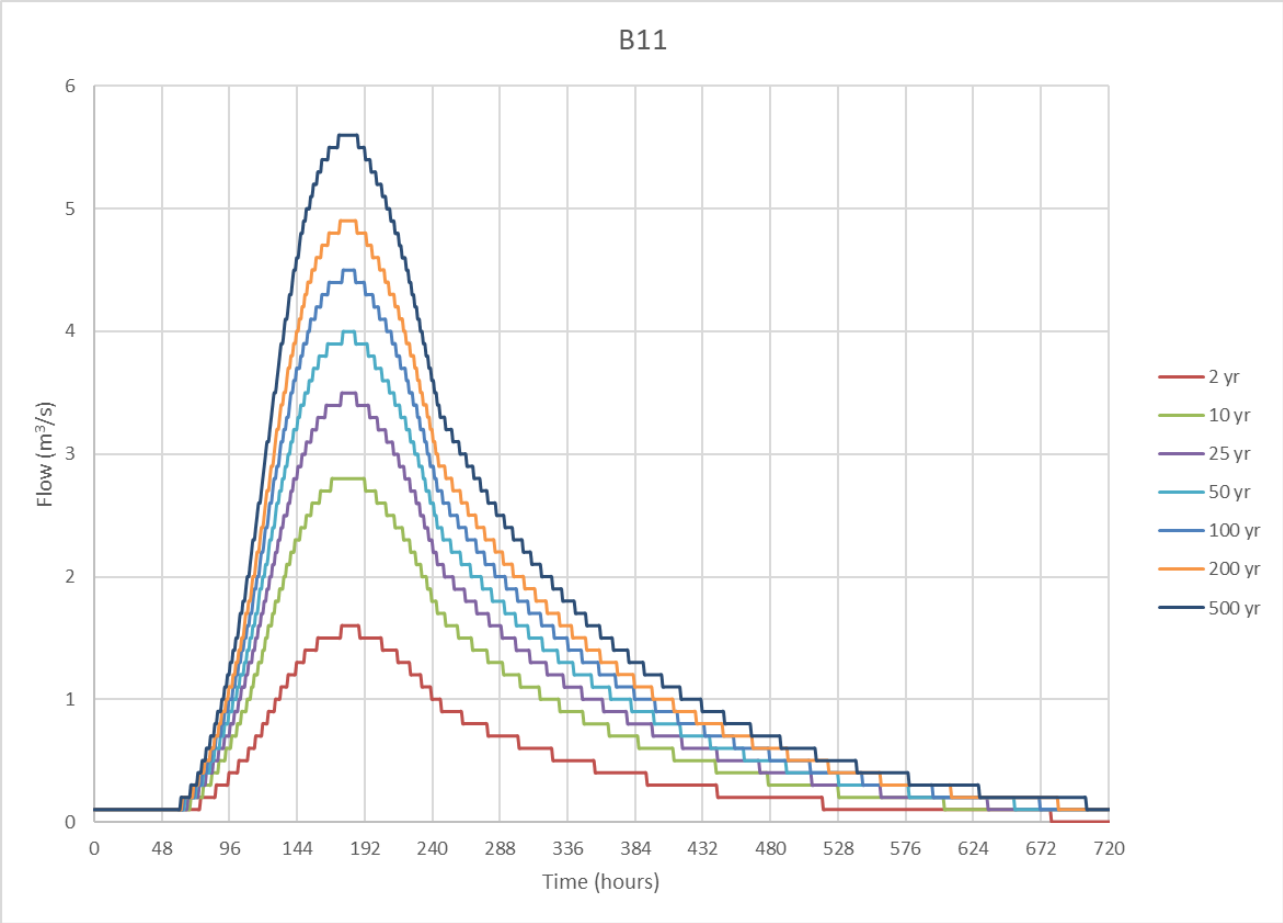
Hydrographs for Kennebec Lake North



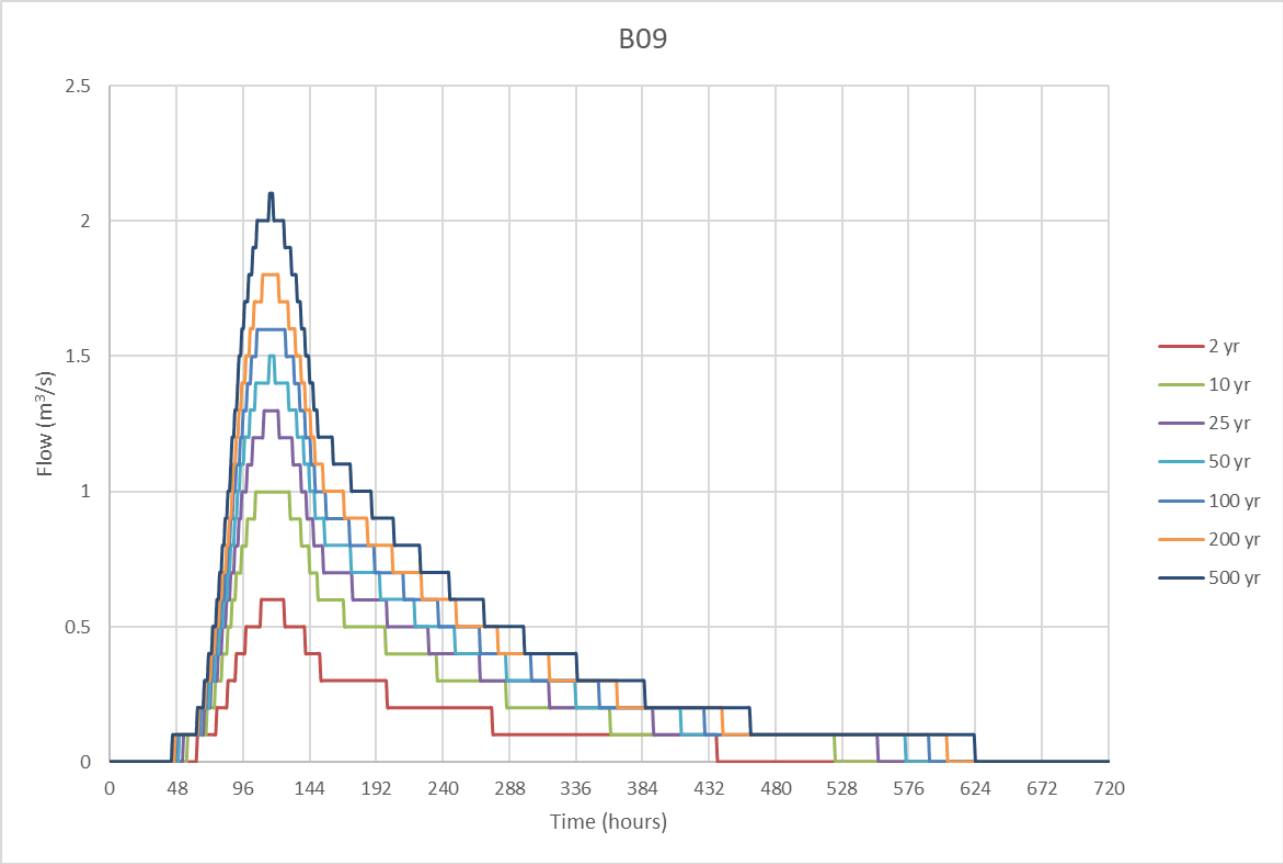
Hydrographs for Big Clear Lake



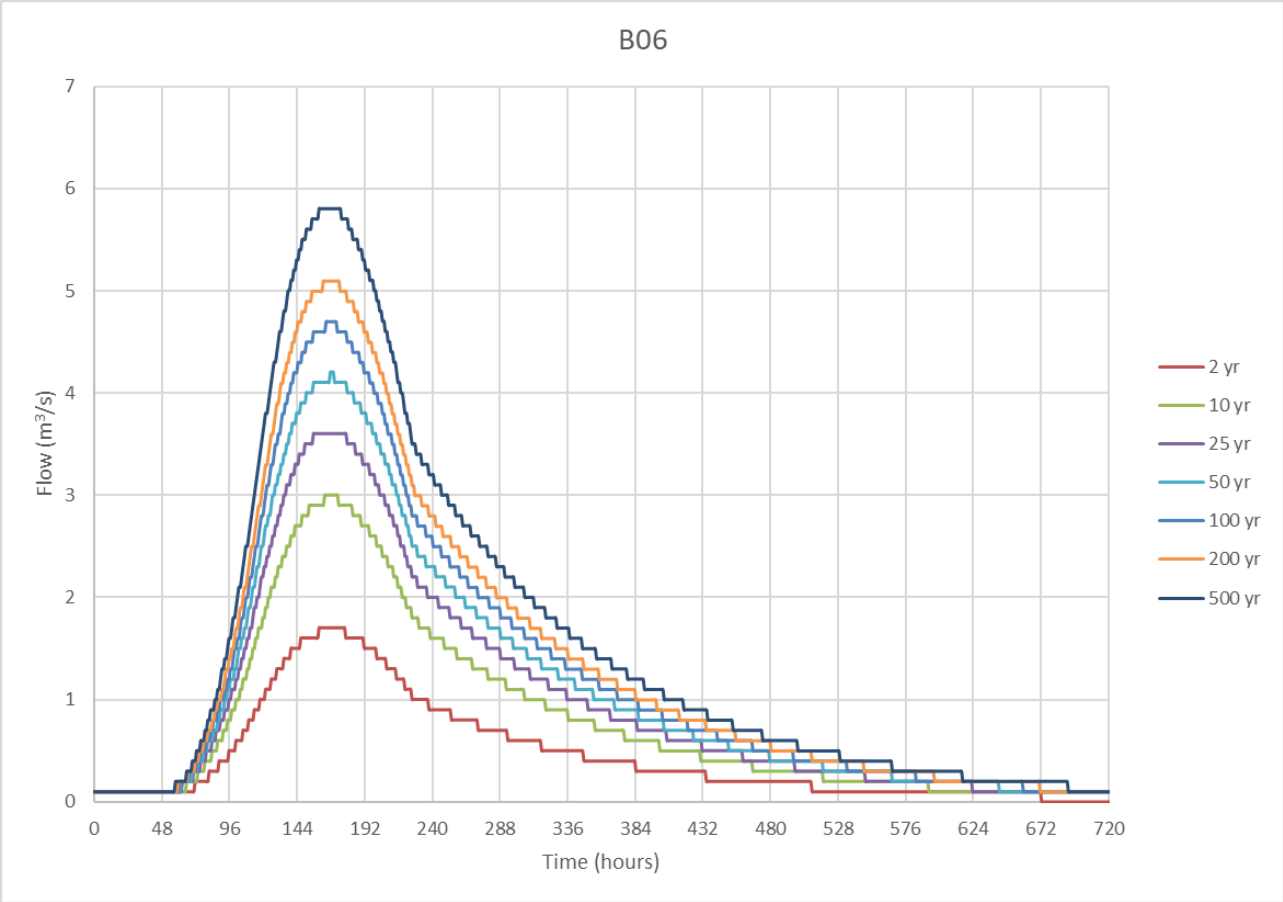
Hydrographs for B11



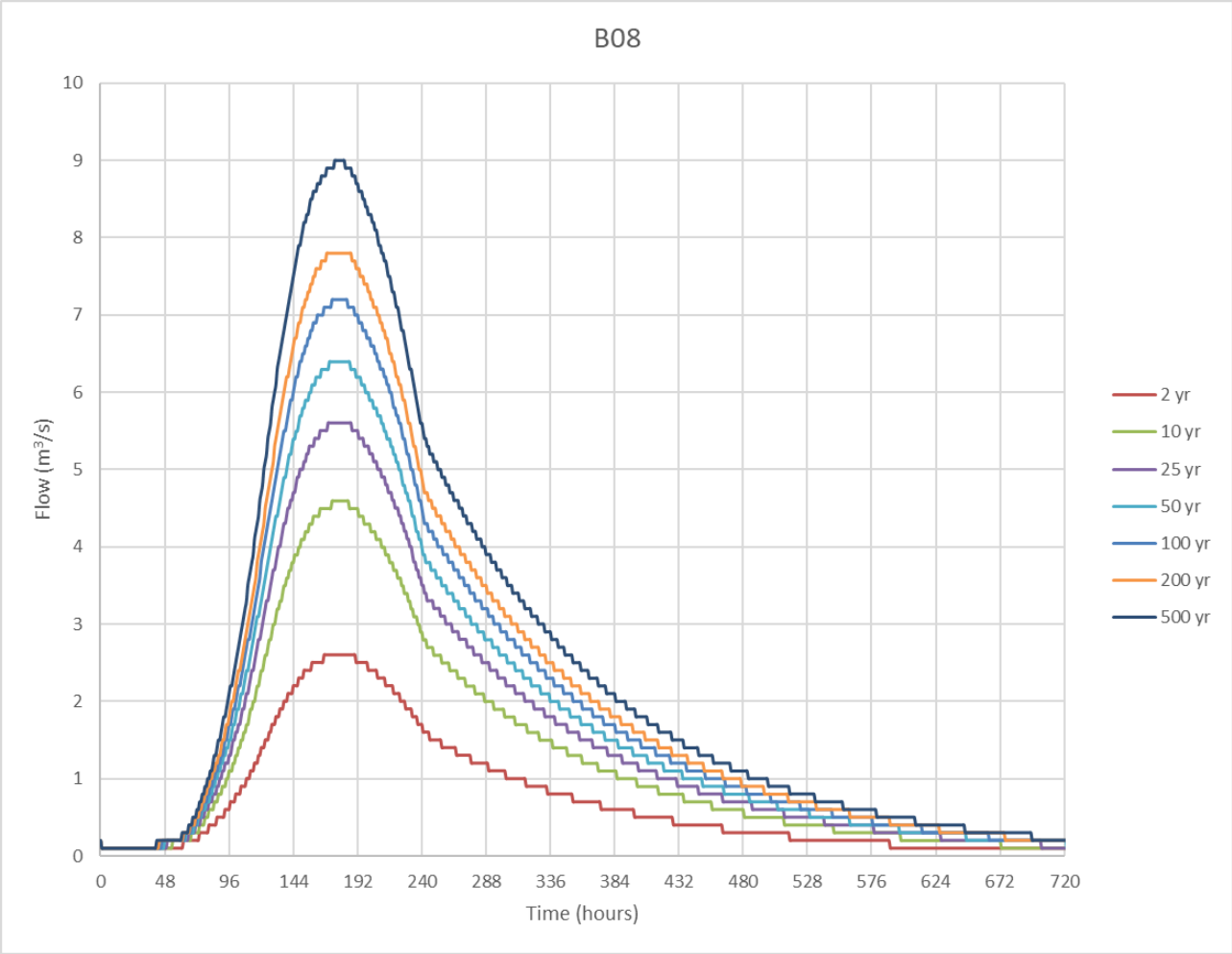
Hydrographs for B09



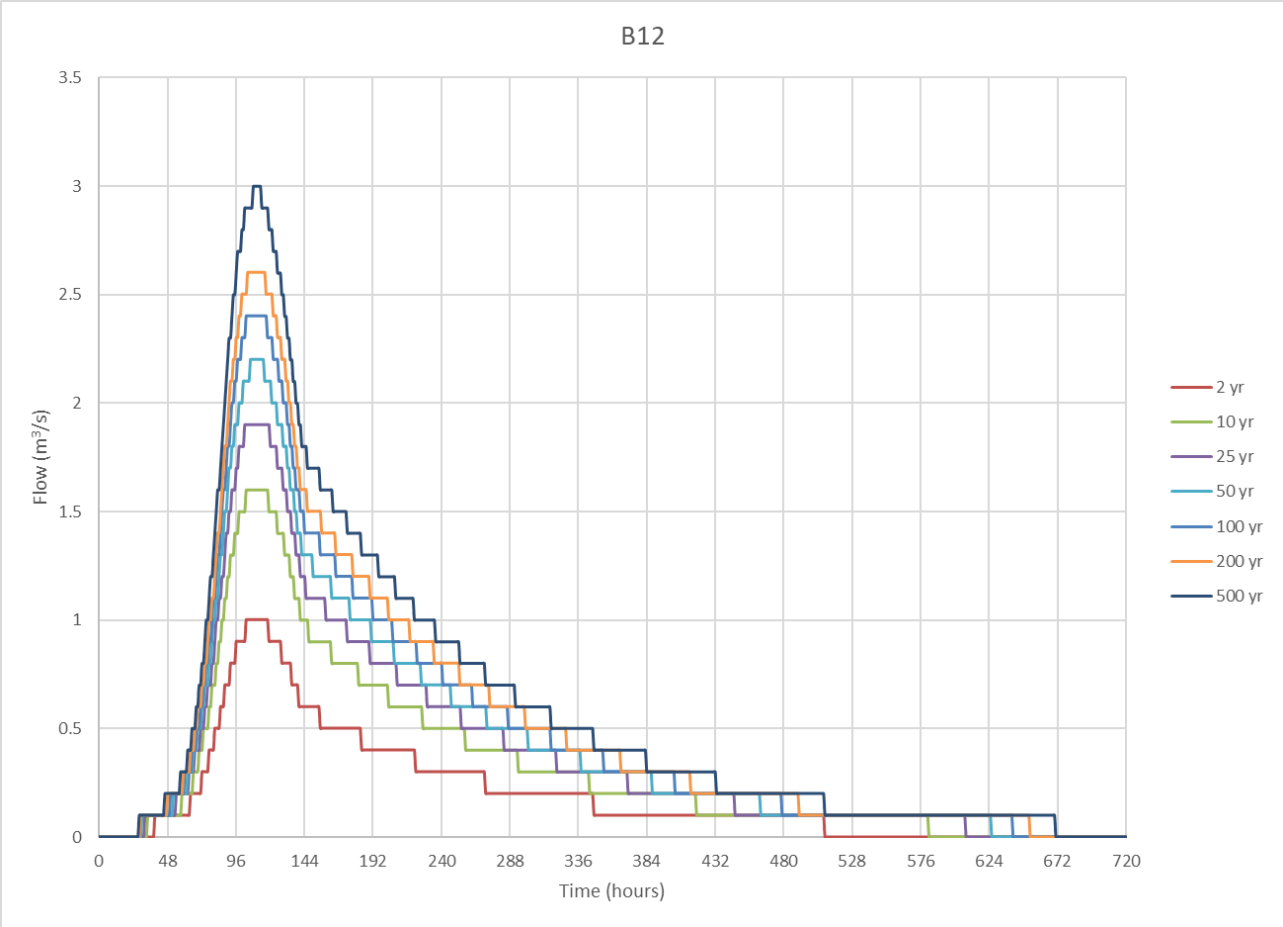
Hydrographs for B06



Hydrographs for B08



Hydrographs for B12



APPENDIX C

1D Model Results

Summary for 10YR Storm Event

Reach	River Station	Profile	Q Total (m^3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m^2)	Top Width (m)	Froude # Chl
Arden	1353	10JAN2000 0500	3.49	195.42	196.53		196.53	0.000164	0.22	16.08	20.3	0.08
Arden	1324	10JAN2000 0500	3.49	195.41	196.5		196.52	0.001025	0.48	7.21	10.54	0.19
Arden	1284	10JAN2000 0500	3.49	195.39	196.49		196.49	0.000255	0.27	13.11	16.89	0.1
Arden	1262	10JAN2000 0500	3.49	195.32	196.49		196.49	0.000012	0.11	32.44	34.7	0.04
Arden	1224	10JAN2000 0500	3.49	195.37	196.49		196.49	0.000016	0.12	29.14	34.83	0.04
Arden	1173	10JAN2000 0500	3.49	195.34	196.49		196.49	0.000013	0.11	31.34	38.15	0.04
Arden	1143	10JAN2000 0500	3.49	195.43	196.48		196.49	0.000117	0.29	12.1	17.63	0.11
Arden	1133	10JAN2000 0500	3.49	195.39	196.48		196.48	0.000153	0.37	10.13	14.48	0.13
Arden	1130	10JAN2000 0500	3.49	195.27	196.48	195.81	196.48	0.00012	0.34	10.85	13.52	0.11
Arden	1125		Inl Struct									
Arden	1122	10JAN2000 0500	3.49	194.46	194.85	194.96	195.23	0.045116	2.72	1.28	5.22	1.76
Arden	1117	10JAN2000 0500	3.49	194.18	194.73		194.85	0.008381	1.54	2.27	6.19	0.81
Arden	1109	10JAN2000 0500	3.49	194.1	194.69		194.72	0.002144	0.8	4.38	11.66	0.42
Arden	1087	10JAN2000 0500	3.49	194.09	194.59		194.65	0.005358	1.09	3.19	10.5	0.63
Arden	1058	10JAN2000 0500	3.49	192.95	194.52		194.52	0.000002	0.05	74.81	66.75	0.01
Arden	1026	10JAN2000 0500	3.49	192.96	194.52		194.52	0.000031	0.18	19.39	19.73	0.06
Arden	1011	10JAN2000 0500	3.49	193.42	194.51		194.52	0.000403	0.57	6.34	8.82	0.2
Arden	1007	10JAN2000 0500	3.49	193.42	194.5	193.9	194.52	0.000416	0.64	5.79	8.81	0.21
Arden	1006		Inl Struct									
Arden	1004	10JAN2000 0500	3.49	191.95	192.77		192.81	0.003316	0.96	3.71	7.08	0.4
Arden	996	10JAN2000 0500	3.49	191.95	192.17	192.48	194.72	1.135033	7.08	0.49	3.53	6.06
Arden	965	10JAN2000 0500	3.49	189.26	190.39		190.4	0.000342	0.37	9.31	12.24	0.14
Arden	939	10JAN2000 0500	3.49	189.25	190.39		190.39	0.000168	0.29	11.9	20.95	0.12
Arden	919	10JAN2000 0500	3.49	189.19	190.39		190.39	0.000129	0.31	11.64	20.41	0.11
Arden	900	10JAN2000 0500	3.49	188.7	190.39		190.39	0.000048	0.25	14.36	13.92	0.07
Arden	893	10JAN2000 0500	3.49	188.76	190.38		190.39	0.000109	0.33	10.46	10.31	0.11
Arden	890	10JAN2000 0500	3.49	188.87	190.36		190.39	0.000515	0.87	4.02	6.63	0.24
Arden	888		Culvert									
Arden	887	10JAN2000 0500	3.49	189.06	189.76	189.81	190.09	0.015879	2.59	1.44	3.8	1.14
Arden	883	10JAN2000 0500	3.49	188.46	189.72		189.73	0.000275	0.48	7.44	10.2	0.16
Arden	865	10JAN2000 0500	3.49	188.2	189.72		189.72	0.000046	0.24	15.72	20.38	0.07
Arden	835	10JAN2000 0500	3.49	188.18	189.72		189.72	0.000035	0.22	17.63	24.78	0.06
Arden	817	10JAN2000 0500	3.49	188.05	189.72		189.72	0.000013	0.15	24.96	27.65	0.04
Arden	801	10JAN2000 0500	3.49	188.15	189.72		189.72	0.000016	0.17	25.11	25.46	0.05

Reach	River Station	Profile	Q Total (m^3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m^2)	Top Width (m)	Froude # Chl
Arden	796	10JAN2000 0500	3.49	188.53	189.71	188.91	189.72	0.000135	0.41	8.97	20.54	0.12
Arden	790		Inl Struct									
Arden	789	10JAN2000 0500	3.49	187.01	187.32	187.5	188	0.105369	3.63	0.96	4.87	2.61
Arden	779	10JAN2000 0500	3.49	186.25	186.91		186.93	0.001297	0.7	4.98	10.96	0.33
Arden	762	10JAN2000 0500	3.49	186.17	186.9		186.92	0.000641	0.5	7.02	15.36	0.23
Arden	736	10JAN2000 0500	3.49	186.2	186.89		186.9	0.000699	0.52	10.45	43.89	0.25
Arden	704	10JAN2000 0500	3.49	186.23	186.88		186.88	0.000403	0.42	15.81	57.28	0.19
Arden	627	10JAN2000 0500	3.49	186.22	186.86		186.86	0.00013	0.21	28.59	64.21	0.1
Arden	588	10JAN2000 0500	3.49	186.22	186.82		186.85	0.001653	0.77	6.76	28.83	0.37
Arden	549	10JAN2000 0500	3.49	185.87	186.78		186.8	0.000707	0.67	5.9	24.04	0.26
Arden	531	10JAN2000 0500	3.49	186.01	186.74		186.81	0.002915	1.11	3.41	16.72	0.5
Arden	495	10JAN2000 0500	3.49	185.88	186.69		186.71	0.001051	0.7	5.52	23.15	0.31
Arden	474	10JAN2000 0500	3.49	185.9	186.68		186.69	0.000458	0.51	9.68	32.88	0.21
Arden	434	10JAN2000 0500	3.5	185.93	186.67		186.68	0.000401	0.51	11.54	32.1	0.2
Arden	388	10JAN2000 0500	3.52	185.96	186.61		186.64	0.001554	0.81	4.76	11.52	0.37
Arden	371	10JAN2000 0500	3.54	185.82	186.6		186.62	0.000917	0.79	6.81	17.44	0.3
Arden	347	10JAN2000 0500	3.55	186.01	186.55	186.53	186.73	0.009737	1.91	2.03	5.85	0.91
Arden	317	10JAN2000 0500	3.57	185.82	186.49		186.51	0.000863	0.72	4.98	8	0.29
Arden	310		Culvert									
Arden	308	10JAN2000 0500	3.57	185.93	186.32		186.4	0.005439	1.24	2.89	8.25	0.66
Arden	284	10JAN2000 0500	3.54	185.78	186.26		186.3	0.003108	0.88	4.02	12.28	0.49
Arden	275	10JAN2000 0500	3.52	185.41	186.24		186.25	0.000394	0.5	7.56	20.14	0.2
Arden	271	10JAN2000 0500	3.51	185.35	186.24		186.25	0.000369	0.48	10.63	96.43	0.19
Arden	260	10JAN2000 0500	3.5	185.31	186.22	185.82	186.25	0.001107	0.77	4.57	7.48	0.31
Arden	255		Bridge									
Arden	252	10JAN2000 0500	3.5	185.15	186.23		186.24	0.000528	0.57	6.12	8.86	0.22
Arden	234	10JAN2000 0500	3.5	185.29	186.23		186.24	0.000254	0.39	14.07	92.41	0.16
Arden	168	10JAN2000 0500	3.49	185.35	186.22		186.23	0.000195	0.26	29.86	212.35	0.13
Arden	115	10JAN2000 0500	3.49	185.32	186.22		186.22	0.000096	0.26	24.12	126.81	0.1
Arden	68	10JAN2000 0500	3.49	185.38	186.21		186.21	0.000368	0.45	16.85	110.54	0.19
Arden	8	10JAN2000 0500	3.49	185.14	186.2	185.32	186.2	0.000004	0.04	86.93	199.76	0.02

Summary for 100YR Storm Event

Reach	River Station	Profile	Q Total (m^3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m^2)	Top Width (m)	Froude # Chl
Arden	1353	10JAN2000 0500	5.59	195.42	196.67		196.67	0.00025	0.3	18.96	21.64	0.1
Arden	1324	10JAN2000 0500	5.59	195.41	196.63		196.65	0.001611	0.65	8.55	11.34	0.24
Arden	1284	10JAN2000 0500	5.59	195.39	196.6		196.61	0.000433	0.37	15.08	17.54	0.13
Arden	1262	10JAN2000 0500	5.59	195.32	196.6		196.6	0.00002	0.15	36.44	35.03	0.05
Arden	1224	10JAN2000 0500	5.59	195.37	196.6		196.6	0.000028	0.17	33.26	37.21	0.06
Arden	1173	10JAN2000 0500	5.59	195.34	196.6		196.6	0.000023	0.16	35.74	39.04	0.05
Arden	1143	10JAN2000 0500	5.59	195.43	196.59		196.6	0.000187	0.4	14.13	19.26	0.14
Arden	1133	10JAN2000 0500	5.59	195.39	196.58		196.6	0.000263	0.53	11.72	15.34	0.17
Arden	1130	10JAN2000 0500	5.59	195.27	196.58	195.99	196.6	0.000212	0.49	12.32	14.03	0.15
Arden	1125		Inl Struct									
Arden	1122	10JAN2000 0500	5.59	194.46	195	195.1	195.37	0.026647	2.7	2.07	5.66	1.43
Arden	1117	10JAN2000 0500	5.59	194.18	194.91		195.04	0.006213	1.58	3.54	7.4	0.73
Arden	1109	10JAN2000 0500	5.59	194.1	194.9		194.93	0.00138	0.79	7.03	13.48	0.35
Arden	1087	10JAN2000 0500	5.59	194.09	194.86		194.9	0.001887	0.87	6.45	13.79	0.4
Arden	1058	10JAN2000 0500	5.59	192.95	194.84		194.84	0.000002	0.06	97.45	73.4	0.02
Arden	1026	10JAN2000 0500	5.59	192.96	194.84		194.84	0.000033	0.21	26.04	21.3	0.06
Arden	1011	10JAN2000 0500	5.59	193.42	194.82		194.85	0.000342	0.65	9.47	11.01	0.19
Arden	1007	10JAN2000 0500	5.59	193.42	194.82	194.03	194.84	0.000401	0.76	7.85	10.98	0.22
Arden	1006		Inl Struct									
Arden	1004	10JAN2000 0500	5.59	191.95	192.84		192.93	0.005769	1.36	4.23	7.28	0.54
Arden	996	10JAN2000 0500	5.59	191.95	192.32	192.63	193.69	0.308454	5.18	1.08	4.59	3.41
Arden	965	10JAN2000 0500	5.59	189.26	190.79		190.8	0.000247	0.38	14.52	14.11	0.12
Arden	939	10JAN2000 0500	5.59	189.25	190.79		190.79	0.000078	0.26	21.39	25.21	0.09
Arden	919	10JAN2000 0500	5.59	189.19	190.79		190.79	0.000072	0.3	20.99	25.4	0.09
Arden	900	10JAN2000 0500	5.59	188.7	190.79		190.79	0.000045	0.29	20.75	17.91	0.07
Arden	893	10JAN2000 0500	5.59	188.76	190.78		190.79	0.000096	0.38	14.89	11.77	0.1
Arden	890	10JAN2000 0500	5.59	188.87	190.74		190.8	0.000566	1.08	5.18	7.94	0.26
Arden	888		Culvert									
Arden	887	10JAN2000 0500	5.59	189.06	189.92	190.01	190.4	0.01647	3.15	1.92	4.12	1.21
Arden	883	10JAN2000 0500	5.59	188.46	189.87		189.89	0.000397	0.64	9.09	10.77	0.2
Arden	865	10JAN2000 0500	5.59	188.2	189.88		189.89	0.000073	0.33	19.1	21.54	0.09
Arden	835	10JAN2000 0500	5.59	188.18	189.88		189.88	0.000057	0.3	21.65	25.32	0.08
Arden	817	10JAN2000 0500	5.59	188.05	189.88		189.88	0.000023	0.22	29.5	28.82	0.05
Arden	801	10JAN2000 0500	5.59	188.15	189.88		189.88	0.000028	0.24	29.25	26.23	0.06

Reach	River Station	Profile	Q Total (m^3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m^2)	Top Width (m)	Froude # Chl
Arden	796	10JAN2000 0500	5.59	188.53	189.87	189	189.89	0.000221	0.57	10.27	22.18	0.16
Arden	790		Inl Struct									
Arden	789	10JAN2000 0500	5.59	187.01	187.41	187.63	188.24	0.089204	4.03	1.39	5.25	2.51
Arden	779	10JAN2000 0500	5.59	186.25	187.04		187.07	0.001473	0.87	6.5	12.28	0.37
Arden	762	10JAN2000 0500	5.59	186.17	187.04		187.06	0.000739	0.61	9.12	16.21	0.26
Arden	736	10JAN2000 0500	5.59	186.2	187.03		187.04	0.000584	0.57	17.43	61.19	0.23
Arden	704	10JAN2000 0500	5.59	186.23	187.02		187.02	0.00034	0.46	23.88	60.33	0.18
Arden	627	10JAN2000 0500	5.59	186.22	187		187	0.000137	0.26	37.68	66.26	0.11
Arden	588	10JAN2000 0500	5.59	186.22	186.96		186.99	0.001262	0.81	11.47	36.32	0.34
Arden	549	10JAN2000 0500	5.59	185.87	186.92		186.95	0.00081	0.82	10.52	36.21	0.29
Arden	531	10JAN2000 0500	5.59	186.01	186.88		186.95	0.002408	1.19	8.28	42.25	0.47
Arden	495	10JAN2000 0500	5.59	185.88	186.85		186.87	0.000914	0.77	11.08	42.28	0.3
Arden	474	10JAN2000 0500	5.59	185.9	186.84		186.85	0.000439	0.58	15.25	38.22	0.21
Arden	434	10JAN2000 0500	5.59	185.93	186.83		186.84	0.000413	0.59	17.37	40.47	0.21
Arden	388	10JAN2000 0500	5.59	185.96	186.76		186.8	0.001565	0.97	6.69	13.97	0.39
Arden	371	10JAN2000 0500	5.59	185.82	186.75		186.78	0.00103	0.96	9.72	21.02	0.33
Arden	347	10JAN2000 0500	5.59	186.01	186.7	186.67	186.93	0.008457	2.17	3	7.26	0.89
Arden	317	10JAN2000 0500	5.59	185.82	186.65		186.69	0.000982	0.9	6.28	8.04	0.32
Arden	310		Culvert									
Arden	308	10JAN2000 0500	5.59	185.93	186.43		186.54	0.005386	1.47	3.79	8.35	0.68
Arden	284	10JAN2000 0500	5.59	185.78	186.33		186.39	0.005008	1.16	4.82	13.94	0.63
Arden	275	10JAN2000 0500	5.59	185.41	186.27		186.3	0.000836	0.75	8.29	24.56	0.29
Arden	271	10JAN2000 0500	5.59	185.35	186.27		186.29	0.000713	0.7	14.3	119.67	0.26
Arden	260	10JAN2000 0500	5.59	185.31	186.23	185.95	186.3	0.002667	1.2	4.66	7.51	0.49
Arden	255		Bridge									
Arden	252	10JAN2000 0500	5.59	185.15	186.26		186.3	0.001185	0.87	6.39	8.98	0.33
Arden	234	10JAN2000 0500	5.59	185.29	186.27		186.28	0.000485	0.56	17.48	103.85	0.22
Arden	168	10JAN2000 0500	5.59	185.35	186.25		186.25	0.000342	0.36	35.79	216.81	0.17
Arden	115	10JAN2000 0500	5.59	185.32	186.24		186.25	0.000208	0.39	26.88	128.35	0.15
Arden	68	10JAN2000 0500	5.59	185.38	186.22		186.23	0.000854	0.69	17.87	111.08	0.28
Arden	8	10JAN2000 0500	5.59	185.14	186.2	185.37	186.2	0.000011	0.06	86.93	199.76	0.03

Summary for 200YR Storm Event

Reach	River Station	Profile	Q Total (m^3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m^2)	Top Width (m)	Froude # Chl
Arden	1353	10JAN2000 0500	6.13	195.42	196.7		196.7	0.000268	0.31	19.68	22.04	0.1
Arden	1324	10JAN2000 0500	6.13	195.41	196.66		196.68	0.001722	0.69	8.89	11.54	0.25
Arden	1284	10JAN2000 0500	6.13	195.39	196.63		196.64	0.000475	0.39	15.56	17.69	0.13
Arden	1262	10JAN2000 0500	6.13	195.32	196.63		196.63	0.000023	0.16	37.4	35.1	0.05
Arden	1224	10JAN2000 0500	6.13	195.37	196.63		196.63	0.00003	0.18	34.28	37.83	0.06
Arden	1173	10JAN2000 0500	6.13	195.34	196.63		196.63	0.000025	0.17	36.8	39.2	0.05
Arden	1143	10JAN2000 0500	6.13	195.43	196.62		196.63	0.000203	0.43	14.64	19.71	0.15
Arden	1133	10JAN2000 0500	6.13	195.39	196.61		196.62	0.00029	0.56	12.11	15.55	0.18
Arden	1130	10JAN2000 0500	6.13	195.27	196.61	196.04	196.62	0.000235	0.53	12.68	14.15	0.16
Arden	1125		Inl Struct									
Arden	1122	10JAN2000 0500	6.13	194.46	195.04	195.13	195.4	0.023554	2.68	2.29	5.77	1.36
Arden	1117	10JAN2000 0500	6.13	194.18	194.96		195.09	0.005591	1.58	3.91	8.11	0.7
Arden	1109	10JAN2000 0500	6.13	194.1	194.96		194.99	0.001175	0.78	7.89	13.83	0.33
Arden	1087	10JAN2000 0500	6.13	194.09	194.93		194.97	0.001529	0.82	7.5	14.88	0.37
Arden	1058	10JAN2000 0500	6.13	192.95	194.92		194.92	0.000002	0.06	103.24	74.92	0.02
Arden	1026	10JAN2000 0500	6.13	192.96	194.92		194.92	0.000032	0.22	27.71	21.89	0.06
Arden	1011	10JAN2000 0500	6.13	193.42	194.9		194.92	0.000327	0.67	10.33	11.26	0.19
Arden	1007	10JAN2000 0500	6.13	193.42	194.89	194.06	194.92	0.000395	0.78	8.36	11.23	0.22
Arden	1006		Inl Struct									
Arden	1004	10JAN2000 0500	6.13	191.95	192.86		192.97	0.006124	1.43	4.42	7.34	0.56
Arden	996	10JAN2000 0500	6.13	191.95	192.36	192.65	193.54	0.223979	4.8	1.28	4.78	2.97
Arden	965	10JAN2000 0500	6.13	189.26	190.89		190.89	0.000235	0.39	15.87	14.64	0.12
Arden	939	10JAN2000 0500	6.13	189.25	190.89		190.89	0.000068	0.26	23.79	25.65	0.09
Arden	919	10JAN2000 0500	6.13	189.19	190.88		190.89	0.000065	0.3	23.43	26.13	0.09
Arden	900	10JAN2000 0500	6.13	188.7	190.88		190.89	0.000044	0.3	22.47	18.58	0.07
Arden	893	10JAN2000 0500	6.13	188.76	190.88		190.89	0.000092	0.39	16.01	12.08	0.1
Arden	890	10JAN2000 0500	6.13	188.87	190.83		190.9	0.000575	1.13	5.45	8.26	0.27
Arden	888		Culvert									
Arden	887	10JAN2000 0500	6.13	189.06	189.96	190.06	190.48	0.016405	3.26	2.03	4.21	1.22
Arden	883	10JAN2000 0500	6.13	188.46	189.91		189.93	0.000421	0.68	9.51	10.87	0.21
Arden	865	10JAN2000 0500	6.13	188.2	189.92		189.93	0.000078	0.35	19.97	21.67	0.1
Arden	835	10JAN2000 0500	6.13	188.18	189.92		189.92	0.000062	0.32	22.66	25.45	0.09
Arden	817	10JAN2000 0500	6.13	188.05	189.92		189.92	0.000026	0.23	30.67	29.1	0.06
Arden	801	10JAN2000 0500	6.13	188.15	189.92		189.92	0.000031	0.25	30.31	26.46	0.06

Reach	River Station	Profile	Q Total (m^3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m^2)	Top Width (m)	Froude # Chl
Arden	796	10JAN2000 0500	6.13	188.53	189.91	189.03	189.93	0.00024	0.6	10.6	22.92	0.17
Arden	790		Inl Struct									
Arden	789	10JAN2000 0500	6.13	187.01	187.43	187.66	188.3	0.088424	4.15	1.48	5.33	2.51
Arden	779	10JAN2000 0500	6.13	186.25	187.06		187.1	0.001529	0.91	6.84	12.45	0.38
Arden	762	10JAN2000 0500	6.13	186.17	187.06		187.08	0.000768	0.64	9.57	16.33	0.27
Arden	736	10JAN2000 0500	6.13	186.2	187.06		187.07	0.000566	0.58	19.28	64.17	0.23
Arden	704	10JAN2000 0500	6.13	186.23	187.05		187.05	0.000333	0.47	25.69	60.67	0.18
Arden	627	10JAN2000 0500	6.13	186.22	187.03		187.03	0.00014	0.27	39.69	66.42	0.11
Arden	588	10JAN2000 0500	6.13	186.22	186.99		187.02	0.001232	0.83	12.59	38.59	0.34
Arden	549	10JAN2000 0500	6.13	185.87	186.95		186.98	0.00082	0.84	11.67	37.99	0.29
Arden	531	10JAN2000 0500	6.13	186.01	186.92		186.98	0.002184	1.17	9.78	44.13	0.46
Arden	495	10JAN2000 0500	6.13	185.88	186.88		186.91	0.000858	0.78	12.69	43.7	0.29
Arden	474	10JAN2000 0500	6.13	185.9	186.88		186.89	0.000431	0.59	16.68	39.48	0.21
Arden	434	10JAN2000 0500	6.13	185.93	186.86		186.88	0.000406	0.61	18.9	41.42	0.21
Arden	388	10JAN2000 0500	6.13	185.96	186.8		186.84	0.001534	0.99	7.22	14.21	0.39
Arden	371	10JAN2000 0500	6.13	185.82	186.79		186.82	0.001023	0.98	10.54	21.45	0.33
Arden	347	10JAN2000 0500	6.13	186.01	186.74	186.7	186.98	0.00813	2.22	3.3	7.63	0.88
Arden	317	10JAN2000 0500	6.13	185.82	186.69		186.73	0.001005	0.94	6.6	8.05	0.33
Arden	310		Culvert									
Arden	308	10JAN2000 0500	6.13	185.93	186.46		186.58	0.005286	1.52	4.03	8.38	0.68
Arden	284	10JAN2000 0500	6.13	185.78	186.34		186.42	0.005577	1.21	5.05	14.74	0.66
Arden	275	10JAN2000 0500	6.13	185.41	186.28		186.31	0.000972	0.82	8.47	26.09	0.31
Arden	271	10JAN2000 0500	6.13	185.35	186.28		186.3	0.00081	0.75	15.16	123.56	0.28
Arden	260	10JAN2000 0500	6.13	185.31	186.23	185.98	186.32	0.003188	1.31	4.67	7.52	0.53
Arden	255		Bridge									
Arden	252	10JAN2000 0500	6.13	185.15	186.27		186.31	0.00138	0.95	6.47	9.01	0.36
Arden	234	10JAN2000 0500	6.13	185.29	186.28		186.29	0.00054	0.59	18.52	108.3	0.23
Arden	168	10JAN2000 0500	6.13	185.35	186.26		186.26	0.000372	0.38	37.59	220.6	0.18
Arden	115	10JAN2000 0500	6.13	185.32	186.25		186.25	0.000239	0.42	27.71	129.16	0.16
Arden	68	10JAN2000 0500	6.14	185.38	186.22		186.24	0.001003	0.75	18.14	111.24	0.31
Arden	8	10JAN2000 0500	6.14	185.14	186.2	185.38	186.2	0.000014	0.07	86.93	199.76	0.03

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Experience in Action