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Abbreviations

AAR	alkali-aggregate reaction
AB WQG	Environmental Quality Guidelines for Alberta Surface Waters
AEP	Alberta Environment and Parks
AER	Alberta Energy Regulator
AWWID	Alberta Water Well Information Database
BOD	biochemical oxygen demand
BRPMP	Bow River Phosphorus Management Plan
BSP	Biologically Sensitive Period
CCME	Canadian Council of Ministers of the Environment
CEAA	*Canadian Environmental Assessment Act*
CEAR	Canadian Environmental Assessment Registry
COV	coefficient of variation
CWQG	Canadian Water Quality Guidelines f
D_{50}	median particle size
DFO	Fisheries and Oceans Canada
DO	dissolved oxygen
ECO Plan	Environmental Construction Operations Plan
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EM	electromagnetic
EPEA	*Environmental Protection and Enhancement Act*
FSI	fish sustainability index
FWMIS	Fisheries and Wildlife Management Information System
HD	hydrodynamic modelling
HEC-HMS	Hydrologic Engineering Center Hydrological Modeling System
HUC	hydrologic unit
IR	Information Request

LAA	local Assessment Area
LiDAR	light detection and ranging
LUA	land use area
LWD	large woody debris
MT	mud transport
NRCB	Natural Resources Conservation Board
PDA	Project development area
PMF	probable maximum flood
PQL	practical quantitation limit
Project	Springbank Off-stream Reservoir
QAES	qualified aquatic environmental specialist
QUAT	quaternary ammonium compounds
RAA	regional assessment area
RAP	restricted activity period
SOD	sediment oxygen demand
SSC	suspended sediment concentrations
ST	sand transport
SVM	seasonal variability metric
TDR	technical data report
TDS	total dissolved sediments
TOC	total organic content
TOR	terms of reference
TSS	total suspended solids
USACE	United States Army Corps of Engineers
VC	valued component
WQMF	Water Quality Management Framework
WSC	Water Survey of Canada

5 WATER

5.1 WATER MANAGEMENT

Question 211

Volume 1, Section 3.2.1.4, Page 3.8

Alberta Transportation states that the floodplain berm …*acts to constrain flow in the Elbow River and direct it to the diversion structure*. The CEAA 2012 Project Description Executive Summary Figure 3 identified that this affects a 93 ha area upstream of the diversion structure. There does not appear to be any information on the environmental impacts to this area.

a. Describe the potential changes to hydrology and geomorphic conditions upstream of the diversion structure.

b. Describe the environmental effects predicted during various flood events in the area upstream of the diversion structure. This should address hydrologic effects and include effects of sediment and debris deposition on vegetation, fish habitat and land productivity.

Response 211

a-b. The floodplain berm constrains overland flood flow from the floodplain of Elbow River, directing it towards the service spillway and diversion inlet.

- It is expected that flood operations for a large flood will cause sediment and woody debris to accumulate in the floodplain area upstream of the floodplain berm. While mitigation measures for head-cut and channel switch are provided to reduce major erosion, there is the potential for some avulsion of surficial soils from currents within the backwater generated by flood operations. There are no effects to the hydrology of the Elbow River from the presence of the floodplain berm.
- Aside from the diversion of floodwater during flood operations (the purpose of the Project), there is no change in the hydrology of the Elbow River from the expected changes upstream of the diversion structure during dry operations and post-flood operations.
- The effects on vegetation from inundation in the area upstream of the diversion structure are described in Volume 3B, Section 10.2.2.3. As described in Volume 3B, Section 10.3, residual effects to community diversity are not predicted because plant communities are expected to recover post-flood.

In response to concerns regarding debris management during the Indigenous and public engagement programs for the Project, Alberta Transportation filed an environmental assessment addendum in May 2018 for the installation of a debris deflector, which is provided in Canadian Environmental Assessment Registry #25 (CEAR #25).

The debris deflector will be installed along the west side of Elbow River, at the opening of the diversion channel. The structure is an added Project component that will be located within the PDA. The debris deflector will reduce risks of infrastructure damage and operating failure of Project components, including the diversion inlet, diversion channel and off-stream reservoir and dam.

The environmental assessment addendum for the debris deflector included an additional effects assessment of the following valued components (VCs) because they were considered to have effects beyond those that were assessed in the EIA:

- aquatic ecology
- wildlife and biodiversity
- traditional land and resource use

An assessment was not completed for the following VCs because the debris deflector will not cause measurable effects beyond the effects assessed in the EIA:

- air quality and climate
- acoustic environment
- hydrogeology
- hydrology
- surface water quality
- terrain and soils
- vegetation and wetlands
- land use and management
- historical resources
- public health
- infrastructure and services
- employment and economy
- federal lands

The environmental assessment addendum for the debris deflector was completed following the assessment methods in Volume 2.

The addendum found that Project residual effects on aquatic ecology, wildlife and traditional land and resource use remain unchanged from those presented in the EIA:

- For aquatic ecology, see Volume 3A (Section 8.4.4.4, Table 8-8) and Volume 3B (Section 8.2.5, Table 8-2)

- For wildlife, see Volume 3A, Section 11.4.6, Table 11-14 and Volume 3B, Section 11.3.7, Table 11-17
- For traditional land and resource use, see Volume 3A, Section 14.3.6, Table 14-8 and Volume 3B, Section 14.2.6, Table 14-2

Overall, the environmental assessment addendum focused on the potential interactions of selected VCs with the construction and operation of the debris deflector. The assessment conducted in the addendum fully incorporated information and results as provided in the EIA. The findings of the addendum are that the effects from the addition of the debris deflector do not alter the conclusions of the EIA for any of the VCs.

REFERENCES

Stantec Consulting. May 14, 2018. Springbank Off-stream Reservoir Project Debris Deflector - Environmental Assessment Addendum. Available on the Canadian Environmental Assessment Registry (CEAR #25) at: https://ceaaacee.gc.ca/050/documents/p80123/122722E.pdf

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Question 212

Volume 1, Section 3.2.4, Table 3.3, Page 3.12

Alberta Transportation has identified the potential duration of discharge for various flood frequency events. The detention time in the off-stream reservoir has implications for sedimentation time, uptake of elements from the reservoir soil, and operational interactions with the Glenmore Reservoir.

a. Provide a detailed outline for a *Water Management Plan* that could be included in the proposed *Operation, Maintenance and Surveillance Plan* for both the filling and release of water from the Project under all foreseen operating conditions.

b. Within the *Water Management Plan* provide scenarios that would provide options for the operation of the Project discharge in conjunction with the operation of the Glenmore Reservoir to reduce the impact of flow on the Elbow River in Calgary.

Response 212

a. A detailed water management plan is in the EIA (Volume 1, Attachment A), and it describes how water will be managed through all stages of the Project for both filling and release of water under all foreseen operating conditions.

b. The purpose of the Project is to prevent flooding of communities downstream of the Project. The Project is designed to be operated in conjunction with the Glenmore Reservoir to achieve that goal and reduce the effect of flow on the Elbow River in Calgary. The Glenmore Reservoir can safely pass water up to flows of 160 m^3/s without causing downstream damage. AEP Operations will be in communication with the City of Calgary in advance of and during the flood season each year, so each party will maintain an understanding of the system's status. Flood water will be partially diverted into the off-stream reservoir when flows in Elbow River at the diversion structure exceed 160 m^3/s. Water diversion will cease once flows in the Elbow River recede to less than 160 m^3/s or when the off-stream reservoir is at capacity.

Question 213

<u>Volume 1, Section 3.5, Page 3.34</u>
<u>Volume 1, Section 5.2, Pages 5.6 – 5.8</u>
<u>Volume 3B, Section 6.4, Pages 6.12 and 6.13</u>

The TOR asked for a description of how the project will be utilized to manage back to back storm events. The EIA identifies that once the project design inflow is reached then excess flow will be passed onto the Glenmore Reservoir which is assumed to also be full.

a. How is the Glenmore Reservoir equipped to manage back to back storms given that the Project is not able to accommodate flows beyond those of the 2013 flood event and given the lengthy residence and release times in the off stream reservoir?

b. Provide information on the potential for overland flow from the Glenmore reservoir to the Bow River if the Glenmore Dam Spillway is not able to manage the floodwater inflow.

Response 213

a. Since 1934, Glenmore Reservoir has operated and managed flows within Elbow River. This operation included the passage of large flow events, including the June 2013 flood. Glenmore Reservoir has an extreme consequence rating and its spillway is designed to pass the probable maximum flood. Should multiple storm events occur in the same year that, combined, exceed the retention capacity of the off-stream reservoir, then Glenmore Reservoir will operate as it currently does: inflows to the Glenmore Reservoir will be passed downstream through the Glenmore spillway.

b. The Glenmore spillway is designed to pass the probable maximum flood for the Glenmore dam without consideration of Project. Construction and operation of the Project reduces the risk for overland flow from the Glenmore Reservoir to Bow River if the Glenmore Dam spillway is not able to manage the floodwater inflow.

Question 214

Volume 1, Section 3.5.1, Page 3.35

Alberta Transportation states *The flow in the diversion channel would be monitored continuously. The reservoir elevation and fill rate also would be monitored, as well as the pore pressure within the dam and at its foundations*.

a. **Provide details on how flows in the river and the diversion channel as well as fill rates in the reservoir will be monitored.**

b. **Will Alberta Transportation or the operator, Alberta Environment and Parks assess impacts on the Glenmore reservoir and other downstream users as well as determine losses for the purposes of the Prairie Provinces Water Board Master Agreement on Apportionment by monitoring of flows leaving the Project through the outfall?**

c. **If the answer to (b) is yes, provide the means and frequency of monitoring.**

d. **If the answer to (b) is no, provide details on why monitoring is not necessary.**

Response 214

a. Flood flow monitoring will include:

- Existing permanent stream flow monitoring stations are situated on Elbow River at Bragg Creek (upstream of the Project) and Sarcee Bridge (downstream of the Project) to monitor flows in the river.
- An additional stream monitoring station will be incorporated into the Project near the diversion inlet and service spillway. This station will include a pressure transducer or ultrasonic water level sensor in a well affixed to the wall of the diversion structure and a staff gauge located on the wall of the diversion structure that is visible to the operator.
- In addition to the monitoring station at the diversion structure, there will be operational rating curves for the service spillway and the diversion inlet gates that will inform the operator to know how much water is being diverted and how much is continuing downstream, based on tail water elevation and gate openings.
- When Elbow River reaches the target service water elevation associated with 760 m^3/s (i.e., sum of 160 m^3/s through the spillway and 600 m^3/s through the diversion inlet), water diversions will be maintained at 600 m^3/s and water flow in the river above 760 m^3/s will pass through the service spillway and remain in the river.
- A secondary monitoring location in the diversion channel will be used as a backup to confirm that the diversion rate is below 600 m^3/s.

- A transducer will be installed in the diversion channel to monitor diversion rates and confirm flows into the off-stream reservoir.
- Reservoir filling will be monitored with a pressure transducer situated in the reservoir near the reservoir outlet gate and supplemented by a visual staff gauge.
- The outlet gate will also have a rating curve that the operators can use to confirm water release from the reservoir.

Details of the monitoring plan are provided the Surface Water Monitoring Plan (see the response to IR302, Appendix IR302-1; in particular, refer to Section 9.3.1 [Elbow River Stream Flows], Section 9.4. [Operational Monitoring – Flooding], and 9.5.2 [Reservoir Depth/Volume]).

b. The operation of the Project will not result in losses of natural flows, as defined in PPWB (2019a). In addition, the operation of the Project is consistent with the requirements of PPWB (2019b; Schedule A, Section (30(4)(a)). It is Alberta's position that the Project is not removing water from the South Saskatchewan system. Flood waters coming into the Project will be released back into the system after the risk of flooding to downstream stakeholders has passed. When released, the water will be available to downstream stakeholders.

c. The results associated with the Project monitoring program will be available to meet the terms of PPWB (2019b) or to meet the needs of downstream users. This will include near real-time (maximum 15-minute intervals) Elbow River flow monitoring during flood and post-flood operations.

d. Given the response to b., this question is not applicable.

REFERENCES

PPWB (Prairie Provinces Water Board). 2019a. 1969 Master Agreement on Apportionment. Available at: https://www.ppwb.ca/information/79/index.html

PPWB. 2019b. Master Agreement on Apportionment: Schedule A. Available at: https://www.ppwb.ca/information/110/index.html

5.2 HYDROGEOLOGY

Question 215

Volume 3A, Section 5.2, Page 5.2
Volume 3B, Section 5.4, Page 5.29
Volume 4, Appendix I, Section 4.2, Page 4.4
Volume 4, Appendix I, Figure 5-2 and 5-3, Pages 5.4-5.6

Alberta Transportation states *Distributed groundwater recharge was not applied to the model domain. As discussed in Section 2.3, the annual evapotranspiration rate exceeds the annual precipitation rate, meaning there is minimal groundwater recharge from precipitation.* (Volume 4 - Appendix I, Groundwater Numerical Modeling Technical Data R, Section 4.2, Page 4.4)

The groundwater model is used for the Environment Impact Assessment for different scenarios. The evaporation data is based on a shallow lake area. The groundwater evapotranspiration is different from the evaporation data, as it varies based on the surface vegetation, soil type and groundwater depth. No groundwater recharge appears to have been applied to the model, which appears to have caused the simulated groundwater levels to be less than the observed groundwater levels (Volume 4, Appendix I - Groundwater Numerical Modeling Technical Data Report, Figure 5-2 and 5-3, Pages 5.4-5.6).

During a flood, the groundwater recharge fully saturates the soil so precipitation cannot infiltrate, even for a significant period after the flood. Therefore, the assumption of no groundwater recharge in the modeling is not realistic for the flood scenarios.

a. Re-calibrate the groundwater model using a reasonable groundwater recharge to improve the matching of the simulated groundwater levels vs. the observed groundwater levels. Then use the re-calibrated groundwater model to do the Environmental Impact Assessments for the scenario of "Construction and Dry Operations".

b. Apply significant groundwater recharge to the model to create surface run-off, then use it for the Environmental Impact Assessment for the scenario of "Flood and Post- Flood Operations".

Response 215

a-b. A distributed recharge has now been applied over the numerical model domain and has been implemented through use of specified fluxes over the model domain. This is described in further detail in Section 4.4 of the Hydrogeology TDR Update (see the response to IR42, Appendix IR42-1). The groundwater model does not explicitly model surface water runoff and subsequent streamflow routing.

Question 216

Volume 3B, Section 5.2.2.1, Page 5.45
Volume 4, Appendix I, Section 4.2, Page 4.4

Alberta Transportation states *From Figure 5-27, the net change in head, at the point in time the reservoir is filled, varies from an increase of 28 m (near the upstream toes of the dam) to a decrease of 7 m (in the diversion channel near the inlet structure). This increase in head in the reservoir is a result of the added "weight" of the water stored there.*

….. However, in all cases, effects on groundwater levels are well within the LAA, and changes are only observed north of the Elbow River.

A textbook example of the loading effect of a passing train's weight can cause the groundwater level to instantaneously increase in a confined aquifer (Veatch 1906; Jacob 1939). The Springbank off-stream reservoir covers a large area (Figure 5-27) and the maximum thickness of water would be 28 m during Design Flood conditions. The loading effect on confined aquifer would be much bigger and longer than the passing train effect. The fully saturated soil during flooding would also add loading on the confined aquifer.

When the groundwater level in confined aquifer is higher than the topography (artesian condition), the groundwater may gush out through weak overburden areas, such as thinner overburden locations, unsealed boreholes, improperly sealed wells or basements, etc.

a. Simulate the loading effect of the Springbank off-stream reservoir on the confined aquifer.

b. Predict the potential artesian areas under the loading conditions, such as the area to the East and South-East of the low topography areas in the Local and Regional Assessment Areas. If there is clay layer underneath the sand and gravel layer in the Elbow River, the artesian area may extend to the south of the Elbow River.

c. Assess the Environmental Impact of the loading effect.

d. Propose a monitoring plan for the loading effect.

e. Design a mitigation plan for the loading effect.

Response 216

a. Poroelastic response of an aquifer "loading effect" is generally limited to cases where the aquifer is fully confined over a wide area. By contrast, the groundwater regime in the RAA is characterized as an unconfined to semi-confined system, as is discussed in Section 3.2 of the Hydrogeology TDR Update (see the response to IR42, Appendix IR42-1). While some localized subsurface pressure response is expected near the Project components, regional scale poroelastic response within the bedrock aquifer is not expected to occur due to a lack of regional scale confinement.

b. A regionally mappable clay layer does not exist underneath the fluvial deposits of the Elbow River. In general, the fluvial deposits of the Elbow River directly overlie bedrock.

c. Potential changes in groundwater levels are assessed by the numerical groundwater model, as described in the Hydrogeology TDR Update. However, changes in groundwater levels within the bedrock are not expected to be caused by poroelastic response because the bedrock is not regionally confined.

d-e. A draft groundwater monitoring plan for changes in groundwater levels is presented in the response to IR46, Appendix IR46-1. While poroelastic pressure response in the bedrock is not anticipated, monitoring of bedrock is included as part of the draft groundwater monitoring plan.

Question 217

Volume 3A, Section 5.4.2.2, Figure 5-10
Volume 3A, Section 5.4.2.2, Figure 5-11
Volume 3A, Section 5.4.2.2, Figure 5-12
Volume 4 Appendix I

The majority of this section is a repeat of Volume 4 Appendix I. The assessment presented in Volume 3A does not appear to be a true impact assessment for construction and dry operations.

a. Subtract Figure 5-10 by Figure 5-11 to get the drawdown for Dry Operations. Identify what reasons produced the positive and the negative drawdown areas.

b. Compare Figure 5-12 with the above drawdown for Dry Operation and analyze if the positive head change in Figure 5-12 is caused by the additional infiltration of water into this area or caused by other reasons.

c. What kind of boundary condition exists and where is it applied in the groundwater model to produce the positive and negative head change in Figure 5-12?

d. Provide the calibration results around the local diversion channel area including groundwater data in both of the surficial and bedrock layers. In the regional model, geology layers are simplified. Local important sand units may not be shown in the regional model.

e. Analyze and discuss if the regional groundwater model can properly characterize conditions for the local impact assessment. If not, how can the calibration and prediction be improved?

f. How much seepage discharge is anticipated into the diversion channel during the dry operation? Explain.

g. How will the groundwater flow direction and velocity be altered around the diversion channel for the dry operation scenario when compared to the pre- construction scenario?

h. What is the expected water chemistry from the channel seepage water?

i. During drought years, seepage water will flow out of the channel to the reservoir and the velocity of water will likely decrease in the off-stream reservoir. As a result, TDS will likely increase in the reservoir due to slow movement and evaporation. What is the expected TDS increase?

j. How much salt is likely to be deposited in the reservoir during drought years?

k. What will be the impact on vegetation and groundwater by the salty water?

l. Are there any requirements or plans to monitor and mitigate the impact? If not, why not? If there are plans in place to monitor the impact explain what they are.

m. Compare the local groundwater discharge from the diversion channel area to the Elbow River under the conditions of pre-diversion channel and post-diversion channel construction.

n. Evaluate the local groundwater mounding and local ponding around the off-stream Dam to determine:

i. What is the groundwater level increase compared with the pre-construction conditions?

ii. What are the changes to the groundwater discharge to the Elbow River at this location?

Response 217

a. Section 5 of the Hydrogeology TDR Update (see the response to IR42, Appendix IR42-1) presents simulation results from the updated numerical groundwater model. Maps of net change in groundwater levels during dry operations are presented in Section 5, Figure 5-7.

b. Maps of net change in groundwater levels during dry operations based on the updated simulations are presented in Section 5.5 of the Hydrogeology TDR Update.

c. Section 4 of the Hydrogeology TDR Update presents the construction and calibration of the updated numerical groundwater model, including a description of the boundary conditions used. The implementation of additional time-varying boundary conditions is described in Section 5.

d. Calibration results for the updated numerical groundwater model are presented in Section 4.5 of the Hydrogeology TDR Update. Calibration points near the diversion channel were used, based on information collected from the hydrogeologic and geotechnical field programs. Residuals for each of the calibration points are summarized in Table 4-1 and are plotted in Figure 4-13.

e. Calibration results for the updated numerical groundwater model are presented in Section 4.5 of the Hydrogeology TDR Update. The numerical model domain is regional in nature. However, the PDA and groundwater LAA have a model resolution commensurate with assessing the PDA-scale Project effects. Nodal spacing of the mesh varies from approximately 150 m where the mesh is coarse, to approximately 1 m where the mesh is fine (near Project components and surface water features). Further, the data density and calibration points in the model were selected to provide calibration at both scales (i.e., local- and regional-scale). The inclusion of the large region surrounding the PDA and LAA allows the numerical simulation to provide calibrated model predictions in the PDA and LAA without the influence of the boundary conditions applied to outside the domain.

f. Seepage into the diversion channel (when it is dry) was estimated by the numerical groundwater flow model (see Hydrogeology TDR Update, Section 5.5). Estimates of seepage into the diversion channel (when dry) were obtained by examining flux values at nodes within the diversion channel based on the PPX0 simulation results. Based on these flux values, the estimated net seepage is predicted to be 0.013 m^3/s. This is an estimate of groundwater flows that are "intercepted" by the diversion channel. These changes in groundwater discharge to the Elbow River would not be perceptible, given the mean flows (monthly average) in the Elbow River are approximately 3 m^3/s to 4 m^3/s during winter months when flow is the lowest.

g. Section 5.5 of the Hydrogeology TDR Update presents results from the updated model simulations. The groundwater flow pattern in the unconsolidated materials up-gradient of the diversion channel will be towards the free-draining diversion channel. The pre-disturbance groundwater flow is in general downslope, east towards the Elbow River. The flow direction may change subtly as the diversion channel is oriented more in a north-south direction at the intake into the off-stream reservoir. In some areas, the diversion channel intersects the basal silt, sand and gravel unit. In these areas the dewatering effect will have a greater area of influence, given the increased permeability of this unit and the ambient head measured in the unit.

h. The diversion channel (when dry) is expected to receive seepage from both the local-scale water table hosted by the unconsolidated material and seepage from the bedrock aquifer. Given that the baseline water chemistry shows a high degree of chemical variability with samples ranging in total dissolved solids (TDS) concentrations from 440 mg/L to 6,900 mg/L, the seepage water quality is expected to vary over a similar range (i.e., water quality of the seepage water is expected to be similar to insitu groundwater quality).

i. Under baseline conditions, groundwater seepage occurs throughout the groundwater RAA, either into open drainage features (i.e., creeks and wetlands) or as diffuse discharge at surface supporting high evapotranspiration rates. Springs with flow into the off-stream reservoir have also been mapped on the flanks of the reservoir. Due to the low seepage rate into the diversion channel (0.013 m^3/s), changes in TDS concentrations are not expected to substantially change relative to the natural fluctuations that already occur.

j. Salt deposition was not a component of the groundwater study. Due to the low seepage rate into the diversion channel, salt deposition is not expected to be substantial relative to the natural deposition under baseline conditions. Groundwater with a similar chemistry currently discharges from the springs mapped along the sides of the off-stream reservoir and into the unnamed creek.

k. Due to the low seepage rate into the diversion channel, effects on vegetation are not expected.

l. A draft groundwater monitoring plan is presented in the response to IR46, Appendix IR46-1. The draft monitoring plan is designed to detect potential changes in groundwater levels and chemistry in the off-stream reservoir.

m. The seepage rate into the diversion channel (when dry) is estimated to be approximately 0.013 m^3/s. These fluxes represent groundwater that could be "intercepted" on its flowpath toward Elbow River and are an estimate of net change in discharge along that reach of the river.

n. The Hydrogeology TDR Update, Section 5.5.2, presents updated simulation results for the design flood. Net changes in groundwater levels for a design flood are presented in Figure 5-11 to Figure 5-16. An estimate of seepage out of the reservoir area when full and just prior to commencement of release (when seepage rates out of the reservoir area would be at their maximum) was obtained through examination of the flux values at each of the nodes within the reservoir. Summation of the net fluxes yielded an estimated seepage rate of 426 m^3/day out of the reservoir. Even if all this seepage ends up as discharge in Elbow River, the additional flux would not be perceptible relative to flows in the River during a design flood, which reaches an instantaneous peak flow of 1,170 m^3/s (equivalent to approximately 1.01×10^8 m^3/day).

Question 218

Volume 3A, Section 5.1.3, Table 5-1, Page 5.4

In the row of "Change in groundwater quantity" and in the column "Measurable Parameter(s) and Units of Measurement", the following needs to be added:

a. Seepage rate (cubic meter per day). Update and provide the updated table.

Response 218

a. The measurable parameter for a change in groundwater quantity, as noted in Volume 3A, Section 5.1.3, Table 5-1, is potentiometric head, as measured in metres above sea level. Potentiometric head is the broadest metric that is applicable in evaluating potential changes in groundwater quantity caused by the effects pathways considered. Seepage rate is a head-dependent measure, and changes in potentiometric head can be used to evaluate potential changes in seepage rate.

   Seepage into the diversion channel (when dry) is estimated by the numerical groundwater flow model. The estimated net seepage into the diversion channel is 0.013 m^3/s (see Hydrogeology TDR Update, Section 5.5.1)

Question 219

Volume 3A, Section 5.2.1, Figure 5-2, Page 5.10
Volume 4, Appendix I, Table 3-1; Figure 2-3

Alberta Transportation states *Single well response tests were conducted on 15 monitoring wells*. 15 wells were monitored, but only 10 are shown.

a. Clarify in the third paragraph that 15 tests were completed but only 10 were successful. Add the 5 wells that were tested but unsuccessful to Table 3-1 in Volume 4, Appendix I, Hydrogeology Baseline. Populate the K-values as 'N/A' and add a footnote that the tests were unsuccessful. Add a paragraph(s) where both documents are explained for consistency and clarity.

b. In Figure 5-2, the green, light blue and dark blue colours are difficult to distinguish. Adjust the colour selection to correct for this issue (apply this change to Figure 2-3 in Volume 4, Hydrogeology baseline).

c. Post the well IDs for the groundwater monitoring wells (apply this change to Figure 2-3 in Volume 4, Hydrogeology baseline).

Response 219

a. The third paragraph in Volume 3A, Section 5.2.1, page 5.10 is incorrect. Single well response tests were conducted on ten monitoring wells, not 15. The 15 included the additional five wells where the packer tests were completed to estimate hydraulic conductivity of discrete intervals within the Project boreholes.

b. The colours have been changed for clarity in the Figure 2-3 of the Hydrogeology TDR Update (see the response to IR42, Appendix IR42-1).

c. The scale of Figure 2-3 is too small to effectively post well ID labels. As such, instead of posting the well IDs on that figure, the well IDs are posted on Figure 2-2 of Appendix IR42-1.

Question 220

Volume 3A, Section 5.2.2.2, Figures 5-7 and 5-8, Pages 5.19-5.21
Volume 4, Appendix I

A number of springs were identified based on air photos and the model, but only one was verified/discovered in the field.

a. **Explain how the air photographs and 3D CSM were used to identify springs.**

b. **Expand the map area to the east to include Range Road 33 to show how many springs exist east of the PDA, and if there are any changes to the spring's locations and number during the 2013 flood compared to a normal year.**

c. **Was the field-verified spring used as a data point when creating any of the potentiometric surface maps? If not, why not? Were any attempts made to verify the other springs when the field survey was conducted? If not, why not? Did any landowners talk about springs on their property (existence, use and changes)? If so, explain what landowners described about the springs on their property.**

d. **It is difficult to correlate location of springs shown on the 3D map (Figure 5-7) to the 2D maps due to distortion of scale. If the springs were used to develop the potentiometric map, show their locations and labels on Figure 5-8.**

e. **Apply changes to figures and explanations with similar sections in Volume 4, Appendix I, Hydrogeology Baseline.**

Response 220

a. Air photographs superimposed on the geological/hydrogeological framework allowed for identification of areas with potential springs (using indications such as vegetation patterns, rills). This information, together with an understanding of the underlying geologic framework and water levels, allowed for identification of areas with potential springs.

b. Springs are temporal in nature, so a detailed inventory of the groundwater springs in the groundwater RAA would require years of dedicated mapping to account for climactic variability and seasonal/temporal variability. There is no data source available that compiles spring locations east of the PDA as of June 2013 that Alberta Transportation is aware of.

c. Mapped spring locations were used as a water table control point rather than a bedrock potentiometric surface control point. These springs are useful to denote the water table surface where it crosses the land surface. Many of the springs are located on the flanks of elevated topographic features and likely represent perched water table conditions, making them unsuitable for potentiometric surface modelling. Mapping of spring locations was limited to the PDA where land access was established; no field mapping was completed outside the PDA. The spring locations shown in Figure 3-21 of the Hydrogeology TDR Update (see the response to IR42, Appendix IR42-1) are based on field-verified springs, springs identified in the Alberta Water Well Information Database (AWWID), and the Alberta Geological Survey Spring Inventory.

d. Appendix IR42-1, Figure 3-17 shows the locations of the springs from the aforementioned data sources. The springs are also shown as a water table control points on Figure 3-19.

e. Appendix IR42-1, Section 3.2.4 includes modifications to the data related to springs.

Question 221

Volume 3A, Section 5.4.3.1, Page 5.40
Volume 3A, Section 5.2.2.3, Page 5.23 to 5.26

Alberta Transportation states *…natural groundwater flowpaths can be disturbed at a local scale, potentially resulting in changes in groundwater quality*.

In addition, Section 5.2.2.3 Groundwater Quality also discusses the presence of high sodium, TDS and sulphate concentrations in groundwater samples from the unconsolidated deposits.

a. Discuss any risks/concerns with discharging groundwater to the surface and affecting surface water, shallow groundwater and soil within the PDA and LAA, and subsequent implications for terrestrial or riparian vegetation, wildlife and aquatic resources, including wetlands.

Response 221

a. Potential effects related to discharging groundwater into surface water and on soil quality may occur; however, the effects will be localized and are not expected to incrementally change the quality of these valued components because such discharge is already occurring under baseline conditions. In the PDA, shallow groundwater discharge to ground surface is occurring in the form of springs, and subsurface discharge is occurring as baseflow into the unnamed creek.

Similarly, at a regional scale (southern portion of groundwater LAA and over the broader RAA), groundwater discharge to the Elbow River is occurring under baseline conditions. With the addition of the Project, this groundwater discharge will continue to provide the baseflow inputs to the unnamed creek and the Elbow River.

The regional water balance will not be affected by the Project because the groundwater seepage will continue to be directed to the unnamed creek and from there to the Elbow River. Therefore, if the regional water balance remains unchanged, so too does the regional water quality.

Question 222

Volume 3A, Section 5.5, 5.6 and 5.7, Page 5.43
Volume 3A, Section 5.4.3.3, Table 5-4, Page 5.42

The determination of significance is based on domestic consumption (sufficient yield and quality meeting CDWQG). As such, the changes/residual effects to GW quantity and quality are deemed to be *not significant, with a moderate degree of confidence*. However, in the previous Table 5-4 and Section 5.4.3.3, the effects (when dry) are quantified as being *moderate in magnitude…, continuous…, long-term…, irreversible… and disturbed*.

a. **Revise the determination of significance by including all receptors, including vegetation, wildlife and aquatic resources. If receptors are excluded, provide the rationale.**

b. **Discuss what would be required to increase the level of confidence above 'moderate'.**

Response 222

a. The significance determination for hydrogeology is based on the potential use of groundwater for domestic purposes because early engagement during scoping of the EIA indicated that this would be the key issue of concern for groundwater resources. It is acknowledged that other valued components, such as vegetation, may be affected by changes in groundwater. The effect pathway between groundwater and vegetation is assessed in Volume 3A, Section 10.3 in the EIA. It was found that with the application of mitigation, residual project effects related to vegetation and groundwater are predicted to be not significant (Volume 3A, Section 10.6).

b. Additional detailed information will become available during pre-construction planning to better constrain the potential effects pathways considered and increase confidence in prediction of effects. For example, during pre-construction planning, the schedule for construction of a component of the Project would be defined. This will make it possible to identify locations and timing for construction dewatering.

   Ongoing baseline groundwater monitoring conducted before and during construction will also better constrain the depth to groundwater in a local area as the construction window approaches. Ongoing operational groundwater monitoring during dry operations would also allow for validation of the numerical groundwater model simulations. This additional information would also increase the confidence of the significance determination.

Question 223

Volume 3B, Section 5.2.1.3, Figures 5-3 to 5-14, Pages 5.6-5.24

Alberta Transportation states *The potentiometric head distribution presented in Figure 5-3 suggests that shallow groundwater flow patterns are controlled to a large degree by the regional topography.* (Page 5.6)

Since no recharge has been applied to the groundwater model, the shallow groundwater level is mainly controlled by the boundary conditions, such as the river boundary, constant head boundary etc. Topography should not control slopes of groundwater levels. For example, cross sections A-A' (Figure 5-4, 5-8 and 5-12) show no groundwater mounding at topographic highs. The groundwater water table is a sloped line controlled by the river boundary conditions.

a. Apply recharge rates on the groundwater model to improve calibration.

b. Update the figures referenced above and the associated wording.

Response 223

a. In the response to IR42, Appendix IR42-1 (Hydrogeology TDR Update), a net recharge flux has been added in the updated model to the top of the model domain (see Section 4.4.2). The following provides some relevant descriptive details.

The land surface elevation gradient, type of soil, and vegetation present at surface are important factors in determining whether precipitation will become runoff, based on surface water flow processes, or enter the subsurface as groundwater recharge. Since a detailed study over a large land area such as the groundwater RAA was beyond the scope of the hydrogeology assessment, literature values for recharge appropriate for the region were used (Klassen et al. 2018). Those recharge estimates were rigourously developed specifically to account for terrain characteristics such as depression focused recharge following the methods developed by the University of Calgary (Farrow et al. 2014; Pavlovskii et al. 2017). The terrain analysis was used as an input parameter for a 1-D, multi-layer recharge simulation model referred to as the versatile soil moisture budget (VSMB) with a depression upland storage (DUS) module. In addition to the terrain analysis, the VSMB-DUS model is driven by meteorological data (e.g., hourly precipitation, air temperature, relative humidity), evapotranspiration parameters (e.g., growth curves), and soil properties (e.g., wilting point, field capacity), as described in Klassen et al. 92018).

Groundwater recharge rates ranging from 12 mm/year to 25 mm/year were established by the regional groundwater study (Klassen et al. 2018). Given the regional nature of the study cited, and the large topographic variability of the RAA with many areas without significant depressions (i.e., well drained slopes without prairie-like depressions), the minimum recharge value of 12 mm/year was used. Relatively good model calibration resulted from application of this rate, as assigned to the hydrostratigraphic units exposed at the top of the model domain.

b. Updated figures depicting the new model simulations (inclusive of applied recharge) are provided in detail in Section 5 of the Hydrogeology TDR Update.

REFERENCES

Farrow, C.R. 2014. Winter surficial processes and groundwater recharge in the southern Alberta Prairies; MSc thesis, University of Calgary, 195 p.

Klassen,J., Liggett, J.E. , Pavlovskii, I. and Abdrakhimova, P. 2018. First-order groundwater availability assessment for southern Alberta; Alberta Energy Regulator / Alberta Geological Survey, AER/AGS Open File Report 2018-09, 37 p.

Pavlovskii, I., Noorduijn, S. and Hayashi, M. 2017. Regional-scale mapping of a depression-focussed groundwater recharge rate in the prairie landscape of Alberta. GeoOttawa 2017, 70th Canadian Geotechnical Conference and the 12th Joint CGS/IAH-CNC Groundwater Conference, October 1-4, 2017, Ottawa, Canada, 6 p.

Question 224

Volume 3B, Section 5.2.1.2, Figure 5-2, Pages 5.5-5.7

Last paragraph: potential locations of interest were identified, *up to near the LAA boundary*. Two points were within the RAA (shown on Figure 5-5).

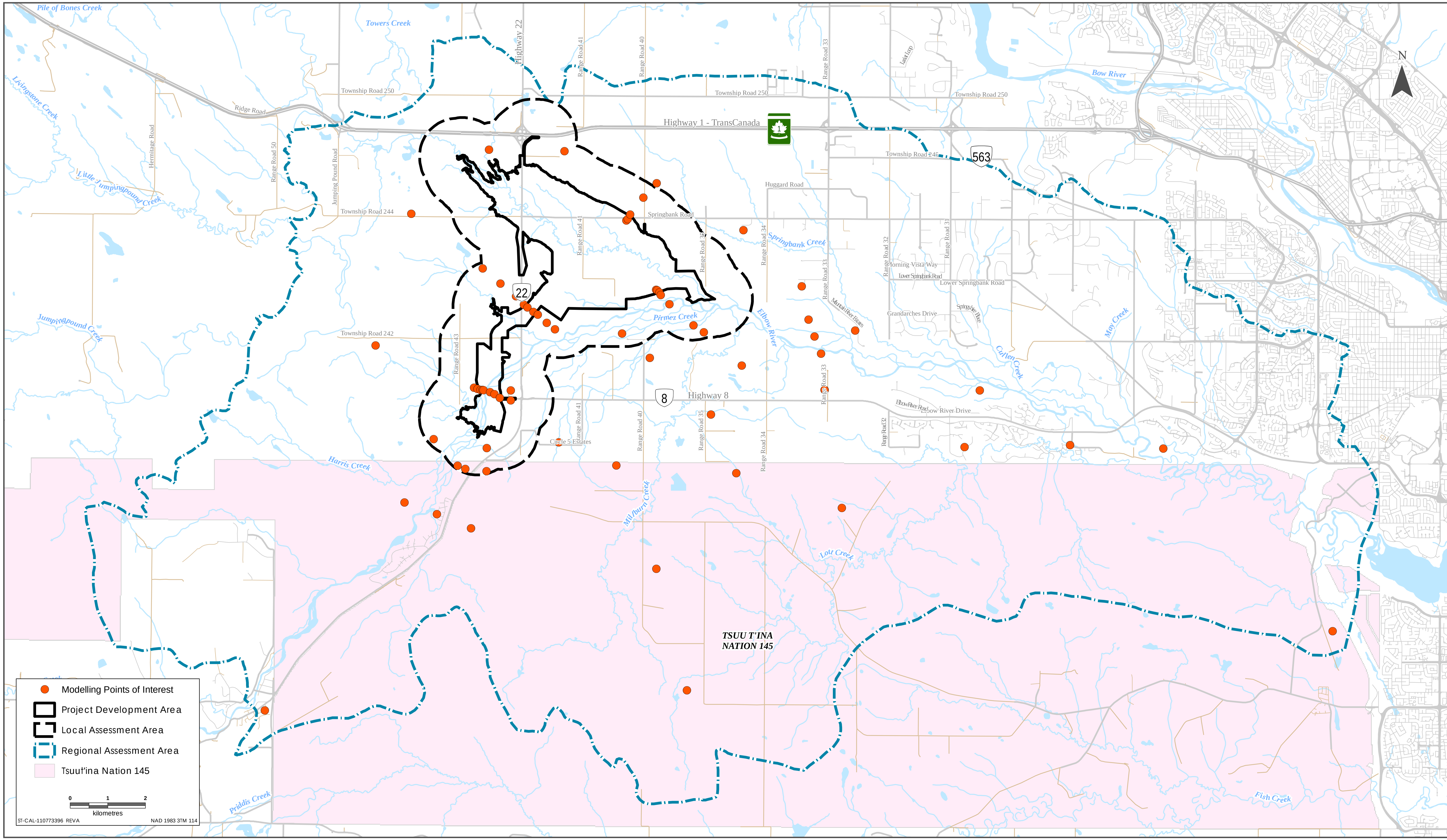
a. What is the rationale for selecting each location of interest (e.g. adjacent to dam structure, flooding area, hydrostratigraphic units of interest, etc.)? Do any of them correlate with existing monitoring well locations?

Response 224

a. Points of interest have been updated in the Hydrogeology TDR Update, Section 5.4 (see the response to IR42, Appendix IR42-1). A total of 67 points were chosen across the groundwater LAA and expanded RAA to evaluate potential effects on groundwater levels from the construction and operation of the Project. The points are presented in Figure IR224-1 and were chosen as follows:

- A line of nine points located perpendicular and across the diversion structure are used to evaluate potential water levels changes in the fluvial deposits in the Elbow River valley and farther out into the adjacent clay, till and bedrock units.
- A line of nine points located perpendicular and across the diversion channel are used to evaluate the effects of construction (excavation) and operation of the channel (flood and non-flood conditions).
- A line of eight points located perpendicular and across the dam are used to evaluate the propagation of water level changes through the dam structure and downgradient of the Elbow River as well as points south of the Elbow River to confirm that the effects do not propagate beyond the fluvial deposits.
- A line of five points located perpendicular and across the bedrock ridge on the northeast side of the dam area are used to evaluate potential propagation of effects through the ridge.
- Twelve points located on the Tsuut'ina Nation Reserve were used to address concerns raised by that Nation.

The remaining 24 points are distributed across the groundwater LAA and RAA to include both upland and lowland areas of the domain as well as to include points within the various geological units. The points do not correlate with monitoring well locations.



Sources: Base Data - Government of Alberta, Government of Canada. Thematic Data - Stantec Ltd.

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Modelling Points of Interest

Figure IR224-1

Question 225

Volume 3B, Section 5.2.1.3. Pages 5.6-5.24

Based on visual inspection, groundwater levels are nearly the same for scenarios EE1, EE2 and EE3. For example, Figures 5-4, 5-8 and 5-12 (cross sections A-A') are similar. The same, Figures 5-5, 5-9 and 5-13 (cross sections C-C') are similar, Figures 5-6, 5-10 and 5-14 (cross sections B-B') are also similar. Figures 5-3, 5-7 and 5-11 (potentiometric head distributions for the three proposed flood scenarios) are also similar. This is interpreted to mean that the groundwater conditions will not change according to the flood conditions, regardless if it is the Design (2013) Flood, 1:100 Year Flood or 1:10 Year Flood. These results are unrealistic.

a. **Show the river valley on all cross sections. Confirm the river has been incorporated into the model as a boundary condition and how is it varied according to the different flood scenarios.**

b. **Apply recharge on the groundwater model to improve the calibration.**

c. **Update the figures referenced above and associated wording.**

Response 225

a. Groundwater levels in upland areas, not in hydraulic communication with the Elbow River, do not appreciably change with floods. However, new cross-sections have been developed across the expanded groundwater RAA based on previous and expanded datasets. On the new cross sections (Figures 3-14 through 3-18 in the Hydrogeology TDR Update in the response to IR42, Appendix 42-1), the Elbow River is marked. Elbow River has been included in the updated model as a specified time varying boundary condition throughout each transient simulation. Section 5.3 of the Hydrogeology TDR Update describes the application of time varying specified heads in the updated numerical model.

b. Distributed recharge has now been added as a boundary condition in the model. Section 4.4 of the Hydrogeology TDR Update describes the application of boundary conditions in the updated model.

c. The updated model simulations presented in Section 5 of the Hydrogeology TDR Update supersede the previous model simulations.

Question 226

Volume 3B, Section 5.2.1.3, Figures 5-4, 5-8, 5-12, Pages 5.6-5.21

There is a water level drop at the location of a well to the right of cross-section A-A' in all three figures.

a. **Explain the cause of the water level drop. Is there a pumping well in the model at this location?**

b. **How many pumping wells are included in the model calibration and prediction? If any were used, plot the pumping wells in a map to identify the locations.**

c. **Label the pumping rates on the map to illustrate the diversion rates at each location. Explain how the pumping rates influence the water levels at each location.**

Response 226

a. No, pumping wells are not simulated in the numerical model. The data used from the Prairie Farm Rehabilitation Administration (PFRA) studies by Hydrogeological Consultants Ltd. and the newer Alberta Water Well Information Database (AWWID) records incorporated into the model report a static water level. The static levels could have been obtained during acute drought conditions, or before wells had completely recovered after development or pumping testing. As such, there is inherent data-noise that results from the transient nature of the static water levels based on environmental factors over time. Screening of the head data attempted to remove data control points with obvious data accuracy issues based on incongruencies with the topographic surface and adjacent static water level values, but some data-noise will remain in the dataset related to mis-reporting of static/pumping levels in the AWWID.

b-c. Pumping wells are not explicitly modelled in the numerical model. The intent of the modelling was to characterize Project-related hydrogeological effects. Beyond domestic and/or agricultural groundwater pumping occurring in the PDA, there is no anticipated change to the pumping rates or locations elsewhere in the groundwater RAA; therefore, inclusion of pumping wells within the model was not material to the effects assessment.

Question 227

Volume 3B, Section 5.2.1.3, Figures 5-6, 5-10, 5-14, Pages 5.6-5.23

There are three wells in cross-section B-B'. The simulated potentiometric surfaces at the location of the Diversion Channel in the cross-section B-B' for different scenarios (EE1, EE2, EE3, PP1, PP2 and PP3) are all below the top of bedrock layer, which are lower than the recorded water level. The actual monitored data around the Diversion Channel show the water levels are above the top of bedrock layer:

MW 16-19-19 (DC-25D) – water level is 6.57 mBGS on June 08, 2016, it is about 3.79 m above the top of bedrock layer.

MW 16-18-10 (DC-21D) – water level is 1213.25 masl in May 2017, that is roughly 3.62 m above the top of bedrock layer.

a. Compare and analyze the difference of observed water levels vs. simulated water levels at the wells' locations for the scenarios EE1, EE2 and EE3.

b. If there is significant difference between the observed water levels and the simulated water levels, recalibrate the models by incorporating the monitored data in the Diversion Channel area.

c. Update all the above Figures and the associated report.

d. There is no visual water level difference in Figures 5-6, 5-10 and 5-14. Are there any differences for the river boundary conditions in Elbow River for the three scenarios EE1, EE2 and EE3? Explain.

Response 227

a-d. The numerical groundwater has been updated in accordance with the expanded groundwater RAA. As such, the cited figures and simulated levels have been superseded. Updated simulation results for dry operations and the design flood are presented in Section 5 of the Hydrogeology TDR Update (see the response to IR42, Appendix IR42-1).

Question 228

Volume 3B, Section 5.2.1.4, Figures 5-16, 5-17, 5-20, 5-21, 5-24 and 5-25, Pages 5.24-5.40

Groundwater levels drop sharply outside the boundary of the off-stream reservoir, which is unrealistic.

a. Verify the modeling to confirm the simulation converged properly.

b. Check the grid size around the groundwater level drop-off area. If the grid size is too large, the model may not simulate the water level transition change. What are the findings after checking the grid size?

c. Check if the time step is too large. If it is too large, the model cannot handle the transition change. What are the findings after checking the time step?

d. Refine the grid size at the location of the groundwater level drop-off area and combine this with the reduction of the time step to modify the model to simulate a more gradual decrease in the groundwater level. Report the findings.

Response 228

a. The numerical groundwater model has been updated to expand the domain in accordance with the updated groundwater RAA, as is summarized in the Hydrogeology TDR Update (see response to IR42, Appendix IR42-1). Updated model simulations have been completed and are confirmed to have converged properly.

b. 3D grid definition in the updated numerical model is discussed in Section 4.3 of the Hydrogeology TDR Update. Grid refinement in areas of Project components was implemented.

c. The updated numerical model uses a 0.5 hour timestep for transient simulations, which is adequate to enable numerical stability during transient simulations.

d. The model grid and time step are sufficiently refined to simulate water level transitions in areas of Project components. Steep declines in water levels are due to the unconfined conditions and underlying hydraulic conductivities of the geologic materials.

Question 229

Volume 3B, Section 5.2.1.4, Figures 5-18, 5-22 and 5-26, Pages 5.24-5.41

Alberta Transportation states *Additional boundary conditions were also added within the FEFLOW model in areas that would become wetted during operation of the Project. Such areas include the diversion channel and the footprint of the off-stream reservoir. Head conditions over time within these features were based upon hydrographs extracted from the hydrodynamic model.* The results of the hydrographs extracted from the hydrodynamic model are not provided. The volume of water applied in the scenarios is not quantified.

a. **What is the depth of the water contained in the diversion channel for the scenarios PP0, PP1, PP2 and PP3?**

b. **What is the volume of groundwater discharge to the diversion channel for the scenarios PP0, PP1, PP2 and PP3?**

Response 229

a. The depth of water flowing through the diversion channel is dependent on the location along the channel and the time after diversion begins. Every position along the diversion channel has a unique hydrograph for each flood with depths varying in time and location. By way of example, Figure 5-3 in the Hydrogeology TDR Update (see the response to IR42, Appendix IR42-1) presents a hydrograph for a point in the diversion channel near its outlet into the off-stream reservoir. The depth of water in the diversion channel varies by flood, but it has a maximum depth of approximately 4 m when the off-stream reservoir is full.

b. The volume of groundwater discharge is transient, varying over time during each of the floods. Seepage will be reduced during diversion as a result of the hydraulic head within the diversion channel. Groundwater discharge to the diversion channel during diversion will be less than the net seepage rate during dry operations, which is estimated to be 0.013 m^3/s.

Question 230

Volume 3B, Section 5.2.1, Page 5.2

Alberta Transportation states *A mathematical groundwater model is used to depict the subsurface geologic setting and associated physical parameters that govern the flow of groundwater through porous media (in this case for the PDA, unconsolidated and/or bedrock materials)* – Page 5.2.

The potentiometric head distribution for the water table across the RAA is presented and discussed mainly for the unconsolidated layer. For the confined shallow bedrock aquifer:

a. Provide the potentiometric head in the confined bedrock layer for the scenarios of PP0, PP1, PP2 and PP3.

b. Produce the potential artesian area for the scenarios of PP0, PP1, PP2 and PP3.

c. Evaluate the impact of the potential artesian conditions.

d. Propose a monitoring plan for the confined shallow bedrock aquifer.

e. Design a mitigation plan to reduce or eliminate the potential artesian impact.

Response 230

a. The bedrock varies from unconfined to semi-confined to confined across the groundwater RAA. The potentiometric heads presented in the numerical model simulations are representative of the heads in the bedrock for all the Project phases. Further description of the groundwater flow regime in the RAA is in the Hydrogeology TDR Update (see the response to IR42, Appendix IR42-1), Section 3.2. Updated numerical model results are presented in Section 5.

b-c. The numerical model has been updated and new simulation results are presented in Section 5 of the Hydrogeology TDR Update.

d-e. A draft groundwater monitoring plan is provided in the response to IR46 as Appendix IR46-1, and mitigation measures for changes in groundwater levels are presented there.

Question 231

<u>Volume 3B, Section 5.2.2.1, Figure 5-27, Pages 5.42 and 5.43</u>

Alberta Transportation states *Groundwater levels in the RAA are anticipated to respond to floods in the Elbow River due to their hydraulic connection to surface water and interactions between the hydrologic and hydrogeologic systems. These responses to floods are anticipated to occur with or without the Project.*

This statement is contradictory because the groundwater level effects shown in the different modelling scenarios show very little effect.

a. Explain with evidence where and in which geological/hydrogeological conditions groundwater levels in the RAA will respond to floods in the Elbow River.

Response 231

a. The numerical model does simulate responses in the Elbow River fluvial deposits because of floods. Because of the scale of the groundwater RAA and amount of topographic relief, changes in water levels in Elbow River during floods is relatively small and is difficult to see at the scale of the cross sections. Time varying boundary conditions that simulate the various flood hydrographs are included in the model along Elbow River (see the response to IR42, Appendix IR42-1, Section 5.5.2).

Question 232

Volume 3B, Section 5.2.3.3, Page 5.50

Alberta Transportation states *The potential effects on groundwater quality related to flood and post-flood operations of the project can be characterized as follows:*

Direction would be positive or adverse, depending upon the chemical species under consideration.....

Magnitude would be low to high depending upon the chemical species under consideration.

a. List the chemical species that may have positive effects on groundwater quality and how.

b. List the chemical species that may have adverse effects on groundwater quality and how.

c. List the chemical species that may have high magnitude effects on the groundwater quality and how.

Response 232

a. While the water chemistry of a future flood cannot be predicted with certainty, in general the diverted water in the off-stream reservoir will have lower concentrations of major dissolved ions relative to groundwater. The addition of flood water with lower total dissolved solids concentrations could improve groundwater quality through dilution of naturally elevated parameters. For example, total dissolved solids, electrical conductivity, nitrite, sulphate, sodium, and chloride are elevated under baseline conditions above Alberta Tier 1 Soil and Groundwater Remediation Guidelines and/or Health Canada Guidelines for Canadian Drinking Water Quality in the shallow groundwater beneath the LAA. It is also expected that the dilution of concentrations of some metal parameters that are naturally elevated in groundwater (iron, manganese, selenium and uranium) may have a positive effect on water quality. However, it is important to note that the effects will be limited because of the low permeability clay beneath the off-stream reservoir, which is demonstrated in the results of the numerical groundwater modelling scenarios in Section 5 of the Hydrogeology TDR Update (see the response to IR42, Appendix IR42-1).

b. There is potential for some metal parameters to have adverse effects on groundwater quality as a result of the high total suspended solids (TSS) in flood water. It is expected that the high TSS concentrations in the floodwater may result in increases in some metal parameters that are not naturally elevated in the groundwater, thus having an adverse effect on water quality. Changes in bacteriological concentrations (e.g., coliforms and e. coli) are also possible because they are often associated with flood water. However, elevated e. coli and total coliforms were noted in the baseline groundwater quality in the groundwater LAA and, as such, the effect of flooding could be positive or negative depending on the bacteriological concentrations of the floodwater.

c. Effects on groundwater quality are considered high in magnitude where a measurable change in groundwater quality parameters is beyond the range of expected natural variability and directly leads to an exceedance of an applicable water quality guideline for those parameters which did not exceed the guideline under baseline conditions. Various metals and bacteriological parameters may have high magnitude effects on groundwater quality as a result of infiltration of water into the off-stream reservoir; however, effects will be limited because of the low permeability clay beneath the off-stream reservoir.

Question 233

Volume 3A, Section 5.4.2.4, Pages 5.38 and 5.39
Volume 3C, Section 1.2.3, Page 1.22

Alberta Transportation states *Adverse residual effects on hydrogeology from the Project are anticipated to occur during the construction phase only and not during dry operation.*

Alberta Transportation also states *The potential effects on groundwater quantity related to groundwater seepage into the diversion channel (when dry) can be characterized as follows: The effects due to seepage into the diversion channel would be irreversible because it is expected that the diversion channel would be in place indefinitely and the potential for seepage into the diversion channel would persist indefinitely.*

a. The above statements are contradictory to one another. Explain the contradictory statements and revise the statements to be consistent.

Response 233

a. The two statements are not contradictory in that they are referring to two separate effects pathways. The statement in Volume 3A, Section 5.4.2.4, page 5.38 is referring to the construction dewatering effects pathway. No construction dewatering will occur during dry operations (since construction of subsurface infrastructure will be complete); therefore, there will be no residual effects related to dewatering during dry operations.

   The second statement in Volume 3A, Section 5.4.2.4, page 5.39 refers to the effects pathway related to seepage into the diversion channel (when dry and not construction dewatering). This effects pathway is active during dry operations. The associated effects are expected to be irreversible because the diversion channel will remain in place indefinitely.

Question 234

Volume 3C, Section 2.4, Page 2.4

Alberta Transportation states *To monitor for potential effects to groundwater, a selection of domestic water wells outside the PDA but within the LAA will be sampled during dry operations and as soon as practical following a diverted flood.*

Monitoring the potential loading effect areas is very important for public safety.

a. Identify the key monitoring locations to continuously monitor the baseline information.

b. Will any of the existing project-specific monitoring wells be included in the monitoring program? If so, identify monitoring wells within the RAA to be included in the monitoring network. If not, why?

c. Will any wells have continuous water level monitoring throughout the life of the project? If so, identify continuous water monitoring wells within the RAA to be included in the monitoring network. If not, why?

d. Will an assessment of springs be included in the monitoring programs? If so, which ones? If not, why?

e. Provide a description of mitigation options for all potential effects, including seepage around the diversion structure and channel, and from potential loading effects on existing groundwater users and artesian areas.

Response 234

a-e. A draft groundwater monitoring plan for the Project is provided in the response to IR46, Appendix IR46-1. Details regarding proposed monitoring well locations (Section 6.2), instrumentation and frequency of monitoring (Section 6.4), field sampling protocols (Section 6.7), and analytical parameters (Section 6.3) to be measured are presented within that draft plan. The draft monitoring plan will be finalized in consultation with AEP and regulators.

Question 235

Volume 4, Appendix I – Hydrogeology Baseline, Section 2.0, Page 2.1

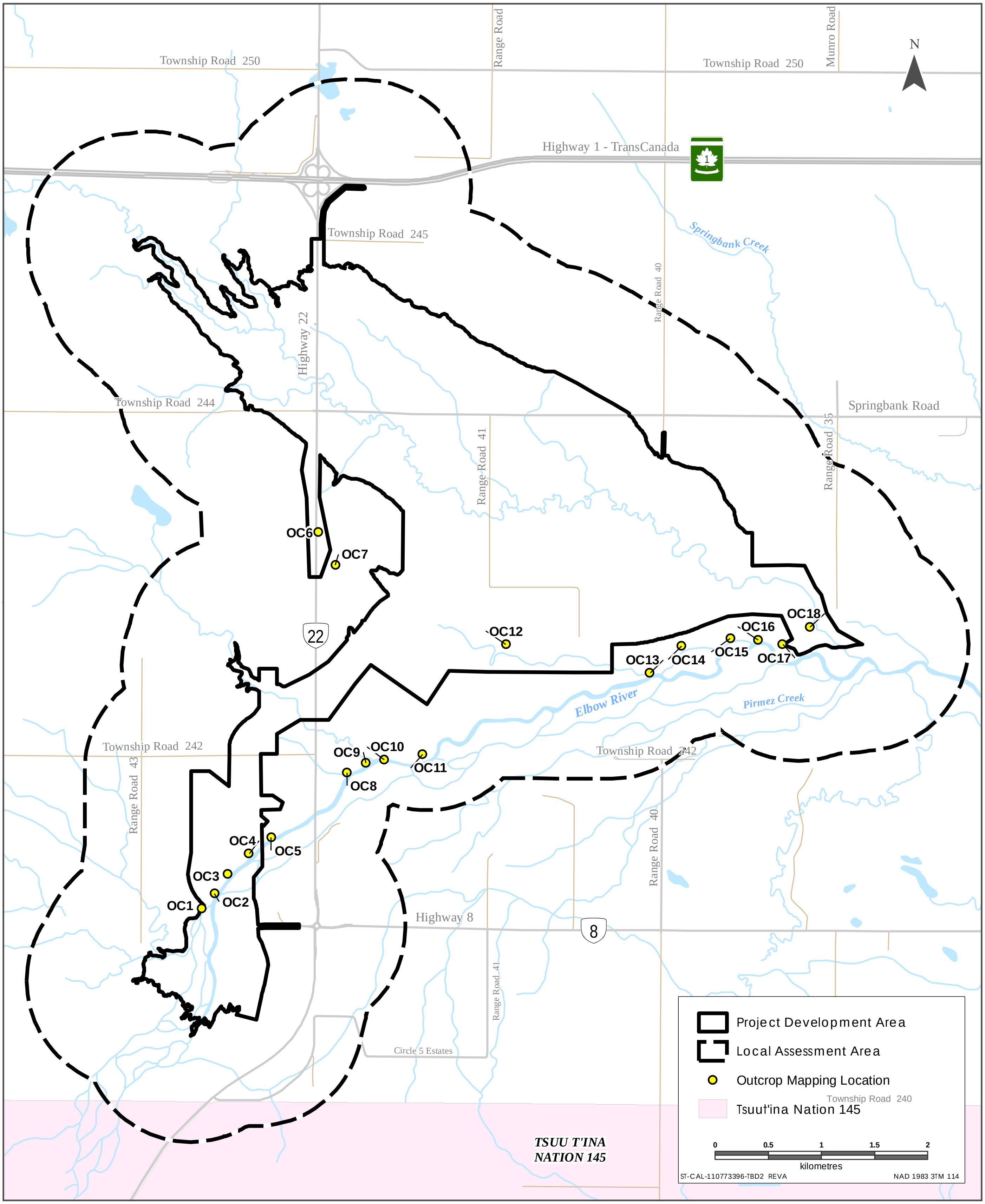
Geological mapping of outcrops was completed but the results were not provided.

a. Show the mapped areas/outcrops on a figure (e.g. field-verified survey figure or other figure).

b. Provide a discussion of the mapping results, such as the geological units, layers, etc.. Do the mapping results correlate with the local area geology from the literature review and other available data? If not, provide the explanation for the differences in results.

Response 235

a. The mapped outcrop locations are presented in Figure IR235-1.



Sources: Base Data - Government of Alberta, Government of Canada, Thematic Data - Stantec Ltd.

Outcrop Mapping Locations

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Figure IR235-1

b. The observations made during the outcrop mapping are summarized in Table IR235-1. The observations are consistent with the regional mapping and literature review described in Volume 4, Appendix I. The 3D conceptual site model and hydrostratigraphic framework presented in the baseline report considered both the regional geological information as well as the outcrop mapping.

Table IR235-1 Outcrop Mapping Descriptions

Outcrop ID	3TM North	3TM East	Description
OC1	5654403	-33801	Approximately 120 m long outcrop along the northwest bank of Elbow River; upstream of the Diversion Structure Inlet. Sub-vertical bedding of the Brazeau Formation and overlying glacigenic units are exposed.
OC2	5654547	-33682	180 m section of outcrop along the northwest bank of Elbow River at the location of the Diversion Structure Inlet. Sub-vertical bedding of the Brazeau Formation and overlying glacigenic units are exposed.
OC3	5654729	-33558	200 m section of outcrops along the northwest bank of Elbow River; downstream of the Diversion Structure Inlet. Heavily folded rock mass and sub-vertical bedding of the Brazeau Formation and overlying glacigenic units are exposed. Possible location of the Brazeau Thrust.
OC4	5654920	-33358	50 m section of outcrops along Elbow River at the location of the Diversion Structure Inlet. Sub-horizontal bedding of sandstone units within Brazeau Formation and overlying glacigenic units are exposed.
OC5	5655073	-33149	150 m long outcrop along Elbow River at the location of the Diversion Structure Inlet. Sub-horizontal bedding of sandstone units within Brazeau Formation and overlying glacigenic units are exposed.
OC6	5657950	-32705	200 m long road cutting on the east side of Highway 22. The Brazeau-Coalspur Formation boundary (Entrance conglomerate) is exposed.
OC7	5657640	-32544	150 m long outcrop of Coalspur Formation on a NW-SE trending ridge.
OC8	5655683	-32437	120 m section of outcrops along the north bank of an old channel on Elbow River. Sub-horizontal bedding of sandstone units within Brazeau Formation and overlying glacigenic units are exposed.
OC9	5655777	-32257	70 m section of outcrops along the north bank of Elbow River. Sub-horizontal bedding of sandstone units within Brazeau Formation and overlying glacigenic units are exposed.
OC10	5655804	-32083	200 m section of outcrops along the north bank of Elbow River. Sub-horizontal bedding of sandstone units within Brazeau Formation and overlying glacigenic units are exposed.

Table IR235-1 Outcrop Mapping Descriptions

Outcrop ID	3TM North	3TM East	Description
OC11	5655858	-31725	220 m section of outcrops along the north bank of Elbow River. Sub-horizontal bedding of sandstone units within Brazeau Formation and overlying glacigenic units are exposed.
OC12	5656894	-30939	130 m long outcrop of Coalspur Formation on a NW-SE trending ridge.
OC13	5656622	-29584	200 m long outcrop along the north bank of Elbow River. Sub-horizontal bedding of Paskapoo Formation is exposed.
OC14	5656876	-29287	300 m section of outcrops and landslides along north bank of an old channel on Elbow River. Glacial lacustrine and glacial till units are exposed.
OC15	5656950	-28826	220 m section of outcrops and landslides along Elbow River. Glacial lacustrine and glacial till units are exposed.
OC16	5656936	-28566	150 m section outcrops and landslides along Elbow River. Glacial lacustrine and glacial till units (including the basal grey till) are exposed.
OC17	5656893	-28334	50 m long outcrop along Elbow River. Glacial lacustrine and glacial till units (including the basal grey till) are exposed.
OC18	5657058	-28079	20 m long outcrop along the East Unnamed Creek. Fluvial lag deposits are exposed.

Question 236

<u>Volume 4, Appendix I – Hydrogeology Baseline, Table 2-1, Page 2.6 and 2.7</u>

Baseline water level data should be provided for comparison throughout the EIA.

a. Add the baseline water level data (May 2016) to the table for comparison.

Response 236

a. No May 2016 water level data are available. The water level data measured in September 2016 has been added to the Hydrogeology TDR Update (see the response to IR42, Appendix IR42-1), Section 2.3, Table 2-1.

Question 237

Volume 4, Appendix I – Hydrogeology Baseline, Section 2.2, Page 2.2

Alberta Transportation states *The LAA is the maximum area within which Project-related environmental effects can be predicted or measured with a reasonable degree of accuracy and confidence. The LAA includes the PDA and any adjacent areas where Project-related environmental effects may reasonably be expected to occur.*

a. **Based on the above description of the LAA, modify the extent of LAA to include the area affected by the loading effects area in the confined aquifer.**

Response 237

a. The original groundwater LAA did include the area over which potential "loading effects" could occur. The description of the LAA in Section 2.2 of the Hydrogeology TDR Update (see the response to IR42, Appendix IR42-1) has been updated to clarify this inclusion as is described below (red text indicates the clarification for the LAA).

   "The LAA includes the PDA plus a 1-km buffer surrounding the PDA to address potential localized hydrogeological effects, including water level and water quality changes near the Project components, and localized changes in groundwater levels near the off-stream reservoir and dam. The LAA is the maximum area within which Project-related environmental effects can be predicted or measured with a reasonable degree of accuracy and confidence. The LAA includes the PDA and any adjacent areas where Project-related environmental effects may reasonably be expected to occur."

Question 238

Volume 4, Appendix I – Hydrogeology Baseline, Section 2.3, Page 2.9; Table 2-1, Page 2.7; Section 3.2.4, Page 3.39

The third paragraph states that five nested well pairs were installed. Table 2-1 and Section 3.2.4 (Page 3.39) indicates there are only four.

a. **Confirm if five or four well pairs were installed. Update the required pages so that the number of well pairs is consistent.**

Response 238

a. Five well pairs were installed. This change has been made in the Hydrogeological TDR Update (see the response to IR42, Appendix IR42-1) in Section 3.2.4.

Question 239

Volume 4, Appendix I – Hydrogeology Baseline, Section 2.3, Page 2.11

a. Add the ground elevations and top of casing elevations to the borehole logs in Attachment A for comparison.

Response 239

a. Ground and top of casing elevations have been added to the borehole logs which are included in Attachment A of the Hydrogeology TDR Update (see the response to IR42, Appendix IR42-1).

Question 240

Volume 4, Appendix I – Hydrogeology Baseline, Section 3.1.7, Page 3.23

No local geological cross-sections are included in the EIA.

a. Using the monitoring well logs and geotechnical borehole data, create two localized cross-sections (NW-SE) to include the local detailed aquifer and aquitard features in the Project Area; one across the Diversion Structure and one across the Off-Stream Dam, extending across the Elbow River and including the proposed development features. Label water levels in the river and in the boreholes.

b. Compare them against the two similar cross-sections derived from the regional model. Analyze the differences.

c. Explain which model most accurately represents the actual situation for the local impact assessment.

Response 240

a. There is only one 3D conceptual site model (3D CSM) that covers the entire groundwater RAA. Both the local and regional scale hydrostratigraphy are accounted for in the model. The data used to construct the model is described in Volume 4, Appendix I, Section 2.6 and includes all the monitoring well logs and geotechnical borehole data. The local detail within the PDA and groundwater LAA is maintained in the 3D CSM and numerical model. The node spacing and minimum layer thickness used to maintain the detail in the numerical model are described in Section 5 of the Hydrogeology TDR Update (see the response to IR42, Appendix IR42-1).

Five new cross-sections have been prepared and are presented in Figures 3-14 to Figure 3-15 in the Hydrogeology TDR Update. The cross-sections span the entire groundwater RAA; however, the three cross-sections that traverse the PDA (A-A', B-B' and C-C') now include figure insets that are focused at a local scale on the PDA to provide a better visual representation of the hydrostratigraphy in that area.

b-c. There are no differences in the model at local versus regional scales because these two scales are fully accounted for.

Question 241

Volume 4, Appendix I – Hydrogeology Baseline, Section 3.2.1 Page 3.29

Alberta Transportation states *The response test analyses are presented in Attachment A*, however, the response test analyses are not presented in Attachment A.

a. Include the Response Test Analysis results.

Response 241

a. Response test analysis results were unintentionally omitted from Volume 4, Appendix I and are now included in Attachment A of the Hydrogeology TDR Update (see the response to IR42, Appendix IR42-1).

Question 242

Volume 4, Appendix I – Hydrogeology Baseline, Figures 3-17 & 3-19, Page 3.37

To improve the calibration, use the observed data to constrain the model, especially for the shallow bedrock aquifer:

a. List the data points [well ID, UTMx, UTMy, aquifer name, surface elevation (masl), and groundwater level (masl)] used to generate Figure 3-19 potentiometric surface contour in a table as an attachment.

b. Add these points to the groundwater model calibration.

c. Produce the groundwater depth map in the Upper Bedrock layer.

d. Subtract the potentiometric surface in the Unconsolidated Deposits (Figure 3-17) by the potentiometric surface in the Upper Bedrock layer (Figure 3-19). Map and analyze if there is an upward gradient in the area.

Response 242

a. The data points used to generate the potentiometric surface include 1,155 data points derived from public water well drilling records as described in Section 3.2.3 of Hydrogeology TDR Update (see the response to IR42, Appendix IR42-1). The locations of the data points are presented in Figure 3-20.

b. Calibration of the updated model includes the potentiometric data points used to create the surface. This was done in two ways: directly by comparing simulated hydraulic head directly at select locations and, globally, by comparing the entire simulated head surface to the potentiometric surface created using the water well record data. Calibration of the new model and the calibration points used are discussed in Section 4.5 of the Hydrogeology TDR Update.

c. A depth to groundwater map is presented in the Hydrogeology TDR Update, Figure 3-23.

d. A map of the water table surface minus the potentiometric surface is presented in the Hydrogeology TDR Update, Figure 3-22. An analysis of the hydraulic gradients and how they relate to the hydrostratigraphy is provided in Section 3.2.4.

Question 243

<u>Volume 4, Appendix I – Hydrogeology Baseline, Section 3.2.4, Page 3.39</u>

Alberta Transportation states *Vertical hydraulic gradients between the unconsolidated and bedrock deposits indicate the potential for upward-directed groundwater flow (discharge) at each of the four nested monitoring well locations…. In addition to the contact springs discussed in Section 3.2.2, the relatively high magnitude vertical gradients likely result in artesian springs along the valley walls and in low-lying areas where the confining layers are thin or in areas of more permeable material.*

a. Describe or show where the high magnitude vertical gradients are located and state whether or not they were incorporated into the model. If they were not, explain why.

b. Subtract the DEM by the potentiometric contours (Figure 3-19) to analyze if there are any artesian areas. Label MW16-8-8/MW16-8-19 and MW16-6-11/MW16-6-20 to verify if they are situated in the predicted artesian areas.

c. Survey the well owners to the east and south east of the PDA to find out if there were any artesian wells or water level increases in the domestic wells during the 2013 flood, particularly for the wells screened in the shallow bedrock aquifer.

d. Modify Section 3.2.4 if necessary, based on the above information. Provide the updated information.

Response 243

a. At the groundwater RAA scale, the areas with high magnitude vertical gradients were evaluated by calculating the difference between the interpreted water table surface and the bedrock potentiometric surface. The resulting difference showed areas with potential for strong recharge (positive) or discharge (negative) conditions (see Figure 3-22 in the Hydrogeology TDR Update in the response to IR42, Appendix IR42-1). This approach can also highlight where semi-confined conditions may exist. Fully confined conditions were not observed because flowing artesian conditions were not reported in any hydrostratigraphic unit. They are unlikely due to erosional unconformities limiting the lateral extent of potential confining layers.

   The methods to interpret the two surfaces are described in Section 2.6 of the Hydrogeology TDR Update. At the PDA scale, the data shows semi-confined conditions in the area of the dam may exist. Hydraulic head in the bedrock unit is observed above the bedrock/unconsolidated sediment interface, but not up to and/or above land surface. Given the hydrostratigraphic framework as determined in the 3D CSM, the numerical flow simulations were run to simulate unconfined conditions.

b. As noted in a., no flowing artesian conditions were reported in the groundwater RAA. The contours shown in Figure 3-22 of the Hydrogeology TDR Update highlight areas where the head in surficial hydrostratigraphic units are different than that of the deeper bedrock unit. There are some areas in the southwest portion of the RAA that, due to the topographic variation and sparse hydraulic head control data, the head difference may be above the land surface due to interpolation across valley features. Despite the interpolation error in these areas, the method can be used as an indicator of where flowing artesian conditions may exist, although none are reported.

c. Field verification of landowner wells was not completed outside the PDA access area. The head data from this area are representative of when the well was installed, developed and measured after recovery. Hydraulic head values during the 2013 flood in this area are unknown. However, the 2013 flooding was related to unusually high runoff in the alpine headwaters of the Elbow River rather than local-scale recharge conditions. The limited lateral extent of the confining layers (clay and till) effectively limits development of flowing artesian conditions.

d. Section 3.2 of the Hydrogeology TDR Update discusses the groundwater regime in the RAA in detail.

Question 244

Volume 4, Appendix I – Hydrogeology Baseline, Section 3.2.5, Figures 3-20, 3-21, Pages 3.39-3.42

Groundwater level fluctuations are discussed but the visual information provided is limited and difficult to correlate with lithological conditions and specific locations in the LAA. Monitoring was completed in nested wells pairs but a discussion of the water level results and significance is not provided. The artesian conditions in individual and nested wells should be discussed, as the impact to these areas will likely be significant during flood events.

a. Provide the rationale for selecting which wells have data logging pressure transducers.

b. Make x-axis and y-axis labels larger and/or bolder, as they are difficult to read when printed.

c. Use the same scale for all charts.

d. Update the charts to extend the date range and include monitoring data collected since June 2017.

e. The charts for MW16-6-20 and MW16-28-18 show water levels above ground elevation, indicative of artesian conditions.

- **i. Do any other wells have artesian conditions? If so, which ones?**
- **ii. Discuss the hydrogeological significance and extent of the artesian conditions in these wells and any other wells where the water level is above ground level.**
- **iii. For all the bedrock monitoring wells, identify which ones belong to confined or unconfined aquifers.**
- **iv. Is this data reflected in the potentiometric surface maps and incorporated into the model as actual data points? If not incorporate this data into the map and model and provide the updated information. If this data was not reflected why was it excluded?**

f. The charts for nested wells MW16-8-8/MW16-8-19 show that the water levels in the bedrock aquifer are higher than the water levels in the unconsolidated deposits.

- **i. Discuss the hydrogeological significance of this (e.g vertical gradients, connectivity).**
- **ii. Show the groundwater elevations, ground elevation and top of bedrock elevation for both wells in one chart to facilitate analysis (the scale for this chart may be different than the others due to the broader range of the y-axis).**

g. The charts for nested wells MW16-6-11/MW16-6-20 show that the water levels in the unconsolidated deposits and bedrock aquifer are at or near ground level.

i. Discuss the hydrogeological significance of this (e.g vertical gradients, connectivity).

ii. Show the groundwater elevations, ground elevation and top of bedrock elevation for both wells in one chart to facilitate analysis (the scale for this chart may be different than the others due to the broader range of the y-axis).

Response 244

a. The locations of the data logging pressure transducers were chosen to achieve spatial distribution across the groundwater LAA and to include the various hydrostratigraphic units.

b. The X-axis and Y-axis label size has been increased for print legibility and the revised time-series charts are included in Section 3.2.5, Figures 3-24 to 3-26 in the Hydrogeology TDR Update (see the response to IR42, Appendix IR42-1).

c. The scales have been revised to make them consistent where possible on all time-series charts included in Hydrogeology TDR Update, Section 3.2.5, Figure 3-24 to Figure 3-26.

d. The wells have not been accessed and loggers have not been downloaded since June 2017.

e. i. It is assumed that this question refers to flowing artesian conditions (i.e., hydraulic head above ground surface) rather than simply artesian conditions (i.e. hydraulic head above the top of the aquifer). No other flowing artesian conditions were observed in the groundwater monitoring wells.

ii. The flowing artesian conditions are indicative of potential groundwater discharge areas. Potential groundwater discharge areas across the groundwater RAA are presented in Appendix IR42-1, Figure 3-22 and Figure 3-23.

iii. There are both confined and unconfined conditions within the bedrock aquifer in the groundwater LAA. While there may be discrete water bearing intervals that are confined at a local scale, the shallow bedrock is considered unconfined or semi-confined.

iv. Yes, the bedrock monitoring well water-level data are reflected as actual data points in the potentiometric mapping.

f. i-ii. The nested monitoring well pair MW16-8-8/MW16-8-19 is located 35 m hydraulically upgradient of a groundwater spring. Figure IR244-1 presents the hydraulic head in these monitoring wells along with the bedrock and ground surface elevations for reference. The lower hydraulic head in MW16-8-8 is a result of groundwater flow and discharge from the sand and silt layer (the layer in which the MW16-8-8 well was completed) to the spring. Upward flow of groundwater from the underlying units is slow as a result of lower vertical hydraulic conductivity (compared to horizontal). As a result, the monitoring well completed in the lower unit is able to support a higher hydraulic head.

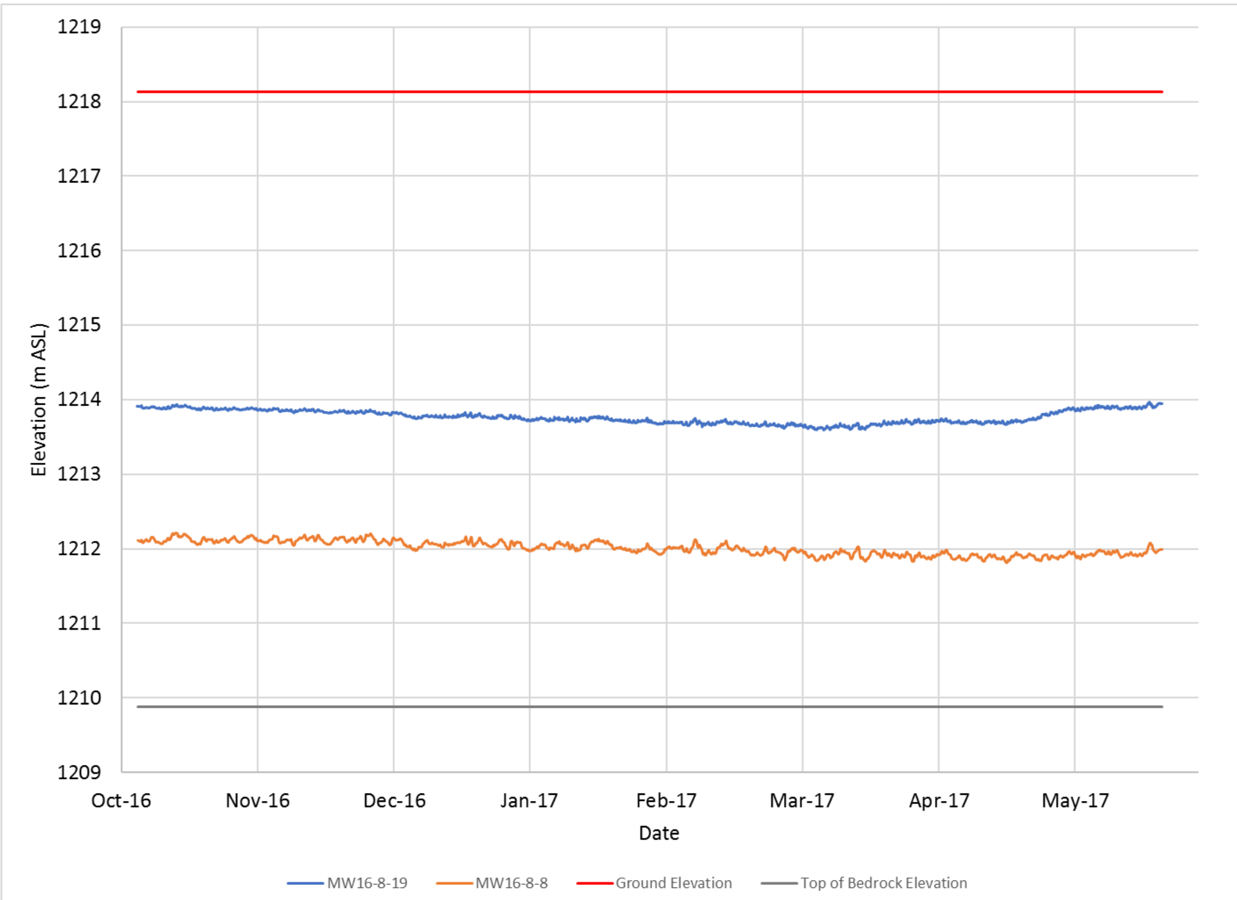


Figure IR244-1 Hydrograph of MW16-8-8/MW16-8-19

g. i-ii. The nested monitoring well pair MW16-6-11/MW16-8-20 is located 20 m from the channel of the unnamed creek that runs through the reservoir. Figure IR244-2 presents the hydraulic head in these monitoring wells along with the bedrock and ground surface elevations for reference. Groundwater discharge conditions are expected in this low-lying area, an expectation that is supported by the water levels presented in Figure IR244-2. The hydrographs of the two nested monitoring wells differ. However, similar trends are observed during some periods of the year (October to December and April to June). The similar trends in hydraulic head and the relatively low vertical gradient indicate that there is hydraulic communication between the completion intervals.

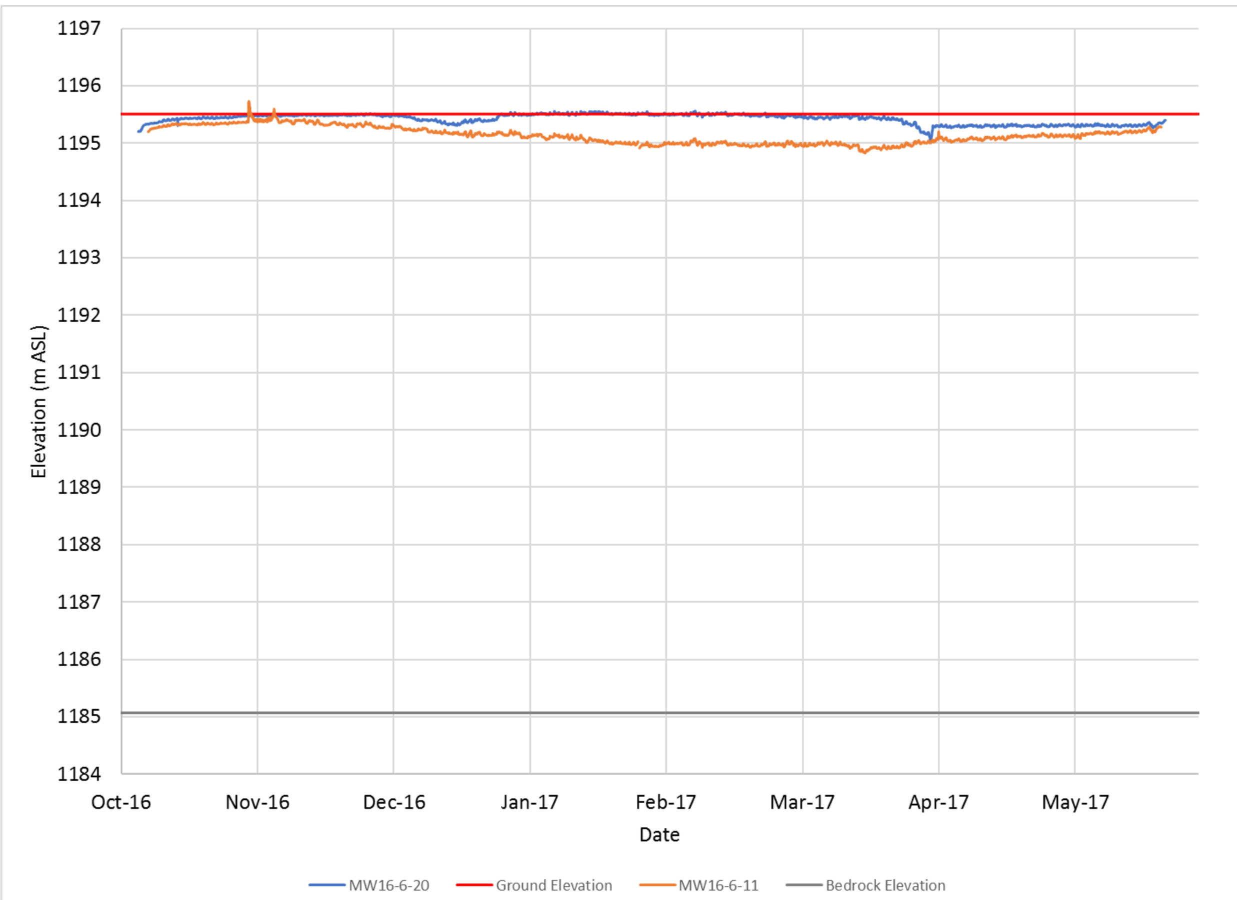


Figure IR244-2 Hydrograph of MW16-6-11/MW16-6-20

Question 245

Volume 4, Appendix I – Hydrogeology Baseline, Figure 3-24, Table 3-3, Pages 3.46 to 3.49

a. Of the 392 relevant records, 19 were field-verified during the domestic well testing program. The only data provided is the analytical summary Table 3-5 and the locations summarized in Attachment B.

  i. Provide an explanation for the low number of field-verified locations. How many landowners were contacted and how many responded?

  ii. Describe what was done during the field-verified survey (collection of GPS coordinates, water levels and/or water samples, etc…).

  iii. Provide the field-verified survey results in a table, including water levels and sampling, etc.

  iv. Was surface water and spring locations included in the survey? If not, why not?

  v. Where is the discussion and/or report outlining the methodology and complete results of the domestic well testing program? If this was not included provide the discussion and/or report. If they are in a separate document, provide a reference.

b. Figure 3-24 only shows the histogram of water well depth. Show the amount of wells completed in overburden material and bedrock.

c. To visually show the locations and densities of the field-verified and licensed water users, post the locations in Table 3-3 on a map using different symbols to differentiate between the groundwater and surface water licences and registrations. Include spring locations on the figure and differentiate between confirmed (e.g. field- verified) and interpreted locations.

d. Assign 'Groundwater' as the water sources for Licences 0025968-00-01 and 0032320-00-00 in Table 3-3, since they are identified as being production wells in the groundwater licence.

e. Explain whether or not the allocated groundwater licence volumes were incorporated into the groundwater model for calibration.

Response 245

a. i. Domestic water well testing was conducted as requested by landowners in the PDA. A total of 31 landowners were identified across the PDA and 14 participated in the domestic water well testing program. A field-verified survey was not extended to the groundwater RAA because it is beyond the area in which Project effects are expected to occur and not considered material to the assessment.

ii. Water well testing was completed in accordance with AER (2016). While the standard is not strictly applicable to the Project, it provides guidance toward completing domestic water well tests to an appropriate level of rigour.

iii. Land access agreements negotiated for the Project included data confidentiality and, as a result, the requested information cannot be provided.

iv. Surface water and spring locations were discussed with landowners and were included in the survey, if requested by the landowner.

v. As indicated in the response to iii, this information is confidential, at the request of the landowners.

b. A histogram showing the proportion of wells installed in the unconsolidated and bedrock units in each depth range is presented in the Hydrogeology TDR Update, Figure 3-24 (see the response to IR42, Appendix IR42-1.

c. Groundwater license and registration locations are presented in the Hydrogeology TDR Update, Figure 3-24, which also shows locations of the field-verified well locations from the domestic water well testing program. Spring locations are presented in Figure 3-21. Surface water license and registration locations are not presented because they are not directly related to the groundwater valued assessment.

d. Groundwater has been assigned as the water source for Licences 0025968-00-01 and 0032320-00-00 in the Hydrogeology TDR Update, Table 3-3.

e. Allocated groundwater license volumes were not incorporated into the numerical groundwater model.

References

AER (Alberta Energy Regulator). 2006. Standard for Baseline Water-Well Testing for Coalbed Methane/Natural Gas in Coal Operations. Available at: https://www.aer.ca/documents/applications/WA_StandardBaselineWater-WellTestingCoal.pdf

Question 246

Volume 4, Appendix I – Hydrogeology Baseline, Section 3.4. Table 3-5. Pages 3.49, 3.56
Volume 3A, Section 5.2.2.3, Pages 5.23 to 5.26

A total of 31 groundwater samples were collected from monitoring wells within the LAA (17 from wells screened in unconsolidated deposits, 14 from wells screened in bedrock). Analysis of groundwater from wells screened in unconsolidated deposits was conducted on wells sampled in fall 2016. Analysis of groundwater from wells screened in bedrock was conducted on wells sampled in fall 2016 and from the April 2016 domestic well testing program.

a. **Where are the results of the April 2016 domestic well testing program captured? Include a reference to the existing report or tabulate and append the data to the Baseline report. Show the locations of the tested domestic wells in a figure. Include completion information for the domestic wells, including the source aquifer.**

Response 246

a. The scope and terms of the domestic well sampling program were negotiated within the land access agreements executed to enable the hydrogeology and geotechnical field programs. During these negotiations, landowners expressed concerns regarding confidentiality of the results. To conform to such requests, Alberta Transportation committed to local landowners to present only aggregated results within the hydrogeology assessment. The fall 2016 sampling program included the greatest number of domestic wells. These results were also aggregated and presented in the hydrogeology assessment because they are most representative of conditions across the LAA.

Question 247

Volume 4, Appendix I – Groundwater Numerical Modelling, Section 2.3.1, Page 2.4

a. **Define the eastern boundary of the perimeter of the model domain.**

Response 247

a. The eastern boundary of the numerical model domain is consistent with the eastern boundary of the now expanded RAA. This eastern boundary of the numerical model domain is based on a subwatershed of Elbow River that is situated just west of the Glenmore Reservoir as described in Section 2.2 of the Hydrogeology TDR Update (see the response to IR42, Appendix IR42-1).

Question 248

<u>Volume 4, Appendix I – Groundwater Numerical Modelling, Section 3.2, Figure 3-1, Page 3.2</u>

To view the conductivity zones clearly in different layers;

a. Split Figure 3-1 into a series of maps to present the calibrated conductivities clearly, with overlays (such as RAA, LAA, PDA and highways etc.) to identify the relative locations of the conductivity zones:

   i. Provide the conductivity distribution in the deep bedrock layer;

   ii. Add the conductivities for the shallow bedrock aquifer on top of the deep bedrock layer;

   iii. Add the conductivities for the basal silt, sand and gravel on top of the shallow bedrock aquifer;

   iv. Add the conductivities for the till layer on top of the basal silt, sand and gravel;

   v. Add the conductivities for the glaciolacustrine clay on top of the till; and

   vi. Add the conductivities for recent fluvial sand and gravel on top of the glaciolacustrine clay.

b. Was a universal conductivity or variable conductivities applied to the same geologic/hydrogeologic units after the calibration? Explain why or why not.

Response 248

a. Section 4.3.2 of the Hydrogeology TDR Update (see the response to IR42, Appendix IR42-1) describes the parameterization of model layers. Hydraulic conductivity values for each of the model layers was parameterized based upon the hydrogeologic framework developed within the 3D CSM and on results of the steady state calibration runs.

b. Spatially variable hydraulic conductivities were assigned in most model layers, depending upon the geologic materials being represented by that layer.

Question 249

Volume 4, Appendix I – Groundwater Numerical Modeling, Section 3.2.2, Page 3.8

Alberta Transportation states *The potentiometric surface of the upper water table…These groundwater elevations were used as initial hydraulic heads during calibration of the numerical model.*

a. Were the data points or the digitized contours used as the initial hydraulic heads? Explain the rationale for the selection.

b. Were any bedrock data points (Figure 3-19, Page 3.37 of Hydrogeology Baseline Report) used for the initial hydraulic heads? Why?

Response 249

a. Both individual data points and 3D surfaces (not 2D contours) were used during calibration of the numerical model. Following expansion of the model domain, calibration was conducted based on both individual data points and as interpreted surfaces derived from the 3D CSM. Calibration targets at a subset of individual points were established within the model during calibration and residuals were calculated at each point as calibration progressed. 3D interpreted potentiometric surfaces were also used in areas outside of calibration points to aid in the calibration, by importing potential solutions into the 3D CSM for comparison against the interpreted surface. Calibration of the model is described in further detail in Section 4.5 of the Hydrogeology TDR Update (see the response to IR42, Appendix 42-1).

b. Yes, water level data from wells completed within bedrock were used during model calibration, as described in further detail in Section 4.5 of the Hydrogeology TDR Update.

Question 250

Volume 4, Appendix I – Groundwater Numerical Modeling, Section 4.1, Page 4.1

a. How many layers of 3-D mesh are in the groundwater model?

b. Which geological/hydrogeological units are correlated to which mesh layers?

c. Is there only one layer for the bedrock unit? If so, two layers are recommended to represent the upper bedrock aquifer and the underlying low permeability bedrock to model the practical features in the field. If there is only one layer for the bedrock unit explain why only one was selected.

Response 250

a. There are seven layers of 3D mesh in the updated numerical groundwater model. Section 4.3 of the Hydrogeology TDR Update (see the response to IR42, Appendix IR42-1) provides further details regarding the setup of model layers.

b. The numerical groundwater model is setup using full 3D layers and each layer does not correspond to a single hydrostratigraphic unit in all cases. Section 4.3 of the Hydrogeology TDR Update provides further details regarding the setup of model layers.

c. Two layers were created for the bedrock unit. An upper layer was parameterized with a higher hydraulic conductivity value than the lower layer to represent potential fracturing of the unconformable surface. Section 4.3 of the Hydrogeology TDR Update provides further details regarding the setup of model layers.

Question 251

Volume 4, Appendix I – Groundwater Numerical Modeling, Section 4.2, Page 4.4

a. Alberta Transportation states *Time varying river water level boundary conditions along Elbow River, at the diversion channel and off-stream reservoir were applied to assess response of groundwater system to three floods*.

b. Were the off-stream reservoir time-varying water level boundary conditions applied to the whole off-stream reservoir area or only around the edge of the reservoir? Explain why or why not.

c. To which mesh layer(s) were the time-varying water level boundary conditions applied? Explain the rationale.

Response 251

a. The statement as stated in the question is correct.

b. Time varying boundary conditions were applied to both the perimeter and within the off-stream reservoir. Given that the off-stream reservoir wetted area itself changes as it fills and drains, both the head values assigned to the specified head nodes, as well as the area over which the nodes were active, changed between timesteps in the transient runs.

c. The time varying boundary conditions were applied to the uppermost layer of the model. This was done to simulate the effect of temporarily retaining water on the land surface in the off-stream reservoir.

Question 252

Volume 4, Appendix I – Groundwater Numerical Modelling, Section 4.2.1, Page 4.4

Alberta Transportation states *Figure 4-6 to Figure 4-14 present time varying water level boundary conditions used in the model for the design flood for both the existing environment ... The time varying surface water level hydrographs were obtained from the hydrodynamic modeling results (Volume 4. Appendix H).*

a. Make changes to the time-varying water level boundary conditions if the hydrodynamic modeling results change as a result of SIR1.

Response 252

a. Time varying boundary conditions for Elbow River, the off-stream reservoir, and the diversion channel were exported from the hydrodynamic model for both flood and non-flood conditions.

For non-flood conditions (when diversion of the Elbow River water is not occurring), time varying boundary conditions were only applied in the Elbow River because there is not any water in the diversion channel or into the off-stream reservoir during these times.

For the design, 1:100 year, and 1:10 year floods, time varying boundary conditions for the Elbow River, the diversion channel, and the off-stream reservoir were exported from the hydrodynamic model.

The implementation of time varying boundary conditions within the numerical groundwater flow model is discussed in further detail in Section 5.3 of the Hydrogeology TDR Update (see the response to IR42, Appendix IR42-1).

Question 253

Volume 4, Appendix I – Groundwater Numerical Modeling, Section 4.2.1, Figure 4- 4, Page 4.4-4.5; Section 4.2.2, Figure 4-15, Page 4.16

Alberta Transportation states *Prescribed head boundaries, dirchilet boundaries, were specified to the top…and at the perimeter of the model domain.*

Fluid-flux boundaries, Neumann boundaries, were used to represent inflows and outflows for saturated aquifers in the model domain…The location of the prescribed-flux boundaries is presented on Figure 4-15.

a. There is already a prescribed head boundary (Figure 4-4) at the location of the prescribed-flux boundaries (Figure 4-15). How does the model choose the boundary condition at these locations for the simulation when two boundary conditions were applied to the same nodes?

b. Why were the prescribed flux boundary conditions applied at these locations (Figure 4-15)? Are there other similar hydrogeological condition locations where the prescribed flux boundary should be applied?

Response 253

a-b. The numerical groundwater model has been updated to include an expanded domain consistent with the expanded RAA. The boundary conditions used in the updated numerical model are presented in Section 4.4 of the Hydrogeology TDR Update (see the response to IR42, Appendix IR42-1). Updated figures presenting each of the boundary condition types are included therein.

Question 254

<u>Volume 4, Appendix I – Groundwater Numerical Modeling, Section 5.1.1, Figures 5- 1, 5-2 and 5-3, Table 5-2, Pages 5.1-5.6</u>

Alberta Transportation states *The spatial distribution of the monitoring well water level points that were used for model calibration is shown on Figure 5-1. Additional domestic well records were also considered during the model calibration within the border RAA (not shown)*.

a. Explain why there are no calibration targets located beyond the LAA boundaries and discuss how this affects the modeling results.

b. Show the locations of the additional domestic wells used for the calibration.

c. Add the monitoring data from Upper Bedrock (Figure 3-19, Hydrogeology Baseline) for the calibration, if it has not already been done.

d. Update Figures 5-1, 5-2, 5-3 and Table 5-2.

e. How will monitoring occur in the diversion channel area after construction? Will the monitoring wells in the diversion channel area be destroyed during construction? If so, will they be replaced? If not, why not?

Response 254

a. Calibration of the model considered observed head measurements at specific calibration points inside and outside the groundwater LAA, and 3D surfaces of both the water table and potentiometric surfaces as were interpreted within the 3D CSM. Section 4.5 of the Hydrogeology TDR Update (see the response to IR42, Appendix IR42-1) presents the calibration points used in the updated numerical model.

b. The updated calibration dataset includes information from domestic water wells both directly as a calibration point, and indirectly through use of 3D surfaces derived from interpolation of data originating from domestic wells in the expanded groundwater RAA. Section 4.5 of the Hydrogeology TDR Update presents the calibration points used in the update numerical model.

c. Monitoring data collected from the upper bedrock was included in the calibration dataset. Section 4.5.1 of the Hydrogeology TDR Update presents the calibration points used in the updated numerical model.

d. Figure 5-1, Figure 5-2, Figure 5-3, and Table 5-2 are updated in the Hydrogeology TDR Update as Figure 4-13 to Figure 4-15 and Table 4-2.

e. It is anticipated that monitoring wells that were installed in the diversion channel area will be decommissioned prior to construction. The procedures to be used to decommission these monitoring wells are described in the response to IR44. Groundwater monitoring in the area of the diversion channel will be a component of the long-term groundwater monitoring program and new monitoring wells may need to be installed in these areas (but not within the diversion channel footprint). The siting of monitoring wells to be included in the groundwater monitoring program will consider the anticipated extent of Project effects. The draft groundwater monitoring plan is provided in Appendix IR46-1 in the response to IR46.

Question 255

<u>Volume 4, Appendix I – Groundwater Numerical Modeling, Section 5.1, Table 5-1, Page 5.3</u>

Table 5-1 shows Shallow Bedrock Hydraulic Conductivity Zones in the *West Zone, Central Zone* and *East Zone*. These zones are not discussed elsewhere in the EIA and are difficult to correlate with what has been presented in the geologic setting for the RAA. Hydraulic conductivity values are presented but no rationale is provided.

a. Provide a map to correlate to the table and show where the zones are distributed in relation to the bedrock subcrops.

b. **The shallow bedrock's conductivity varies significantly from 3.40e-6 m/s to 4.27e-9. Discuss the geological and hydrogeological reasons for this. Do the zones correlate to the upper bedrock subcrops throughout the RAA? If not, why? If so, include the bedrock units in the table so they can be correlated to the zones.**

c. **Alberta Transportation states *Groundwater use in the RAA is primarily from the shallow bedrock aquifers* (Page. 3.45 of Hydrogeology Baseline). Are there any groundwater users located in the low permeable area (East Zone with hydraulic conductivity of 4.27e-9 m/s)? If so, what is the typical yield of the well(s)?**

d. **Is there any pumping test data to support the hydraulic conductivity variance? If not, why?**

e. **What are the hydraulic conductivity differences between the shallow and the deep bedrock units?**

Response 255

a-b. The numerical groundwater flow model has been updated as is described in the Hydrogeology TDR Update (see the response to IR42, Appendix IR42-1). Table 5-1 has been superseded along with the approach to assignment of hydraulic conductivity values in the updated model. The updated distribution of hydraulic conductivity assigned to model layers is described in Section 4.3.

c. There are existing water wells broadly distributed across the groundwater RAA. Lemay and Guha (2009) depict water well yield ranging from less than 1 imperial gallon per minute (Igpm), up to the 5 Igpm to 25 Igpm. However, the behaviour of a given water bearing bed within a thick formation like the Paskapoo can vary significantly from the average vertical and horizontal hydraulic conductivity. The low permeability is consistent with available data for the eastern part of the RAA.

d. Insitu hydraulic response testing and packer testing completed on numerous bedrock intervals show a large variation in hydraulic conductivity within the groundwater RAA. Further, the lithological descriptions of the various upper Cretaceous-aged bedrock formations and the Paleocene-aged Paskapoo Formation present within the RAA all indicate major lithological variability from sandstone to mudstone and are all heavily interbedded.

In west central Alberta, the Paskapoo alone ranges in hydraulic conductivity from 1.1x10E-10 to 1.0x10E-3 m/s (Hughes et al. 2017). The hydraulic conductivity was used as a calibration parameter to match modelled versus observed heads within reasonable hydraulic conductivity envelopes.

e. The areas of the model domain with topographically elevated bedrock (mountainous areas with outcrop) were pre-supposed to be deformed and fractured with increased permeability relative to buried subcrop areas. These areas were inferred to have some secondary porosity and were assigned increased hydraulic conductivity relative to buried sub-crop areas. The bedrock in the updated model is represented with two layers. The upper bedrock layer in the model was assigned a higher hydraulic conductivity value (1.4E-06 m/s) than the lower layer (2.7E-07 m/s) to represent the potential for fracturing of this unconformable surface.

REFERENCES

Hughes, A, Smerdon, B., Alessi, D. 2017. Summary of Hydraulic Conductivity Values for the Paskapoo Formation in West-Central Alberta. Alberta Geological Survey Open File Report 2016-03.

Lemay, T.G. and Guha, S. 2009. Compilation of Alberta groundwater information from existing maps and data sources; Energy Resources Conservation Board, ERCB/AGS Open File Report 2009-02, 43 p.

Question 256

Volume 4, Appendix I – Groundwater Numerical Modeling, Section 5.2, Figures 5-2, 5-3, Table 5-2, Pages 5.3-5.6

a. There are 27 points in Figure 5-2 and 5-3, and 31 points in Table 5-2. Why are they different?

b. Modify Table 5-2 to include well IDs, simulated water heads, observed water heads, differences of simulated water heads vs observed water heads, and the statistics parameters.

c. Expand the modified Table 5-2 to include the simulated and observed water heads in the Upper Bedrock layer.

Response 256

a. Figure 5-2, Figure 5-3, and Table 5-2 have now been superseded by the Hydrogeology TDR Update (see the response to IR42, Appendix IR42-1). Figure 4-16 presents a comparison of observed vs. simulated groundwater levels (update of former Figure 5-2), and Figure 4-17 presents the comparison of residuals to simulated groundwater levels (update of former Figure 5-3). Both have been updated with the current calibration information.

b. A new table comparing simulated and observed heads at the updated calibration points is presented in Hydrogeology TDR Update, Section 4, Table 4-1.

c. Residuals (simulated heads minus observed heads) for updated calibration points completed in the bedrock unit are presented in Hydrogeology TDR Update, Section 4, Table 4-1.

Question 257

Volume 4, Appendix I – Groundwater Numerical Modeling, Section 6.1, Figures 6-2, 6-3, 6-4, 6-5, 6-6, 6-10, 6-11, 6-12, 6-15, 6-16, 6-17, Pages 6.3-6.21

There are at least two major aquifers in the study area – one aquifer in the unconsolidated layer and one confined aquifer in the shallow bedrock layer. It looks like all the above maps are related to the aquifer in the unconsolidated layer.

a. For all of the above Groundwater Hydraulic Head Distribution maps, explain which overburden material layers belong to each map.

b. Update the above maps with reasonable recharge in the groundwater model.

c. Provide similar updated maps in the Shallow Bedrock confined aquifer, applying the loading effect.

Response 257

a,c. The numerical model was run using unconfined conditions given the limited lateral extent of confining layers due to topographic variation and erosional unconformities. Since the model is setup as an unconfined system, the simulated heads are the same within each model layer and, therefore, only one map of head distributions is presented per simulation. The groundwater regime is described in detail in Sections 3.1.8, 3.2.2 and 3.2.3 in the Hydrogeology TDR Update (see the response to IR42, Appendix IR42-1). There are areas within the groundwater RAA that demonstrate semi-confined conditions, given the variation from hydrostatic pressure distribution in the grouped bedrock unit as shown in Hydrogeology TDR Update, Section 3, Figure 3-22.

b. The numerical flow model has been updated with appropriate recharge boundaries, as described in Hydrogeology TDR Update, Section 4.4.2. Updated simulation results with the inclusion of recharge are presented in Section 5.5, including maps of simulated heads across the model domain.

Question 258

Volume 4, Appendix I – Groundwater Numerical Modeling, Section 6.1, Figures 6-7, 6-8, 6-9, 6-13, 6-14, 6-18, 6-19, Pages 6.3-6.24

a. Change the size and colours of the pink and light blue control point labels so they are easier to read.

b. The above Figures mention Control Points and simulated hydrographs. In which layer(s) are they screened?

c. Apply a reasonable recharge rate to the groundwater model. Update the above figures.

d. Add Control Points at the locations of the deepest water thickness in the reservoir and to the east and southeast of the PDA in the low-lying topographical areas. Screen the new Control Points in the upper bedrock aquifer. Simulate and plot the hydrographs at the new Control Points with the loading effect incorporated into the model.

Response 258

a. The figures cited have been superseded by new model simulation results. The response to IR224 discusses the selection and placement of new points of interest (control points) in the updated numerical model in the Hydrogeological TDR Update (see the response to IR42, Appendix IR42-1; Section 5.5 and figures therein for the updated discussion. There is not a one to one equivalence of old figures to new figures)

b. The groundwater regime in the groundwater RAA is essentially a hydrostatic pressure distribution, simulated as unconfined conditions. Therefore, the layer in which the control point is installed is not critical as head across all hydrostratigraphic layers is consistent.

c. Groundwater recharge rates ranging from 12 mm/year to 25 mm/year were established by the regional groundwater study (Klassen et al. 2018). Given the regional nature of the study cited, and the large topographic variability of the RAA with many areas without significant depressions (i.e., well drained slopes without prairie-like depressions), the minimum recharge value of 12 mm/year was used. Relatively good model calibration resulted from application of 12 mm/year recharge as assigned to the hydrostratigraphic units exposed at the top of the model domain. Application of recharge in the updated numerical model is discussed in Section 4.4.2 of the Hydrogeology TDR Update.

d. The response to IR224 discusses the selection and placement of new points of interest in the updated numerical model. Transient data from select points of interest are presented in Section 5 of the Hydrogeology TDR Update.

REFERENCES

J. Klassen, J.E. Liggett, I. Pavlovskii and P. Abdrakhimova. 2018. First-order groundwater availability assessment for southern Alberta; Alberta Energy Regulator / Alberta Geological Survey, AER/AGS Open File Report 2018-09, 37 p.

Question 259

Volume 2, Section 5.2, Table 5-2, Page 5.10

a. Explain why hydrogeology was not flagged as having a potential interaction during 'water diversion construction' and 'retention of water in reservoir'.

b. Ensure all blank squares are populated.

Response 259

a. The "water diversion construction" will take place within the Elbow River channel and the potential interactions are related to hydrology and not to hydrogeology. The rational for not including the potential interaction of hydrology with hydrogeology is provided in the response to IR40.

The interaction between the "retention of water in the reservoir" and hydrogeology was incorrectly omitted from Volume 2, Section 5, Table 5-2. However, the assessment of this Project interaction with hydrogeology is discussed in Section 5.0 of the Hydrogeology TDR Update (see the response to IR 42, Appendix 42-1).

b. Table IR259-1 provides revisions to Volume 2, Section 5, Table 5-2, as red text to indicate an added row for "retention of water in the reservoir" and a clarifying edit with respect to sediment partial cleanup.

Table IR259-1 Interactions between Valued Components and the Project (Revised from Volume 2, Section 5, Table 5-2)

Project Components and Physical Activities	Air Quality and Climate	Acoustic Environment	Hydrogeology	Hydrology	Surface Water Quality	Aquatic Ecology	Terrain and Soils	Vegetation and Wetlands	Wildlife and Biodiversity	Land Use and Management	Historical Resources	Traditional Land and Resource Use	Public Health	Infrastructure & Services	Economy & Employment
Construction															
Clearing	✓	✓	–	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–	✓
Channel excavation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–	✓
Water diversion construction	✓	✓	–	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dam and berm construction	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Low-level outlet works construction	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–	✓
Road construction	✓	✓	–	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Bridge construction	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Lay down areas	✓	✓	✓	–	✓	✓	✓	✓	✓	✓	✓	✓	–	–	✓
Borrow extraction	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	–	–	✓
Reclamation	✓	✓	–	–	✓	✓	✓	✓	✓	✓	✓	✓	–	–	✓
Dry Operations															
Maintenance	–	–	✓	✓	✓	✓	–	✓	✓	✓	–	✓	–	–	–
Flood and Post-flood Operations															
Reservoir filling	–	–	✓	✓	✓	✓	–	✓	✓	✓	–	✓	✓	✓	–
Retention of water in the reservoir	–	–	✓	✓	–	–	–	–	–	–	–	–	–	–	–
Reservoir draining	–	–	✓	✓	✓	✓	✓	✓	✓	✓	–	✓	✓	✓	–

Table IR259-1 Interactions between Valued Components and the Project (Revised from Volume 2, Section 5, Table 5-2)

Project Components and Physical Activities	Air Quality and Climate	Acoustic Environment	Hydrogeology	Hydrology	Surface Water Quality	Aquatic Ecology	Terrain and Soils	Vegetation and Wetlands	Wildlife and Biodiversity	Land Use and Management	Historical Resources	Traditional Land and Resource Use	Public Health	Infrastructure & Services	Economy & Employment
Soil drainage and drying	–	–	–	–	–	–	✓	–	–	–	–	–	–	–	–
Reservoir drainage maintenance	✓	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Reservoir sediment partial cleanup: sediment will remain in the reservoir but moved and contoured to maintain free water flow into and out of the reservoir for future floods	–	✓	–	✓	✓	✓	✓	✓	✓	✓	–	✓	–	✓	–
Drained reservoir	✓	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Channel maintenance	–	✓	–	✓	✓	✓	–	–	✓	–	–	✓	–	✓	–
Road and bridge maintenance	–	✓	–	–	–	✓	–	–	✓	✓	–	✓	–	✓	–
Flood damage cleanup and restoration	–	–	–	–	–	–	–	–	–	–	–	–	–	–	✓

NOTES:
✓ = Potential interaction
– = No interaction

5.3 HYDROLOGY

Question 260

Volume 1, Section 3.1, Page 3.1

Alberta Transportation states *The data used to develop the design hydrograph is considered preliminary data. In January 2017, Water Survey Canada (WSC) released hydrometric data for the 2013 flood that is herein referred to as "the 2013 hydrographs" and their respective monitoring stations*.

a. **Was the preliminary and official (released on January 2017) data compared? If the data was compared how are they different? If the data was not compared, compare the data and explain how the data is different.**

b. **What are the potential implications of using the preliminary data?**

Response 260

a. The Water Survey of Canada (WSC) data released in 2017 were not compared with the preliminary data in the hydrology assessment. The flood and volumetric hydrological analysis used data that was completed in 2015 using the preliminary data released by WSC. The 2013 flow data released by WSC in 2017 is reviewed here: Figure IR260-1 compares the hydrograph preliminary data with 2017 hydrograph data for Elbow River at Bragg Creek and Figure IR260-2 for Elbow River at Sarcee Bridge. Flow data from both locations are used to estimate the flood and volumetric flood analysis.

   Table IR260-1 summarizes the peak flow and volume for the two locations from the preliminary and 2017 data. The peak flow comparisons show that there is minor difference between the two datasets for peak flows at both locations. The 2017 data for volume is 10% more than the preliminary data for volume at Sarcee Bridge.

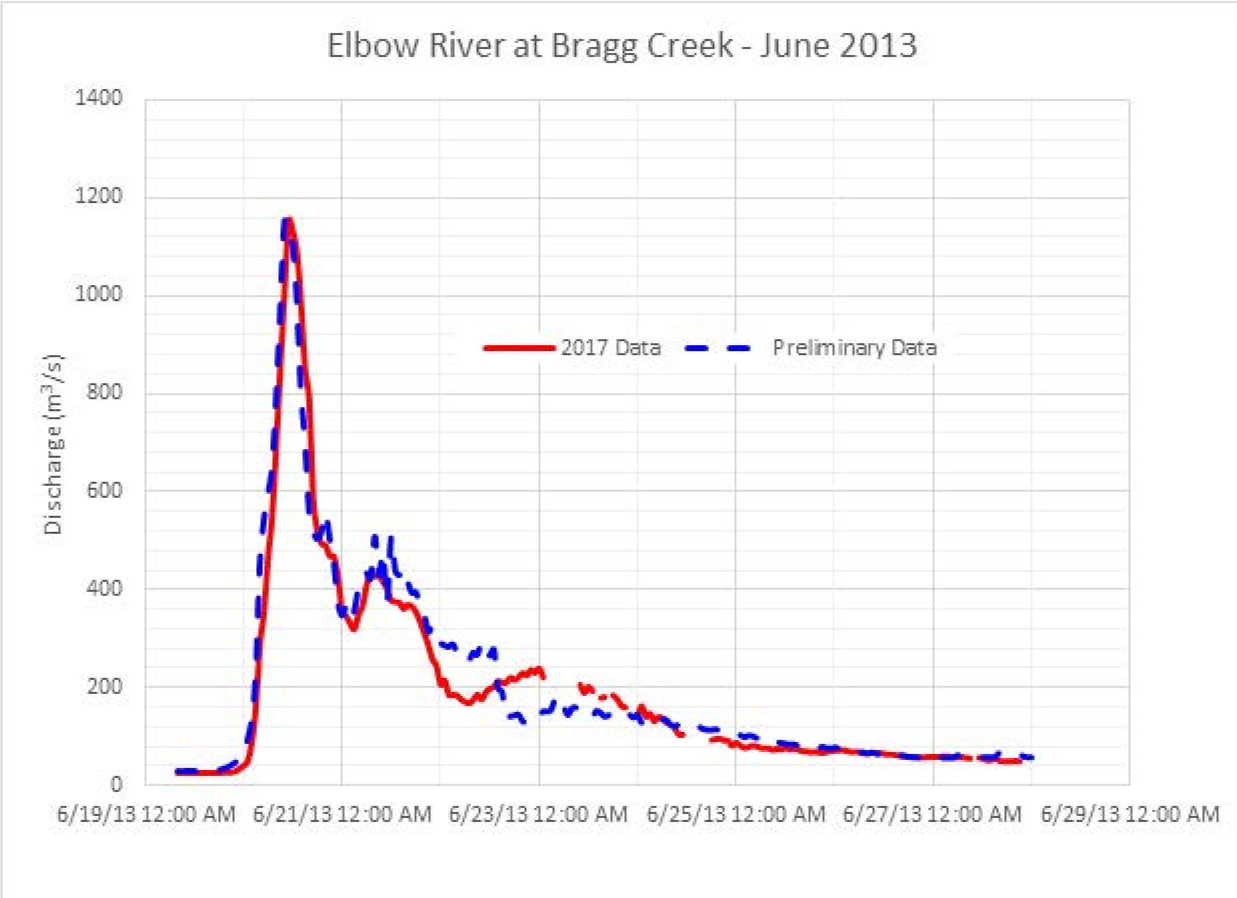


Figure IR260-1 Elbow River at Bragg Creek: Comparison of 2017 Final Hydrograph Data and Preliminary Hydrograph Data

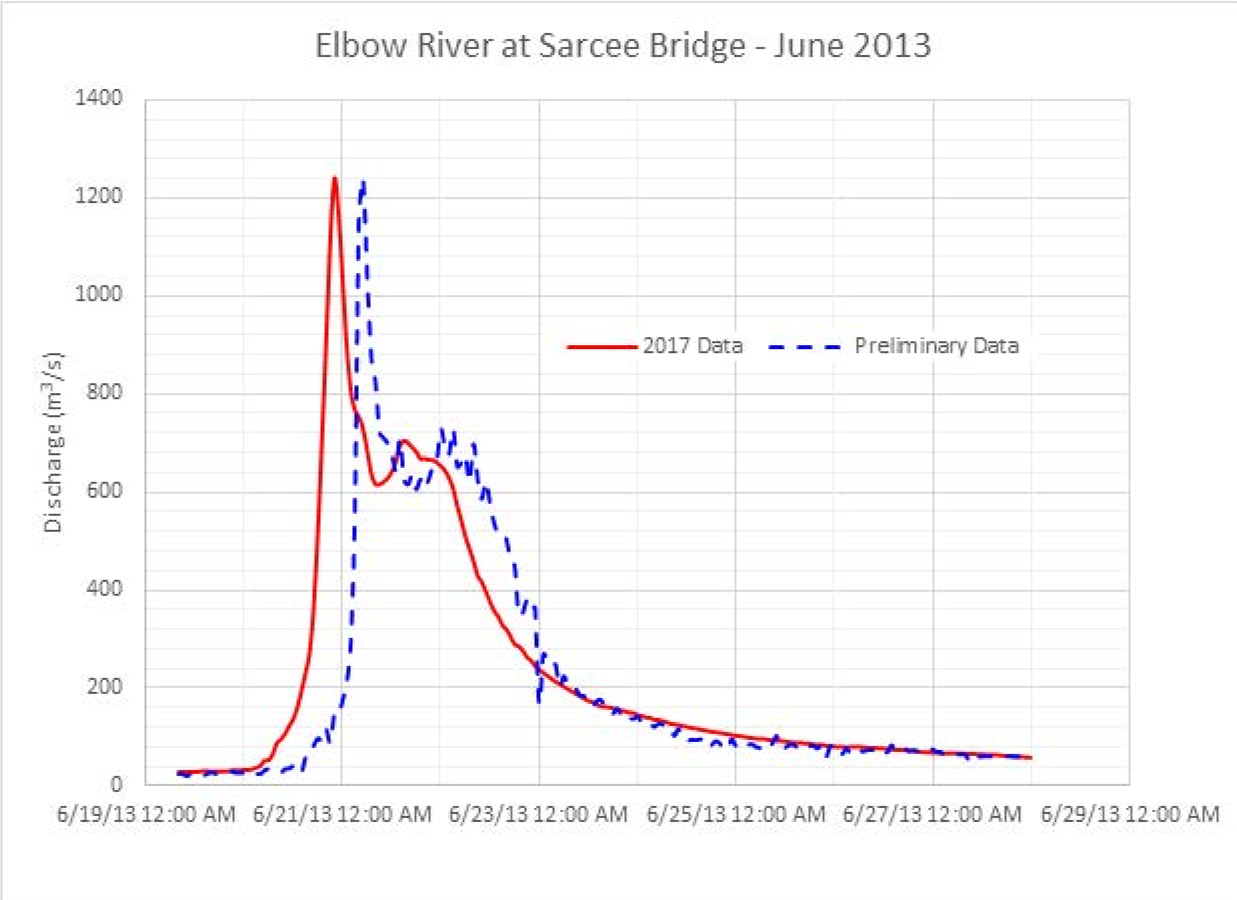


Figure IR260-2 Elbow River at Sarcee Bridge: Comparison of 2017 Final Hydrograph Data and Preliminary Hydrograph Data

Table IR260-1 Comparison of 2017 Hydrograph Data and Preliminary Hydrograph Data at Two Locations

Streamflow station	Preliminary Hydrograph Data		2017 Hydrograph Data		Difference	
	Peak flow (m^3/s)	Volume (m^3)	Peak flow (m^3/s)	Volume (m^3)	Peak flow (%)	Volume (%)
Elbow River at Bragg Creek (05BJ004) (The volume estimate is missing because the hydrograph for 2017 at Bragg Creek has missing values.)	1,150	3,542,244	1,155	–	0.39	–
Elbow River at Sarcee Bridge (05BJ010)	1,240	3,779,127	1,239	4,142,070	-0.1	9.6

b. Peak flows for Elbow River at Bragg Creek and Sarcee Bridge are almost the same with both data sets. The design of the Project and flood water management between the Project and Glenmore Reservoir is not modified when 2017 data are used, instead of preliminary data.

The would be no change to the design of the Project or hydrology assessment, based on review of the 2017 data.

Question 261

Volume 1, Section 3.1, Page 3.1
Volume 3B, Section 6.1, Page 6.1
Volume 3B, Section 6.4.1.1, Page 6.14

Alberta Transportation states *The estimated peak flow rates of the Elbow River at the diversion site are presented for different return periods in Table 3-1*.

Alberta Transportation states on page 6.1 that *The (2013) design flood volume that is used to estimate engineering storage volumes required for the Project is based directly on volumes derived from the estimated hydrograph at Glenmore Reservoir, not at Bragg Creek, due to data limitations at the time*.

Alberta Transportation states on page 6.14 that *The hydrographs used in the analytical assessment are primarily based on hydrographs sourced from the WSC for the WSC Station 07BJ004 Bragg Creek*.

a. Provide a clear description on which flow data from which location was used to do the frequency analysis to determine peak flows for design flood, 1:100 year flood and 1:10 year flood.

b. Describe which flow data from which location was used to estimate storage volume of the reservoir. Was any other local runoff volume other than the Elbow River flow volume used to estimate the total storage capacity of the reservoir? If yes, describe these local areas, and show them on the respective figures. Explain how these runoff volumes were estimated. If not, describe why these local runoff volumes were not included in estimating the reservoir storage volume and describe the impacts of not considering these volumes in the estimation of total flood storage for the proposed reservoir.

Response 261

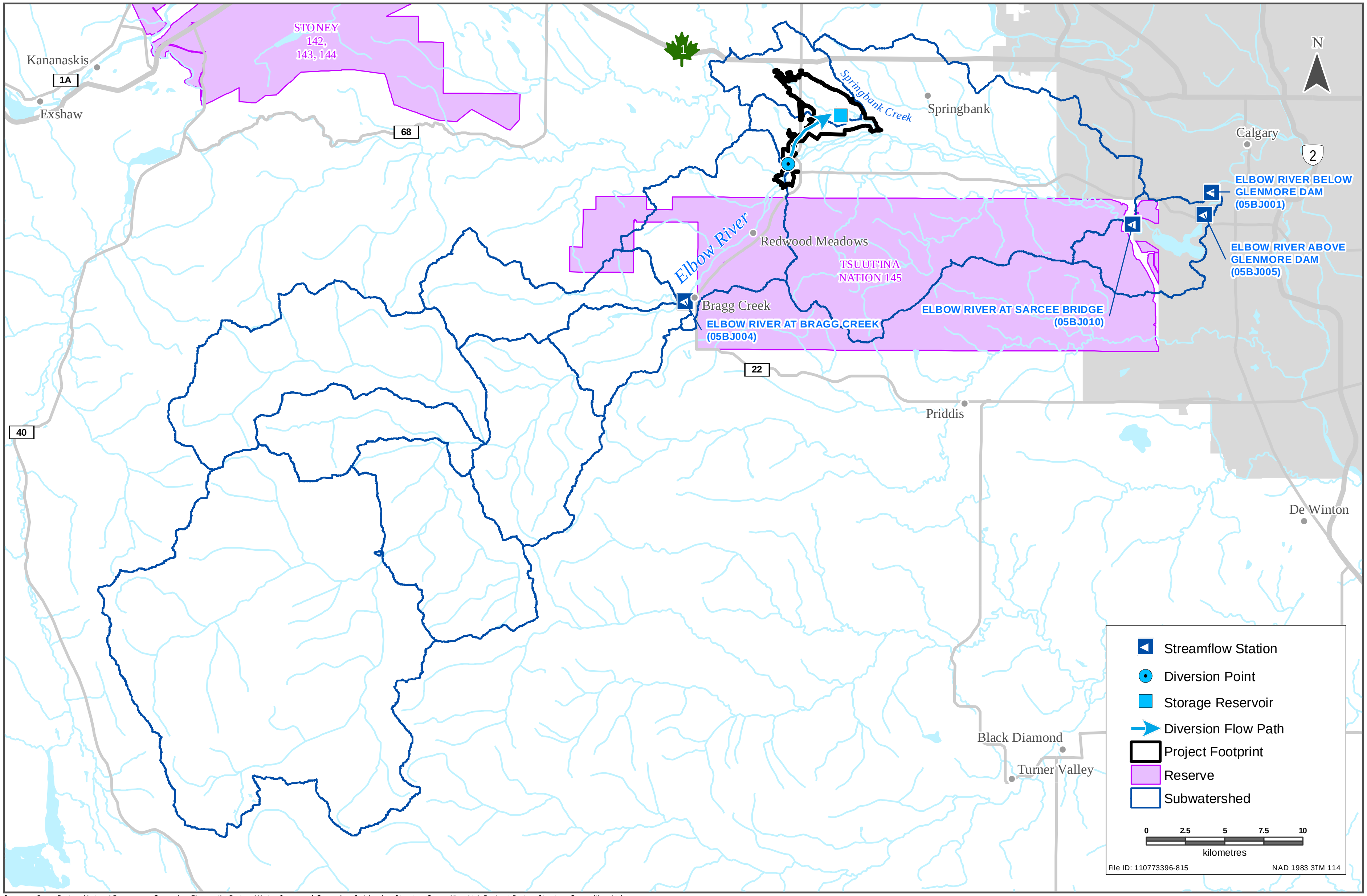
a. The flood frequency analysis was interpolated based on an analysis of Water Survey of Canada (WSC) data from four hydrometric locations: Elbow River below Glenmore Dam (WSC *05BJ001*), at Bragg Creek (WSC *05BJ004*), above Glenmore Dam (WSC *05BJ005*), and at Sarcee Bridge (WSC *05BJ010*), see Figure IR261-1. The Bragg Creek Station is located upstream of the diversion site, while the remaining stations are situated downstream near Glenmore Reservoir. Table IR261-1 provides data for these hydrometric stations.

Table IR261-1 Hydrometric Stations Summary for Calculation of Flood Frequency Analysis

Station ID	Station Name	Drainage Area (km²)	Period of Record		Percent Missing Data	Years of Acceptable Flow Data[1]	Type of Flow	Operation Schedule
			From	To				
05BJ001	Elbow River below Glenmore Dam	1,235.7	1908	2011	2%	102	Unregulated (1908 – 1932)/ Regulated	Continuous
05BJ004	Elbow River at Bragg Creek	790.8	1934	2012	25%	59	Natural	Continuous
05BJ005	Elbow River above Glenmore Dam	1,220	1933	1977	0%	45	Natural	Continuous
05BJ010	Elbow River at Sarcee Bridge	1,189.3	1979	2012	37%	20	Natural	Continuous

NOTES
[1] Even though data exists for the indicated period, only part of the period that contains unregulated flow was used in the analysis.

Due to their proximity and similar drainage areas, the data for stations 05BJ001, 05BJ005, and 05BJ010 were combined and considered as one dataset ("combined station"). The combined station consists of data from 1908 to 1932 (05BJ001), 1934 to 1977 (05BJ005), and 1979 to 2012 (05BJ010). Only natural, unregulated flow is represented in the dataset. Therefore, flow measurements up until the construction of Glenmore Dam were used from the Elbow River station below Glenmore Dam (05BJ001). No flow data exists for 1978 and 1991 for any of the stations within the combined station grouping.



Sources: Base Data - Natural Resources Canada. Thematic Data - Water Survey of Canada. Subbasin - Stantec Consulting Ltd. Project Data - Stantec Consulting Ltd.

Stantec

ALBERTA TRANSPORTATION SPRINGBANK OFF-STREAM RESERVOIR PROJECT ENVIRONMENTAL IMPACT ASSESSMENT

Elbow River Basin
Streamflow Station Locations

Figure IR261-1

Annual maximum daily flows are available for the combined station for years prior to 1979. Peak instantaneous flows are first available for the combined station in 1979 and for most years between 1979 and the present. Estimated annual maximum instantaneous peak flows for some years prior to 1978 were provided by the Province of Alberta to supplement this dataset and are used as if they were recorded values. These instantaneous peak flows were estimated as part of the Calgary floodplain study (Alberta Environment 1983).

Annual maximum daily flows were recorded at Bragg Creek for years prior to 1950. Peak instantaneous flows were first recorded at Bragg Creek in 1950 and are available for most years between 1950 and the present.

For the period of 1908 to 2013, the combined station is missing 2% and 75% of annual maximum daily and peak instantaneous flows, respectively. During the same period, the Bragg Creek Station is missing 25% and 41% of annual maximum daily and peak instantaneous flows, respectively. The following sections describe the procedure for infilling missing annual maximum daily and peak instantaneous flows at Bragg Creek and the combined station.

To estimate missing instantaneous peak flows, a regression relationship between annual maximum daily and peak instantaneous flow was developed (see Figure IR261-2 and Figure IR261-3). After missing values were estimated, and datasets completed, flood frequency analysis including for 1:10 and 1:100-year events were linearly estimated based on the Bragg Creek and combined station results.

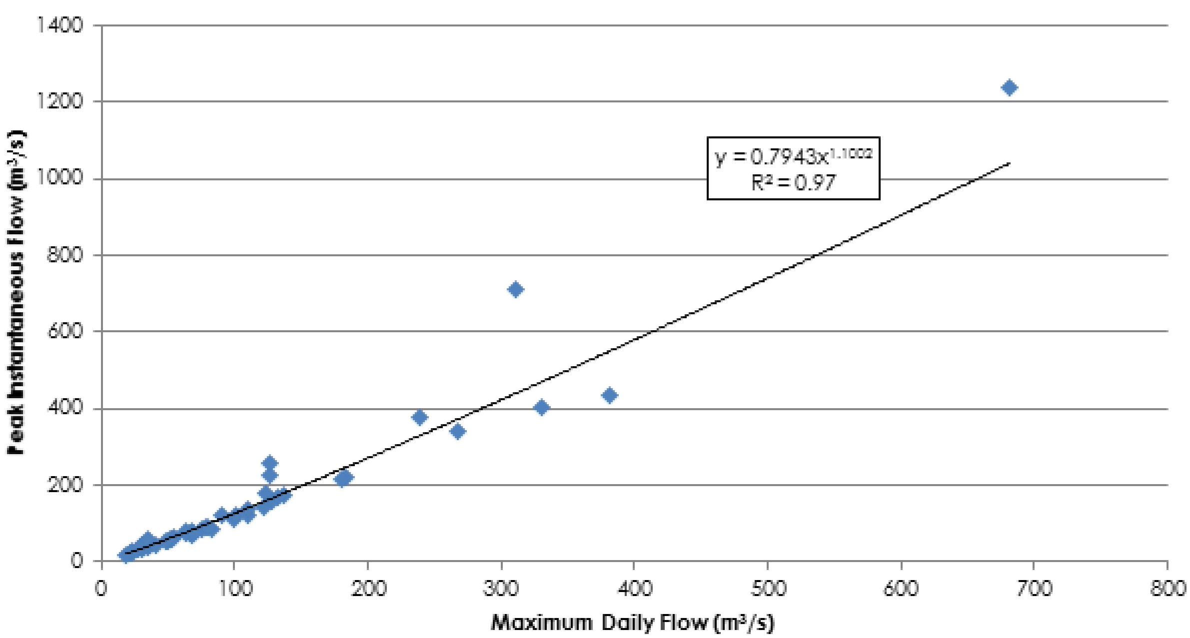


Figure IR261-2 Relationship between Annual Maximum Daily and Peak Instantaneous Flow at the Combined Station.

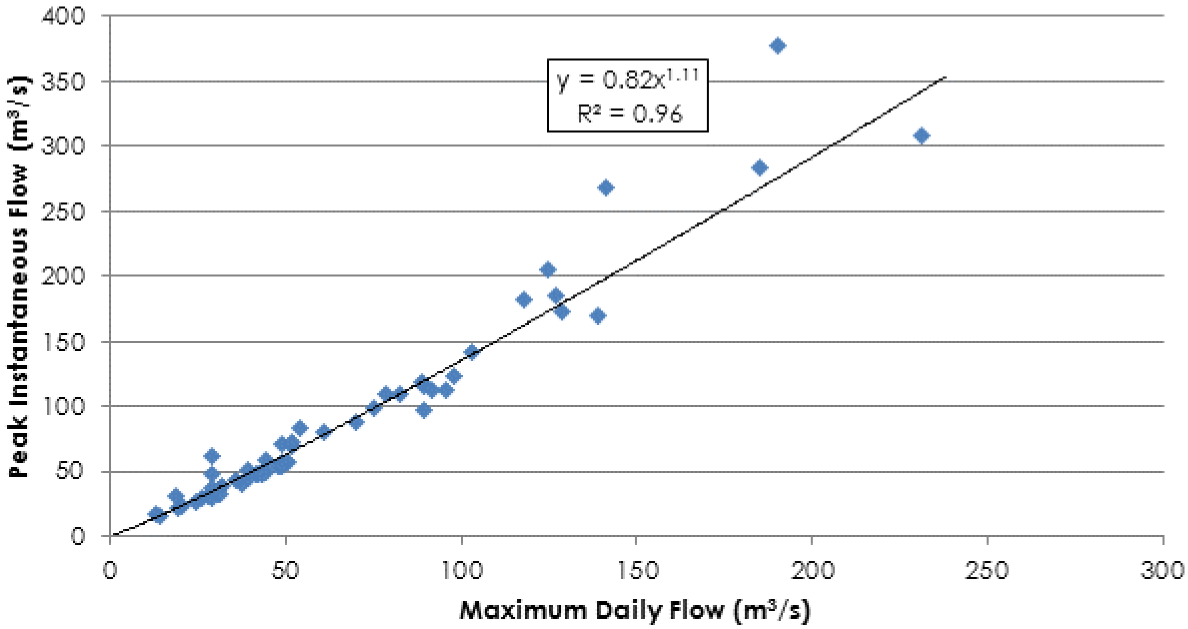


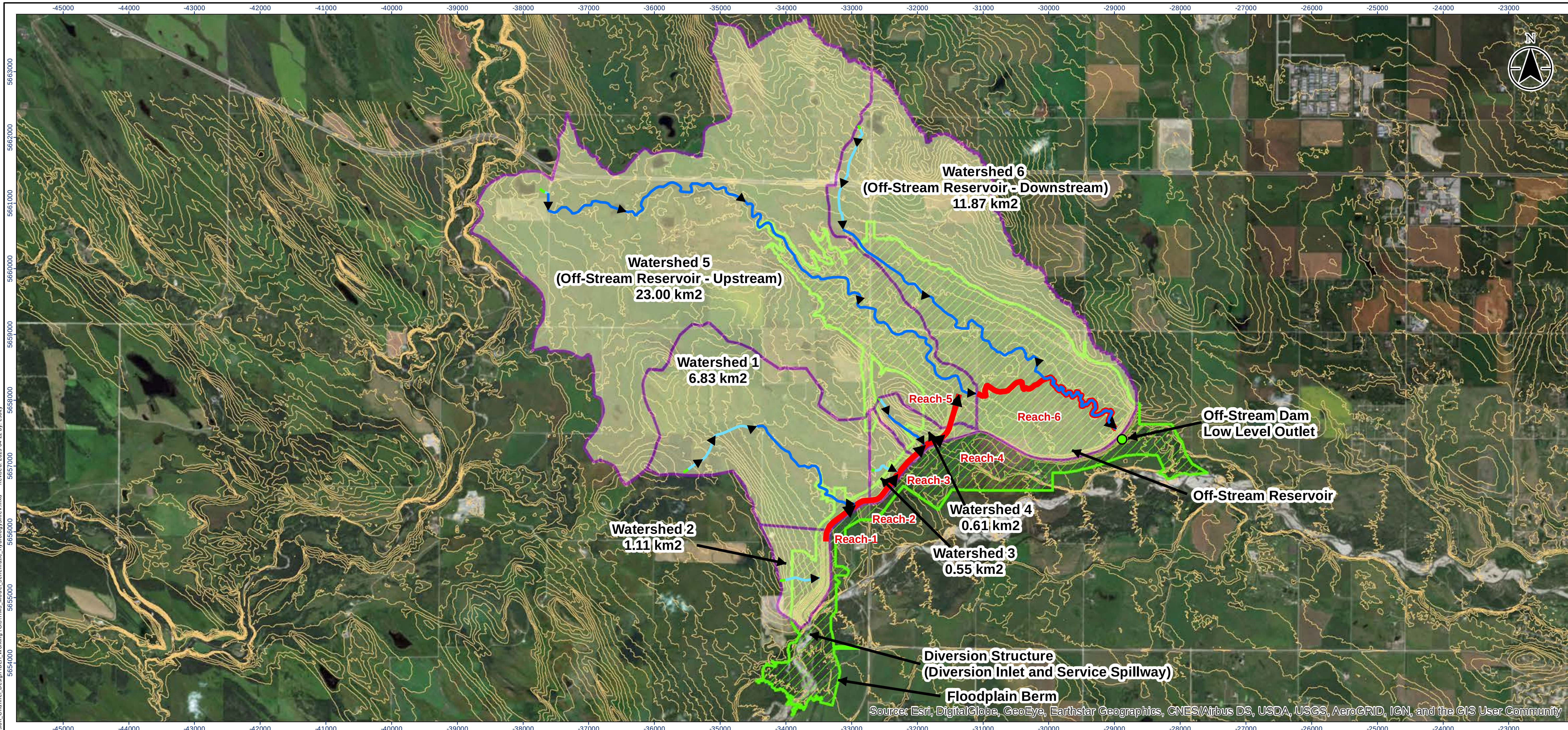
Figure IR261-3 Relationship between Annual Maximum Daily and Peak Instantaneous Flow at the Bragg Creek Station

WSC supplied preliminary 2013 peak instantaneous flows for Elbow River at Sarcee Bridge of 1,240 m^3/s. This was used as the 2013 design flood peak.

b. Local runoff volume was used to estimate the total storage in the river. Figure IR261-4 shows the local areas considered. The runoff volume related to the 2013 flood was calculated based on the hydrograph at Glenmore Reservoir, and the off-stream reservoir is designed to accommodate such a flood. The runoff within the off-stream reservoir drainage area is accounted for in that hydrograph.

REFERENCES

Alberta Environment 1983. Calgary Floodplain Study, Volume II, Appendix B, Hydrologic Analysis by A. DeBoer



Legend

- Preliminary Design Footprint
- Routing Reach Centerlines
- Subbasins
- Elevation Contours (5 m Interval)

Flow Paths for Lag Time Calculation

- Open Channel Flow
- Overland Flow
- Shallow Concentrated Flow

0 300 600
Meters

1:60,000 (At original document size of 11x17)

Stantec

Project Location
City of Calgary
Alberta

110773396
Prepared by DEH on 2018-12-18

Client/Project
Alberta Transportation
Springbank Off-Stream Reservoir

Figure No.
IR261-4

Title
Off-Stream Dam Local Runoff HEC-HMS Model Layout

Notes
1. Coordinate System: NAD 1983 3TM 114

Question 262

<u>Volume 1, Section 3.2.1, Page 3.2</u>

a. In the reach of the river where the diversion inlet, service spillway and flood plain berm will be located will the width of the river at the service spillway location be constricted when compared to the existing natural width? If so, then describe the effects of this constriction on upstream bed scour and bank erosion.

b. What is the potential of the bed scour upstream and downstream of the diversion inlet and service spillway and how the potential erosion and scour in this dynamic zone be mitigated?

c. What is the bank full discharge rate at this diversion location and what is the frequency of occurrence of this bank full discharge.

d. How frequently will water get stored behind the flood plain berm when the flow is above bank full discharge and for how long will water be stored during the different flood events?

e. Describe the effect of a flood plain berm on other return period floods (example, 1:2 year flood, 1:5 year floods etc.).

Response 262

a. The total width of the two bays of the service spillway is designed to match the river's natural bankfull width in that reach, so there will be no constriction during typical river flows and no increased risk of bed scour or bank erosion outside of flood conditions.

b. The stilling basins downstream of the diversion inlet and service spillway prevents scour downstream of the structures. The nested riprap upstream of the diversion inlet and service spillway bays prevents scour in river upstream of the structures.

c. Bankfull flow is approximately equivalent to the 1:2 year flow (50% annual exceedance probability), which is equivalent to approximately 70 m^3/s at the floodplain berm.

d. At flows greater than bankfull (70 m^3/s), the floodplain berm will produce a slight increase in backwater elevations. These elevations will remain until the flow decreases to 70 m^3/s or flows increases to above 160 m^3/s, at which time the service spillway gates will raise and flood operations will begin.

e. Below the 1:2 year flow, the floodplain berm will have no effect on river levels. The floodplain berm does block overland flow in the floodplain and will have a slight increase in backwater for flows between 70 m^3/s and 160 m^3/s (approximately 1:2 year to 1:10 year flows). When flows exceed 160 m^3/s, the service spillway gates will rise and create a backwater level.

Question 263

Volume 1, Section 3.2.2, Page 3.11

Alberta Transportation states *In areas of the channel where the cut does not reach the bedrock, the erosion and scour potential is low enough for lower diversion rates and erosion in non-critical areas during a major flood diversion will not constitute a failure.*

a. Does this sentence mean that no erosion protection will be provided in this area of the channel?

b. Describe what is meant by 'lower diversion rate' in this case?

c. What is the erosion potential in the channel for high diversion rates and what is planned to mitigate erosion?

Response 263

a. Areas of the channel excavated through rock are expected to remain stable during design flood operations. Areas that experience weathering may be expected to see localized scour; however, the underlain rock would remain in place. Over time, areas that weather and erode may need to be supplemented with aggregate or riprap as erosion protection.

Areas of the channel excavated through soil and re-vegetated are at higher risk of erosion. The Class C vegetation[1] improves performance and provides for protection up to the 1:50 year flood. The flow rate of 600 m^3/s produces critical shear stresses more than the allowable shear stress for vegetated channels; therefore, it is expected that some erosion could occur in these locations.

Riprap channel lining is provided at locations along the diversion channel at structural risk from scour and erosion. These areas include utility crossings, bridge foundations, the emergency spillway and areas of embankment that retain channel flow and the reservoir. Riprap for these areas is sized using the methods in USACE (1994), with hydraulics information determined from the HEC-RAS model.

Table IR263-1 lists the extents for riprap, bedrock and grass sections of the diversion channel.

[1] To resolve the problems associated with estimates of flow through vegetation-lined channels, the Soil Conservation Service of the U.S. Department of Agriculture have identified five classes of vegetation, designated retardance classes. Class C vegetation provides moderate retardance and includes grasses such as Kentucky blue grass.

Table IR263-1 Lining for the Diversion Channel

Start Station	End Station	Predominant Channel Lining Option	General Description of Channel and Critical Infrastructure
10+100	10+144	Rip Rap - Class 1	downstream protection of diversion inlet structure
10+144	11+025	Bedrock	cut section
11+025	11+425	Grass	embankment fill section
11+425	11+500	Rip Rap - Class 1	Fill section, Highway 242 bridge armoring
11+500	12+120	Grass	embankment fill section
12+120	12+280	Rip Rap - Class 1	fill section and creek inlet armoring
12+280	12+405	Bedrock/Grass	cut section (bedrock bottom, grass sides)
12+405	12+485	Rip Rap - Class 2	cut section storm water runoff/bridge armoring
12+485	12+900	Bedrock	cut section
12+900	13+300	Bedrock/Grass	cut section (bedrock bottom, grass sides)
13+300	13+500	Rip Rap - Class 1	armoring for emergency spillway structure
13+500	13+900	Rip Rap - Class 2	transition to 40:1 flared channel, saddle dam section of embankment
13+900	14+150	Rip Rap - Class 2	flared channel cut section
14+150	14+270	Rip Rap - Class 2	transition to 10:1 flared channel, saddle dam section of embankment
14+270	14+570	Rip Rap - Class 1	diversion outlet armoring to prevent head cutting

b. Lower diversion rate refers to diversions less than what is required to mitigate a 1:50 year flood; calculations suggest that no erosion will occur for floods up to a 1:50 year flood.

c. It is anticipated that there may be some localized erosion in the grass areas when managing floods greater than a 1:50 year flood. These grass-covered areas are not located near critical infrastructure and localized erosion will not affect flood operations of the diversion channel. Inspection of the diversion channel following a flood is part of post-flood operations, and this would include inspection for erosion. If erosion is present and found to warrant mitigation, then it would be addressed as part of post-flood maintenance operations.

REFERENCES

USACE (U.S. Army Corps of Engineers). 1994. Hydraulic Design of Flood Control Channels. Available at:)https://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/em_1110-2-1601.pdf

Question 264

Volume 1, Table 3-3, Page 3.12
Volume 3B, Section 6.4.1.4, Page 6.17

Alberta Transportation states *Because the diverted flows have a lesser volume, maximum release rates are based on volume drawn down over approximately 40 days (Figure 6-7).*

a. What is the maximum release rate used for each flood scenarios?

b. Describe the reason for keeping the release time at approximately 40 days for all scenarios instead of releasing the Design Flood and 1:100 year flood at a slower rate which could avoid a sudden rise in Elbow River flow, or releasing the1:10 year flood at a faster rate.

Response 264

a-b. The maximum designed release rate from the reservoir is 27 m^3/s, but this is managed to lower rates, depending on the flood. Actual release rates will be decided by AEP Operations in conjunction with downstream stakeholders, especially the City of Calgary with respect to the operation of the Glenmore Reservoir, and in consideration of Elbow River baseflows at the time.

The outlet structure has the operational flexibility to release the retained water in the reservoir at a range of rates to a maximum of 27 m^3/s; this is the same for all three floods.

Release times for the three floods (1:10 year, 1:100 year, and design (2013) flood) are provided in the response to IR283, Table IR283-1. The release times for these floods are based upon real event hydrographs from 2013 (design flood) and 2008 (1:10 year flood), and a modelled hydrograph (1:100 year flood). The release time was modelled to begin release of water from the reservoir on the receding limb of the hydrograph, once the peak river flow had passed. This results in a water residence times for the 1:10, 1:100, and design floods of 20, 43, and 43 days, respectively; and water release times of 30, 39, and 38 days, respectively.

Question 265

Volume 1, Section 3.5.1, Page 3.34

Alberta Transportation states *At that flow, the service spillway gates will be raised to create a backwater upstream of the diversion structure, the diversion inlet gates will be opened, and flood flow will begin to divert into the diversion channel to be retained in the off-stream reservoir*.

a. Describe and show on a figure the area that will be inundated due to the backwater effect in the three flood scenarios (Design flood, 1:100 year flood and 1:10 year flood).

b. For how long will this backwater effect remain for each of the three flood events (Design flood, 1:100 year flood and 1:10 year flood)?

c. What is the impact of backwater on bank erosion, floodplain erosion and sedimentation, hydrology and hydraulics?

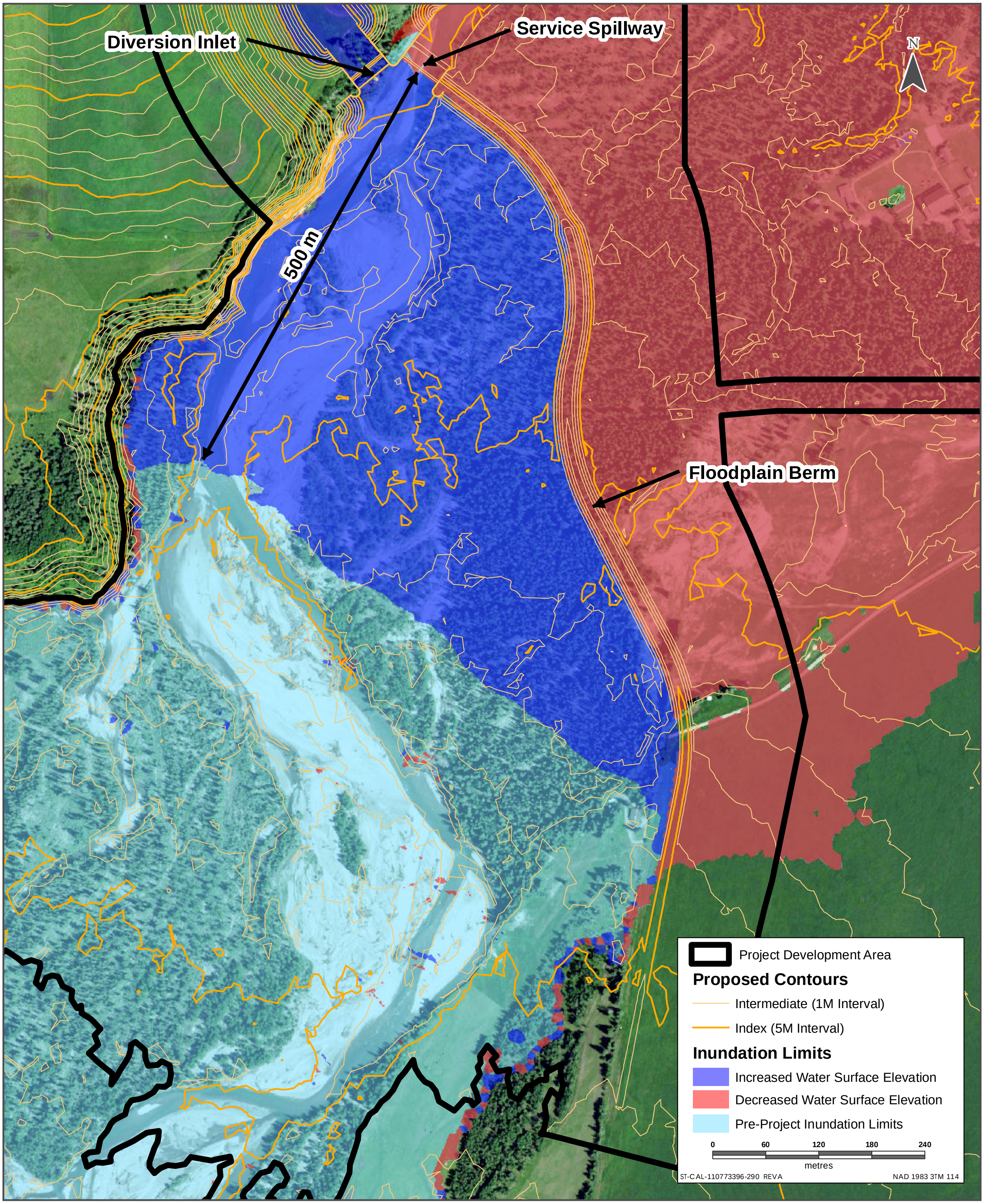
d. What is the potential of flooding to any nearby infrastructure or projects due to the back water effect and what are the mitigation measures?

Response 265

BACKGROUND INFORMATION

Backwater is defined as the area upstream of the diversion structure, service spillway and floodplain berm where the water surface elevation is raised over pre-Project conditions. To determine the backwater area, 2D hydraulic model results for the pre-Project conditions were compared against the results for the post-Project (flood operations) conditions. The area where the water surface elevation is greater for the post-Project than for the pre-Project conditions is the backwater area.

a. At the peak river flow, the operation of the diversion is not expected to change the backwater area upstream during the three floods. Figure IR265-1, Figure IR265-2, and Figure IR265-3 show the results of 2D hydraulic modelling for existing and Project conditions. The effect of the diversion structure on upstream water surface elevations is limited to within the PDA where the water depth will change 500 m upstream for the 1:100 and design flood and 190 m upstream for the 1:10 year flood.



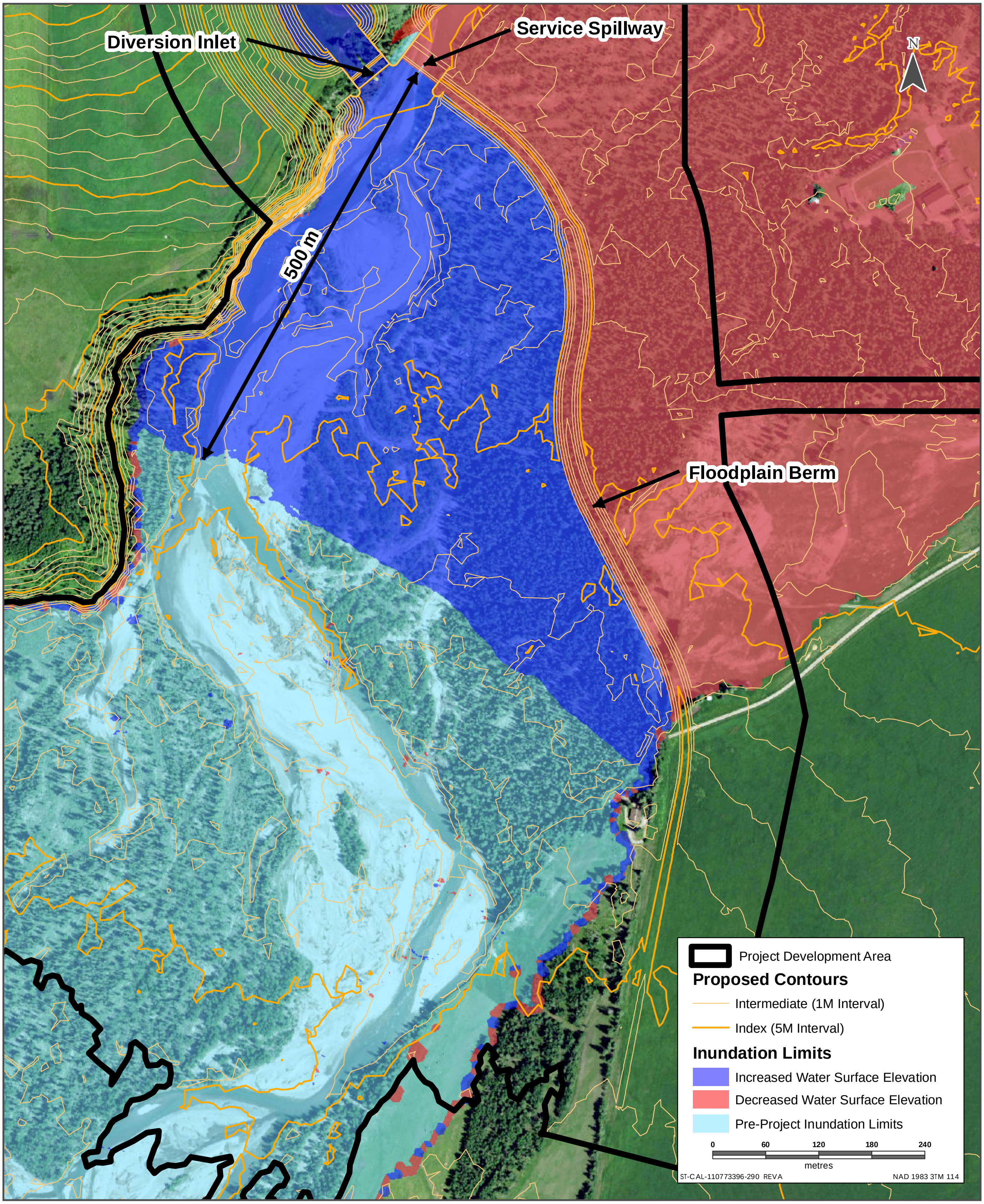
Sources: Base Data - Government of Alberta, Government of Canada, Thematic Data - Stantec Ltd.

Backwater Effects Design Flood

Stantec

ALBERTA TRANSPORTATION SPRINGBANK OFF-STREAM RESEVOIR PROJECT ENVIRONMENTAL ASSESSMENT

Figure IR265-1



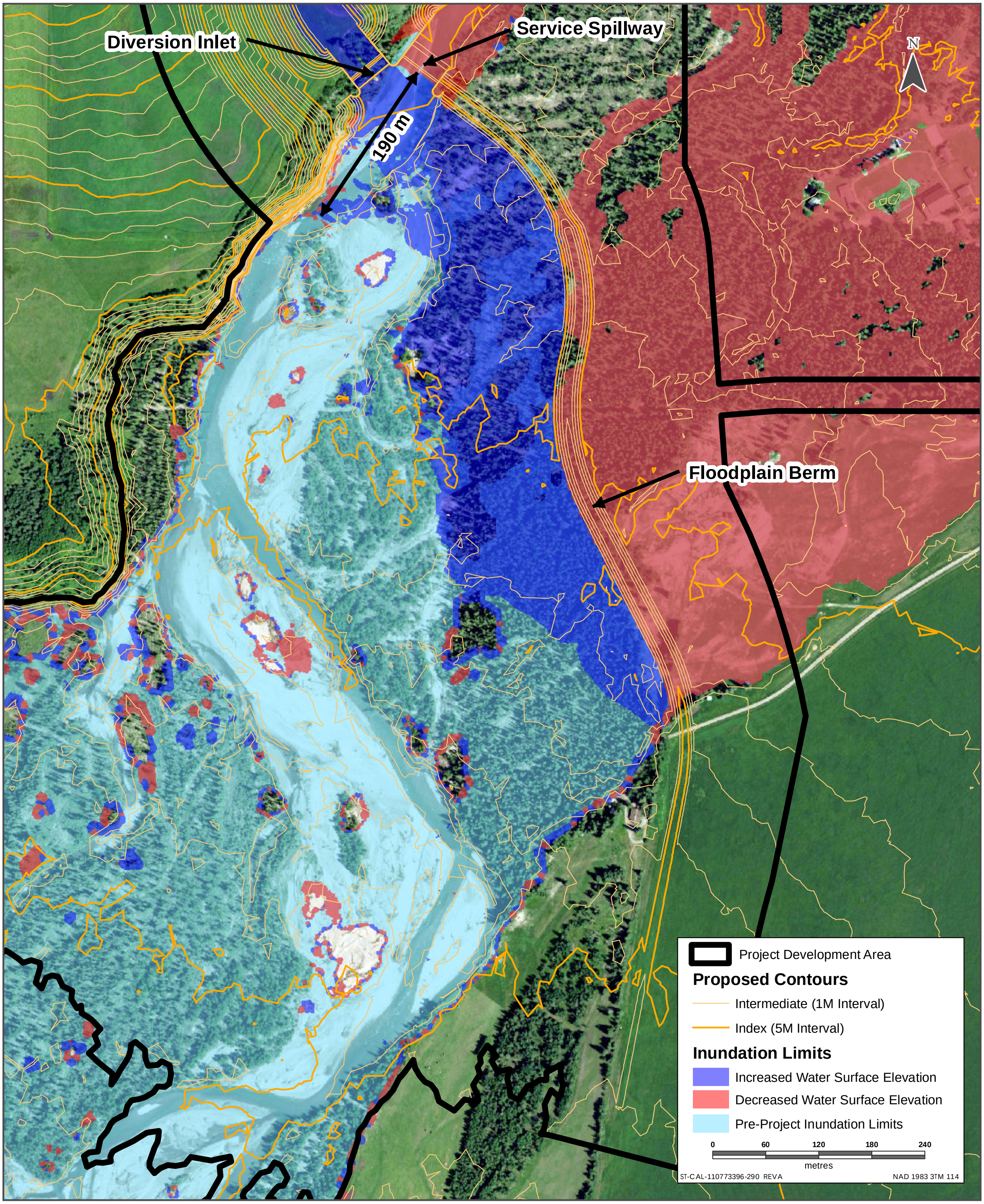
Sources: Base Data - Government of Alberta, Government of Canada, Thematic Data - Stantec Ltd.

Backwater Effects 1:100 Year

Stantec

ALBERTA TRANSPORTATION SPRINGBANK OFF-STREAM RESEVOIR PROJECT ENVIRONMENTAL ASSESSMENT

Figure IR265-2



Sources: Base Data - Government of Alberta, Government of Canada, Thematic Data - Stantec Ltd.

Backwater Effects 1:10 Year

Stantec

ALBERTA TRANSPORTATION SPRINGBANK OFF-STREAM RESEVOIR PROJECT ENVIRONMENTAL ASSESSMENT

Figure IR265-3

b. The backwater effect will vary, based on the size and duration of a flood. The total duration of diversion for a design flood is 3.75 days. The total duration of diversion, and the induced backwater effect, for the 1:10 and 1:100 year floods is expected to be shorter in duration because both the peak and volume of flood waters will be less than for a design flood.

c. The backwater will have limited impact on bank erosion and floodplain erosion. It reduces the shear stresses within the impacted area and will reduce risk of erosion within the affected area. Sediment transport simulations indicate that diversion operations will result in sediment deposition within the backwater area. The deposition may result in a local increase in water surface elevations, but impacts will remain within the PDA.

d. Results of the hydraulic modelling indicate that the diversion structure will not increase the risk of flooding to any structures or projects outside the PDA. No mitigation measures are required.

Question 266

<u>Volume 1, Table 3-10, Page 3.37</u>

There is no description on post-flood repair and maintenance activities for the area behind the flood plain berm that will be flooded to divert the Elbow River flow through the diversion inlet.

a. Provide a description on post flood clearing, repair, and maintenance of the flood plain berm and the area upstream of the berm.

b. Include information on what needs to be removed (e.g. debris, sediment etc.) post- flood from the area behind the flood plain berm.

Response 266

a-b. Post-flood cleaning, repair and maintenance activities of the floodplain berm and area upstream of the berm will include the repair of any erosion damage to the berm, as well as the removal of sediment and debris that would affect the operation of the diversion structure. Post-flood repair and maintenance will commence immediately following a flood and will include inspections to identify structural damage to the berm.

Question 267

Volume 1, Table 3-10, Page 3.37

Alberta Transportation states *partial removal of sediment so that water flow is not blocked* as repair and maintenance activity.

a. **Describe the criteria when sediment deposited in the reservoir will be cleaned to regain full storage capacity of the reservoir.**

b. **Explain the impacts of not removing sediment post-flood from the reservoir and explain the corresponding mitigation measures.**

Response 267

a. The off-stream reservoir is designed for a capacity (full service level elevation) of a 10% volume above that needed to handle the equivalent of the 2013 flood. This excess capacity is designed to account for sediment and debris accumulation over the life of the Project. Post-flood sediment and debris will not be removed from the reservoir. Certain areas may be re-contoured within the reservoir if they interfere with drainage out of the reservoir or the integrity of the dam.

b. Post-flood sediment that remains in place may be either seeded with native plant species or be sprayed with a hydroseed or hydromulch with the addition of a tackifier, if required, in order to reduce the potential of airborne dust while also promoting the re-establishment of vegetation. AEP will have an operation, maintenance and surveillance plan for the Project, which will include post-flood sediment stabilization requirements.

Question 268

Volume 1, Figure A-2, Page A.7

a. **Describe if runoff volume from the Local Inflow Basin (including the unnamed creek and five other tributaries) was considered when determining the total storage capacity of the reservoir. If not, what will be the impact of not considering this volume on the total storage volume calculation and how will the impacts be mitigated?**

b. **In addition to 'a', was runoff volume from the area between the low level outlet and the Glenmore Reservoir considered when estimating the capacity of the proposed reservoir? If not, what will be the impact of not considering this volume on the total storage volume calculation and how will these impacts be mitigated?**

c. What is the expected runoff volume from the Unnamed Creek Basin and five other tributaries located within the Local Inflow Basin for the three flood scenarios (Design flood, 1:100 year flood and 1:10 year flood)?

Response 268

a. Local inflow was considered for the total temporary retention capacity of the off-stream reservoir in the following ways:

- Design flood retention was determined by the volume required to mitigate the 2013 design flood, as estimated from the inflow hydrograph to Glenmore Reservoir and provided by the City of Calgary. This volume includes runoff volume upstream of the proposed diversion structure, as well as runoff volume produced from the local inflow basin.
- Freeboard was determined by a runoff volume of 540 dam^3, which is the runoff from a 6-hour, 1:100 year storm. In the calculation, it was estimated from the full service level elevation and included the routing of the probable maximum flood (PMF).

Because all relevant inflows are considered, no changes to total retention capacity of the off-stream reservoir are required.

b. Yes, as noted in the response to a., the retention volume required to mitigate the 2013 design flood is based on the 2013 inflow hydrograph to Glenmore Reservoir. This volume includes runoff from the area between the unnamed creek and Glenmore Reservoir.

No changes to the total retention capacity of the off-stream reservoir are required.

c. The diversion volumes for the three floods (design flood, 1:100 year flood and 1:10 year flood) are based on flow hydrographs of Elbow River that were developed from recorded data or modelled floods. The flood scenarios were not all produced with rainfall-runoff models and, therefore, corresponding inflows from the local inflow basin for the same floods is not available. The expected volumes for each of these floods from the 40 km^2 local drainage area are expected to be relatively minor in comparison to the total diverted volume from the 863 km^2 Elbow River drainage area and would not affect estimated effects.

Question 269

Volume 1, Figure A-2, Page A.7

Alberta Transportation states *The need for flood operations will be identified through this advanced communication, and will be informed by forecasted and measured flows on Elbow River at the diversion structure and upstream*.

Alberta Transportation states *Flood operations will begin when flows in the Elbow River exceed 160 m³/s*.

a. **Describe how the flow in the Elbow River will be monitored near the diversion structure to decide when diversion to the proposed reservoir should start. Will there be any permanent continuous flow gauge station near the diversion inlet structure and who will own and operate it?**

b. **Describe how the flow in Elbow River at the confluence with the outlet channel will be monitored to decide when to start the release of stored water from the reservoir to the outlet channel and eventually to the Elbow River. Will there be any permanent continuous flow gauge station on the Elbow River at the confluence of the outlet channel with the Elbow River and who will own and operate it?**

c. **Describe how the flow rate through diversion inlet and reservoir outflow will be monitored. Will there be any permanent continuous flow gauge stations at these two locations and who will own and operate them?**

d. **Describe how the water level of the reservoir will be monitored. Will there be any permanent continuous water level gauging stations in the reservoir and who will own and operate it?**

e. **All the above mentioned flow data and water level data are important and needs to be recorded for future use such as for flow naturalization, performance evaluation of the reservoir operation and its impact on the environment. Include the monitoring plan for the items mentioned in a, b, c and d in the 'Monitoring' section. Currently no monitoring information is available on these items in the EIA.**

Response 269

a. The decision to divert water into the off-stream reservoir will be based on the following information:

- flow in the Elbow River upstream at Bragg Creek, at the diversion and downstream at Glenmore Reservoir
- storage volume available within Glenmore Reservoir
- forecasted snow melt and precipitation

Flow gauging stations are currently operated by Water Survey of Canada on Elbow River at Bragg Creek and at Sarcee Bridge, just upstream of Glenmore Dam.

An additional hydrometric gauge station will be installed immediately upstream of the diversion structure and will provide real time river water elevation measurements (i.e., 15-minute intervals). The water elevation measurements may be used with gate position and pre-determined rating curves to calculate the flow split into the diversion channel and that remaining within the Elbow River. The hydrometric station at the diversion inlet will be owned and operated by AEP.

b. The decision to release water from the reservoir will be based on the following information:

- flow in Elbow River at the diversion structure and downstream at Glenmore Reservoir
- storage volume available within Glenmore Reservoir
- forecasted snow melt and precipitation
- condition of infrastructure downstream of Glenmore Dam

Elbow River flow rate will be determined utilizing the Water Survey of Canada gauging station and the proposed water surface elevation monitoring station immediately upstream of the diversion structure. The measured flow rate at the diversion structure will be sufficient to make decisions for when the outlet structure will be operated for release of water back into Elbow River. The additional drainage area between the diversion structure and the confluence of the unnamed creek with Elbow River is insignificant to the decision process. A permanent continuous hydrometric monitoring station will not be installed at the confluence of Elbow River with the unnamed creek.

c. Flow through the diversion inlet will be monitored at an additional hydrometric monitoring station within the diversion channel. In addition, water surface elevations upstream of the diversion inlet will be used in conjunction with the gate rating curves, as a secondary measure.

Water surface elevations at the diversion intake may be used with the gate position to calculate the expected flow rate based on the design rating curves.

These stations will be owned and operated by AEP. The proposed locations of these monitoring stations are discussed in response to IR302 (Appendix IR302-1, Figure 9-2).

d. The water level of the reservoir will be monitored through a pressure transducer located in the outlet structure intake. In addition, secondary staff gauges for visual observation will be installed at the dam crest and at the emergency spillway.

These stations will be owned and operated by AEP.

e. See the response to IR302 (Appendix IR302-1) for the surface water monitoring plan for the Project

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Question 270

Volume 1, Section A.5.1, Page A.28
Volume 3B, Section 6.4, Page 6.13

Alberta Transportation states *For example, release rates may be increased if two back-to-back floods are forecast, or decreased to minimize potential effects on mobilization of sediment in the low-level outlet and remobilization of sediment in Elbow River downstream.*

Alberta Transportation states on page 6.13 that *This variability could occur, for example, from high release rates if back-to-back floods are expected or low release rates if a smaller flood is diverted*.

The maximum release rate from the outlet structure of the dam is limited and may not be enough to draw down the storage quick enough for the second flood, if any.

a. Provide further details on the reservoirs capabilities to manage back to back floods. Describe how much volume can be emptied into the reservoir, at what release rate and within what time period in case back to back floods are expected.

b. Explain how effective the method proposed by Alberta Transportation is to handle back to back floods. Provide an example with two large back to back floods to explain how the back to back flood scenario will be handled?

c. What other mitigation measures will be taken to handle back to back floods?

Response 270

a-b. The environmental assessment evaluates three potential floods (out of an unlimited number): a design flood, a 1:100-year flood and a 1:10 year flood. The off-stream reservoir will be able to handle back-to-back floods up to its capacity of 77,771,000 m^3. The maximum rate a flood can be diverted (emptied into) to the reservoir is 600 m^3/s.

A 1:10 year flood would require 790,000 m^3 or about 1% of the design capacity of the reservoir. Back-to-back 1:10-year floods would occur (the combined probability is 0.1 x 0.1 = 0.01) once in 100 years. The off-stream reservoir has the capacity to contain multiple (90) back-to-back 1:10-year floods within the reservoir without releasing any water back to Elbow River.

A 1:100 year flood would use 33,014,000 m³ or 42% of the retention capacity. If back-to-back 1:100 year floods occurred, the capacity of the reservoir would not be exceeded even if no water were released from the reservoir. Back-to-back 1:100 year floods would be a very rare event, with a probability of occurrence of 1:10,000 years.

The reservoir does not have the ability to contain two back-to-back design floods (an extremely low probability). In the event of back-to-back design floods, flood water that would exceed the capacity of the reservoir would not be diverted into the reservoir and would continue to pass down Elbow River.

The ability of the reservoir to accommodate back to back flood volumes is not dependent on the release rate from the reservoir. A general description of the release criteria is provided in Volume 3B, Section 6.4.1.4, page 6.17. The decision about when, or if, to release the first 1:10-year flood or 1:100 year flood (and at what rate to release it) will depend on the forecast at the time and it cannot be predicted in advance. A decision as to when to release the first flood will be made on the judgment of AEP personnel

c. The reservoir has the capacity to handle back-to-back 1:10 year and 1:100 year floods; therefore, no additional mitigation measures are required.

Question 271

Volume 3A, Section 5.4.2.3, Page 5.38

Alberta Transportation states *Groundwater that would seep into the diversion channel (when dry) would remain within the watershed, although potentially travelling through a more tortuous route. Regional-scale effects on groundwater quantity can be mitigated by allowing seepage in the dry diversion channel to infiltrate back into the subsurface, or flow back into the Elbow River via surface water drainage pathways*.

a. Provide information on volumes of ground water that can be expected during non- flood years and flood-years, especially for the design flood, 1:100 year and 1:10 year flood.

Response 271

a. Seepage into the diversion channel (when dry) has been estimated by the numerical groundwater flow model (see the Hydrogeological TDR Update in Appendix IR42-1, Section 5.5). the estimated net seepage into the diversion channel is 0.013 m^3/s or approximately 410,000 m^3/year during non-flood years.

During flood years, groundwater discharge will be reduced during the period when flood water is partially diverted through the diversion channel. The reduction is a result of the hydraulic head within the channel. Water in the channel will reduce, or potentially reverse, the hydraulic head, which drives groundwater flow and seepage. Therefore, the estimated seepage rate of 0.013 m^3/s is the maximum anticipated rate and would be reduced during the diversion. The groundwater discharge would likely not be detectable compared to the maximum diversion rate from the Elbow River of 600 m^3/s flowing through the channel during the design flood.

Question 272

<u>Volume 3A, Section 5.4.2.4, Page 5.39</u>

Alberta Transportation states *The effects due to seepage into the diversion channel would be irreversible because it is expected that the diversion channel would be in place indefinitely and the potential for seepage into the diversion channel would persist indefinitely.*

a. Describe what types of effects are expected due to seepage into the diversion channel during non-flood and flood years and what the mitigation measures are.

Response 272

a. Alberta Transportation is open to discussion regarding appropriate seed mixes based on revegetation objectives and site conditions.

Shorter-lived species may have beneficial effects such as acting as a cover crop to suppress weed establishment until other natural colonizing species can re-establish. Sheep fescue is an excellent weed control species because it has an extensive and dense bunch-type root system. Once a good stand is established, it excludes the invasion of most weeds (Ogle et al. 2010).

Seed mixes will be adjusted while balancing need for vegetative cover, suppressing weed establishment and managing surrounding undisturbed areas. Species used will also be based on availability of required quantities.

Further communication regarding seed mix recommendations can be referred to Mark Svensen at Alberta Transportation by email at Mark.Svenson@gov.ab.ca. Final seed mix details will be provided in the monitoring and revegetation plan, including the reasoning for the inclusion or rejection of recommended species.

REFERENCES

Ogle, D., M. Stannard, P. Scheinost, and L. St John. 2010. Plant guide for sheep fescue (*Festuca ovina* L.). USDA-Natural Resources Conservation Service, Idaho and Washington Plant Materials Program. https://plants.usda.gov/plantguide/pdf/pg_feov.pdf

Question 273

Volume 3A, Section 6.1.4, Page 6.6
Volume 3A, Figure 6-1, Page 6.7
Volume 4, Appendix J, Section 2.1, Page 2.1

Alberta Transportation states *The local assessment area (LAA) included the project development area (PDA) and the Elbow River from Redwood Meadows to the inlet of Glenmore Reservoir, including the proposed dam, reservoir, diversion channel, and low-level outlet (i.e., the unnamed creek that runs through the off-stream reservoir). The regional assessment area (RAA) is the Elbow River watershed from headwaters to Glenmore Dam. Figure 6-1 presents the spatial boundaries for the hydrology assessment*.

PDA, LAA, RAA boundaries described in Section 6.1.4 do not match the boundaries shown on Figure 6-1 and with the boundaries mentioned in Volume 4, Appendix J, Section 2.1.

a. Correct the description of the boundaries in Section 6.1.4 if it is incorrect. The rest of the EIA appears to use the boundaries shown in Figure 6-1 and Appendix J. Use the correct boundaries in the applicable sections of the EIA and correct all the corresponding analyses and information if those are based on incorrect boundaries. For any corrections provide the sections where the changes were made.

Response 273

a. The boundaries of the LAA for hydrology extend from approximately 2.3 km northeast of Redwood Meadows townsite (approximately 1,100 m southwest of the diversion inlet structure) to the inlet of the Glenmore Reservoir; see Figure IR54-1 in response to IR54. The LAA includes Elbow River to the inlet of Glenmore Reservoir but does not include Glenmore Reservoir except.

   The boundary of the hydrology RAA is the Elbow River watershed from the watershed headwaters to Glenmore Dam. The RAA includes Glenmore Reservoir but does not extend downstream of Glenmore Dam. Volume 3A, Figure 6-1 is incorrect in representing the boundary of the hydrology RAA. Figure IR54-1 shows the correct boundary.

   No updates to the hydrology sections are required because the corrected LAA and RAA are the ones on which the assessment was made.

Question 274

<u>Volume 3A, Section 6.2.2.6, Page 6.33</u>

a. Include map showing locations of the water licences in the LAA and RAA (LAA and RAA boundaries as per Figure 6-1 in Volume 3A_S06).

b. Provide more detail on each of the licences including the types of licences, source of water, location etc.

c. Describe whether these water licences will be affected due to the project and identify the affected licences.

d. What will be the mitigation measures be for the affected licences?

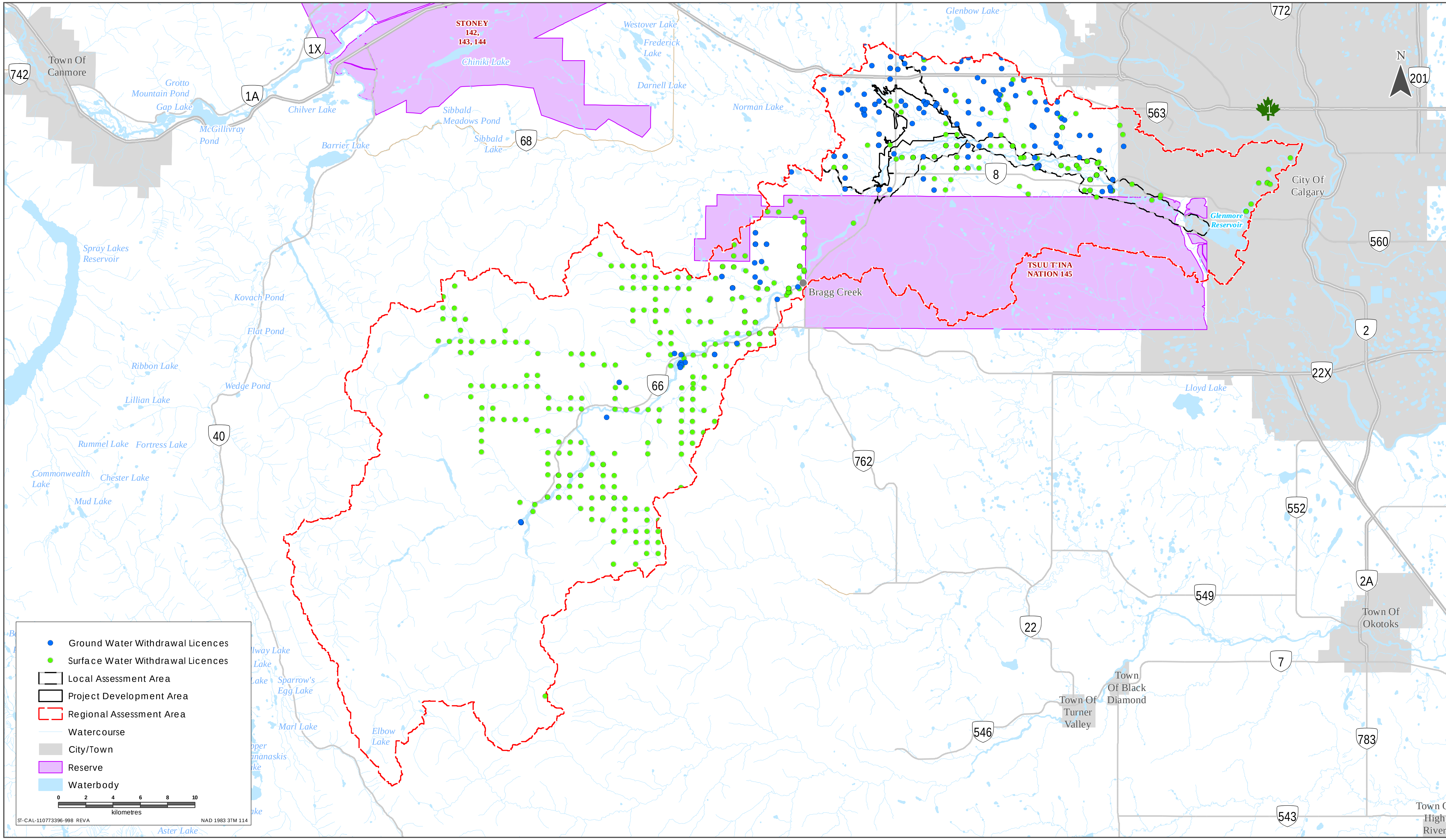
Response 274

Alberta Transportation assumes the question is referring to the information provided Volume 3A, Section 6.2.2.6, page 6.36. Page 6.33 as referenced in this IR does not relate to surface water licences.

a-b. The location of water withdrawal licences and allocations within the hydrology RAA is provided in Figure IR274-1. The hydrology RAA is the Elbow River watershed. Appendix IR274-1 contains two tables, Table IR274-1 and Table IR274-2 that list all surface water and groundwater licences and allocations within the Elbow River watershed.

c. Of the 591 water withdrawal licences and allocations in the RAA, the Project will have an affect on ten groundwater and six surface water withdrawal licences and allocations located within the PDA. When Alberta Transportation acquires the land within the PDA, they will also assume ownership of these water withdrawal licences.

d. No mitigation measures for the ten affected groundwater withdrawal licences and allocations are proposed because they will form part of the land acquisition for the Project and will be decommissioned to prevent groundwater contamination. The surface water licences and allocations will transfer to the Alberta Transportation.



Sources: Base Data - Government of Alberta, Government of Canada. Thematic Data - Stantec Ltd.

Stantec

ALBERTA TRANSPORTATION SPRINGBANK OFF-STREAM RESERVOIR PROJECT ENVIRONMENTAL IMPACT ASSESSMENT

Ground and Surface Water Withdrawal Licences in the Hydrology Regional Assessment Area

Figure IR 274-1

Question 275

Volume 3A, Section 6.2.2.4, Page 6.36

a. **Include a map showing the locations of the water bodies in the PDA.**

b. **Describe whether these water bodies will be preserved or destroyed by construction and sedimentation from flood water.**

c. **Identify which water bodies will be preserved and how they will be preserved.**

d. **Describe how these water bodies will be maintained post-flood.**

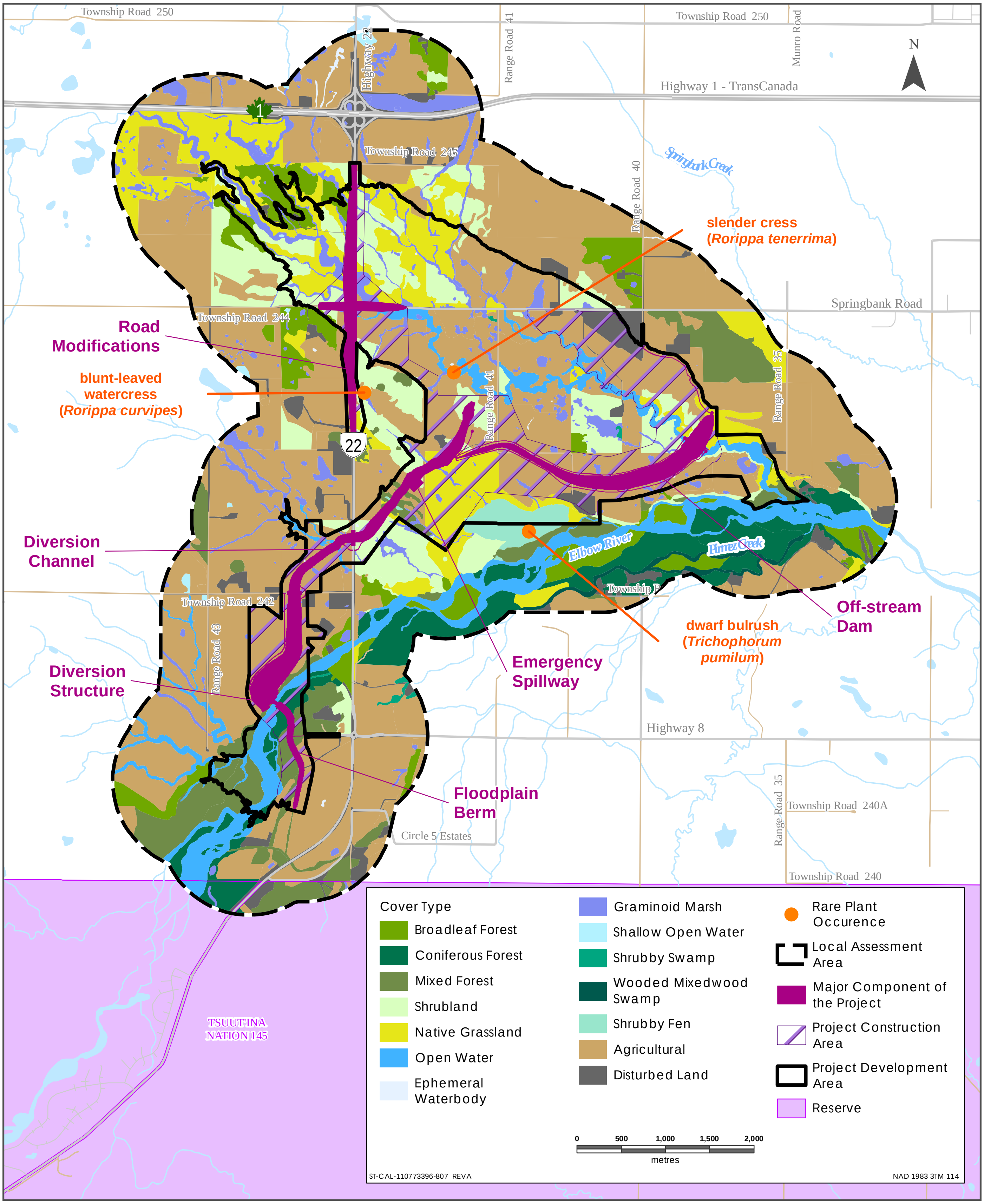
Response 275

a. Volume 3A, Section 10.2.2.2, Figure 10-3 shows the locations of waterbodies in the PDA, including open water and wetland communities. Figure 10-3 is reproduced as Figure IR275-1.

b. Figure IR275-1 shows the location of the construction footprint relative to waterbodies. The effects of construction on open water and wetland communities are described in Volume 3A, Section 10.4.1 and Section 10.4.3. The construction footprint includes both permanent Project structures and temporary disturbance areas (borrow source, pipeline right of way, construction laydown area and soil stockpile locations). Although the extent of temporary disturbance is known, the actual location of these temporary construction areas has not yet been determined. Therefore, for the analysis of effects on wetlands, the entire construction footprint is used.

   During construction, areas of temporary disturbance would only have above ground vegetation clearing, leaving the soils intact, though there are some areas of soil disturbance. Areas with vegetation clearing only would recover to existing conditions, and areas with soil disturbance would likely take longer for native vegetation to establish and would likely be less similar to existing communities. The exact areas of vegetation clearing and soil disturbance have not yet been determined; therefore, it is assumed that all areas would have soil disturbance.

   All temporarily disturbed wetlands would be recontoured and seeded with an approved custom native wetland seed mix following construction. The total loss of wetlands from existing conditions to dry operations is 15.3 ha, and the total loss of open water, from existing conditions to dry operations, is 3.6 ha (Volume 3A, Section 10.4.3).



Sources: Base Data - Government of Alberta, Government of Canada, Thematic Data - Stantec Ltd.

Vegetation and Wetlands in the Local Study Area
(from Volume 3A, Section 10, Figure 10-3)

Stantec

ALBERTA TRANSPORTATION SPRINGBANK OFF-STREAM RESERVOIR PROJECT ENVIRONMENTAL IMPACT ASSESSMENT

Figure IR275-1

The effects of sediment deposition on open water and wetland communities are described in Volume 3B, Section 10.2.2. Effects on wetland communities vary depending on sediment depth as described in the response to IR531 and in Volume 3B, Table 10-4. The spatial extent of sediment deposition relative to open water and wetlands is shown in Volume 3B, Figure 10-2. The total loss of wetlands resulting from sediment deposition of more than 10 cm—the sediment depth at which most of the species at existing conditions are lost in the herbaceous and short shrub layers and are replaced by new species—is 11.7 ha following a design flood (Volume 3B, Section 10.2.2.3, Table 10-11). The total area of waterbodies covered in 10 cm to 100 cm of sediment is 21.6 ha following a design flood (Volume 3B, Section 10.2.2.3, Table 10-11), although this depth of sediment will not necessarily result in a loss of a waterbody.

c-d. No waterbodies are proposed for preservation. The unnamed creek (which will direct released water from the reservoir into Elbow River) will be maintained by the removal of debris and sediment from the outlet components to the degree required to maintain optimal functionality.

With respect to the ephemeral creeks that cross the diversion channel, runoff from these creeks upstream of the diversion channel will be conveyed to the off-stream reservoir and ultimately will pass through the unnamed creek back into Elbow River.

As discussed in the response to IR531c and Volume 3A, Section 10.6, *Water Act* approval would be obtained for disturbances to wetlands before construction, and permanent disturbance to wetlands would be replaced in accordance with the Alberta Wetland Policy.

Question 276

Volume 3A, Section 6.2.2.6, Table 6-9, Page 6.36

TOR 3.4.1[C] identifies that Alberta Transportation is to *Provide an inventory of all surface water users who have existing approvals, permits or licenses in the local and regional study areas*. There is a summary of total water allocations by source in Table 6-9 but there is no inventory.

a. **Provide the inventory required by the TOR.**

b. **Provide an assessment of the regulatory requirements for any licences that are allocated to the project lands and an assessment of the impacts the project may have on downstream licence withdrawals.**

Response 276

a. The response to IR274, Figure IR274-1, Table IR274-1 and Table IR274-2 displays and lists all water licences and allocations in the hydrology LAA and the hydrology RAA.

b. Any licences allocated to the Project lands will meet water licence requirements from AEP and DFO. The Project will not affect downstream licences for water withdrawals. Diversion of water will only occur when river flows are greater than 160 m^3/s so that flood flows in the river remain at 160 m^3/s; therefore, downstream licences for withdrawals will not be curtailed.

   During the release of water from the off-stream reservoir following a flood, water quality modelling shows an increase in sediment concentrations, at the end of the release period, in Elbow River downstream of the unnamed creek with the river. These changes will be small compared to the concentrations and loads transported during a flood in the absence of the Project. It is anticipated that these suspended sediment concentrations at end of the release of water from the reservoir can be controlled with the outlet gate operation (i.e., reducing flow rate) and, possibly, also with sediment and silt fences. The operation of the reservoir will occur infrequently (once every ten years), so the nature of the change is not anticipated to change the water quality of Elbow River or Glenmore Reservoir.

Question 277

<u>Volume 3A_S06, Section 6.3.1, Page 6.37</u>

Alberta Transportation states *All instream works will be completed in a manner that allows for water conveyance. Therefore, hydrology in the Elbow River and low-level outlet will not interact during construction of the water diversion structure, dam and berm, and low-level outlet structure and are not assessed further*.

a. The above sections do not mention if the runoff from tributaries 1 through 5 are going to drain into the diversion channel, or be diverted during construction so that water conveyance from these tributaries is maintained and uninterrupted and does not flow into the construction area. Explain what is to happen to tributaries 1 through 5 during construction.

Response 277

a. During Year 1 of construction, it is anticipated that flows from Tributaries 1 through 5 will be diverted around the construction site using temporary piping or channels and conveyed to their existing drainage pathways. If no piping or channels are present during that time, the water will be pumped out of the diversion channel and into existing drainage pathways. During Year 2 of construction, the flow from Tributaries 1 through 5 will be diverted into the completed sections of the diversion channel. The diverted flow will be isolated from the active construction areas, controlled by temporary piping or ditches with appropriate sediment and erosion control, and allowed to exit the diversion channel by existing drainage pathways. This care of water management will continue through Year 3 or until the earthworks are substantially completed for Project components and water from the tributaries will freely drain into Elbow River. Four sections in the Civil Works Master Specifications are relevant to this water management:

- ECO Plan Section 01390 (Volume 4, Supporting Documentation, Document 10)
- Environment Section 01391 (Volume 4, Supporting Documentation, Document 11)
- Care of Water Section 02240 (Volume 4, Supporting Documentation, Document 12)
- Turbidity Barriers Section 02242 (Volume 4, Supporting Documentation, Document 9)

Question 278

Volume 3B, Section 3.2.4.1, Page 3.9

Alberta Transportation states *To some extent, natural mitigation with respect to future potential fugitive dust emissions has already occurred. The 2013 flood removed an appreciable portion of fine sediment (e.g., clay and fine silt) from the upstream Elbow River drainage basin. The remaining surficial materials in the stream bed and on the banks of the Elbow River and its tributaries that may be prone to mobilization during a future flood would comprise mostly larger material (e.g., sand). Hence, most of the sediment deposited in the reservoir during future floods would be dominated by sand, not fine silt. The sand is less prone to result in fugitive dust during dry windy meteorological conditions*.

Geomorphic processes in watersheds are continuous natural processes that provide a continuous supply of soil particles of various sizes on land surfaces as well as in stream bed and banks. A large flood can have an impact on sediment distribution for some period of time, however, that impact is not permanent. Moreover, Figure 5-5 of Volume 3A_S05, Page 5.16 of the EIA also presents the fact that the watershed, including the PDA and the upstream watershed contain unconsolidated deposits of Clay and Till that will influence the types of sediment that have the potential to get deposited in the reservoir after flood events.

a. Update this section so that all types of sediments (fine and coarse) are considered.

Response 278

a. The potential increase of fines in the upstream Elbow River drainage basin, due to natural geomorphological processes that may occur over a long regeneration period, is estimated to be approximately 7%. A 7% increase of fines in the upstream Elbow River drainage basin could result in a maximum of 7% increase of fines in the deposited sediment in the off-stream reservoir. The hydrological model (Volume 3B, Section 6 and Volume 4, Appendix J) estimates an approximate composition of the deposited sediment in the reservoir to have a mean value of 72% sand and 22% silt. A 7% increase of silt (fines) in the deposited sediment will result in an increase of the silt fraction from 22% to 29%.

The magnitude of the fines increase is based on comparison of surface and subsurface sediment samples taken along Elbow River and bore hole data from the Elbow River floodplain. The shallow subsurface samples are considered representative of river conditions since the 2013 flood; and the bore hole data are considered representative of river conditions before the 2013 flood. The difference of 7% in the fine fraction between the bore hole data (10% fines) and the shallow subsurface samples (3% fines) is an indication of the washout effect of the 2013 flood.

The natural removal of fine sediment (e.g., clay and fine silt) from the upstream Elbow River drainage basin associated with the 2013 or future floods is estimated to have a small effect on potential fugitive dust emissions for post-flood operations. The particulate emission estimation methods described in the air quality assessment for wind erosion emissions from the post-flood sediment are described in Volume 4, Appendix E, Section 3.1. The emission rate calculation is dependent upon the selected soil classification, as indicated in Figure 3-3 of that Appendix.

A 7% increase of fines in the deposited sediment does not change the soil classification and, therefore, does not change the emission calculation. The particulate emission rate is representative of range of both fine and coarse sediment that have the potential to be deposited in the reservoir from diverted flood water.

Question 279

Volume 3B, Section 6.3, Table 6-3, Page 6.11

In the Table it is indicated that Reservoir filling and draining does not have effect on hydrological regime. However, both of these activities have an effect on hydrological regime as it is changing the hydrograph by lowering the peak and artificially increasing the flow in the low flow season. These changes may or may not happen frequently depending on the magnitude of the flood. However, when the project will be in operation these activities will have direct influence on hydrology and will have an impact over the long term.

Similarly, reservoir filling and draining have impacts on channel morphology as a percentage of sediment is removed from the river and released at a later time at a downstream location, bypassing a reach of the Elbow River. Moreover, channel maintenance will have an effect on channel morphology.

a. Update the table to reflect the above discussion on change in hydrological regime. If this is not possible explain.

b. Include plots of hydrographs of the Elbow River (at the diversion structure and after the confluence of the outlet channel within the Elbow River) with and without the project in place to show how it changes the hydrograph and flow pattern of the River.

c. Update the table to reflect the above discussion on change in channel morphology. If this is not possible, explain.

d. Include a description of the change in the Elbow River and outlet channel morphology, if possible using the latest surveyed bathymetries.

Response 279

a. Volume 3B, Section 6, Table 6-3 is revised as indicated in Table IR279-1 (strikeout and red indicates the necessary revisions). The Project effects on hydrology are discussed in Section 6.4.2 but was omitted from the Project Interactions table.

b. The hydrographs with and without the Project are shown at the diversion structure in Volume 3B, Section 6, Figure 6-4 (design flood), Figure 6-5 (1:100 year flood) and Figure 6-6 (1:10 year flood). At the velocity of the river water, it will take about one hour to travel from the diversion structure to the confluence of Elbow River with the unnamed creek. The hydrographs shown in Figure 6-4 to Figure 6-6 would illustrate the condition and be shifted to the right by one hour. They look the same.

   The release will take place later in the summer when the flow in Elbow River is about 20 m³/s. Figure 6-7 shows the release rate from the reservoir for the associated three flood conditions. The modelled release rates (these are not the maximum release rates) are the following: design flood = 20.01 m³/s, 1:100 year flood =11.31 m³/s, and 1:10 year flood = 0.27 m³/s. Adding 20 m³/s to the release rate hydrographs would represent the flow in Elbow River downstream of the unnamed creek.

   If the hydrographs were combined on one graph, it would be difficult to discern the release of water from the off-stream reservoir on the Elbow River hydrograph, when compared to the flood peaks without the Project.

c. Channel maintenance refers to the channel of the unnamed creek and diversion channel. Channel morphology refers to the river channel. The Project effects on river channel morphology is discussed in Volume 3B, Section 6.4.4 but were omitted from the Project Interactions table. Table IR279-1 shows the revision to the Project interactions table. The table also contains a clarifying edits in red text.

Table IR279-1 Project Interactions with Hydrology

Project Components and Physical Activities	Project Effects		
	Change in Hydrological Regime	Change in Suspended Sediment Transport	Change in Channel Morphology
Flood and Post-flood Operations			
Reservoir filling	~~NA~~ ✓	✓	✓
Retention of water in the reservoir–	✓	✓	✓
Reservoir draining	~~NA~~ ✓	✓	✓
Reservoir sediment partial cleanup: moving sediment within the reservoir and contouring to maintain water flow into and out of the reservoir for a future flood	NA	✓	–
Channel maintenance (diversion channel and the unnamed creek channel)	NA	✓	✓
Road and bridge maintenance	NA	–	–
NOTES: ✓ = Potential interaction – = No interaction NA = Not Applicable			

d. Changes to river channel morphology are presented in Section 6.4.4, where comparison between with the Project and without the Project for river channel morphology. The bathymetry available at the time was used as the initial condition in each case and the difference in morphology (with and without the Project after a flood) are compared in the tables and maps shown in that section (Volume 3B, Section 6.4.4, Figure 6-25 through Figure 6-36 and Table 6-10).

Question 280

<u>Volume 3B, Section 6.4, Page 6.12</u>

Alberta Transportation states *Assessing the effect of the Project on hydrology under this context is not applicable because the Project is expected to operate whenever hydrological conditions pose a downstream hazard.*

This statement indicates that assessing the effect of a project on hydrology is not applicable which is not correct as one of the objectives of an EIA is to understand the effects of the proposed project regardless if they are positive or negative.

a. Include an assessment of the short term and long term effects of the Project on Hydrology and include all mitigation measures.

Response 280

a. The following statement in Volume 3B, Section 6.4, page 6.12 is not correct: "Assessing the effect of the Project on hydrology under this context is not applicable because the Project is expected to operate whenever hydrological conditions pose a downstream hazard." In fact, the analysis is completed for the design flood, 1:100 year flood, and 1:10 year flood. The following summarizes the relevant content in Volume 3B, Section 6.

   Volume 3B, Section 6, Figure 6-4, Figure 6-5, and Figure 6-6 illustrate that the Project reduces (compared to without the Project) the design flood peak by about 50% (1,150 m^3/s to 550 m^3/s), the 1:100 year flood peak by about 80% (760 m^3/s to 160 m^3/s) and the 1:10 year flood peak by about 20% (200 m^3/s to 160 m^3/s).

   These effects are positive in direction (reduction in ecological and economic damages) and moderate to high in magnitude (as stated in Volume 3A, Table 6-2). Because the effect is positive to reduce flood peaks, no mitigation for effects on hydrology is required.

   Volume 3B, Section 6, Table 6-11 is not correct and should be revised as shown in Table IR280-1.

   The assessment of long-term changes in hydrology is unchanged because there is less than 0.5% water loss from evaporation, which is adverse and negligible.

Table IR280-1 Project Effects on Hydrology during Flood and Post-Flood Operations (revision to Volume 3B, Section 6, Table 6-11)

Effect	Effects Characterization								
	Project Phase	Timing	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Ecological and Socio-economic Context
Change in Hydrology (long term)	F, PF	N/A	A	N	~~PDA~~ RAA	~~ST~~ LT	IR	I	D
Change in Hydrology (short Term) [this is a new row]	F, PF	N/A	P	H	RAA	ST	IR	I	D
Change in Suspended Sediment Transport	F, PF	N/A	~~A~~ A, P	H	LAA	ST to LT	IR	I	D, U
Change in Channel River Morphology	F, PF	N/A	A	~~H~~ N to M	PDA	LT	IR	I	D

Project Phase
F: Flood Operations
PF: Post-Flood Operations

Timing Consideration
S: Seasonality
T: Time of day
R: Regulatory

Direction:
P: Positive
A: Adverse
N: Neutral

Magnitude:
N: Negligible
L: Low
M: Moderate
H: High

Geographic Extent:
PDA: Project Development Area
LAA: Local Assessment Area
RAA: Regional Assessment Area

Duration:
ST: Short-term;
MT: Medium-term
LT: Long-term

N/A: Not applicable

Frequency:
S: Single event
IR: Irregular event
R: Regular event
C: Continuous

Reversibility:
R: Reversible
I: Irreversible

Ecological/Socio-Economic Context:
D: Disturbed
U: Undisturbed

Question 281

Volume 3B, Section 6.4, Page 6.12

Alberta Transportation states *Given that the Project may have operated approximately 12 times for the period 1934 to 2016, changes to the hydrological regime are unlikely to modify the long term median flow values in a meaningful way, given that the Elbow River is a low flow system.*

a. Discuss the implications of altering high flows on the hydrological regime.

Response 281

a. The following is a summary of the response to IR280, which also applies here.

An assessment of the implications of the Project on high flows is shown in Volume 3B, Section 6, Figure 6-4, Figure 6-5, and Figure 6-6, which show that the Project reduces peak flows (compared to without the Project: the design flood peak is reduced by 50% (about 1,150 m^3/s to 550 m^3/s); the 1:100 year flood peak, by about 80% (760 m^3/s to 160 m^3/s); and the 1:10 year flood peak, by about 20% (200 m^3/s to 160 m^3/s).

Question 282

Volume 3B, Section 6.4.2, Page 6.19

Provide further information on how the natural flow of the Elbow River is going to be changed due to regulated operations of the Springbank and Glenmore Reservoirs during flood and post flood conditions.

a. Describe the overall changes (timing, magnitude) along the Elbow River (from upstream of the diversion inlet to downstream of Glenmore Reservoir) in terms of flow, water level and velocity in natural and regulated (due to the project) conditions.

b. Provide plots of natural and regulated hydrographs of the Elbow River just after the diversion location, for the three flood scenarios (Design, 1:100 year and 1:10 year floods).

c. Provide plots of natural and regulated hydrographs of the Elbow River just after the confluence of the outlet channel from the dam, for the three flood scenarios (Design, 1:100 year and 1:10 year floods).

d. Provide plots of natural and regulated hydrographs of the Elbow River just after the Glenmore reservoir, for the three flood scenarios (Design, 1:100 year and 1:10 year floods).

Response 282

BACKGROUND INFORMATION

Rather than answering the parts in sequence, it is more reasonable to answer in the sequence of the scientific logic involved such that hydrographs and flows are discussed first, followed by changes in water velocity and depth. The reason for this is that the change in the hydrograph from upstream to downstream is the key factor determining water velocity and depth.

Therefore, answers are provided to the sequence of b., c., d., and a. The hydrographs in the hydrology assessment are correct and applicable for the additional locations requested, but the graphs are time shifted, based on how fast the water is moving in Elbow River and how far downstream effects are evaluated.

The hydrology assessment considers the effect of the Project on Elbow River hydrographs. Existing conditions without the Project are compared to the hydrographs with the Project. Natural flows have been altered upstream of the Project and so the existing conditions are not technically "natural." It is assumed that natural flows are without the Project and regulated flows are with the Project in operation during a flood.

b. The hydrographs in Figure 6-4, Figure 6-5 and Figure 6-6 are applicable to Elbow River immediately downstream of the diversion structure. The hydrographs with and without the Project are shown in Figure 6-4 (design flood), Figure 6-5 (1:100-year flood), and Figure 6-6 (1:10-year flood).

c. The hydrographs in Figure 6-4 to Figure 6-6 are applicable to Elbow River downstream of the confluence with the unnamed creek, but time shifted to the right by one hour because it will take about one hour for water to travel from the diversion structure to the confluence. The hydrograph peak will decrease as it moves downstream, and some local inflow will occur. Over this short distance, the reduction of the peak will be small, around 1% to 2%, and the local contribution to the peak will be of similar percentage. These differences would not be possible to measure in the field and would be difficult to discern in a graph. Therefore, the shape of the hydrograph is essentially the same.

   The release of water from the off-stream reservoir will take place later in the summer when the flow in Elbow River is about 20 m^3/s. Figure 6-7 shows the modelled release rates from the reservoir (these are not the maximum release rates) for the three floods. The release rates are as follows: design flood = 20.01 m^3/s; 1:100 year flood =11.31 m^3/s; and the 1:10 year flood = 0.27 m^3/s. Adding 20 m^3/s to the release rate hydrographs would represent the Elbow River flow downstream of its confluence with the unnamed creek. If the flood hydrographs and the water release hydrographs are combined on one graph it would be difficult to discern the release of water on the Elbow River hydrograph, when compared to the flood peaks.

d. The hydrographs in Figure 6-5 to Figure 6-6 are applicable to just before Glenmore Reservoir for the 1:100 year and 1:10 year floods, except time shifted to the right by four hours because it will take about four hours for river water to travel from the diversion structure to Glenmore Reservoir. Over this distance, the reduction of the peak will be small, around 3% to 4%, and the local runoff between the diversion structure and Glenmore Reservoir contribution to the peak will be a similar percentage. These differences would not be possible to measure in the field and would be difficult to discern in a graph. Therefore, the shape of the hydrograph is essentially the same.

   Downstream of Glenmore Reservoir, the hydrographs for the 1:100 year and 1:10 year floods would be determined by the operation of Glenmore Reservoir and are, therefore, not provided.

   The design flood hydrograph would be similar to Figure 6-4 but shifted to the right by four hours and would remain at a maximum 160 m^3/s to the end of the graph. As described in Volume 1, Section 1.2:

   "The off-stream reservoir will work in tandem with the Glenmore Reservoir to limit flood flows downstream of the Glenmore Reservoir in Calgary to less than 160 m^3/s, for floods up to the design flood (2013 flood), or equivalent."

a. Without the Project, water velocity in Elbow River can vary between 7.0 m/s to almost zero, depending on the conditions and the location in the river (even across the same cross-section in the river).

   The Project reduces peak flows (compared to flood conditions without the Project) most dramatically for the 1:100 year flood. Flood peaks drop from 760 m^3/s to 160 m^3/s (80% decrease). To estimate the changes in velocity and depth, the model results were reviewed for one cross-sectional location where the water velocity was relatively high (4.0 m/s): the velocity dropped by about 40% (2.5 m/s to 3.0 m/s) with the Project and the depth dropped from 2.5 m to 2.0 m (20% decrease) with the Project. These percent changes for each parameter are representative of the change in velocity and depth that would occur due to the Project.

   For the other floods, the change in peak flow is smaller (50% decrease for design flood, 20% decrease for the 1:10 year flood) and the percent change in velocity and depth are comparably less.

Question 283

Volume 3B, Section 6.4.2.1, Table 6-4, Page 6.20

a. Add the maximum release rates used in the table for each of the flood scenarios. Provide the updated tables.

Response 283

a. Table IR283-1 is an update to Volume 3B, Section 6, Table 6-4 with release rates (from modelling) added in red text and a clarifying edit in red text for the last column. The maximum release rate possible from the reservoir is 27 m^3/s (this is the design of the outlet gate), regardless of the retention volume for any of the three floods.

Table IR283-1 Volumes Diverted, Retained in the Reservoir and Released back to the Elbow River (updated Volume 3B, Section 6, Table 6-4)

Flood	Elbow River Volume Non-Diversion (dam^3)	Volume Diverted (dam^3)	Elbow River Volume Reduction During Diversion (%)	Diverted Volume / Annual Volume[4] (%)	Diversion Time (days)	Residence Time in Reservoir (days)	Modelled Release Rate (m^3/s)	Release Time (days)	Volume Released[5] (dam^3)	Diverted Volume Remaining In Reservoir (%)
Design[1]	113,985	55,138	48	11.2	3.75	20	20.01	38	54,380	1.4
1:100[2]	58,933	33,014	56	5.4	1.8	43	11.31	39	32,680	1.0
1:10[3]	6,017	790	14	0.2	0.38	43	0.27	30	654	17

NOTES:

[1] Period of diversion: 06/20/2013 04:00 h to 06/23/2013 22:00 h; Residence time: 06/24/2013 to 07/14/2013

[2] Period of diversion: 05/31/2100 05:00 h to 06/02/2100 02:00 h: Residence time: 06/02/2100 to 07/15/2100

[3] Period of diversion: 05/24/2008 15:00 h to 05/24/2008 23:00 h; Residence time: 05/25/2008 to 07/07/2008

[4] Based on actual WSC Record at Sarcee Bridge for Design Flood and 1:10; modelled annual data for 1:100. Calculated annual flow volumes are design flood, 490,136 dam^3 ; 1:100 year flood, 613,411 dam^3; and 1:10 year flood, 380,797 dam^3

[5] Does not include evaporated volume

Question 284

<u>Volume 3B, Section 6.4.2.1, Table 6-5, Page 6.21</u>

Evaporation volume will be higher for the Design flood if it happens earlier in the year.

a. Provide the evaporation volume and other relevant parameters presented on the table if the Design flood happens at the end of May or early June.

b. Provide a figure and description of the design flood hydrograph used in the analysis for answering 'a' with peak shifted earlier in the year.

Response 284

a-b. Three floods are assessed: 1:10 year, 1:100 year and design (2013). These provide a robust description of the range of natural variability in flood conditions. The 2013 flood however, within known historical record, was the flood of greatest magnitude (includes both precipitation and snowmelt runoff); hence, it was chosen as the Project design basis, and representative of likely maximum effects on valued components (VCs). Regardless of the timing of a flood (late May or early June), the residence time for the water in the off-stream reservoir is the same, but evaporation would be less earlier in the season (ESRD 2013).

Regarding seasonal timing, 67% of the historical flood events since 1934 occurred in June and 33% in the last week of May (Volume 3A, Table 6-7). Empirical hydrograph information was also available for the 2013 flood, which provided time versus flow rate data for modelling, based on real-time information.

REFERENCES

ESRD (Environment and Sustainable Resource Development). 2013. Evaporation and Evapotranspiration in Alberta 1912-2009. April 2013.

Question 285

<u>Volume 3B, Section 6.4.3.1, Table 6-6, Page 6.28</u>
<u>Volume 3B, Section 6.4.3.2, Figure 6-12, Page 6.31</u>

Estimated reservoir sedimentation depth, loss of reservoir retention volume due to sediment remaining in the reservoir will be higher if the design flood happens earlier in the year and residence time in the reservoir increases.

a. Describe what would be the reservoir sedimentation depth, suspended sediment mass released into the low-level outlet, loss of retention capacity and other relevant parameters of Table 6-6 if the design flood happens at the end of May or Early June.

b. Provide a figure and description of the design flood hydrograph used in the analysis for answering 'a' with peak shifted earlier in the year.

c. Explain why modelled suspended sediment mass released into the low-level outlet for design flood is less (90 kt) than the 1:100 year flood (220 kt). Include if this is due to modelling limitations. If so, what are those limitations and how should these results be interpreted and used?

Response 285

a-b. The timing of the design flood does not change its characteristics with respect to sediment transport and, as a result, if the design flood were to occur earlier (late May or early June), it would not materially affect the sedimentation depth, retention capacity or suspended sediment mass released. Regardless of the timing of the flood, the residence time for the water in the off-stream reservoir is the same. Most of the sediment will settle out in the reservoir in the early stages of retention. Slight changes to residence time will not affect this process.

c. The explanation for why sediment mass for the design flood is less than the 1:100 flood is provided in Volume 3B, Section 6.4.3.1, p. 6.2.7, reproduced below.

> "Model results for the 1:100 year flood suggest that up to 65% of the suspended sediment in the Elbow River would be diverted into the reservoir. After retention, approximately 220 kt are estimated as being released into the low-level outlet. This is larger than for the design flood because of differences in the sediment deposition pattern in the reservoir for the 1:100 year flood. This is due to the smaller water volume and different circulatory patterns in the reservoir for a smaller diversion volume. Volumetrically, the deposited sediment remaining in the reservoir after release is estimated as 0.5% of the full-service volume (Table 6-6)."

Question 286

Volume 3B, Section 6.4.3.4, Figure 6-21, Page 6.46
Volume 3B, Section 6.4.3.4, Figure 6-24, Page 6.51

a. The grey graphs are not visible behind the solid blue graphs. Change the solid blue into semi-transparent or use line graphs to make all the items in the legend visible.

Response 286

a. There are three sets of information contained in Volume 3B, Section 6, Figures 6-21 and 6-24 that overlap: upper outlet channel (the unnamed creek) and illustrated in a black line and gray shading; confluence of the outlet channel (the unnamed creek) with Elbow River and illustrated by a red line; and Elbow River at a location approximately 1 km downstream of the confluence and illustrated using blue line and shading. The gray and blue shading overlapped in these two figures.

Volume 3B, Section 6, Figure 6-21 has been revised by separating the information into two graphs, as Figure IR286-1: the top graph illustrates the suspended sediment concentration over time and the bottom graph illustrates off-stream reservoir elevation over time.

Volume 3B, Section 6, Figure 6-24 included three plots; the first plot contained information that was overlapping and has been revised here as Figure IR286-2 to better illustrate the information being presented.

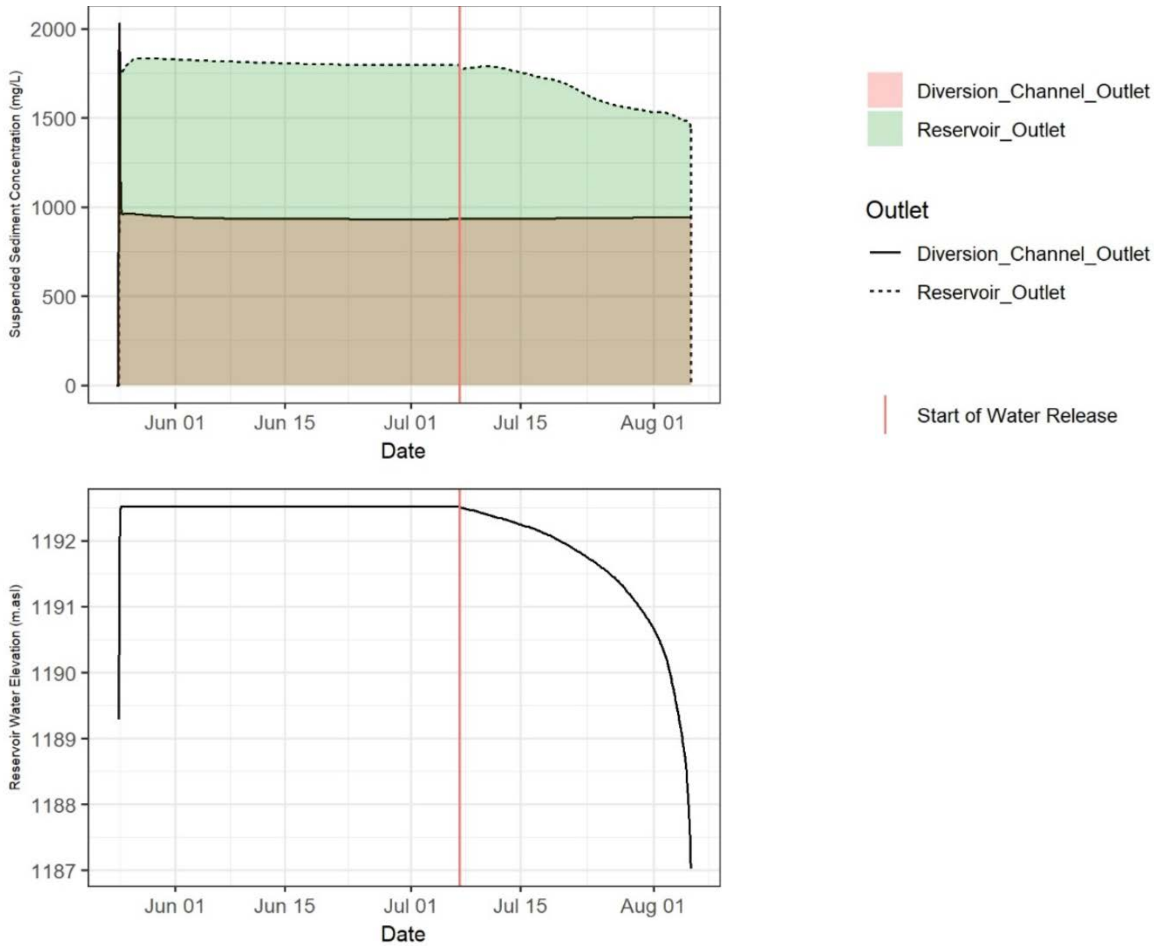


Figure IR286-1 Suspended Sediment Concentrations in the Diversion Channel and Reservoir for a 1:10 Year Flood

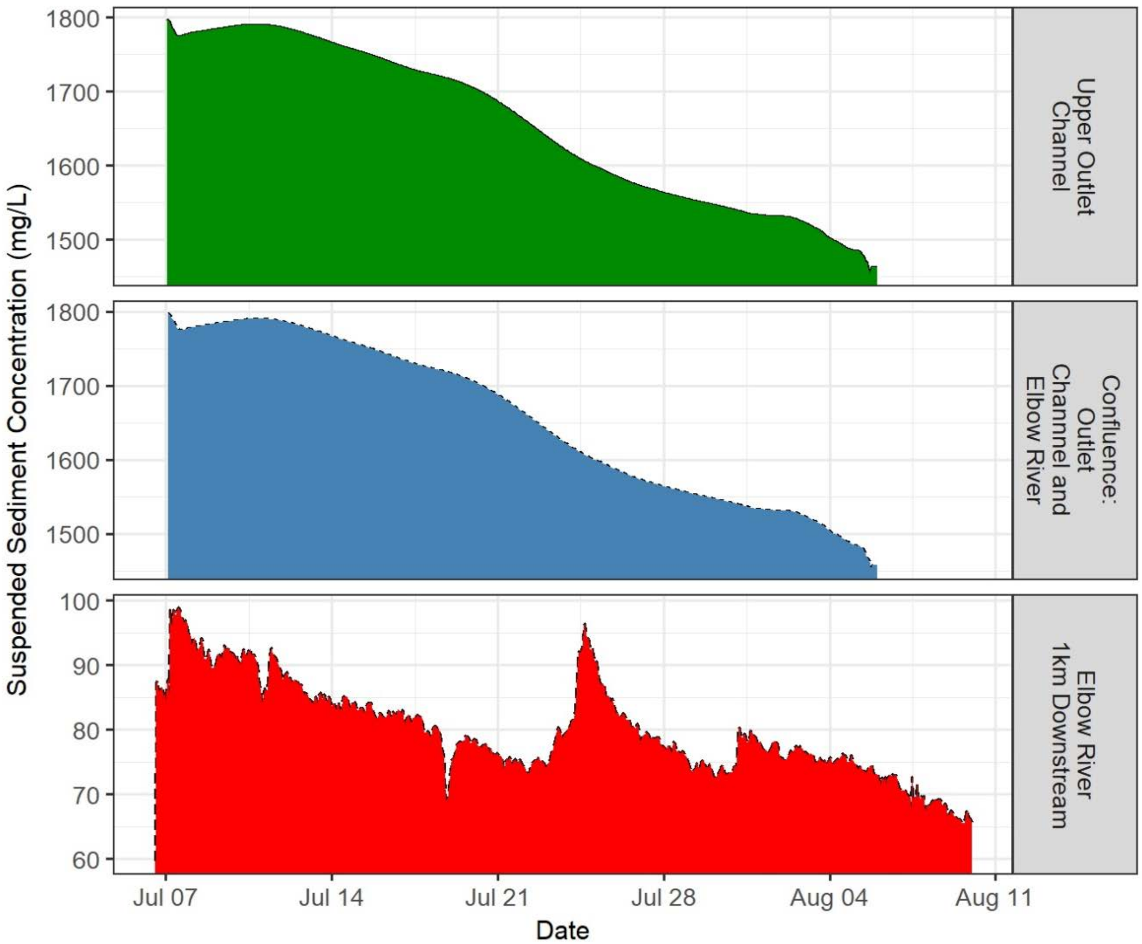


Figure IR286-2 Suspended Sediment Concentrations in Released Water Associated with a 1:10 Year Flood

Question 287

Volume 3B, Section 6.4.5, Table 6-11, Page 6.74

a. ***Geographic extent*** **for 'Change in hydrology' is discussed for the PDA. Why is the extent only addressed for the PDA? Hydrology will change in the RAA (RAA boundary as per Figure 6-1 in Volume 3A_S06) as the objective of this project is to lower the peak flow in the downstream reach of the Elbow River. This change will be observed for all flood years having flows more than 160 m^3/s.**

Response 287

a. The flood protection provided does extend downstream of Glenmore Reservoir; therefore, the geographic extent should be the RAA. Table IR287-1 is a revision (indicated by strikeout and red text and also red text for clarifying edits) to Volume 3B, Section 6, Table 6-11.

Table IR287-1 Project Effects on Hydrology during Flood and Post-Flood Operations

Effect	Effects Characterization								
	Project Phase	Timing	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Ecological and Socio-economic Context
Change in Hydrology (long term)	F, PF	N/A	A	N	~~PDA~~ RAA	~~ST~~ LT	IR	I	D
Change in Hydrology (short term)[this is a new row]	F, PF	N/A	P	H	RAA	ST	IR	I	D
Change in Suspended Sediment Transport	F, PF	N/A	~~A~~ A,P	H	LAA	ST to LT	IR	I	D, U

Table IR287-1 Project Effects on Hydrology during Flood and Post-Flood Operations

Effect	Effects Characterization								
	Project Phase	Timing	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Ecological and Socio-economic Context
Change in River Channel Morphology	F, PF	N/A	A	~~H~~ N to M	PDA	LT	IR	I	D

Project Phase
F: Flood Operations
PF: Post-Flood Operations

Timing Consideration
S: Seasonality
T: Time of day
R: Regulatory

Direction:
P: Positive
A: Adverse
N: Neutral

Magnitude:
N: Negligible
L: Low
M: Moderate
H: High

Geographic Extent:
PDA: Project Development Area
LAA: Local Assessment Area
RAA: Regional Assessment Area

Duration:
ST: Short-term;
MT: Medium-term
LT: Long-term

Frequency:
S: Single event
IR: Irregular event
R: Regular event
C: Continuous

Reversibility:
R: Reversible
I: Irreversible

Ecological/Socio-Economic Context:
D: Disturbed
U: Undisturbed

N/A: Not applicable

Question 288

Volume 4, Appendix J, Section 2.2.4, Page 2.13
Volume 4, Appendix J, Table 2-6, Page 2.14

a. Describe how data from flow gauge station 05BJ001 was used in the frequency analysis. If flow data from the regulated period was used in the frequency analysis describe if this data was naturalized before being used in the frequency analysis.

b. If so, describe how the regulated flow data was naturalized.

c. If not, explain why the regulated flow data was not naturalized for the frequency analysis. What is the impact of using regulated flow data in estimating the peak flow rate and volume using the frequency analysis, in estimation of storage volume of the Springbank reservoir and on HD, ST and MT modelling results.

Response 288

a. Only natural, unregulated flow is used for frequency analysis. Therefore, flow measurements up until the construction of Glenmore Dam iwere considered for the station below Glenmore Dam (05BJ001). No regulated flow from station 05BJ001 was considered for frequency analysis. Therefore, the impact of regulated flow data on estimation of volume of retained water in the off-stream reservoir and hydrodynamic modelling (HD), sand transport (ST) and mud transport (MT) modelling were not carried out.

b. No regulated flow was used for frequency analysis.

c. There were unregulated flows from Elbow River above Glenmore Dam (05BJ005) and Elbow River at Sarcee Bridge (05BJ010). These stations have proximity and similar drainage area to 05BJ001 that lend themselves to combining into one station. Table IR261-1 (see the response to IR261) provides a summary of the three stations used for frequency analysis. Sufficient natural flow data is available for the frequency analysis; therefore, regulated flow data was not used.

Question 289

Volume 4, Appendix J, Section 2.4.1, Page 2.30

Alberta Transportation states *The overall model domain includes an approximately 37-km reach of Elbow River from Bragg Creek to Glenmore Reservoir and the entire Glenmore Reservoir.*

a. The EIA does not include any results on the Glenmore Reservoir. Provide the modelling results of the Glenmore Reservoir and describe the impact of the Springbank reservoir flood operation on the Glenmore reservoir in terms of hydrology and sedimentation.

b. Provide a figure of the entire model domain used in HD, ST and MT modelling.

c. Provide the simulation time period (start date, end date) used for the HD, ST and MT modelling in the report.

Response 289

a. The assessment of potential Project effects on hydrology included Glenmore Reservoir, which is in the model domain of the hydrology RAA.

   Overall, the effects of the Project on the Glenmore Reservoir are positive by reducing the volume of water entering the off-stream reservoir during floods and, as a result, reducing sediment loading. The influence of all aspects of water operations on hydrology, due to the combined operations of the Project and the Glenmore Reservoir.

b. Three model domains are used in HD (hydrodynamic), ST (sand transport) and MT (mud transport) modelling:

   - Model Domain (I) for Elbow River between Bragg Creek and Glenmore Reservoir Dam (Figure IR289-1)
   - Model Domain (II) for diversion channel and off-stream reservoir (Figure IR289-2)
   - Model Domain (III) for the unnamed creek channel and Elbow River (Figure IR289-3)

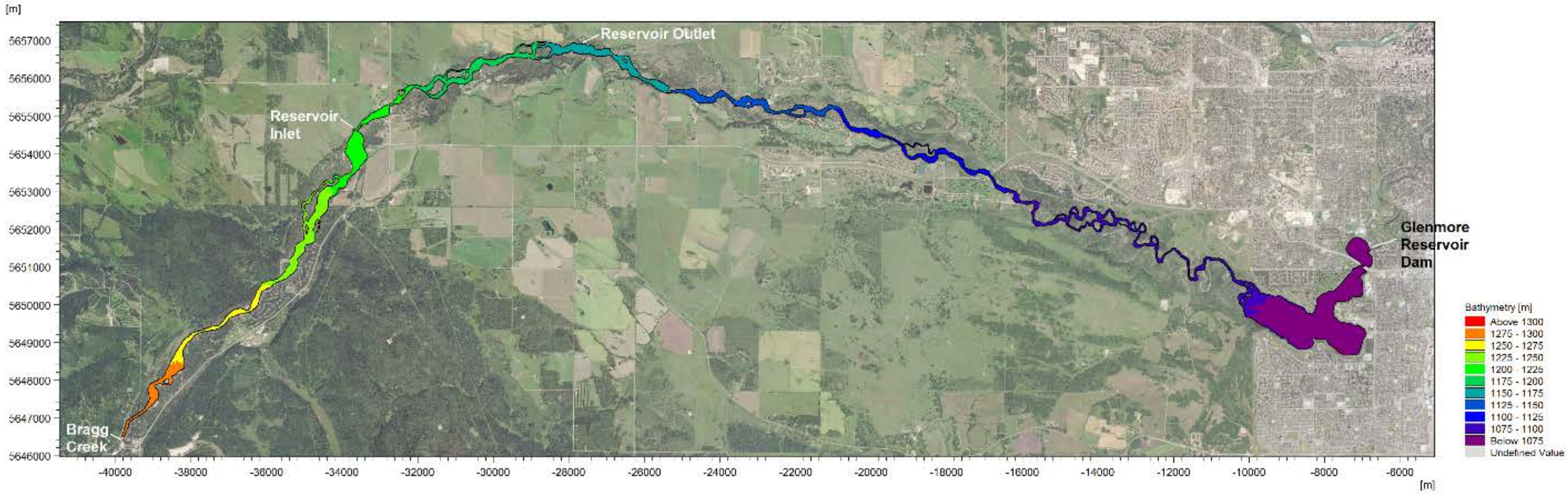


Figure IR289-1 Model Domain (I) for Elbow River between Bragg Creek and Glenmore Reservoir Dam

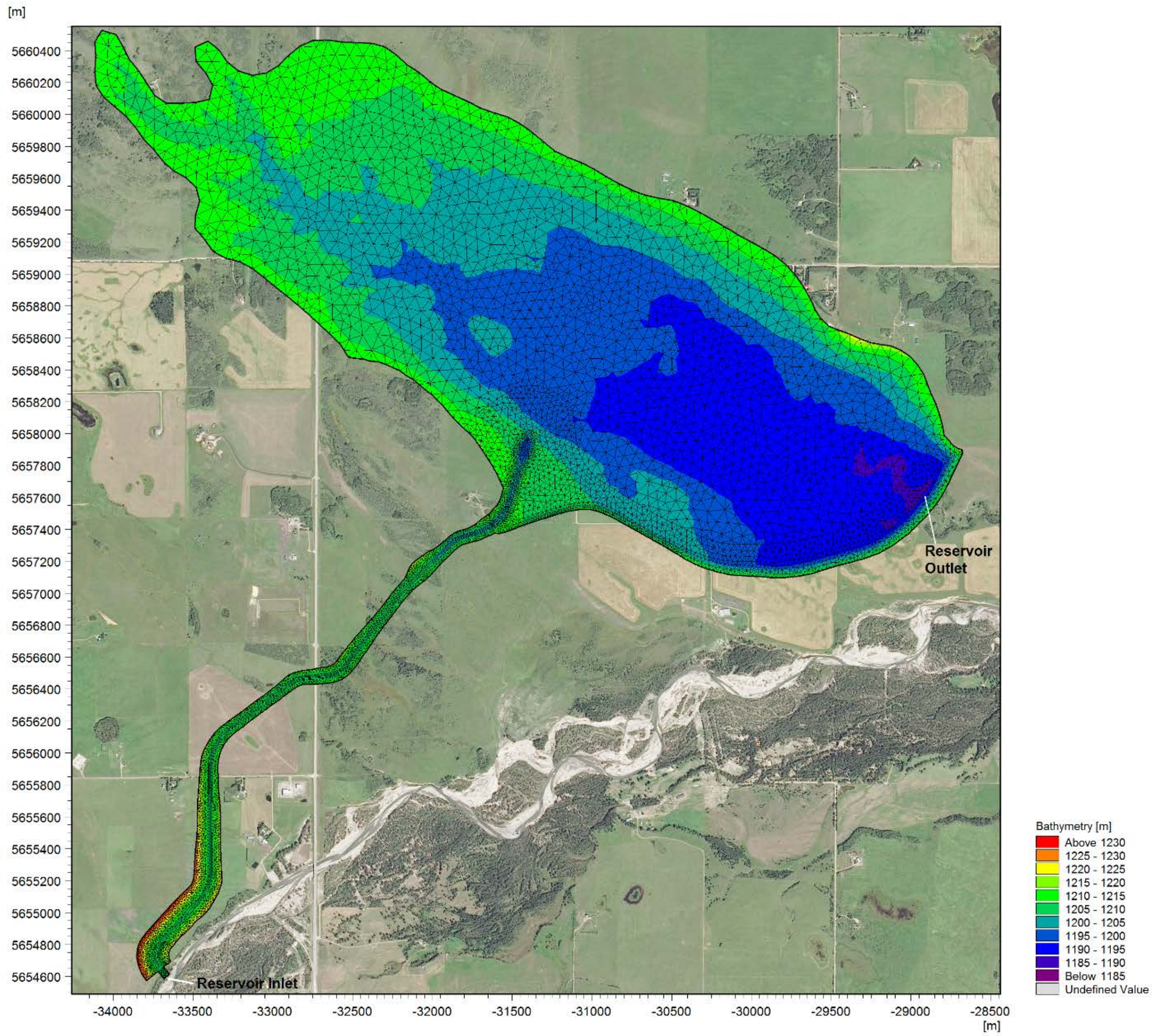


Figure IR289-2 Model Domain (II) for Diversion Channel and Off-Stream Reservoir

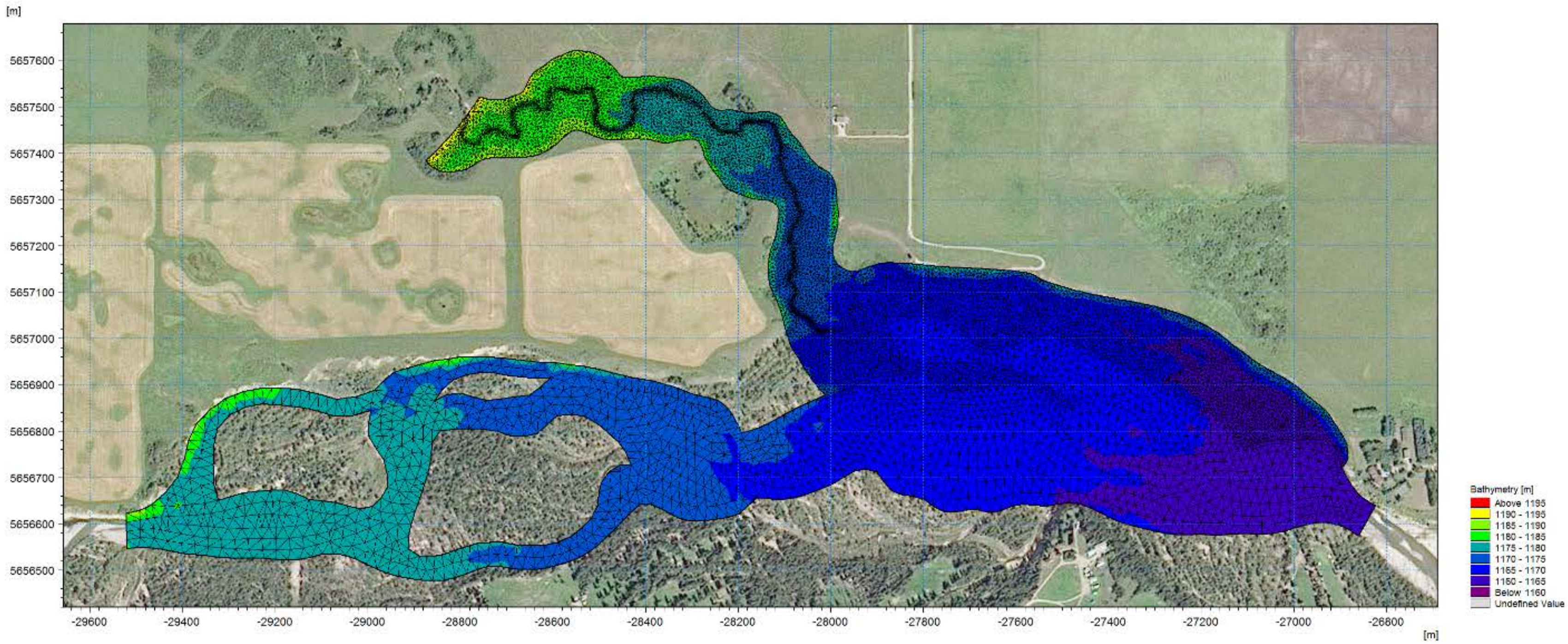


Figure IR289-3 Model Domain (III) for the Unnamed Creek Channel and Elbow River

c. All model runs were conducted within four-month simulation period from May 1 to August 31, as summarized in Table IR289-1.

Table IR289-1 Simulation Time Period used for the HD, ST and MT modelling

Flood Event	Model Domain	Start Time	End Time
1:10 year	(I) Elbow River	1-May	31-Aug
	(II) diversion channel and off-stream reservoir	24-May	31-Aug
	(III) unnamed creek channel	6-Jul	31-Aug
1:100 year	(I) Elbow River	1-May	31-Aug
	(II) diversion channel and off-stream reservoir	31-May	31-Aug
	(III) unnamed creek channel	14-Jul	31-Aug
Design	(I) Elbow River	1-May	31-Aug
	(II) diversion channel and off-stream reservoir	20-Jun	31-Aug
	(III) unnamed creek channel	14-Jul	31-Aug

Question 290

Volume 1, Section 3.1, Page 3.1
Volume 1, Section 3.2.4, Table 3.3, Page 3.12

Alberta Transportation has identified that *The diversion capacity and combined storage of Glenmore Reservoir allows the Project to mitigate downstream flood damages and keep flows downstream of Glenmore below 160 m^3/s for floods up to the 2013 flood or equivalent. That flood had an estimated peak flow of 1,240 m^3/s, a 7-day volume of 149,600,000 m^3 and is estimated to be slightly greater than a 1:200 year flood*. It also identifies different reservoir residence times and discharge durations in three scenarios: design flood, 1:10 year and 1:100 year frequencies.

a. Provide a detailed explanation of a scenario where the 2013 flood could occur earlier in June in conjunction with snowmelt runoff and detail how this would change the estimates of sediment loading, detention times in the reservoir and subsequent effects on hydrogeology and water quality in the reservoir.

b. Provide a hydrograph that shows the 2013 flood occurring in conjunction with snowmelt runoff.

Response 290

a-b. Three flood scenarios are assessed: 1:10 year, 1:100 year and design (2013). These provide a robust description of the range of natural variability in flood conditions. The 2013 flood however, within known historical record, was the flood of greatest magnitude (includes both precipitation and snowmelt runoff); hence, it was chosen as the Project design basis, and representative of likely maximum effects on valued components (VCs). If the design flood happens earlier and the peak is larger, the Project will still only divert a maximum of 600 m^3/s. This will largely limit the amount of sediment that will be deposited into the off-stream reservoir, regardless of the concentration in the Elbow River.

Regarding seasonal timing, 67% of the historical flood events since 1934 occurred in June, and 33% in the last week of May (Volume 3A, Table 6-7). Empirical hydrograph information was also available for the 2013 flood, providing time-water volume flow rate data for modelling, based on real-time information.

5.4 SURFACE WATER QUALITY

Question 291

Volume 3A, Section 7.2.2, Page 7.10

Alberta Transportation states that *There are no approved wastewater discharges to the Elbow River upstream of Glenmore Reservoir.* This was from a 2004 report that is outdated with respect to the topic of wastewater releases.

a. Provide details of the potential impacts on the Project and on Elbow River water quality as a result of overflows or bypasses during flood events or approved release from;

i. Bragg Creek Wastewater Treatment Plant (continuous release);

ii. Wintergreen Wastewater Treatment Plant (seasonal irrigation);

iii. Redwood Meadows Lift Station and Lagoon (under Federal jurisdiction);

iv. Petro-Canada Lagoon at Highway 22 and TransCanada Highway (retained on site, not approved under EPEA); and

v. Calaway Park Lagoon (seasonal irrigation).

Response 291

a. The water quantity of wastewater as a result of overflows and bypasses during floods or approved releases from each source mentioned above is expected to be small compared to even a 1:10 year flood. The volumes of how much waste could be released from each source and how much would reach Elbow River is uncertain; the amount that may be diverted into the off-stream reservoir is even smaller.

Depending on the size of the flood, the portion of any wastewater that enters the river upstream of the diversion structure and subsequently be diverted into the off-stream reservoir will vary. For the design flood, up to 48% of Elbow River flood flow will be diverted into the off-stream reservoir (Volume 3B, Section 6.4.2, Table 6-4). Under mixed conditions (i.e., it is assumed that runoff will mix with Elbow River flows and be diverted to the off-stream reservoir in similar proportions as flood water), a portion of wastewater from the above sources is expected to be diverted in a similar manner.

For the 1:100 year flood, approximately 56% of the flood flow is predicted to be diverted and for the 1:10 year flood, 14% will be diverted. Therefore, approximately half of the overland flows during a design and 1:100 flood, and approximately 85% of the overland flows during a

1:10 year flood, will not enter the off-stream reservoir. The remainder of Elbow River flood flows not diverted into the off-stream reservoir will remain in the Elbow River and flow into Glenmore Reservoir.

Particulate matter associated with wastewater that is diverted into the off-stream reservoir will settle out similar to total suspended solids (TSS) as described in Volume 3B, Section 7.4.2. Most of this particulate matter will settle and remain in the off-stream reservoir with only a small portion returning to Elbow River during release of water from the reservoir as follows:

- design flood, 1.8% of sediment and related parameters will return to Elbow River.
- 1:100 year flood, 11.7% of sediment and related parameters will return to Elbow River.
- 1:10 year flood, 4.6% of sediment and related parameters will return to Elbow River.

Particulate organic material and dissolved organic carbon associated with wastewater has the potential to affect oxygen levels in the off-stream reservoir. Bacterial activity resulting in biological respiration and chemical oxidation of particulate and dissolved, and organic matter will consume oxygen in water and sediments. (This is discussed in Volume 3B, Section 7.4.3, page 7.24.)

The particulate organic material is predicted to settle in the off-stream reservoir with suspended sediments, thus removing biological oxygen demand in the water column. The amount of organic material accumulating in the off-stream reservoir sediments from the watershed is relatively small and the predicted sediment oxygen demand is predicted to be similar to Glenmore Reservoir. The addition of organic particulate matter from the wastewater is also small and the incremental effect on oxygen demand is predicted to be correspondingly low.

A portion of the organic carbon in the dissolved fraction will be assimilated through biological activity and respiration will consume a portion of the oxygen in the water column. However, effects on oxygen levels in the off-stream reservoir will be reduced by wind turbulence and the shallow reservoir. Furthermore, dissolved oxygen concentrations in the unnamed creek increase due to increased water velocity that causes increased mixing and re-aeration. Any effects on Elbow River water quality will be localized and temporary because of rapid re-aeration in the river.

The balance of dissolved organic carbon not assimilated in the off-stream reservoir will flow through the reservoir and return to Elbow River unaltered similar to dissolved nutrients and dissolved metals (Volume 3B Section 7.4.2, page 7.23).

In summary, the Project mitigates the impacts of wastewater release and overflow into the Elbow River upstream of the diversion structure during a flood. A portion of wastewater in the river will be diverted into the off-stream reservoir where related particulate matter will settle out similarly to suspended sediment, thus reducing the load on Glenmore Reservoir due to the decreased flood flows in the Elbow River passing downstream of the diversion structure.

Question 292

Volume 4, Appendix J, Section 2.4, Page 2.27

Alberta Transportation states *As a 2D model is mesh based, the mesh network, if based on, for example, LiDAR, better represents large spatial areas [...] than surveyed cross-sections.* LiDAR and cross-sections are very often used in conjunction to represent floodplain topography and river channels respectively. The current model did not use cross-sections to better define the thalweg in the river channels.

a. Explain the rationale for not using river cross-sections for the model mesh configuration.

b. To what extent did Alberta Transportation consult with other agencies about any recent bathymetry surveys in the studied area?

c. Discuss any implications of using or not using river cross-sections for the suspended sediment transport to the Elbow River.

Response 292

a-b. River cross-sections for the model mesh configuration were not used because the data that was collected by another consulting company (Golder Associates) for another Government of Alberta project (to complete cross-sections of the Elbow River following the 2013 flood) in the area was not available at the time of the EIA filing. Alberta Transportation contacted the River Forecasting Centre and requested the cross-sections data, but the data was not ready to be released. Alberta Transportation instead obtained light detection and ranging (LiDAR) data by aerial surveillance over Elbow River in the fall of 2015.

c. The LiDAR collected in the fall of 2015 provides a better visual representation of the transects of the floodplain, unlike cross-sections that require greater interpretations of the transect data. The LiDAR and bathymetry provide very good coverage of the river domain used in modelling. The simulations done for hydrodynamics and sediment transport modelling is sufficient for determining Project effects on surface water quality and other VCs.

Question 293

Volume 4, Appendix J, Section 2.4, Page 2.29
Volume 4, Appendix J, Section 2.4.1, Page 2.30

Alberta Transportation indicated that *the spatial density of the flexible mesh was also varied, depending on the necessity for higher, or lower, resolution within the modeling domains*. Additionally, the model domain included the *Elbow River from Bragg Creek to Glenmore Reservoir and the entire Glenmore Reservoir*. However, there are no modelling results for the Glenmore Reservoir.

a. Provide a map of the model domain including the mesh network, the different sub- domains and any boundary conditions used (e.g. tributaries).

b. Provide the results for the Glenmore Reservoir. Otherwise, indicate why these results are not included as this is part of the LAA and RAA.

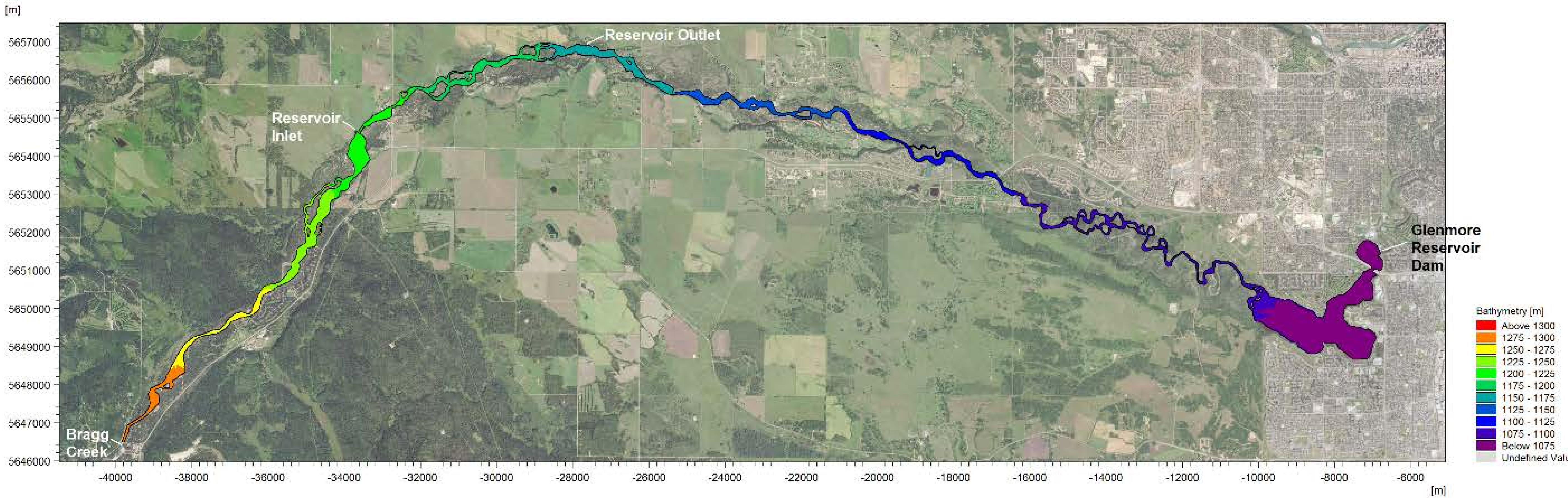
Response 293

a. Three model domains were used in this modelling study as discussed below.

MODEL DOMAIN (I) - ELBOW RIVER AND GLENMORE RESERVOIR

This domain contains 12,388 nodes and 20,579 triangular elements (Figure IR293-1) and has the following boundaries:

- the upstream boundary at Bragg Creek, defined by river discharges from Water Survey of Canada (WSC) station 05BJ004
- the downstream boundary extends to outlet of the Glenmore Reservoir, defined by water levels from WSC station 05BJ008
- the inlet boundary, defined by flow rates based on the inlet operation rules
- the outlet boundary, defined by flow rates based on the outlet operation rules



NOTES:

- In this figure, the domain is color coded to reflect stream and off-stream reservoir elevations.
- The X and Y axis reflect distance, in metres, associated with UTM (Universal Transverse Mercator) coordinates.

Figure IR293-1 Model Domain for Elbow River between Bragg Creek and Outlet of the Glenmore Reservoir Dam.

Figure IR293-2 includes the backwater area in Elbow River and the reach of the river immediately downstream. The pinch in the river is where Elbow River crosses Highway 22.

The flexible mesh system for the MIKE21 model is represented by an unstructured grid comprised triangular and quadrilinear elements. This grid breaks down the domain into discrete cells of finite volume where flow and transport equations are independently calculated. The spatial density of the flexible mesh was varied depending on the necessity for higher or lower resolution within the domain. Smaller grid units can be seen within the main channel of Elbow River and in areas of higher predicted velocity flows.

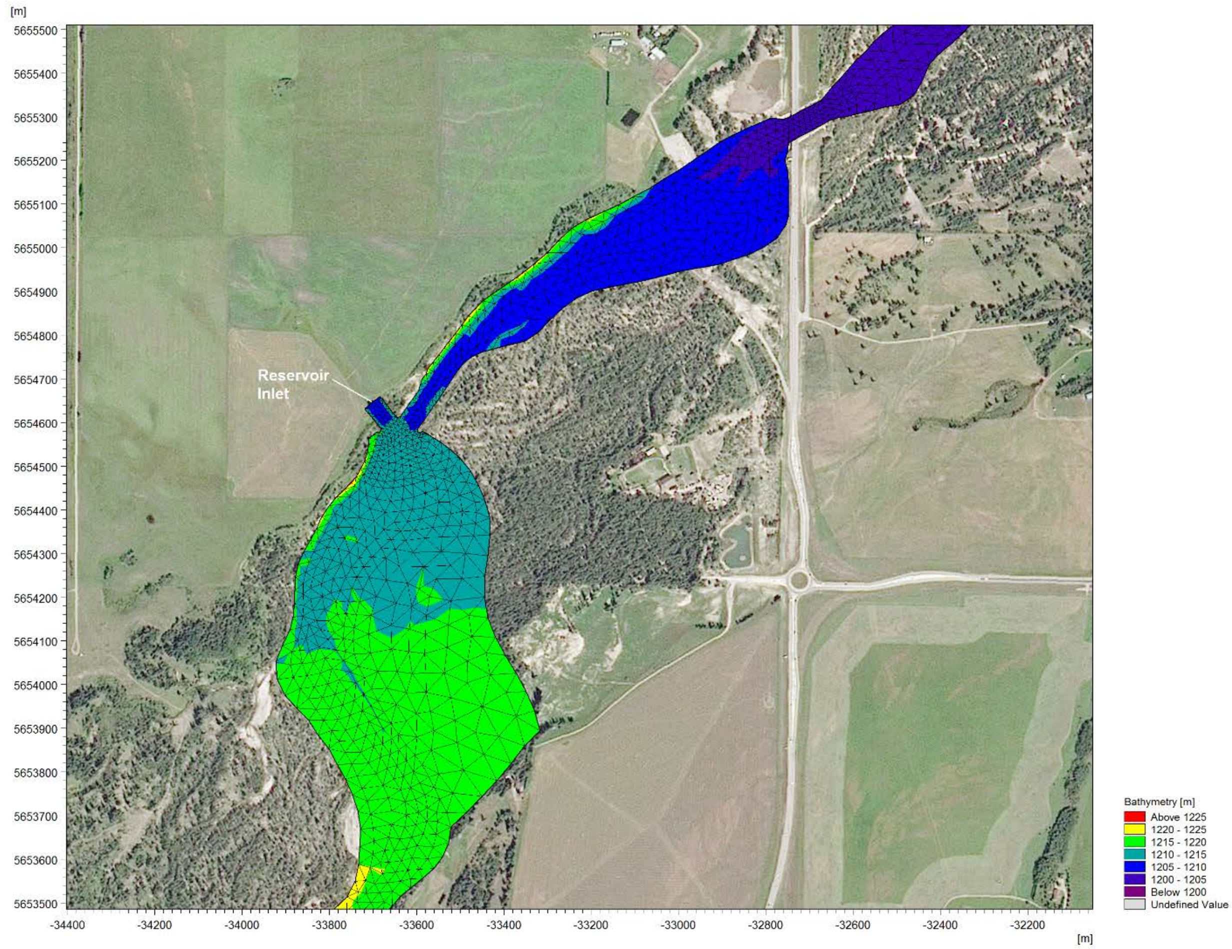


Figure IR293-2 Closeup of Modelling Domain in Elbow River Near the Diversion Inlet.

MODEL DOMAIN (II) – DIVERSION CHANNEL AND RESERVOIR

This domain contains 6,542 nodes and 11,183 triangular and quadrangular elements (Figure IR293-3) with the following boundaries:

- the upstream boundary at diversion inlet, defined by flow rates based on the inlet operation rules
- the downstream boundary at unnamed creek, defined by flow rates based on the off-stream reservoir operation rules

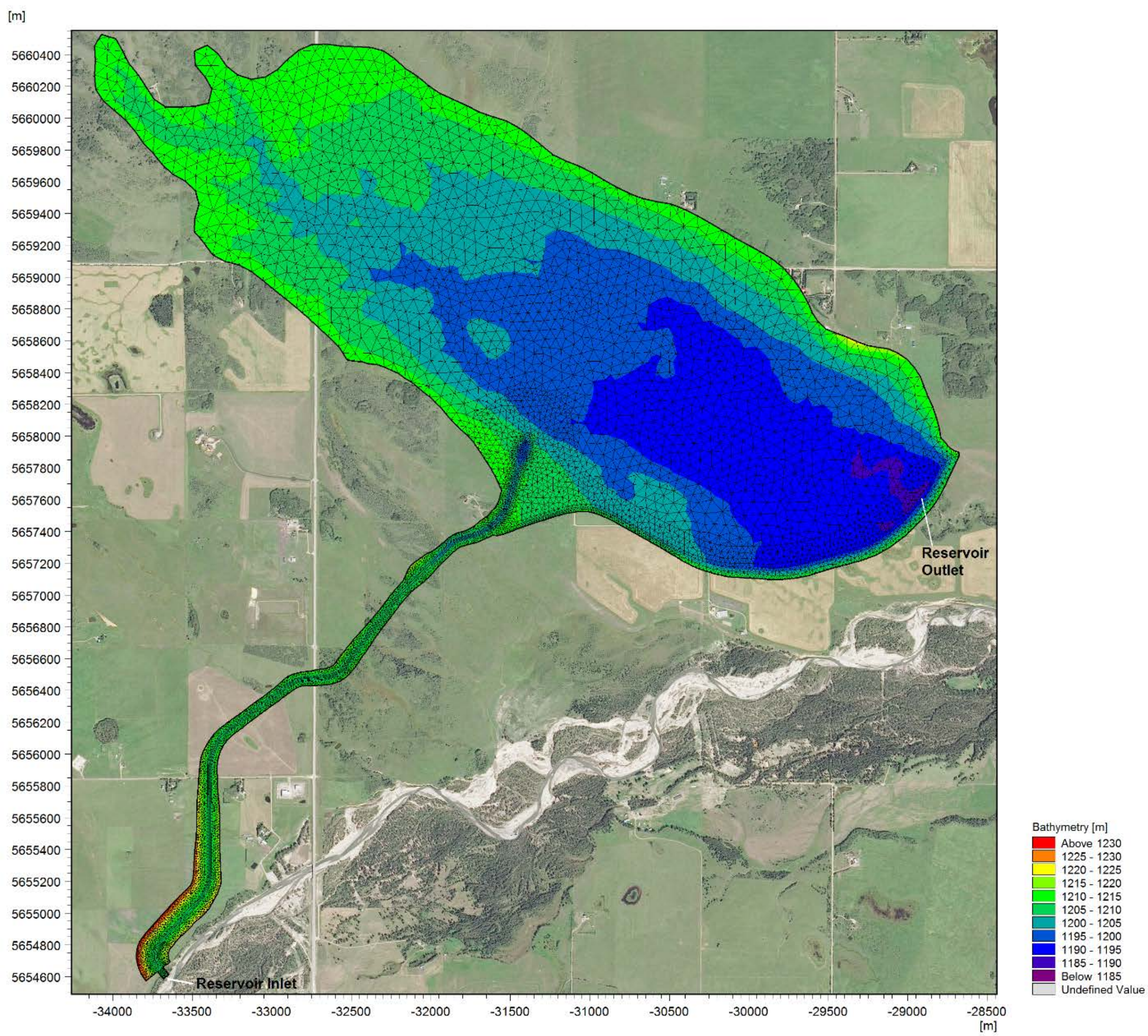


Figure IR293-3 Model Domain and Mesh System of Diversion Channel and Reservoir.

This figure shows the diversion inlet and diversion channel between Elbow River and the off-stream reservoir. The complexity of the MIKE21 model is reflected in the high concentration of grid units in the flexible mesh in the channel and southern portion of the off-stream reservoir.

Model Domain (III) – Reservoir Outlet and Unnamed Creek

This domain contains 9,858 nodes and 18,897 triangular elements (Figure IR293-4) with the following boundaries:

- the off-stream reservoir outlet boundary, defined by flow rates based on the outlet operation rules
- the upstream (U/S) boundary in Elbow River, defined by water levels extracted from the Elbow domain modelling
- the downstream (D/S) boundary in Elbow River, defined by water levels extracted from the Elbow domain modelling

The unnamed creek is a dark line in the upper center of Figure IR293-4 and reflects the high concentration of grid cells in the flexible mesh. The domain in this figure extends from the off-stream reservoir to Elbow River and the reach of the Elbow River upstream and downstream of the unnamed creek. There is a high concentration of node cells in the unnamed creek and in Elbow River immediately downstream of the confluence of the unnamed creek with the river.

b. The LAA includes the inlet to Glenmore Reservoir and the RAA includes the outlet from Glenmore Reservoir but does not extend downstream of the Glenmore Dam.

As discussed in a., the Glenmore Reservoir, up to its outlet, is included in the model in order to create a downstream model boundary. A downstream model boundary is required in order to carry out the mathematical calculations required in the hydraulic model (see Figure IR293-1). Although the model boundary included the Glenmore Reservoir, the MIKE21 modelling results were not provided because potential adverse effects of sediment released from the off-stream reservoir do not extend beyond the LAA, at the inlet of the Glenmore Reservoir.

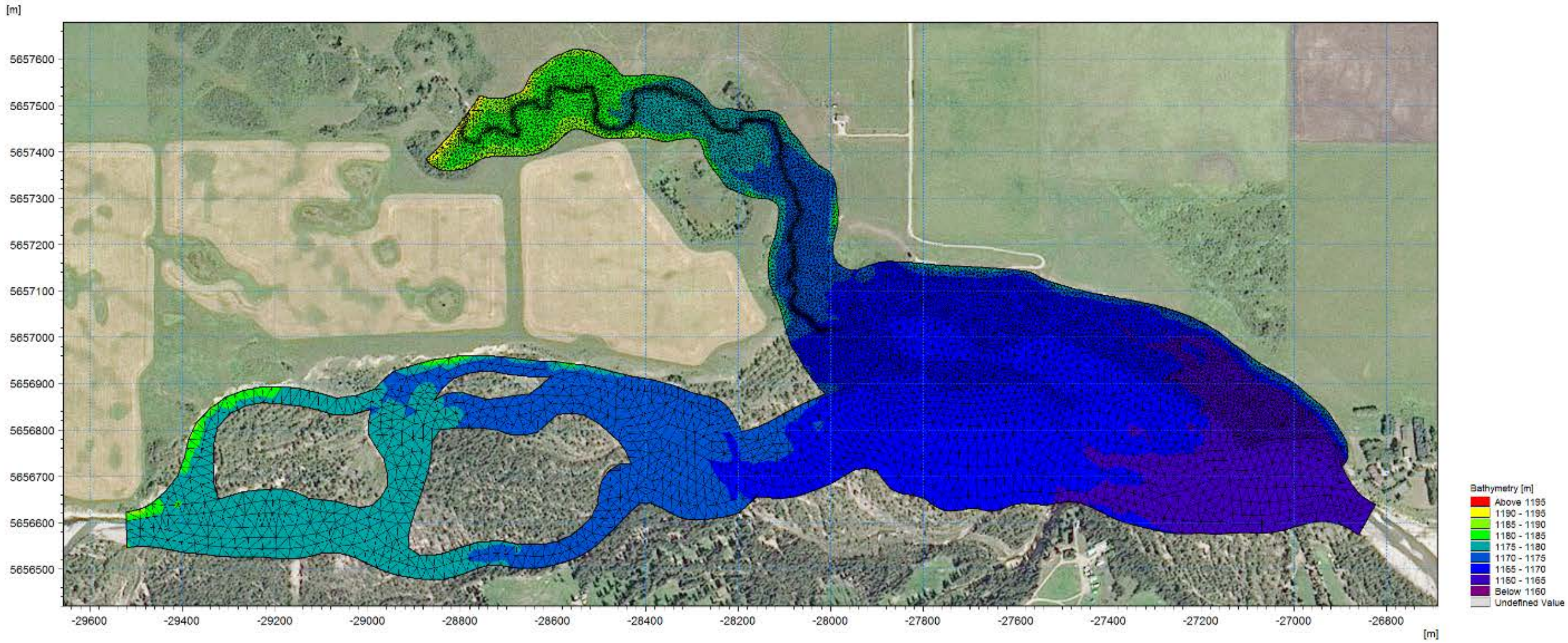


Figure IR293-4 Model Domain and Mesh System of the Unnamed Creek Channel and Elbow River

Question 294

Volume 4, Appendix J, Section 2.4.2, Page 2.32

Alberta Transportation indicated that *the HEC-HMS PMF model was also used to estimate tributary inflows between Bragg Creek and Sarcee Bridge [...]*. These tributaries will also contribute suspended sediments.

a. Indicate how the model considers the TSS contribution between Bragg Creek and the downstream boundary condition.

Response 294

a. The HEC-HMS probable maximum flood (PMF) model only predicts flow and does not consider the total suspended solids (TSS) contribution.

For an explanation of how TSS (also referred to as suspended sediment concentrations (SSC)) is modelled, refer to Volume 4, Appendix J, Section 2.2.6, Pages 2.16 to 2.18. In summary, the SSC (or TSS) in the river is a function of the flow because this determines the carrying capacity of the river. Suspended sediment yields are estimated using site-specific SSC-discharge rating curves. The TSS contributions are modelled using the rating curves generated for locations along Elbow River (Bragg Creek, Highway 22, Twin Bridges and Sarcee Bridge). TSS contributions from tributaries between Bragg Creek and the downstream boundary are accounted for in the site-specific rating curves.

Question 295

Volume 4, Appendix J, Section 2.4.2, Page 2.37
Volume 3B, Section 6.4.1, Page 6.17

Alberta Transportation identified that *the second criteria for release is based on the length of time to drain the reservoir using the engineering design full service volume of approximately 84,500 dam^3*. The criteria used seems to define the upper limits of the release rate. However, there is still operational flexibility to release at lower rates.

a. Discuss the advantages/disadvantages of different lengths of time to drain the reservoir and still be able to meet the two criteria provided (lower release rates). This will include moving the peak concentration of TSS and other related parameters later in the year and different dilution rates.

b. Provide scenarios with different operational release rates leading to different lengths of time to drain the reservoir to minimize impact to water quality.

Response 295

a. As discussed in the response to IR283 and Volume 3B (Section 6.4.1, pages 6.17 and 6.18, and Figure 6-7), the modelled release rate for the design flood is 20 m^3/s. This rate will be sufficient to empty the off-stream reservoir volume in 38 days. Extending the release time (i.e., by decreasing the release rate from the off-) allows operational flexibility to vary the release rates and, therefore, the release of suspended sediments. However, the design of outlet gates does not allow for increasing the maximum release rate out of the reservoir to above 27 m^3/s; that limit prevents the combination of Elbow River flow (20 m^3/s before water is released from the reservoir) and the flow out of the reservoir (maximum design rate being 27 m^3/s) from remobilizing Elbow River sediments (at 47m^3/s, there is a risk of remobilization).

   The hydrology assessment used the precautionary principle and considered the maximum rate of release of water from the off-stream reservoir to consider and assess the maximum effect in the river. Reducing the release rate will result in a corresponding reduction in suspended sediment load and peak concentration entering Elbow River. The loading of sediment related constituents on the river will also be similarly reduced. However, there is an ecological limit to reducing the rate of flow from the off-stream reservoir: a release time extending into October would cause an increase in sediment during the last few days of release to occur during biologically sensitive periods for resident fall spawning fish, including brown trout and mountain whitefish. A sediment pulse during October has the potential to affect staging and spawning behavior and impact fish eggs.

   On the other hand, if the release of water from the off-stream reservoir is extended into late fall, dissolved nutrients released with water from the reservoir are less likely to be available for biological assimilation. Algae and bacterial activity slows considerably at this time of year as the daily photoperiod shortens and water temperatures decrease. Therefore, dissolved nutrients will not stimulate algae and bacterial growth and changes to trophic structure in the river are not expected.

   AEP will manage the release rate in a manner that mitigates detrimental effects to resident fish populations in Elbow River. Operational flexibility provides the off-stream reservoir operator the ability to manage how water is returned to the river while controlling factors such as sediment release. The release rate will be maintained in a manner that results in the off-stream reservoir being empty prior to October to avoid biologically sensitive periods for resident populations of fish in Elbow River.

b. Four different operational release scenarios for the off-stream reservoir full service volume are provided in Figure IR295-1. As discussed in a., a decrease in the release of water through the off-stream reservoir outlet gates will extend the drawdown period.

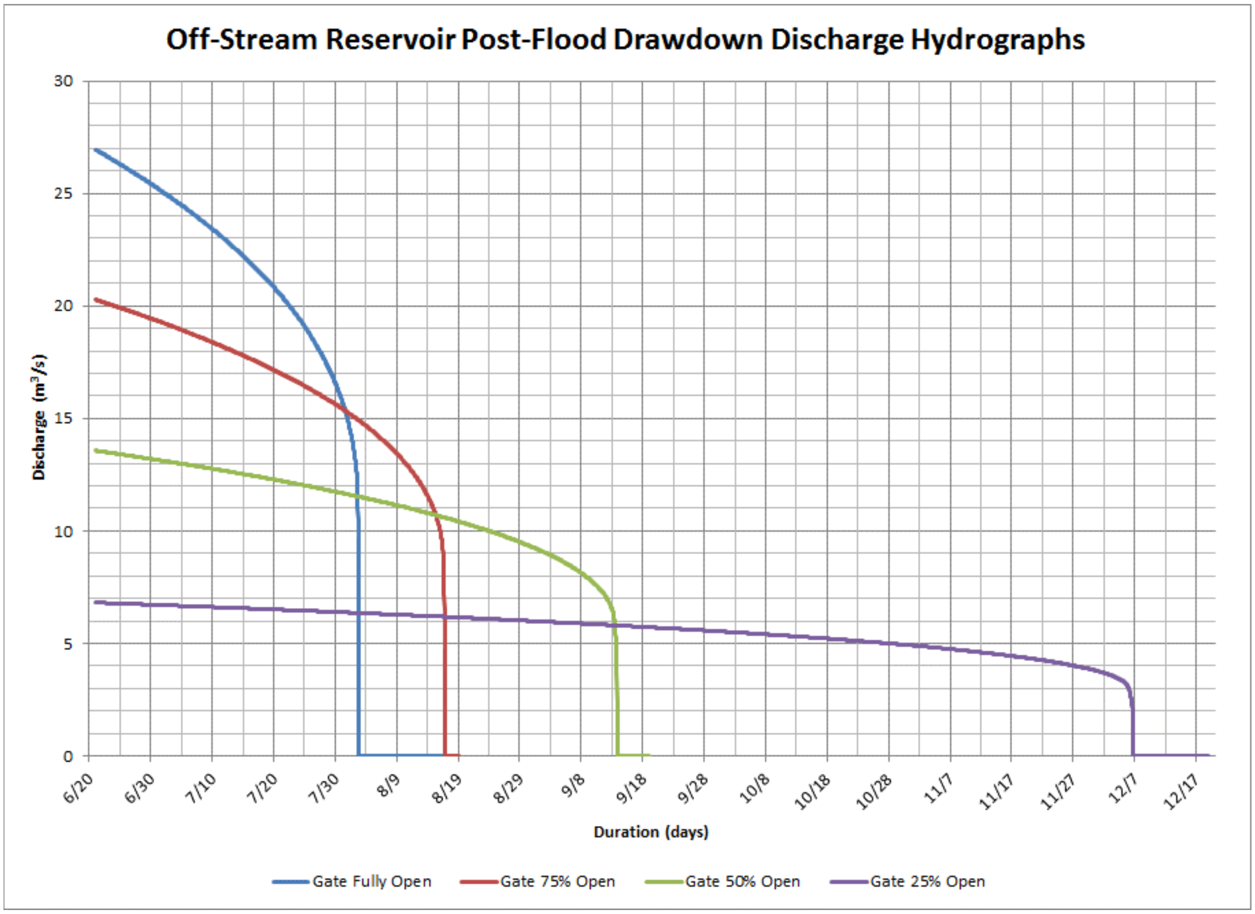


Figure IR295-1 Off-Stream Reservoir Post-Flood Drawdown Hydrographs from Full Service Volume in the Reservoir

The maximum design water release rate of 27 m³/s will empty the full-service volume from the off-stream reservoir in approximately 42 days. If the release start date is on June 20, as in Figure IR295-1, the reservoir will be empty approximately August 2. Total suspended sediment and sediment related parameters are predicted to increase in concentration over the last two weeks of reservoir drawdown. The average total suspended solids (TSS) concentration leaving the reservoir will be 2,188 mg/L with a maximum concentration of 17,961 mg/L. Downstream in Elbow River 1.0 km below the confluence with the unnamed creek, the average TSS concentration will be 754 mg/L and reach a maximum concentration of 5,666 mg/L immediately before the reservoir is empty.

When the release rate is decreased to 75% of maximum to 20 m³/s, the reservoir is predicted to empty over approximately 57 days; the reservoir will be empty by approximately August 17. Suspended sediment concentrations are predicted to increase during the last two weeks of reservoir drawdown but TSS concentrations are predicted to be lower than predicted for the maximum operational release rate because water movement out of the reservoir will be slower and shear stress lower.

When the release rate is decreased to 50% of maximum to 13.5 m^3/s, the reservoir is predicted to empty over approximately 85 days. If the release start date is on June 20, as in Figure IR295-1, the reservoir will be empty approximately September 14. Suspended sediment concentrations are predicted to increase during the last two weeks of reservoir drawdown but TSS concentrations are predicted to be lower than predicted because water movement out of the reservoir will be slower and shear stress lower.

When the release rate is decreased to 25% to 7 m^3/s, the reservoir is predicted to empty over approximately 169 days. If the release start date is on June 20, as in Figure IR295-1, the reservoir will be empty approximately December 7. Suspended sediment concentrations are predicted to increase during the last two weeks of reservoir drawdown but TSS concentrations are predicted to be lower than predicted because water movement out of the reservoir will be slower and shear stress lower.

Water quality parameters associated with TSS will increase in Elbow River in a manner similar to suspended sediments. However, sediment related parameters are bound with sediment particles and will not be available for biological assimilation (Volume 3B. Section 7.4.6, page 7.20-7.23). Only 1.8% of the sediments entering the reservoir (for a design flood) will be released from the reservoir during drawdown (Volume 3B, Section 7.4.6, page 7.23); therefore, the suspended sediment and related parameter loading on Elbow River and Glenmore Reservoir is greatly reduced compared to floods without the Project.

Managing the operational release rates to minimize effects on water quality (i.e., June 20 through December 7) must consider biological sensitive periods in Elbow River. A slower operational release rate will reduce total suspended sediments in the river; however, this may mean TSS is increased during a sensitive period when effects are greater. The period during late summer (i.e., August) is when water temperatures in Elbow River are elevated; the combined effect of sediment and elevated temperatures may affect the ability for resident fish to consume oxygen (Servizi and Martens 1990; Henley et al. 2000). The period of time between October through November is when mountain whitefish and brown trout are spawning and suspended sediments can cause harm to newly spawned eggs.

As discussed in a., AEP will manage the release rate in a manner that mitigates detrimental effects to resident fish populations in Elbow River.

REFERENCES

Henley, W.F., M.A.Patterson, R.J.Neves and A.S. Lemly. 2000. Effects of Sedimentation and Turbididty in Lotic Food Webs: A Concise Review for Natural Resource Managers. Reviews in Fisheries Science. Vol 8(2): 125-139.

Servizi, J.A. and D.W.Martens. 1990. Effects of Temperature, Season and Fish Size on Acute Lethality of Suspended Sediments to Coho Salmon (Oncorhynchus kisutch). Canadian Journal of Fisheries and Aquatic Sciences. Vol. 48: 493-497.

Question 296

<u>Volume 4, Appendix J, Section 2.4.3, Page 2.39</u>

Alberta Transportation indicates that *the models were firstly calibrated using the existing available hydrographic data from historical observation and project field measurements and then applied to project specific modelling.*

a. Provide details on the model calibration procedure including:

   i. Data used.

   ii. Qualitative and quantitative model performance results.

b. Provide a list of the main parameters calibrated and how they compare to literature values.

c. Perform a sensitivity analysis for key parameters with a wide range of possible values indicating how that can affect the model results.

d. Discuss the uncertainty of model results related to the calibration results.

Response 296

a. i. Model calibrations were conducted for three months of simulation, from May 1 to July 31, 2013. Data used for the model calibration are:

- hourly river discharge and suspended sediment concentration (SSC) measured at Water Survey Canada (WSC) station 05BJ004 (Bragg Creek; upstream boundary of the modelling.)
- daily water levels measured at WSC station 05BJ008 (at outlet of the Glenmore Reservoir which is the downstream boundary of the modelling. The downstream boundary is the location where the elevation is fixed to the existing data. Other locations are varied by the model and are compared against existing data)
- daily water levels measured at WSC station 05BJ010 (Sarcee Bridge)
- time series and point measurements of total SSC at Highway 22 Bridge
- time series and point measurements of total SSC at Twin Bridges

ii. Modelling results are compared with measurements quantitatively, as follows:

- water levels were calibrated with the measurements at WSC station 05BJ010 (Sarcee Bridge), as shown in Figure IR296-1. The simulation reproduced the magnitude of the rise and fall of the hydrograph. The measured data was only collected as a daily average and the model produces hourly average, so these points do not match exactly. The hourly peak would be expected to by higher that the daily average (as shown in the calibration Figure IR296-1), so the model can be considered well calibrated.
- total SSC were calibrated with the measurements at stations associated with Highway 22 Bridge and Twin Bridges, as shown in Figure IR296-2. The simulation reproduced the measured SSC concentrations in terms of the variation magnitudes and phases, except at the peaks. This is because
  - the measured SSC at the three stations contain data gaps for the SSC concentrations higher than approximately 500 mg/L during the peak flows
  - the upstream boundary condition of the hydrodynamic model, the SSC at Bragg Creek (top graph in Figure IR296-2), was generated from available measured data and the fitted peak SSC concentrations.

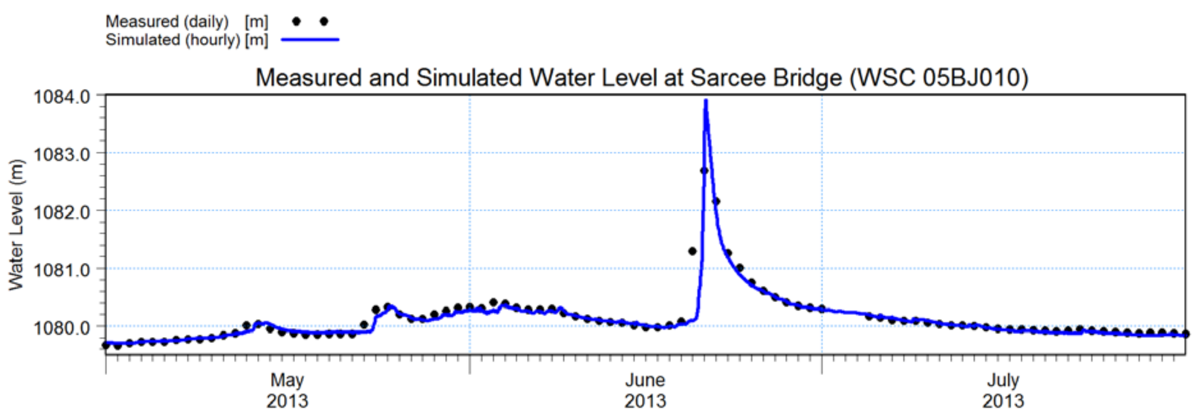


Figure IR296-1 Measured and Simulated Water Level at Sarcee Bridge (WSC 05BJ010)

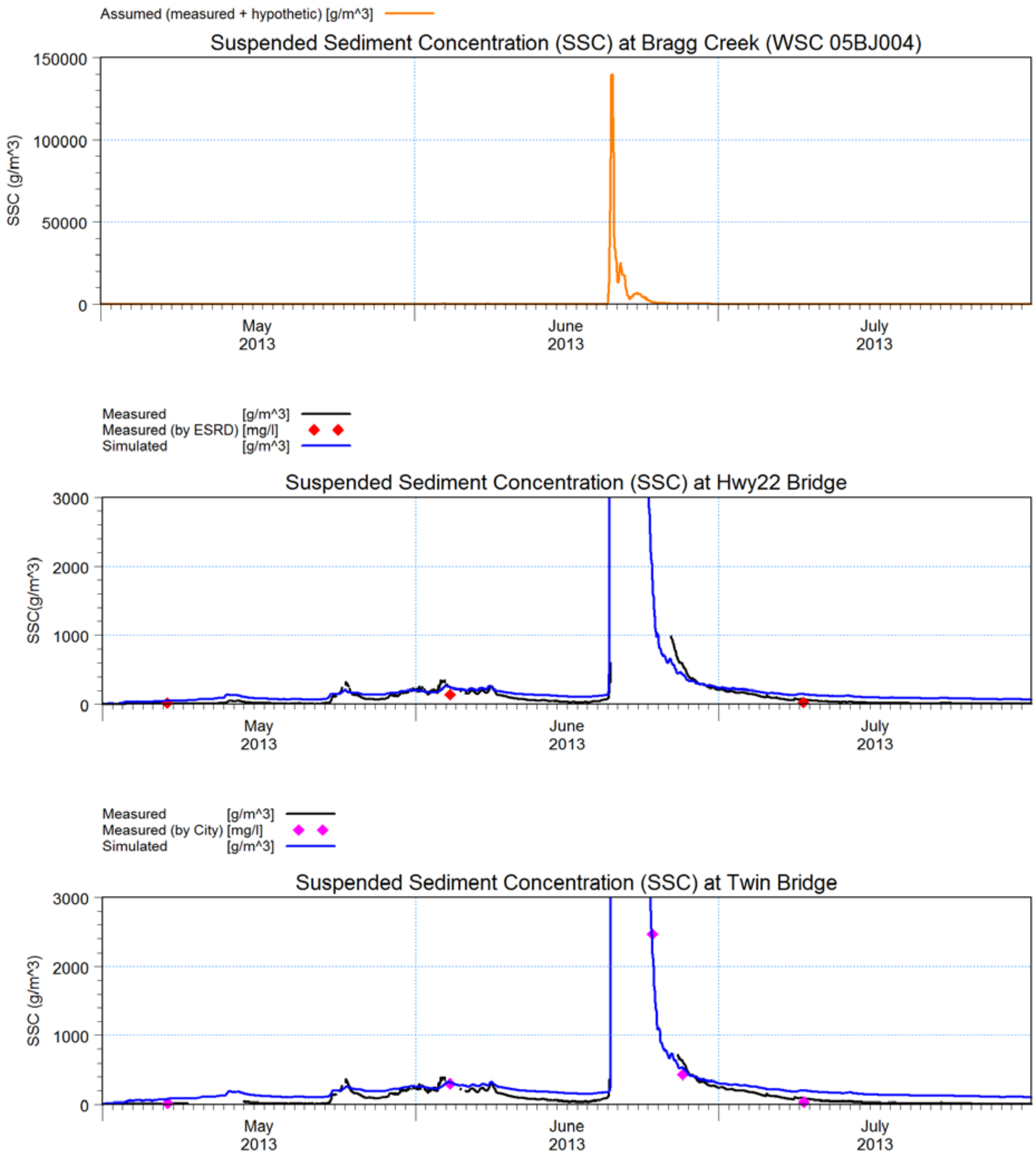


Figure IR296-2 Measured and Simulated Suspended Sediment Concentration (SSC) at Highway 22 Bridge and Twin Bridge

b-c. Model calibration used sensitivity test runs and adjusted model parameters until the modelling results achieved good agreement with the measured records. Various combinations of the key parameters were tested through the model sensitivity runs within the testing ranges of the parameters and were integrated into model results. The following key parameters were calibrated:

- simulation time step

  The choice of time step requires consideration of numerical stability, solution accuracy and computing time. A smaller time step requires less iterations at each time step but increases computing time over the whole simulation period. The time step was tested in a range from 60 to 180 seconds. This allowed model stability and accuracy to be determined over this range. A time step of 60 seconds was ultimately chosen for all model runs.

- Courant number

  The numerical stability and computing time depend not only on the number of nodes in the mesh and the simulation time step, but also the resulting Courant numbers (which need to be less than 1). Sensitivity model runs were conducted with various critical Courant numbers from 0.6 to 1.0, of which a small critical Courant number resulted in a large increase of computing time. A critical Courant number of 0.8 was adopted.

- flood and dry depths

  When the model is located in an area where wet and dry occur, an approach for treatment of the moving boundaries of flooding and drying fronts is required to ensure the numerical stability. For very small values of the tolerance depths of flooding and drying, unrealistic high flow velocities/fluxes can occur in the simulation and cause stability problems. In this study, the dry, flood and wet depths were set to 0.01, 0.05 and 0.1 m, respectively.

- eddy viscosity

  The eddy viscosity is based on a Smagorinsky formulation. A coefficient of 0.28, the default setting in the software, was used.

- bed resistance

  The bed resistance was calibrated as varied in the model domain, i.e., 40 $m^{(1/3)}$/s in river channels, 45 $m^{(1/3)}$/s in Glenmore Reservoir and 10 $m^{(1/3)}$/s at boundaries, where a smaller value gives a higher resistance.

- erosion coefficient

  Bed erosion is the transfer of sediment from the bed to the water column. Erosion takes in areas where the bed shear stress is larger than the critical shear stress for erosion. In sediment transport modelling, a smaller value of the critical shear stress can cause more bed erosion. In this study, the critical shear stress for erosion was tested in a range from 1.0 N/m^2 to 28 N/m^2, a value of 23 N/m^2 was adopted as the critical shear stress.

- deposition coefficients

  Sediment deposition is the transfer of suspended sediment from the water column to the bed. Deposition takes place where the bed shear stress is smaller than the critical shear stress for deposition. In sediment transport modelling, a smaller value of the critical shear stress can cause less sediment deposition. In this study, the critical shear stress for deposition was tested in a range from 0.01 N/m^2 to 1.0 N/m^2, the value of 0.05 N/m^2 – 0.1 N/m^2 was adopted as the critical shear stress for deposition.

The Mike 21 Model manual provides starting values and ranges of values for each parameter. The Danish Hydraulic Institute (developer of MIKE 21) searches the range of parameter values for cohesive (MT-Mud Transport Module) and non-cohesive (ST-Sand Transport Module) sediments. The parameter values are varied within that range to calibrate the model. There were no literature values available to be compared with the calibrated model.

d. The following key factors could cause the uncertainty of model results related to the calibration results:

- lack of instantaneous water level measurements (e.g. hourly records) within the modelled reaches of Elbow River
- data gaps of the measured total suspended solids (TSS) concentrations during high flows (missing data to capture the high suspended sediment concentrations [SSC] values)
- the upstream boundary condition of the hydrodynamic model, the SSC at Bragg Creek (top graph in Figure IR296-2), was generated based on the station available measured data and the estimated (fitted) peak SSC concentrations.

As stated in Volume 3B, Section 6.2.1, page 6.4

> "Although the validity of this estimate is unknown, the concentration weight and volume percentages fall within the range of sediment concentrations associated with high magnitude floods (Scott 1988; Costa 1998). These estimates assume that sediment supply in the Elbow River is not supply limited during floods. However, recognizing the uncertainties surrounding the estimates of suspended concentrations at high flows in Elbow River, the values and data generated from them likely represent near the maximum and should be interpreted as possible rather than probable."

Question 297

<u>Volume 3B, Section 2.4.3, Page 2.40</u>

Alberta Transportation's modelling results on suspended sediment indicated that *without further mitigation, the resulting increase in the Elbow River of suspended sediment concentrations is likely to exceed the Canadian Water Quality Guideline*. Interpretation of dynamic modelling results is aided by graphical and spatial representations of the concentrations compared with baseline conditions and/or against appropriate guidelines.

a. Provide graphs and maps to demonstrate the temporal and spatial extent of any water quality guideline exceedance in the Elbow River with and without mitigation measures (e.g. graph of suspended sediment concentration in the Elbow River during release against the guideline).

b. Demonstrate the effect of the project during the water release by comparing the suspended solids concentration change from Baseline conditions (no release).

c. Indicate how these results can be interpreted for other parameters that behave similarly to suspended sediment.

Response 297

BACKGROUND INFORMATION

The location in the EIA of the text in question is Volume 3B, Section 7.4.2, page 7.

a. A discussion about the temporal and spatial nature of sediment release for each flood scenario is in Volume 3B, Section 6.4.3, where sediment and flow graphs are provided for the unnamed creek channel, the confluence of the channel with Elbow River, and Elbow River 1 km downstream from the confluence (i.e., the farthest point in Elbow River downstream where suspended sediment was modelled). For the design flood, see Figure 6-11, Figure 6-14, and Figure 6-15. For the 1:100 year flood, see Figure 6-16, Figure 6-19, Figure 6-20. For the 1:10 year flood, see Figure 6-21, Figure 6-23, and Figure 6-24. Tables 6-7, 6-8 and 6-9 show the peak concentration at the confluence unnamed creek (low-level outlet channel) and in Elbow River 1.0 km downstream of the confluence.

   For the 1:10 year flood, the following statement is made:

   > "In summary, suspended sediment concentrations and suspended sediment yield are reduced by up to 5% during active diversion (compared to no diversion) with approximately 1.3 kt of suspended sediment diverted into the off-stream reservoir."

The purpose of the Project is not to reduce sedimentation and improve water quality in the Elbow River; rather, the purpose is to control hydrology in Elbow River to reduce the severity of floods. However, controlling hydrology by temporary retention of diverted flood water in the off-stream reservoir will reduce total suspended solids (TSS) in the water (when it is released back into Elbow River) to levels below the TSS concentrations when the flood water was diverted. Measures will be taken to control the rate of water release from the off-stream reservoir by using the outlet structure gates to mitigate re-suspending sediments and manage TSS levels returning to Elbow River. Managing the rate of water release from the off-stream reservoir will reduce sediment resuspension and concentrations of TSS returning to the river during release. This will also reduce concentrations of associated water quality parameters such as nutrients and metals" (Volume 3B, Section 7.4.2, page 7.22 and 7.23).

Concentrations of water quality parameters in water retained in the off-stream reservoir will be dependent on the inflow concentrations of the portion of Elbow River flood water that is diverted to the off-stream reservoir. TSS concentrations released back into Elbow River are shown to increase toward the end of the release period of water from the reservoir for each of the three floods (Volume 3B, Section 6.4.3).

b. For the release after a 1:10 year flood, the following statement is made in Volume 3B, Section 6.4.3:

> "Release of water from the off-stream reservoir would result in a minor and transient increase in suspended sediment concentrations in the low-level outlet and Elbow River (Table 6-9 and Figure 6-24). No substantial effect on discharge in the Elbow River would occur (Figure 6-24). Peak concentrations modelled at the confluence of the low-level outlet with Elbow River are approximately 1,800 g/m^3 but decline to 99 g/m^3 once in the Elbow River approximately 1.0 km downstream Table 6-9). Historical data suggests that monthly suspended sediment concentrations in August, without 2013 data, average 16 g/m^3 with a maximum of approximately 50 g/m^3, at Highway 22 (Figure 6-1). Release of water from a 1:10 year flood would have a negligible effect on suspended sediment concentrations in Elbow River."

Section 6.4.3 describes the suspended sediment concentrations in water released from the off-stream reservoir for the 1:100 year flood and design flood. Suspended sediment concentrations in Elbow River will be above guidelines and above background conditions near the end of the release period. Without the Project in place, the peak spring TSS in the river will be higher than with the Project in place. The Project reduces the peak and total load of suspended sediment in Elbow River.

After the flood has passed, the off-stream reservoir will release suspended sediment at concentrations higher than summer background concentrations (16 mg/L to 50 mg/L) and higher than guidelines (i.e., guideline of 25 mg/L above background TSS levels). However, these concentrations are much lower than peaks occurring during floods without the Project in place (4,800 mg/L to 139,000 mg/L).

c. The description of effects from parameters that behave similarly to suspended sediment is discussed in Volume 3B Section 7.4.2 on pages 7.22 to 7.23 as follows:

- Parameters that behave similar to TSS are expected to increase in concentration in a manner similar to TSS during the end of the retention and release period.
- Metals and nutrients behaving similar to suspended sediments will not be readily available for biological uptake and will deposit downstream.
- The off-stream reservoir is not expected to affect dissolved constituents; these parameters are expected to be released from the off-stream reservoir at concentrations similar to that in water diverted into the reservoir during the flood.
- Potential changes in water quality (i.e., concentrations and loads) associated with increases in TSS at the end of the period of water release from the reservoir are expected to be small compared to what would be expected during a flood in the absence of the Project.

Question 298

Volume 3B, Section 7.4.2, Page 7.21

Alberta Transportation states that *there are no analogous measurements or surrogate parameters in the area of the Project for evaluating the effects of short term water retention in a relatively low organic carbon environment […]. Therefore, there are no available parameters to calibrate and validate a model.* The DO and water temperature was assessed using only qualitative methods. Although the calibration of a hydrodynamic model for the off-stream reservoir may be limited by the available data, there are analytical methods to calculate DO and water temperature that can provide a better characterization of any potential water quality issues in the reservoir and in the Elbow River after mixing. The time that the reservoir will have water is in the order of 1-3 months during the summer when critical DO and water temperature conditions are observed.
Additionally, the water diverted during the floods will most likely have high content of BOD/TOC.

a. Estimate the DO and water temperature in the reservoir and in the Elbow River at the point where the release is completely mixed sing quantitative methods and conservative assumptions.

Response 298

a. Water released from the off-stream reservoir will be aerated as it passes through energy dissipater blocks in the outlet structure and as it flows through the unnamed creek (also referred to as the low-level outlet channel), before it enters Elbow River.

   Water temperatures in Elbow River are expected to increase through the summer months in a manner similar to water temperatures in the reservoir. Therefore, the effects of low dissolved oxygen and increased temperature in the water released to Elbow River are predicted to be of low magnitude, temporary, and localized to the area where the unnamed creek meets Elbow River (Volume 3B, Section 7.4.3, page 7.24).

   As stated in the response to IR310:

   > "Due to low biochemical oxygen demand (BOD), low sediment oxygen demand (SOD) and the influence of wind mixing and shallow water levels, oxygen concentrations in the off-stream reservoir are not predicted to become anoxic; changes in dissolved oxygen are expected to be smaller than currently observed in Glenmore Reservoir.
   >
   > "If low oxygen conditions in the off-stream reservoir occur prior to discharge, these levels will be attenuated as water is released to the low-level outlet channel, which has a gradient of greater than 0.8% over the lower 2 km before the confluence with the Elbow River (Volume 4, Appendix J, Section 3.3, Page 3.5). Turbulence generated through this section of the channel will aerate water before it enters the river.
   >
   > "Median summer dissolved oxygen concentrations in Elbow River were just above and below aquatic life guideline levels (9.5 mg/L CCME 2018) at Highway 22 and Twin Bridges, respectively. Effects in Elbow River from low oxygen are predicted to be localized and temporary because of rapid aeration of water in the river."

   Therefore, dissolved oxygen concentrations in the river downstream of the unnamed creek are predicted to be similar to concentrations in the river upstream of the unnamed creek.

   As discussed in Volume 3B, Section 7.4.3, page 7.24 and 7.25, water temperature in the reservoir can increase if the air temperature is sufficiently warm. However, the water temperatures in Elbow River are expected to similarly rise during the summer months. Thus, any changes in river water temperatures originating from mixing with reservoir water would be temporary and localized due to rapid mixing.

   Because changes to dissolved oxygen in the off-stream reservoir will be ameliorated and temperature in the reservoir and Elbow River will similarly be affected by seasonal conditions, effects on water quality are not predicted.

REFERENCES

CCME (Canadian Council of Ministers of the Environment). 2018. Canadian Environmental Quality Guidelines website. Accessed September 2018 at http://ceqg-rcqe.ccme.ca/en/index.html

Question 299

<u>Volume 3B, Section 7.4.3, Page 7.24</u>

Alberta Transportation identified that *wind mixing in the relatively shallow reservoir is anticipated to replenish dissolved oxygen*.

a. Describe how the thermal and wind mixing effects were considered in the hydrodynamic model for suspended sediment settling and resuspension.

Response 299

a. The hydrodynamic model used in the assessment does not consider thermal and wind mixing effects on suspended sediment settling and resuspension. Thermal and wind mixing will affect the suspended sediment settling and resuspension; however, the short duration of water retention in the off-stream reservoir suggests that it is not likely to have a substantial effect on water quality in Elbow River upon release.

   Water quality modelling, as presented in Volume 3B, Section 7, Section 7.4.2, predicts a short duration increase in suspended sediment concentrations during the last few days of the water release out of the reservoir. This increase can be controlled with the outlet structure gate operation (i.e., reducing flow rate) and, possibly, also with turbidity curtains in the reservoir. The results of modelling of the thermal and wind mixing effects on the suspended sediment settling and resuspension would not alter the conclusion of the effects of the Project on surface water quality or other valued components.

Question 300

Volume 3B, Section 7.4.2, Page 7.23

Alberta Transportation states that *For the design flood, 1.8% of suspended sediment load and associated matter in the retained water exists the reservoir, with 98.2% remaining at the bottom of the reservoir after it is drained. For the 1:100 year flood, 11.7% of suspended sediment exits the reservoir*. Significant amounts of sediment could potentially stay at the bottom of the reservoir after a flood and after partial clean-up.

a. Describe the modeling assumptions related to the initial sediment in the reservoir.

b. Discuss the effects of different initial conditions of sediment accumulated at the bottom of the reservoir on the water quality estimations. Assess this effect using the Mike 21 hydrodynamic model calibrated for this Project.

Response 300

a. Sediment remaining in the off-stream reservoir after each flood is as follows in Table IR300-1 (Volume 3B, Section 6, Table 6-6; Volume 3B, Section 7.4.2, page 7.23):

Table IR300-1 Suspended Sediment Mass, and Percent Diverted and Released from the Off-Stream Reservoir (from Table 6-6 in Volume 3B, Section 6)

Flood	Diversion time (days)	Suspended sediment mass diverted into the reservoir (kt)	Suspended sediment mass released out of the reservoir (kt)	Percent suspended sediment remaining in the reservoir (%)	Percent suspended sediment released out of the reservoir (%)	Loss of retention volume in the reservoir due to remaining sediment (%)
Design Flood	3.75	2,389	90	98.2	1.8	1.1
1:100 year flood	1.80	1,268	220	88.3	11.7	0.5
1:10 year flood	0.38	1.3	1.1	95.4	4.6	0.0
NOTE: kt - kilotonne						

The modelling assumes heavier particle-sized sediments (e.g., sand and heavier silts) will deposit in the off-stream reservoir and finer particles (e.g., clay) will remain in suspension and exit the off-stream reservoir during release of water. Vegetation will re-establish and sediments will consolidate and thus create a stable land surface.

There was no sediment sampling in the off-stream reservoir available to define the initial sediment properties in the reservoir. The suspended sediment discussed here are diverted from Elbow River through the diversion inlet. For each of the three floods, the model simulates sediment transport from the existing natural bed conditions assuming no change in off-stream reservoir functionality (see the response to b.) from sediment deposited due to previous floods.

b. The mass of sediment diverted from Elbow River that accumulates in the off-stream reservoir during a design flood is estimated to be 1.1%. The volume of sediment remaining after a 1:100 year flood is estimated to be 0.5% and after 1:10 year flood, is estimated to be much less (see Table 6.-6, Volume 3B, Section 6.4.3.1, page 6.28 and discussion on 6.26 and 2.27). Post-flood maintenance in the off-stream reservoir will include moving of sediment within the reservoir so that water flow into and out of the reservoir is maintained and the dam integrity is maintained.

Because accumulated sediments are predicted to have such small volumes, and mitigation to facilitate water movement in the off-stream reservoir will be implemented, initial conditions will essentially remain the same for each new flood. As a result, water quality estimates are expected to be the same and additional modelling has not been undertaken.

Question 301

Volume 1, Section 3.6.1, Table 3-10, Page 3.37

Alberta Transportation indicates the plans for sediment removal as *Off-stream reservoir - partial removal of sediment so that water flow is not blocked Low level outlet works - removal of debris and sediment from the outlet components to the degree required to maintain optimal functionality*.

a. If sediment is to stay in the reservoir, how would that change the modeling results for future flooding (i.e. change in initial conditions)?

Response 301

a. See the response to IR300b and, Table IR300-1 for the suspended sediments and settled sediments in the off-stream reservoir for each of the three floods.

Question 302

<u>Volume 3C, Section 2.6.3, Page 2.7</u>
<u>Volume 3C, Section 2.5.3, Page 2.5</u>
<u>Volume 3B, Section 7.4.2, Page 7.20</u>
<u>Volume 4C, Table C-2, Page C.28 to C.39</u>

Alberta Transportation states *Following a flood that results in the diversion of water to the reservoir and prior to discharge from the reservoir, water samples will be collected at the low- level outlet channel*. Alberta Transportation also states *Suspended sediment concentration is predicted to increase during the last few days of discharge*. In addition, surface water sampling is planned as: *Suspended sediment levels will be monitored following a flood. This will include suspended sediment levels in the Elbow River following the flood but prior to release of water from the reservoir and then following release of the water.*

a. **Provide details as to what would be a representative sampling program prior to, and during, the release of a flood event from the reservoir; depending on the duration of discharge and the stated fact that sediment loading would increase near the end of discharge.**

b. **Provide information on how a reservoir inflow water quality monitoring program would be beneficial for assessing contaminant and sediment loading to the reservoir.**

c. **Provide details on the means for the safe collection of samples under normal and adverse weather conditions at the diversion channel, in the reservoir and at the outfall of the reservoir.**

d. **Provide details on impact assessment and any proposed mitigation for the potentially prolonged release of turbid water to downstream small utility drinking water intakes such as the Westridge municipal water intake, Calaway Park water intake etc. as this may pose a burden on water treatment processes.**

Response 302

a. The surface water monitoring plan outlines the water quality monitoring component of the program (see Appendix IR302-1).

b. Because water will mix inside the off-stream reservoir, water quality results from the intake water will have limited value and are not included in the water quality monitoring program. The water quality monitoring program will include water sample collection from within the off-stream reservoir and will be representative of contaminant and total suspended solids (TSS) levels in the reservoir and water quality when it is being released. The surface water monitoring plan outlines the water quality monitoring component of the program and includes a list of relevant analytical parameters.

c. Water quality samples will not be collected in adverse conditions during a flood because water quality is not a factor in determining when to initiate the diversion of Elbow River flood flows and the filling of the off-stream reservoir. Elbow River flow and public safety will dictate when, and how, the diversion intake operates. The diversion intake will be engaged when Elbow River flow reaches 160 m^3/s and will remain engaged until either a) river flow returns below 160 m^3/s or b) the off-stream reservoir has reached its full service volume.

After Elbow River flows have declined to the point where the diversion inlet is closed and water release from the reservoir begins, the post-flood component of the surface water sampling program will be initiated.

Where unforeseen environmental conditions present safety concerns for monitoring personnel, mitigation measures will be put in place to collect samples in a safe manner. Where mitigation cannot be effectively applied, sampling will be suspended until conditions are suitable to resume monitoring. Components for a water sample collection safety program are discussed below.

PLANNING AND PREPARATION

Monitoring staff will have equipment prepared and a plan in place prior to flood conditions and when water quality sampling would be required. Operations personnel will notify monitoring staff as flood conditions approach so they can be on standby to begin sampling as needed. At minimum, two monitoring staff will be involved in sample collection. These preparations will reduce confusion and the need for a hasty response that may lead to distraction and inattention to unsafe conditions.

SAFETY PLAN, HAZARD ASSESSMENT AND IDENTIFICATION

A site safety plan with actions regarding emergency response will be in place in the event a staff member requires safety assistance. Prior to any sampling event, whether under normal or adverse environmental conditions, an assessment will be done to ensure all safety concerns are identified and unsafe conditions are addressed.

COMMUNICATION

A communication plan will be in place for monitoring staff to communicate with each other and the off-stream reservoir operations personal. Monitoring staff will communicate and be aware of each other at all times when working in and around water. Staff will communicate with operations personnel and any safety back-up person noted on the emergency response plan as required using cell phones.

Training

Monitoring staff will have site safety training and safety training for working in and around water under normal and adverse conditions (e.g., swift water training). Staff will be trained in relevant equipment use, including, for example, water samplers; water quality sample collection methods including specific methods for methylmercury samples; sample filtering and preserving; sample handling and chain of custody; and the use of boats.

Personal Protective Equipment

PPE will be used as appropriate for the conditions. This will include, personal floatation device, waders, rain jackets, eye-wear (polarized as needed), and neoprene gloves for preservative handling.

Equipment

Equipment will be maintained and in proper working condition prior to being employed during monitoring events. This equipment will include water quality samplers, water quality multi meters for insitu measurements, boat and motor with anchor, and safety throw bag.

Water samples will be collected in a safe manner as follows:

i) In the diversion channel, water samples will not be collected, as indicated in b.

ii) In the off-stream reservoir, water samples will be collected from a boat using a depth sampler (e.g., Kemmerer or similar) from about mid depth. The boat will be transported by truck and deployed to the reservoir from a location that can be safely reached by truck. Monitoring staff will maintain a safe distance from the reservoir outlet when using the boat. The boat will have an anchor and paddles in the event the motor malfunctions.

iii) In the outlet structure and unnamed creek.

d. Total suspended sediment (TSS) concentrations in Elbow River one km downstream of the unnamed creek will be approximately as follows:

- 1:10 year flood, 81 mg/L (average) and 100 mg/L (peak)
- 1:100 year flood, 1,5704 mg/L (average) and 4,704 mg/L (peak)
- design flood, 754 mg/L (average) and 5,666 mg/L (peak)

These TSS concentrations are similar to the range of TSS concentrations that historically occur in Elbow River; any water treatment plant that is designed to take water from the river will be able to handle these levels of TSS.

Question 303

<u>Volume 4, Appendix A, Concordance Tables, Terms of Reference Section 3.5.2 [E], Page A. 26</u>

In the Terms of Reference for this project, it states *describe the potential and implications for Cyanobacteria/Microcystin in the reservoir to: impact treatment of water from Glenmore Reservoir for drinking water purposes; and to impact recreation of the Springbank Off-Stream Reservoir, Elbow River and Glenmore Reservoir.* The Concordance Table indicates the information is provided in Volume 3B, Sections 7.4.2 and 7.4.4 but the information is not there.

a. Describe the potential for Cyanobacteria blooms to occur within reservoir storage times of over 40 days.

b. If blooms were to occur, describe how this may impact water treatment of water at the Glenmore Reservoir and any other water treatment plants (plants such as Glencoe, Westridge and Calaway) downstream of the Springbank Reservoir outlet and upstream of the Glenmore Reservoir.

c. Describe any recreation impacts in the same reach of the Elbow River.

d. Describe any mitigation measures.

Response 303

a. Cyanobacteria comprise a diverse group of microorganisms with functional traits allowing them to inhabit many habitats. A number of freshwater, planktonic groups are known to affect drinking water and recreational resources. Several environmental factors are involved in the development of these communities in aquatic habitats, including water quality, temperature variation, light attenuation, nutrient levels and nutrient ratios (nitrogen, phosphorus and carbon), water mixing, turbidity levels, and water residence time (Mantzoui et al. 2016; Stroom and Kardinaal 2016; Komarek 2003; Gkelis et al. 2017). The potential for cyanobacteria to bloom in the off-stream reservoir within 84 days (for the 1:100 year flood) is low and the reasons are discussed below.

1. Nutrient availability and eutrophication are the most important factors leading to nuisance cyanobacterial blooms; nitrogen, phosphorus and carbon are needed to varying degrees for growth.

   Several functional groups are known nitrogen fixers and, therefore, can sequester N_2 (nitrogen as gas or dissolved phase in the water column) for their nitrogen needs. However, phosphorus may not be as readily available for uptake and, thus, becomes the limiting factor for continued growth. In some cases, cyanobacteria can be controlled by regulating phosphorus entering a waterbody.

Carbon is used by cyanobacteria in photosynthesis to produce sugar. Atmospheric carbon dioxide will diffuse into the water column from the surface; if it is depleted, it can also be a limiting factor for growth. Volume 3B, Section 7.4.2, page 7.23 predicts that nutrients will settle with suspended sediments in the off-stream reservoir and will have no effect on dissolved nutrients. Nutrients will generally be unavailable for phytoplankton growth; this includes cyanobacteria growth.

The responses to IR83b, IR88a and IR90a discuss nutrients and trophic status in Elbow River. In summary of those IRs, based on median total phosphorus concentrations from samples collected in Elbow River at Bragg Creek, Highway 22 and Twin Bridges, water quality in Elbow River is considered oligotrophic (i.e., total phosphorus less than 10 µg/L; IR308a, Figure IR308-6). Cyanobacterial blooms are associated with total phosphorus concentrations between 20 µg/L and 30 µg/L when other favorable conditions are present (e.g., stratification, water temperature, available carbon); thus, the risk for cyanobacteria to bloom is low.

2. Water quality in the Elbow River upstream of Calgary is considered largely oligotrophic and occasionally mesotrophic; nutrient levels tend to be low. The median total phosphorus levels in the spring and summer at Bragg Creek and Highway 22 generally ranged between 0.002 and 0.003 mg/L. However, the June median level was 0.0055 mg/L (as demonstrated in the response to IR308). The median total nitrogen levels were between 0.1 mg/L and 0.3 mg/L. Guideline exceedances at these two locations for total phosphorus and total nitrogen between from 2010 to 2014 occurred in less than 3% of samples collected and reported by the City of Calgary (2012). These concentrations are below guideline levels and not at levels that will result in trophic changes in the off-stream reservoir or support blooms of nuisance cyanobacteria.

3. Nutrients entering the off-stream reservoir will largely be particle bound and associated with suspended sediments. These concentrations will settle out and be unavailable for biological uptake. Because of the shallow nature of the off-stream reservoir and wind turbulence, water is predicted to remain well oxygenated. Thus, nutrients will stay in particulate form rather than dissolved and diffuse into the water column and become available for biological uptake.

4. Cyanobacteria must compete with algae for resources in aquatic habitats including nutrients and light. In the unlikely event conditions changed and cyanobacteria were to bloom (as suggested in the IR question) pioneer algae species will take advantage of available resources preventing cyanobacteria from establishing at nuisance levels. Algae typically use resources quickly and out compete slower cyanobacteria in the short term. Nutrients, particularly phosphorus, will be taken up by algae leaving cyanobacteria colonies with too few resources.

5. Waterbodies may be subject to the development of nuisance cyanobacteria colonies because of environmental conditions that developed in previous seasons. This includes favorable overwintering or resting conditions in benthic sediments that support recruitment of cyanobacterial colonies. Because of the short term and temporary nature of operating the off-stream reservoir, there will not be any overwintering or resting habitat or populations in the off-stream reservoir. Therefore, a nuisance bloom will not occur.

6. Cyanobacteria have sets of functional traits allowing them to respond to multiple environmental conditions happening simultaneously. This allows them to be competitive and successful in stable habitats.

   For instance, under stratified water conditions such as in a deep lake, vertical mixing is limited: cyanobacteria have gas vesicles allowing them to regulate their position in the water column. This allows them to rise and take advantage of higher light levels required for photosynthesis and dissolved carbon dioxide concentrations. During periods of heavy growth, blooms can attenuate available light, thus limiting the growth of planktonic algae at lower levels. Conversely, in shallow reservoirs and waterbodies such as the off-stream reservoir, environmental conditions tend to be less stable. Wind turbulence will cause mixing through the off-stream reservoir that prevents cyanobacteria from taking advantage of a position in the upper water column. Thus, cyanobacteria will not be able to effectively use their functional traits to outcompete algae.

b. If cyanobacteria were to colonize the off-stream reservoir, it is expected that they would only be in small, localized areas and not in an abundance (see response a). Many cyanobacteral blooms do not result in microcystin because 30-50 percent are non-toxic. Thus, if microcystin is detected, it is predicted to be at low concentrations and dilute throughout the off-stream reservoir. Therefore, it would be released in low concentrations to Elbow River. This will affect water treatment plants in that they will have to increase their monitoring capacity to detect low microcystin levels during release of water back into Elbow River and adjust their treatment options accordingly. Large municipal water treatment facilities like the Glenmore Reservoir water treatment plant can use an oxidation treatment with chlorine, activated carbon, or ozone. Small water intake operators without treatment may choose to temporarily use an alternative water source until microcystin levels return to normal, instead of treating water

c. Conditions predicted in the off-stream reservoir will not be conducive for cyanobacteria to colonize and produce microcystin and, therefore, is not expected to affect downstream recreational users when retained water is released back into Elbow River.

d. There are no practical mitigation measures available to reduce the predicted low cyanobacteria levels predicted in the off-stream reservoir. Considering current low nutrient levels in Elbow River, the most effective approach to control cyanobacteria and potential microcystin in the off-stream reservoir is through source-water protection and watershed management. This to limit nutrient inputs into Elbow River during a flood (Government of Canada 2018). Source water protection is under provincial jurisdiction; therefore, any mitigations applied to source water protection must include the provincial involvement.

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Question 304

Volume 3B, Section 6.7.2, page 6.76
EIS Summary, Section 6.6.2.2, Page 6.32

Alberta Transportation indicated that *Release of water from the reservoir through the low-level outlet will temporarily increase localized suspended sediment concentrations and yields in the Elbow River*. During flood conditions, river velocity is high and the sediment is flushed downstream. However, the storage time in the Springbank reservoir from start of the flood to end of release can be over two months. Conditions in the Elbow River, post flood would be lower flows, clearer water, and warmer water. The timing of release from the reservoir may potentially coincide with critical conditions for instream dissolved oxygen DO.

a. **Explain whether extra Total Phosphorus (TP) loading under these conditions would result in negative effects within the receiving environment (Elbow River and Glenmore Reservoir) (see: end of discharge from early to late August, Fig 7-10 to 7-12).**

b. **Provide the timing (potential range of dates), duration, and magnitude of suspended sediment and related parameters increase for the three flood cases studied and discuss any variations (early flood or back to back flood) that can influence the effects of the temporary increase in suspended sediment and related parameters.**

c. **Discuss the implications of changing the timing and duration of the release of flood related contaminants (TSS, nutrients, salts, and increase in water temperature)**

Response 304

a. Based on the discussion in Volume 3B, Section 7.4.2, the off-stream reservoir will be a "nutrient sink" (i.e., where nutrients accumulate and are temporarily unavailable for biological uptake). Nutrients, including total phosphorus, are expected to be retained in the off-stream reservoir sediments after water is returned to Elbow River, similar to the behaviour of suspended sediments during release of water back into the river.

   Total phosphorus associated with the sediment and the vegetation in the off-stream reservoir will be an organic form that is not readily available for uptake by algae or macrophytes. Organic carbon and biological respiration in the off-stream reservoir are predicted to be low (Volume 3B, Section 7.4.3). Monitoring of Elbow River and Glenmore Reservoir does not indicate low dissolved oxygen at the concentrations considered anoxic (1-2 mg/L (Nürnberg 2002)). Dissolved oxygen concentrations are predicted to be sufficiently high in the off-stream reservoir that would prevent a chemical release of phosphorus from sediments. As stated in the response to IR90, Elbow River and Glenmore Reservoir are generally considered oligotrophic and, thus, additional total phosphorus loading is anticipated to be effectively assimilated without changing the trophic structure of either water body.

As discussed above, the off-stream reservoir will be a sink for nutrients, thereby permanently removing total phosphorus equivalent to that bound in sediments that is diverted to the reservoir. When the Project is active for flood mitigation, it will have generally positive effects (compared to conditions without the Project) on reducing nutrient loads from a flood and will have no effect on the trophic status of the system.

b. The timing (range of dates), duration, and magnitude of suspended sediment for the three floods is shown in Table IR304-1 (a duplicate of Volume 3B, Section 6, Table 6-6). The 1:100 year and 1:10 year flood showed earlier flood peaks than the design flood based on the 2013 hydrograph (Figure IR304-1, Figure IR304-2 and Figure IR304-3):

- 1:10 year flood on May 25
- 1:100 year flood on June 2
- design flood on June 20

The flood timing and the duration for retention and release from the off-stream reservoir cover the range of expected natural conditions and, therefore, are used to assess the potential effects of the Project. Regardless of timing (such as an early flood event), predictions for suspended sediment concentrations remain the same for these three floods. As such, predictions for sediment related parameters also remain the same.

Table IR304-1 Estimated Suspended Sediment Concentrations and Yields in the Elbow River, With and Without Diversion (from Volume 3B, Section 6, Table 6-6)

Flood	Elbow River Peak Suspended Sediment Conc. Non-Diversion (g/m³)	Diversion Channel Average Suspended Sediment Conc. (g/m³)	Diversion Channel Peak Suspended Sediment Conc. (g/m³)	Diversion Time (days)	Elbow River Suspended Sediment Mass Non-Diversion (kt)	Diversion Suspended Sediment Mass (kt)	Elbow River Suspended Sediment Mass Reduction (%)	Suspended Sediment Mass Released into the Low-level Outlet (kt)	Loss of Retention Volume Due to Sediment Remaining In Reservoir[4] (%)
Design[1]	139,682	18,709	89,166	3.75	4,819	2,389	50	90	1.1
1:100 Year[2]	77,649	19,228	74,715	1.80	1,943	1,268	65	220	0.5
1:10 Year[3]	4,818	1,258	2,064	0.38	24	1.3	5	1.1	0.0

NOTES:

[1] Period of diversion: 06/20/2013 04:00 h to 06/23/2013 22:00 h; Residence time: 06/24/2013 to 07/14/2013

[2] Period of diversion: 05/31/2100 05:00 h to 06/02/2100 02:00 h: Residence time: 06/02/2100 to 07/15/2100

[3] Period of diversion: 05/24/2008 15:00 h to 05/24/2008 23:00 h; Residence time: 05/25/2008 to 07/07/2008

[4] Based on full service volume of 77,771 dam³ and assuming a sediment density of 2,650 kg/m³

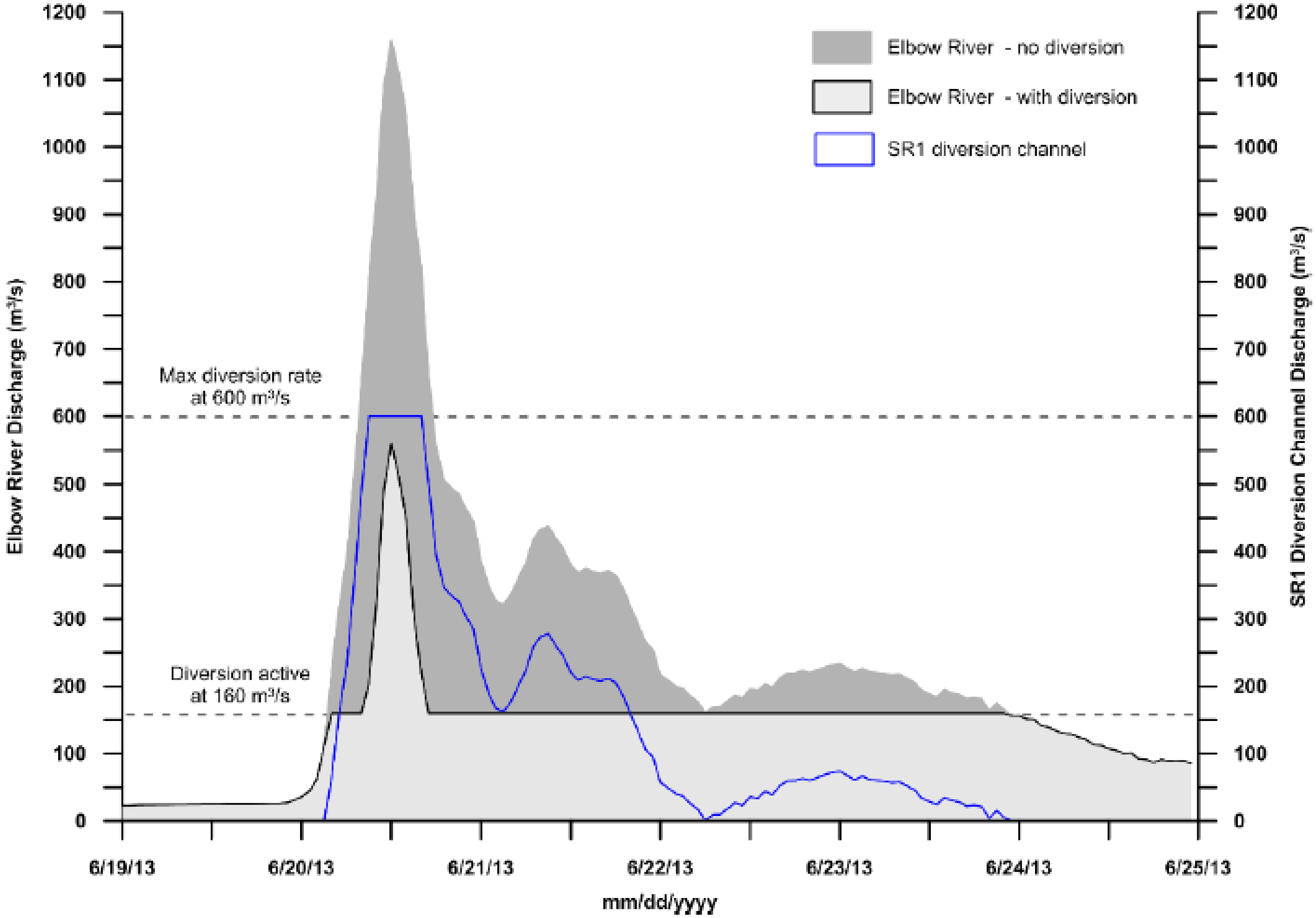


Figure IR304-1 1:100 Year Flood Diversion (from Volume 3B, Section 6, Figure 6-4)

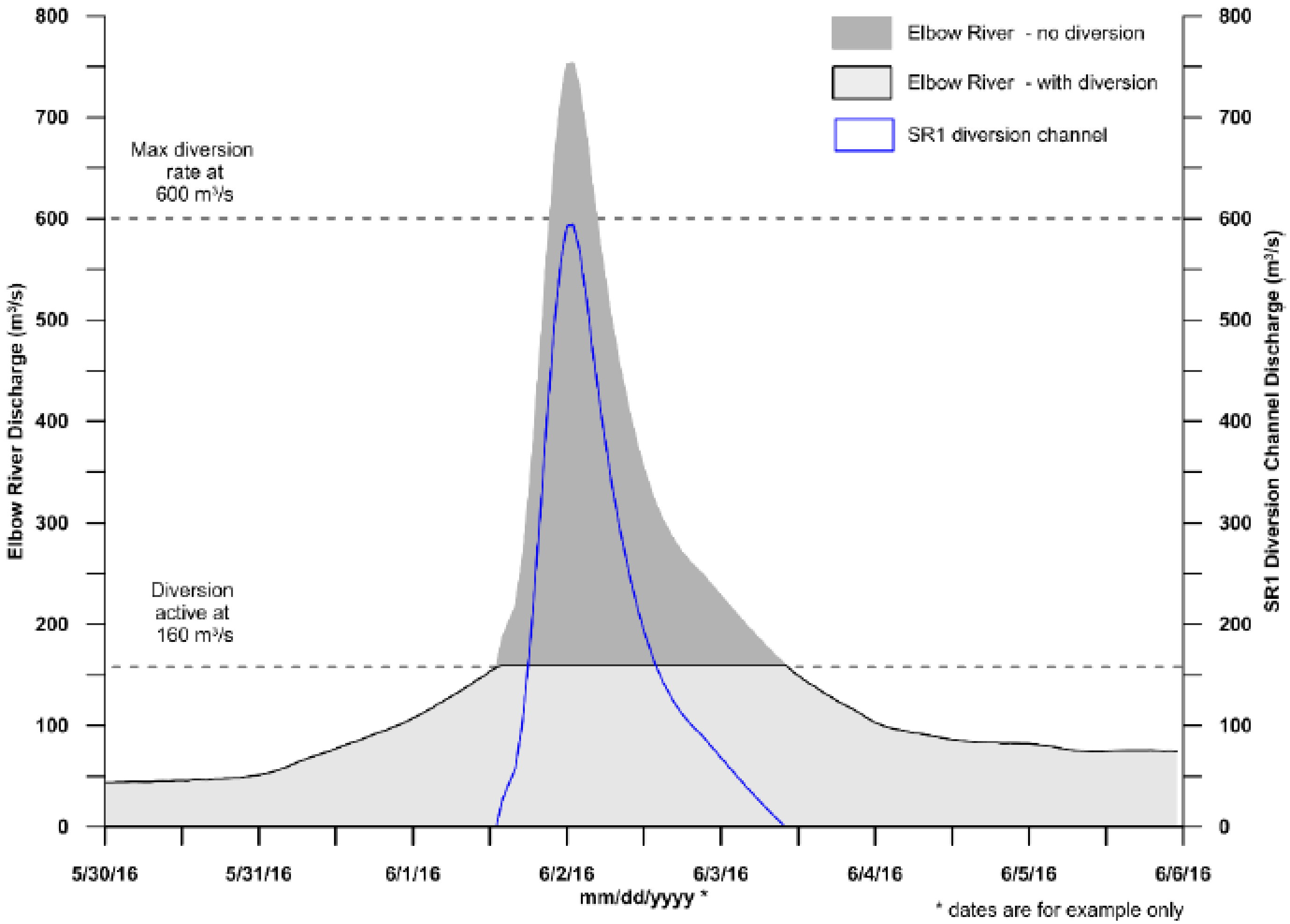


Figure IR304-2 1:100 Year Flood Diversion (from Volume 3B, Section 6, Figure 6-5)

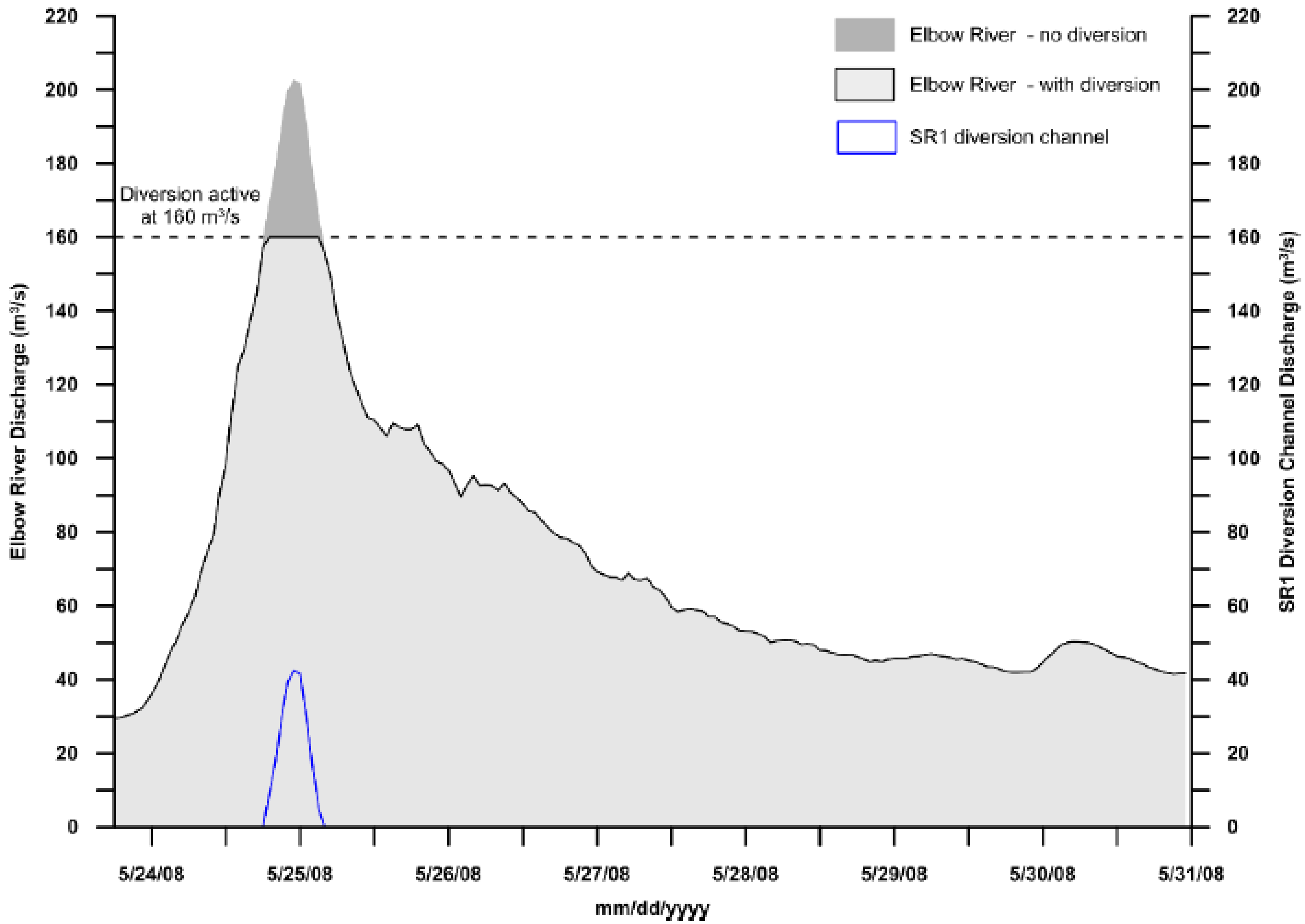


Figure IR304-3 1:10 Year Flood Diversion (from Volume 3B, Section 6, Figure 6-6)

For a flood with increased duration or magnitude, the volume of water and suspended sediment will increase; however, the reservoir cannot accept greater volume than the full service level. When the reservoir is full, diversion will stop and Elbow River flood waters will bypass the off-stream reservoir and continue on to Glenmore Reservoir. Water quality in the reservoir would no longer be affected because there is no diversion.

The ability of the reservoir to accommodate back to back flood volumes is not dependent on the release rate from the reservoir. A general description of the release criteria is provided in Volume 3B Section 6.4.1.4 on page 6.17. The decision about when, or if, to release waters retained from the diversion of the 1:10-year flood or 1:100 year flood (and at what rate to release it) will depend on the forecast at the time and it cannot be predicted in advance. A decision to release will depend on the judgment of the operator the time.

The sediment yield from the reservoir is not expected to be greater than predicted by the design flood scenario. The timing of sediment release into Elbow River may be delayed by a second flood due to the need to wait for the river flow to decrease to 20 m^3/s (i.e., the river flow rate that can accept reservoir water without remobilizing sediments downstream, in combination with a release from the reservoir.

c. The three floods have different release rates from the off-stream reservoir, as shown in Volume 3B, Section 6, Figure 6-7. For lower release rates, there is less resuspension of sediments (and, thus, associated parameters such as nutrients), but changing the release rate would have little impact on soluble parameters. In all cases, total suspended solids (TSS) and associated parameters are reduced by the Project. Increasing the release rate will cause more resuspension of sediments.

   If the release rate of water from the off-stream reservoir is decreased, then retention time is increased, allowing for water temperature to increase. However, it is not expected that water temperatures changed by the Project will be outside of the range of Elbow River historical variation. The temperature differences between this type of release and Elbow River are not similar to the type of development that would require thermal modelling (thermal plant discharge or wastewater plant discharge in winter).

REFERENCES

Nürnberg and Gertrud K. 2002. Quantification of Oxygen Depletion in Lakes and Reservoirs with the Hypoxic Factor, Lake and Reservoir Management, 18:4, 299-306, DOI: 10.1080/07438140209353936.

Question 305

Volume 3B, Section 7.4.2, Page 7.20
EIS Summary, Section 6.5.2.2, Page 6.25

Alberta Transportation identified that *The main effect on water quality during flood and post flood operations is related to suspended sediment, which comprises organic and inorganic matter that is held in water by turbulence.* The report also identified parameters that behave similar to Total Suspended Sediments (TSS) including suspended and dissolved constituents.

a. **What is the effect on other parameters transported with suspended sediment? What are the water quality constituents of major concern besides TSS?**

b. **Discuss the implications of any dissolved constituents (e.g. dissolved phosphorus) increasing during the flood conditions.**

Response 305

a. The water quality constituents of major concern besides total suspended solids (TSS) include:

- herbicides (Volume 3A, Section 7.4.2)
- temperature and dissolved oxygen (Volume 3B, Section 7.4.3)
- methylmercury (Volume 7.4.4, Section 7.4.4)

   The parameters transported with suspended sediment are discussed in Volume 4, Appendix K, Section 3.2.2, Table 3-1. The parameters that have a variation pattern most similar to suspended sediments include phosphorus (total, total dissolved, and dissolved forms), total coliforms, total organic carbon, total hardness, total calcium, total sulphate, total magnesium, and total ammonia. The seasonal pattern for many metal concentrations correspond with suspended sediment levels; however, metals data were not complete enough to assess their variation pattern category. These parameters are predicted to deposit in the off-stream reservoir with a subsequent reduction in downstream loading (i.e., they will be removed and not available to affect water quality; Volume 3B, Section 7.4.2.); thus, other water quality constituents associated with TSS are not considered a concern.

b. Dissolved phosphorus behaves similar to TSS and, therefore, is expected to increase during floods. Dissolved parameters, including the ones that increase in concentration during flooding, will enter the off-stream reservoir and be released during drawdown of water out of the reservoir. Even though dissolved phosphorous acts similarly to TSS with seasonal flows, dissolved nutrients are not expected to settle in the off-stream reservoir. The reservoir is expected to have no effect on dissolved parameters (Volume 3B, Section 7.4.2, page 7.23).

Question 306

Volume 3B, Section 7.4., Page 7.25
EIS Summary, Section 6.10.2.1, Page 6.64

Alberta Transportation proposes the land use of Area C as optional grazing area as stated *The area of the off-stream reservoir north of Springbank Road will be publicly owned and privately stewarded, and have grazing options through public leases.*

a. Discuss any potential effects on increasing nutrient export/loading from cattle manure after release of water from the flooded reservoir to the Elbow River.

Response 306

a. Since filing of the EIA, Alberta Transportation has created a draft post-construction land use document for the Project (Appendix IR2-1). This document provides the draft principles of future land use for the PDA, which was developed through the engagement process and includes feedback received by First Nations and stakeholders. The principles apply to the land use area (LUA) outlined in yellow in Figure 1 of Appendix IR2-1. The primary use of all lands within the PDA, including the LUA, is for flood mitigation. In light of the primary use, the safety of anyone with access or land users will be an overriding factor. Currently, grazing is not identified as a secondary use within the LUA. The future uses of the LUA will be determined after engagement with Indigenous groups and stakeholders.

   As stated in Volume 3B, Section 7.4.3, Table 7.4-1, less than 5% of the flooded area will be north of Springbank Road during a 1:100 year flood and less than 25% during the design flood (this is where the area previously identified in the EIA as Area C is located).

   "In most instances when the off-stream reservoir is operated, the flooded area will primarily be over fallow land and be free of livestock waste, or fertilizers that may be associated with agricultural activities" (page 7.25).

   Any flood less than a 1:100 year will result in minimal to no animal waste mixing with flood water into the off-stream reservoir; thus, effects from nutrient loading are not anticipated

   Organic material from livestock waste carried into the off-stream reservoir during the design flood is predicted to be small and similar to that entering the Elbow River under current conditions (Volume 3B, Section 7.4.3). Subsequent changes in water quality from the export of nutrients into Elbow River from the off-stream reservoir will be similar to that which would occur without the Project.

Question 307

Volume 3A, Section 5.4.3.3, Page 5.38
Volume 3A, Section 5.2.2.3, Page 5.25 and 5.26

Alberta Transportation states *Groundwater that would seep into the diversion channel (when dry) would remain within the watershed, although potentially travelling through a more tortuous route. Regional-scale effects on groundwater quantity can be mitigated by allowing seepage in the dry diversion channel to infiltrate back into the subsurface, or flow back into the Elbow River via surface water drainage pathways.* There will be a continuous flow of groundwater into the dry dam since the diversion channel leading to the dry dam will be cut to below the typical groundwater level. Flow may or may not be of significant volume.

In addition, Section 5.2.2. discusses the presence of high sodium, TDS and sulphate concentration in groundwater samples from the unconsolidated deposits.

a. Discuss the potential for flows to be of significant volume and the resulting potential effect of groundwater on surface water quality discharged to the Elbow River via the dry dam outlet structure.

b. Describe any other groundwater-surface water interactions that can lead to changes in the surface water quality.

Response 307

a. Seepage into the diversion channel (when dry) has been estimated by the numerical groundwater flow model (see the Hydrogeology TDR Update, in the response to IR42, Appendix IR42-1, Section 5.5). Estimates of seepage into the diversion channel (when dry) were obtained by examining flux values at nodes within the diversion channel based on the numerical groundwater simulation results. Based on these flux values, the estimated net seepage into the diversion channel is 0.013 m^3/s. Given the relatively low seepage rate estimate and that groundwater under baseline conditions is already discharging to the unnamed creek, substantial changes to surface water quality are not expected.

b. No other direct effects pathway for groundwater-surface water interactions leading to changes in surface water quality were necessary during dry operations.

Question 308

Volume 3B, Section 7.2.2.1, Page7.7
Volume 4, Appendix K, Section 3.2, Figure 3-2, Page 3.5

Alberta Transportation has provided water quality analysis based on four seasons. The rivers in that region are very dynamic in spring and summer. These are the two seasons where the flood and post-flood operation would have effects on the water quality. Figure 3-2 shows that there is a big variation within each spring and summer season.

a. Evaluate the variability of the different "suspended sediment associated" parameters in a way that can be matched with the scale of the flood and post flood operation (weekly/monthly).

Response 308

a. Descriptions for graph including box and whisker are provided in Figure IR308-1 and in Volume 4, Appendix K, Section 2.2.4.3. Monthly total suspended solids (i.e., total suspended sediment) and suspended sediment associated parameters, as well as temperature and dissolved oxygen, are shown on Figure IR308-2 to Figure IR308-20.

   Some parameters are graphed on a logarithmic axis to accentuate monthly variability (e.g., Figure IR308-2: Total Suspended Solids); consequently, these graphs are truncated and some higher outlier concentrations are excluded. These outliers can be viewed in Volume 4, Appendix K, Section 3.2.1 and 3.2.2.

   Maximum total suspended solids (TSS) concentrations sampled in the 2005 and 2013 flood years are generally within the upper 50^{th} percentile (i.e., between the median and maximum historical concentration). None of the flood year TSS samples are considered outliers (i.e., extreme values).

   Median TSS concentrations were highest in June and the most variable distributions were in the same month. This corresponds with spring freshet; June is also the most common month for flooding. The monthly trend for the maximum flood year TSS concentration is similar to median historical values, with increasing values from March through June and decreasing values through the rest of the summer.

   Total organic carbon, nutrients and coliforms appear to show a similar temporal distribution as TSS; however, coliforms did not appear to decrease through the summer.

   Metals data from Elbow River were not sufficient to determine if metal concentrations had a similar monthly trend compared to TSS; however, metal concentrations in the Glenmore Reservoir were highest in June. Temperature increased through the spring and summer months while dissolved oxygen concentrations decreased.

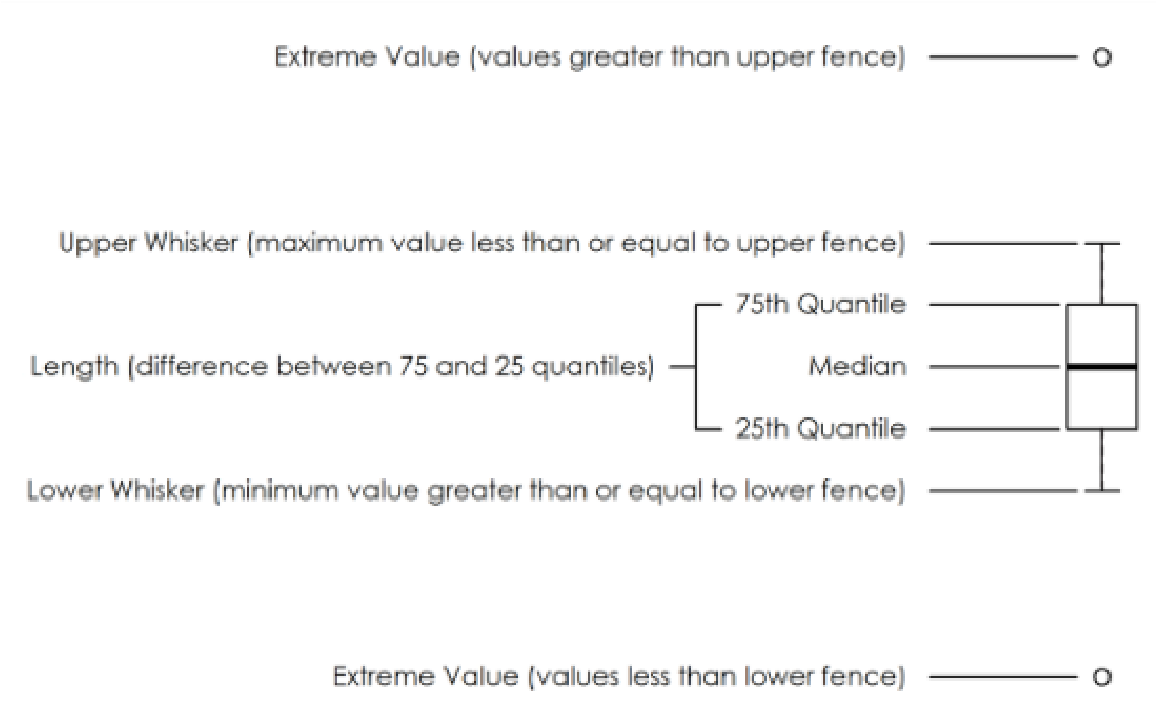
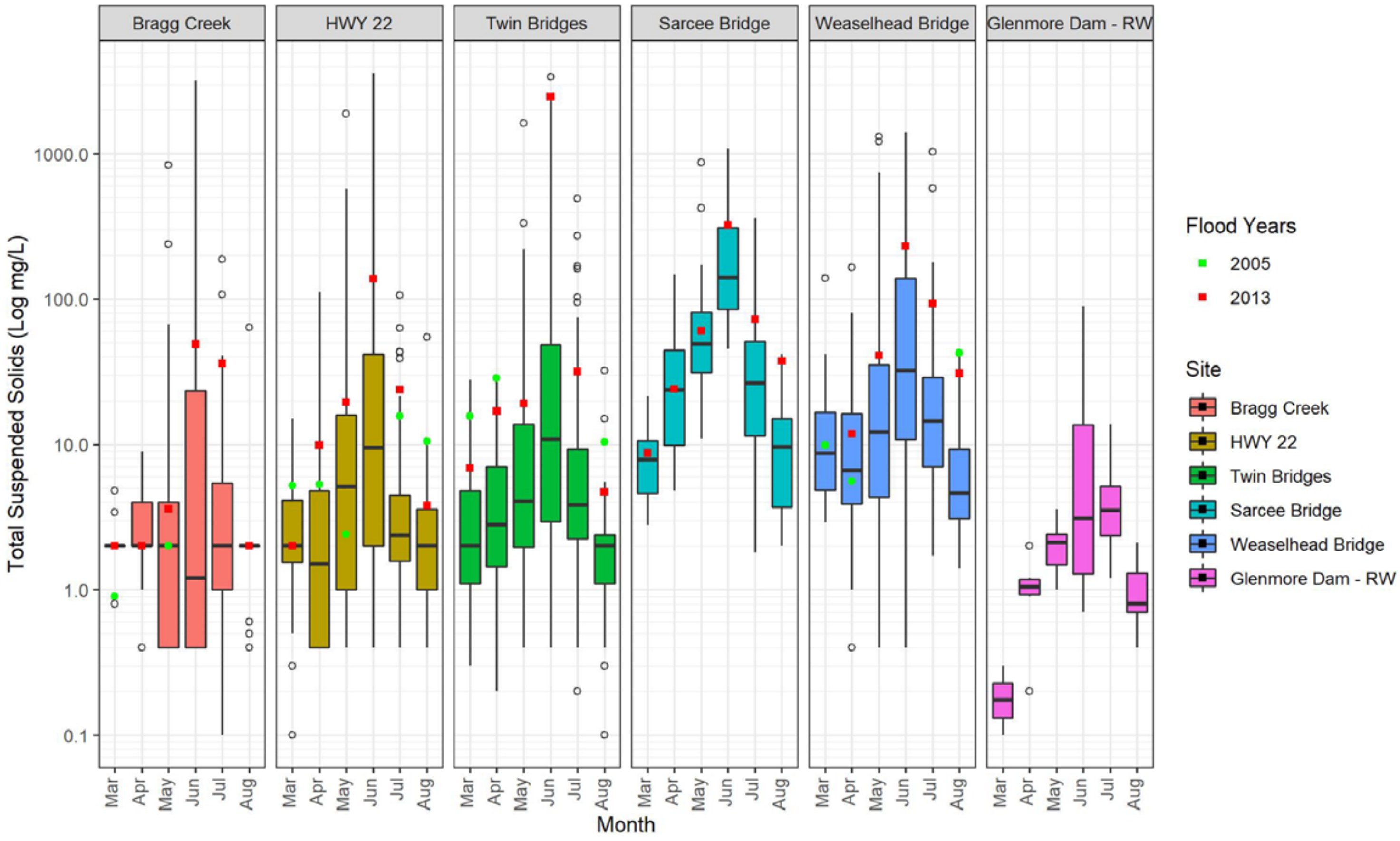
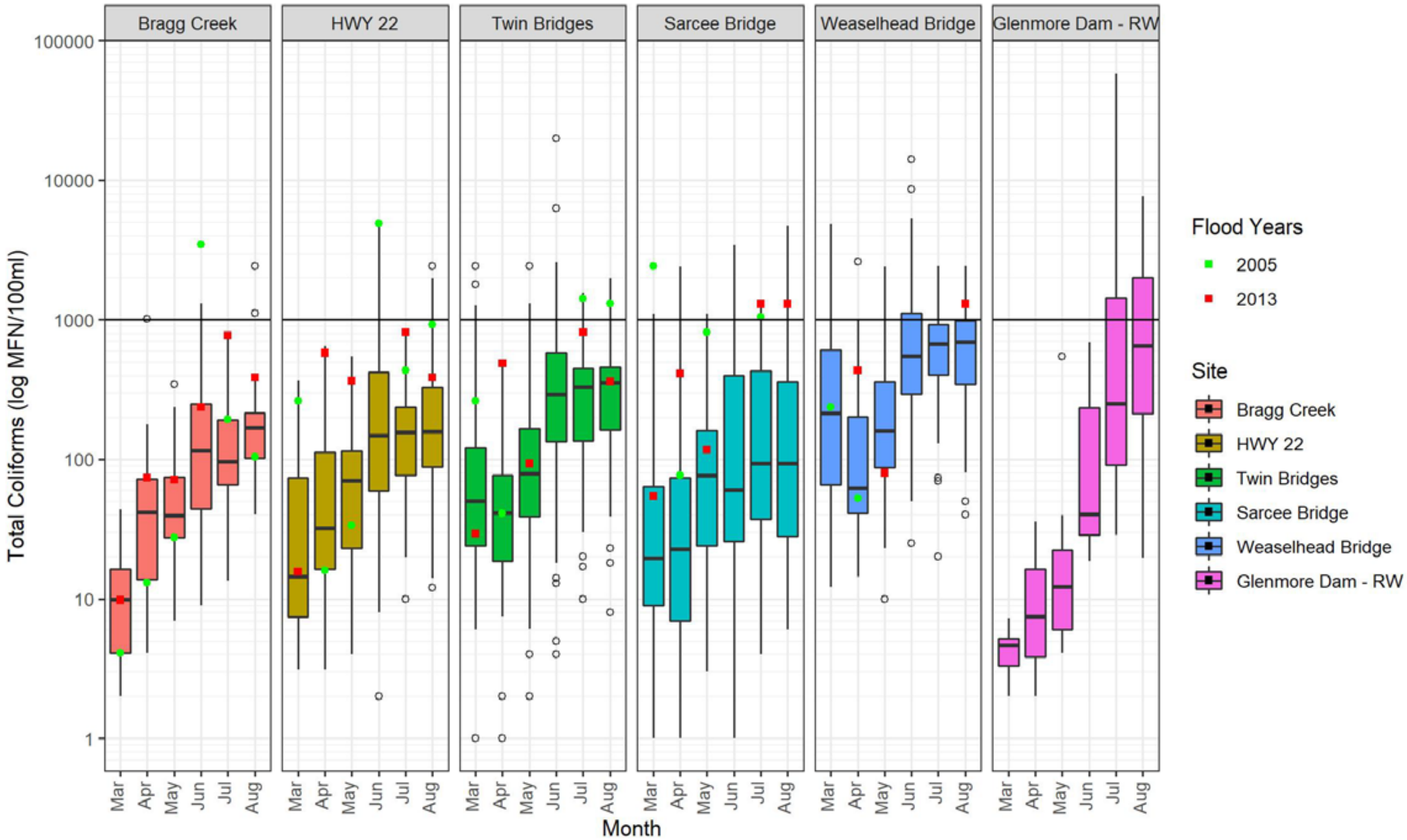


Figure IR308-1 Description for Box and Whisker Plots Used in Monthly Assessments



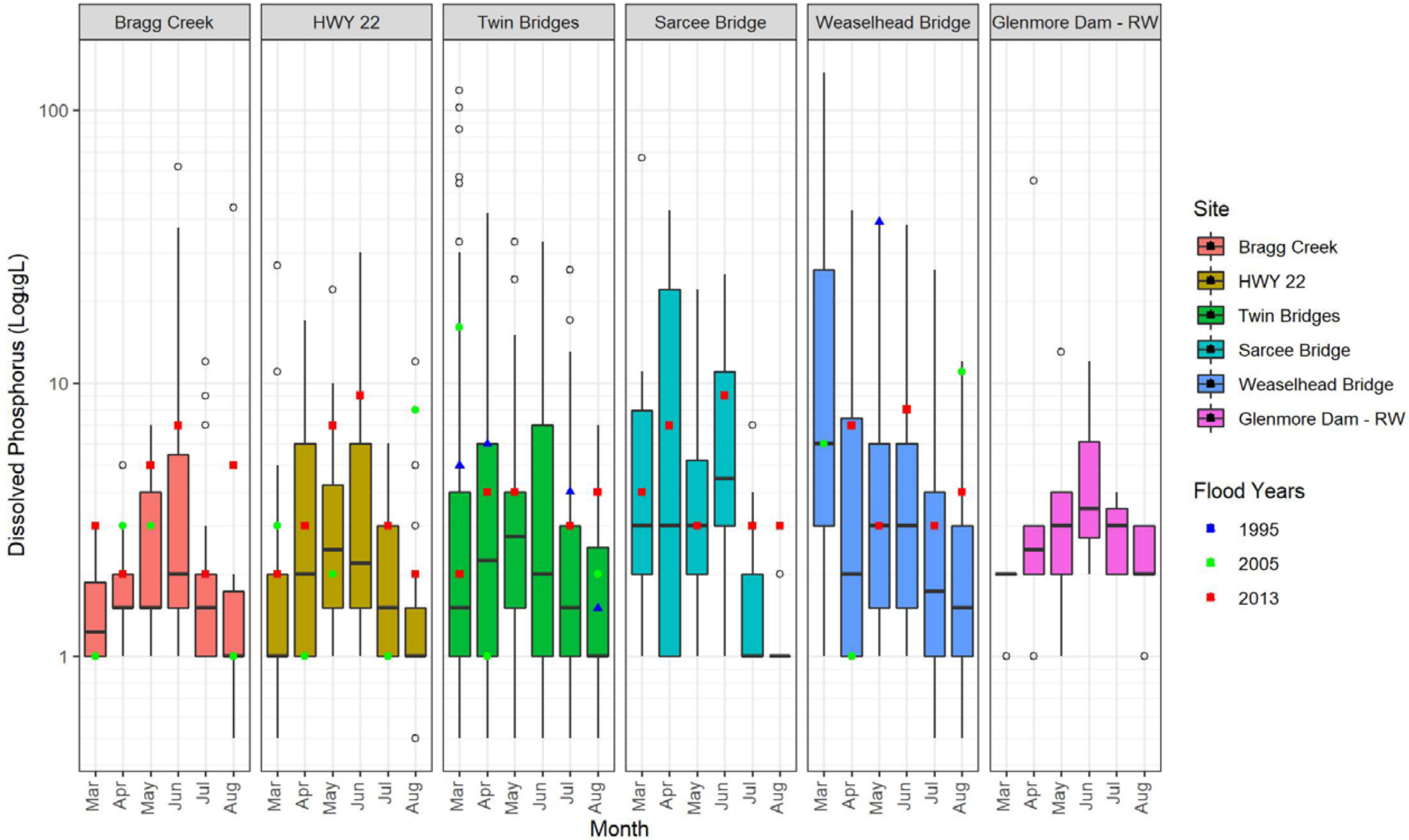
NOTE: green and red symbols represent maximum concentrations during 2005 and 2013 flood years

Figure IR308-2 Total Suspended Solids in the Upper Elbow River Mainstem Sites and at Glenmore Dam from 1979 to 2016



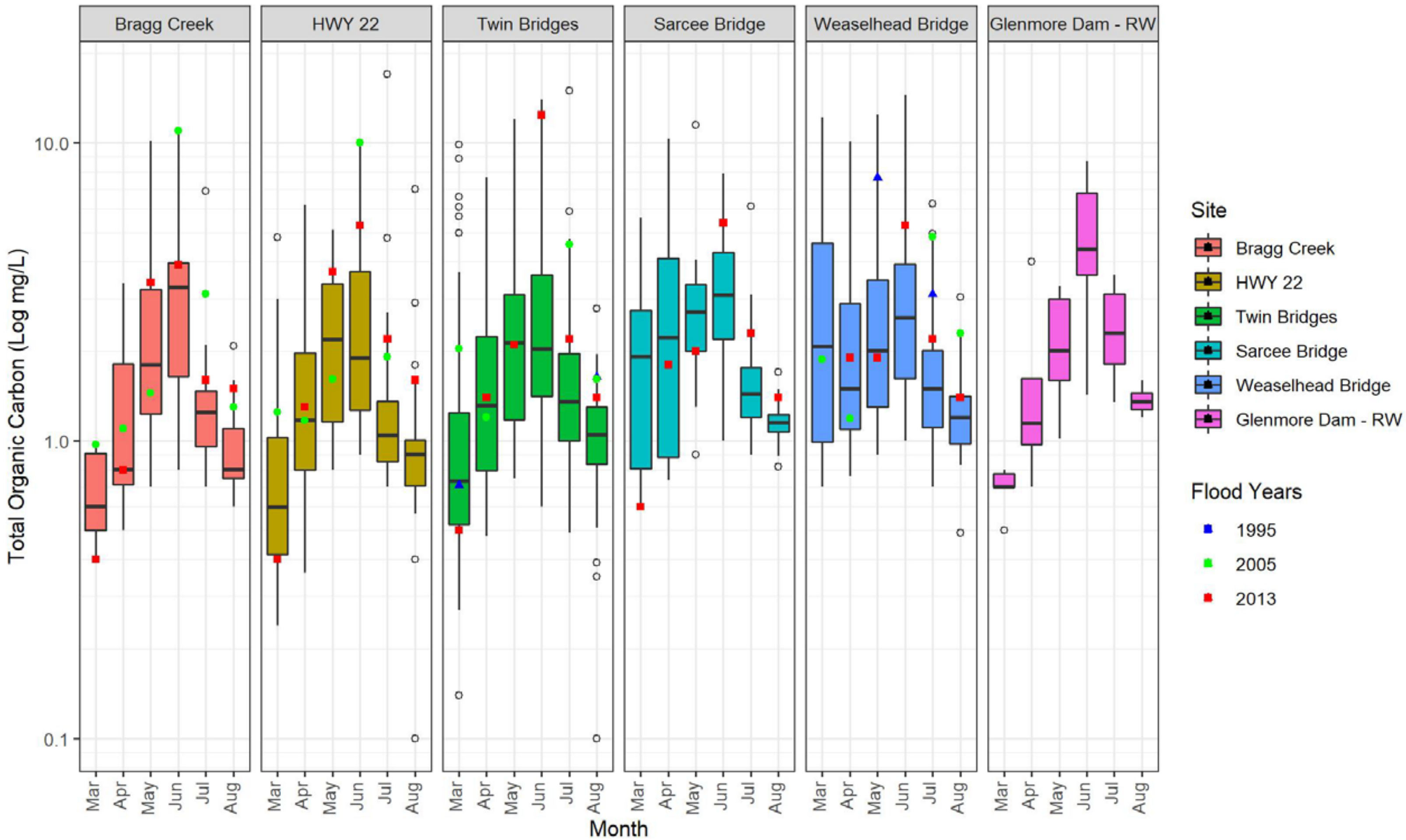
NOTE: green and red symbols represent maximum concentrations during 2005 and 2013 flood years; the black line represents the CCME irrigation guideline, CCME 2018a; no freshwater guideline for total coliforms exists

Figure IR308-3 Total Coliforms in the Upper Elbow River Mainstem Sites and at Glenmore Dam from 1979 to 2016



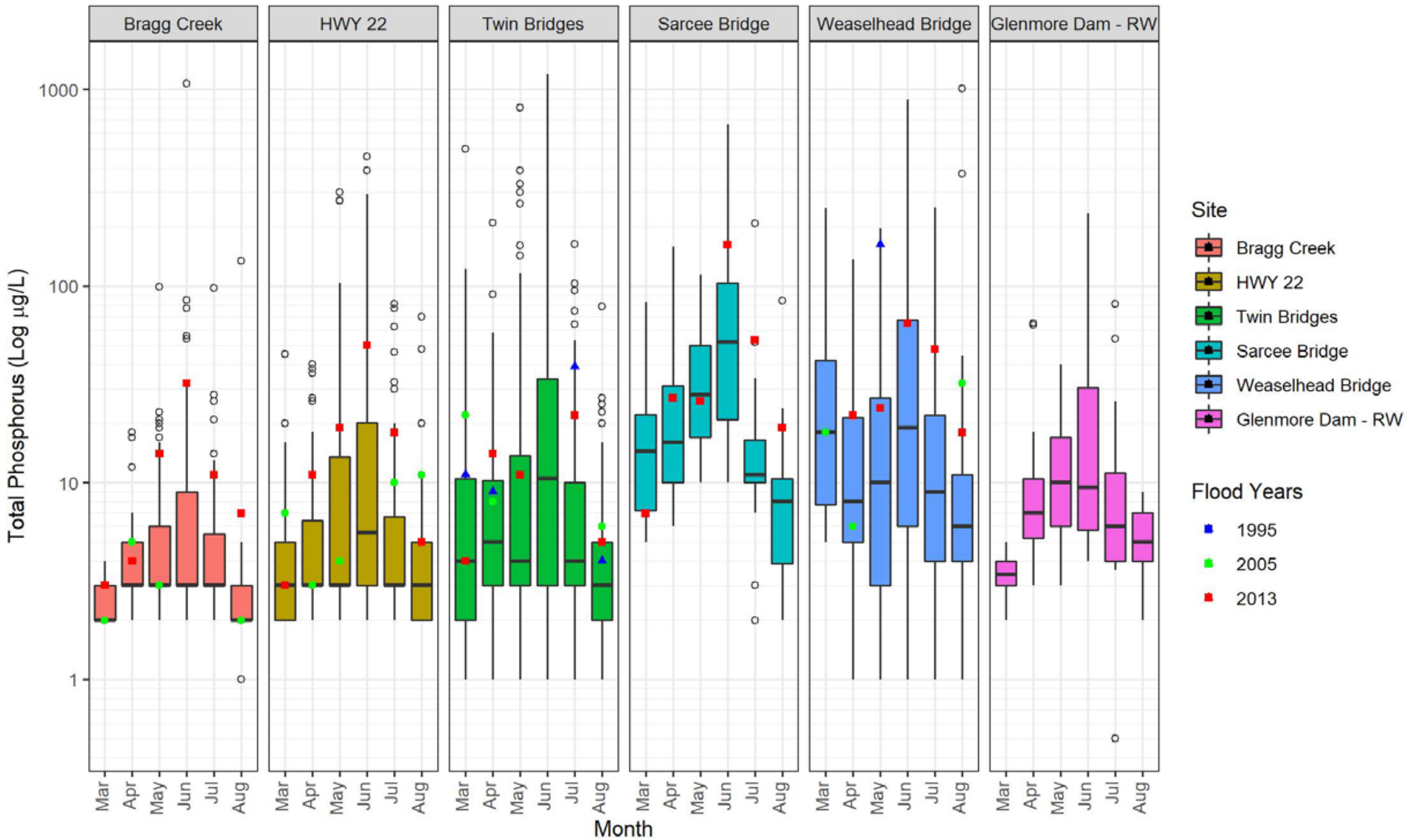
NOTE: blue, green and red symbols represent maximum concentrations during 1995, 2005 and 2013 flood years

Figure IR308-4 Dissolved Phosphorus in the Upper Elbow River Mainstem Sites and at Glenmore Dam from 1979 to 2016



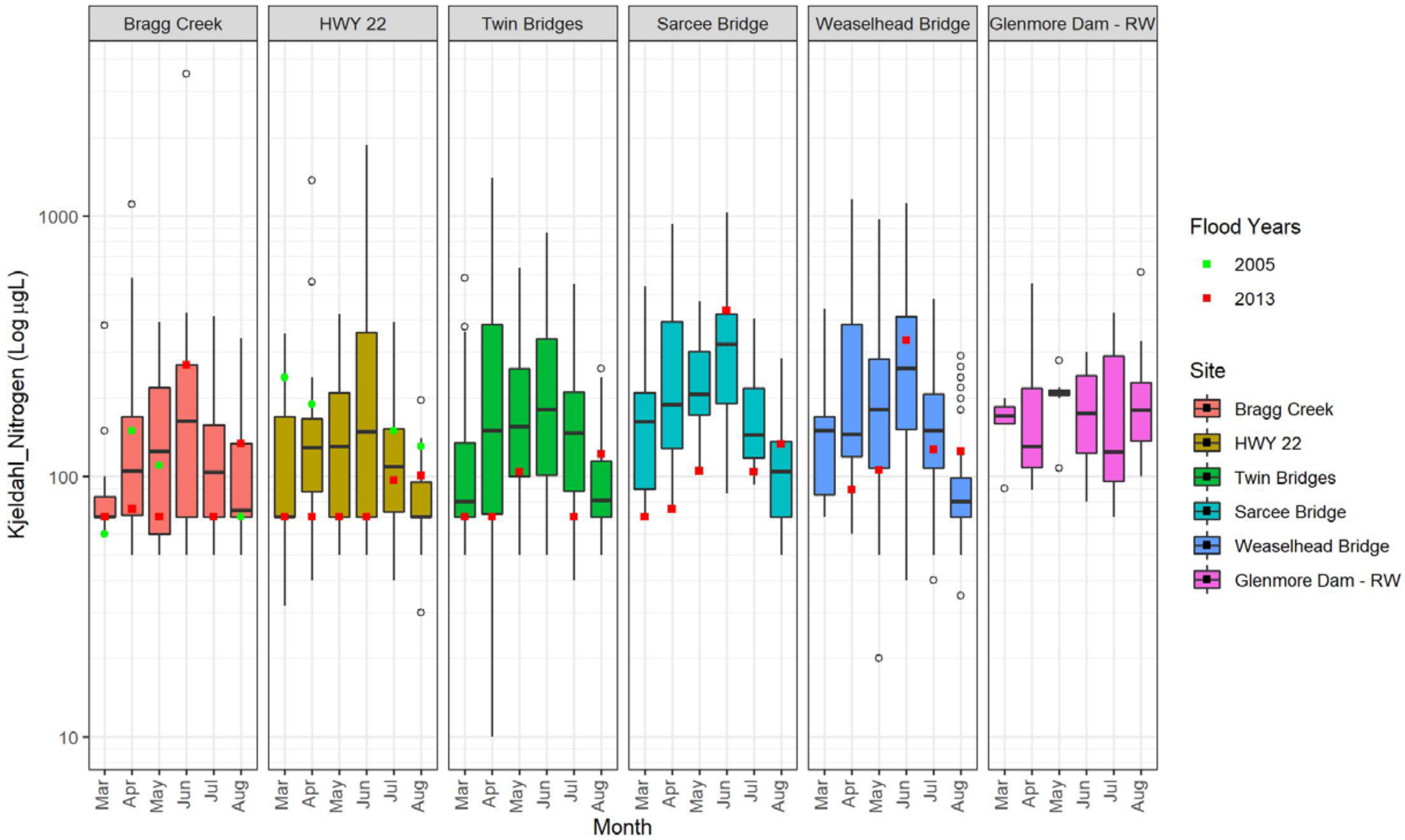
NOTE: blue, green and red symbols represent maximum concentrations during 1995, 2005 and 2013 flood years

Figure IR308-5 Total Organic Carbon in the Upper Elbow River Mainstem Sites and at Glenmore Dam from 1979 to 2016



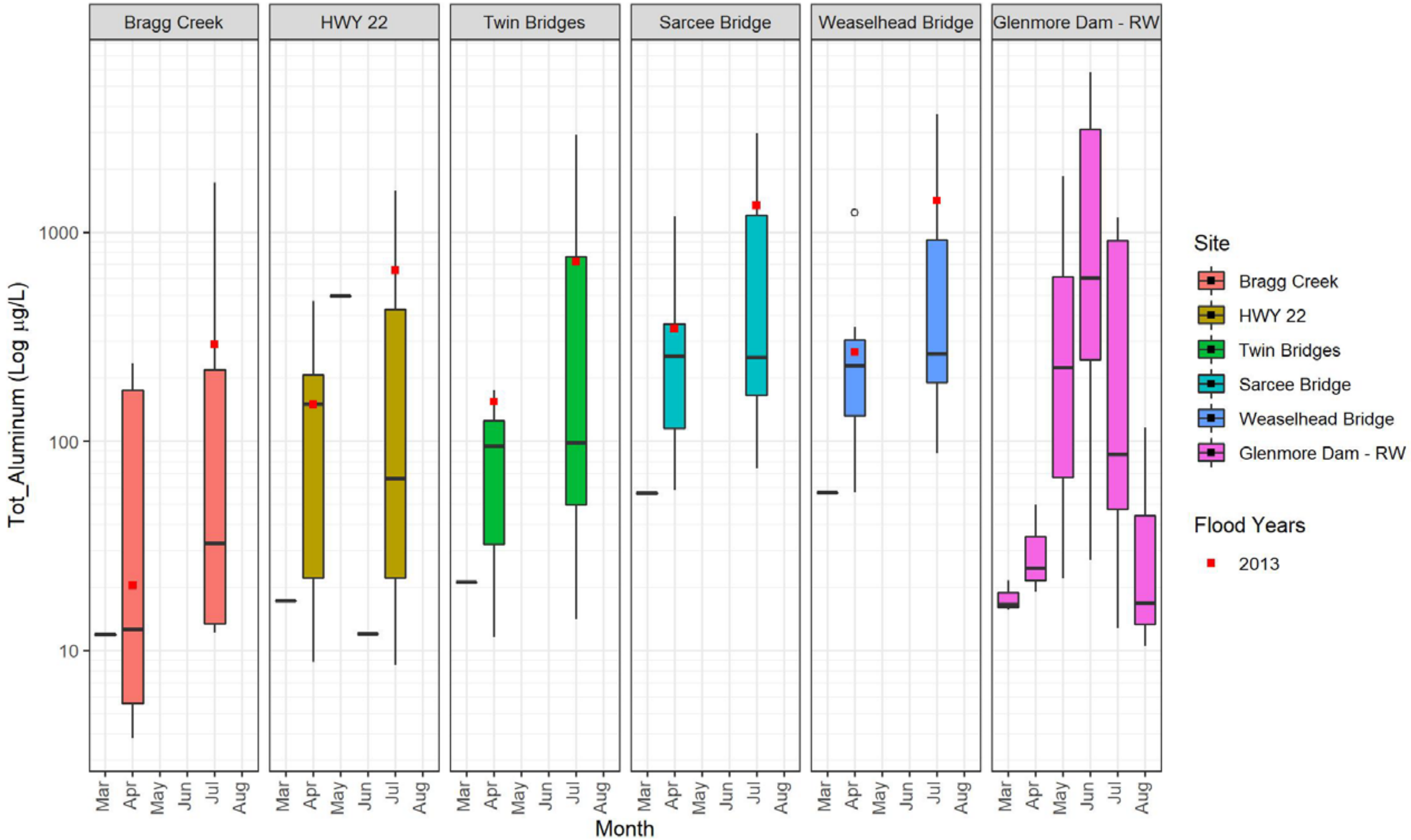
NOTE: blue, green and red symbols represent maximum concentrations during 1995, 2005 and 2013 flood years

Figure IR308-6 Total Phosphorus in the Upper Elbow River Mainstem Sites and at Glenmore Dam from 1979 to 2016



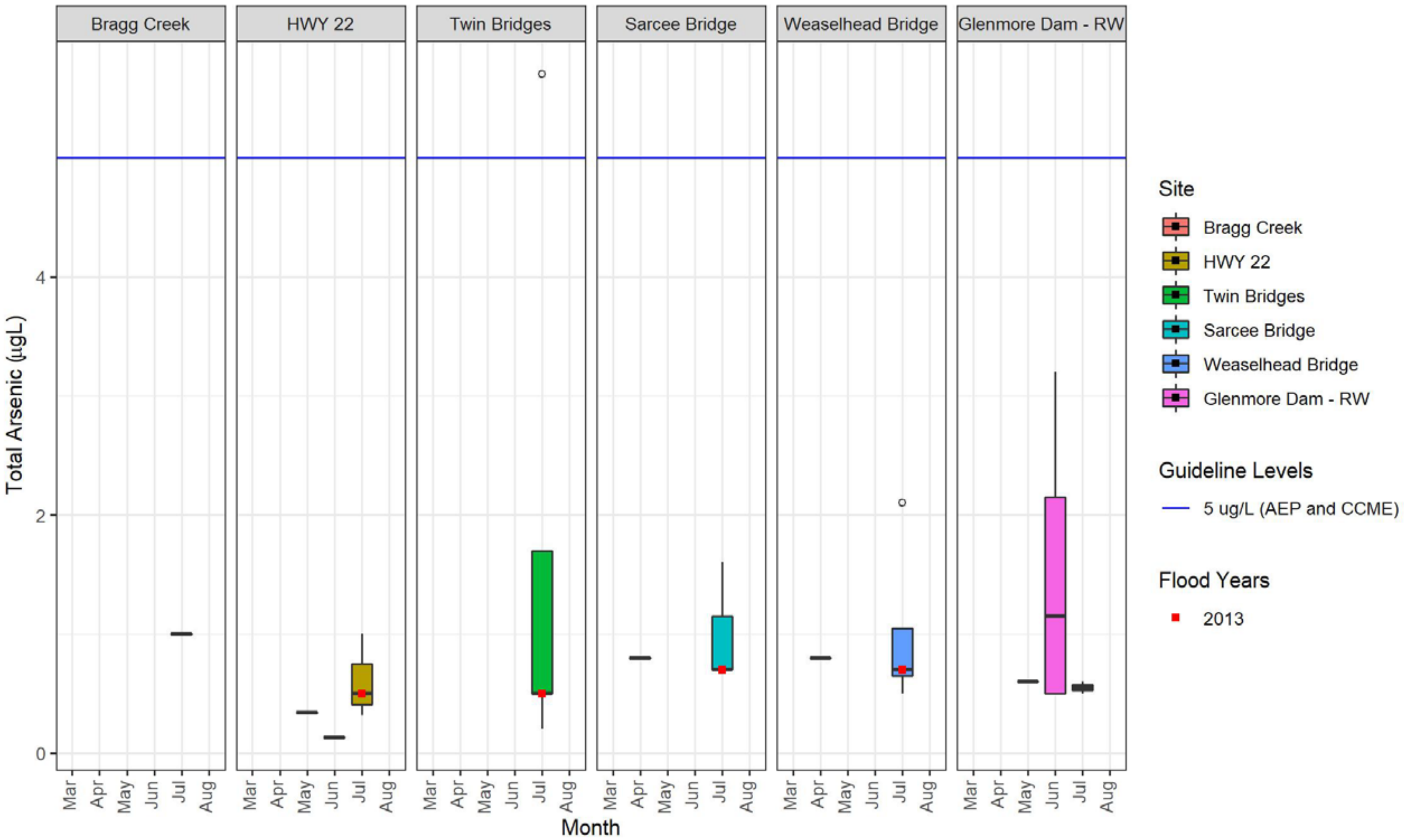
NOTE: green and red symbols represent maximum concentrations during 2005 and 2013 flood years

Figure IR308-7 Total Kjeldahl Nitrogen in the Upper Elbow River Mainstem Sites and at Glenmore Dam from 1979 to 2016



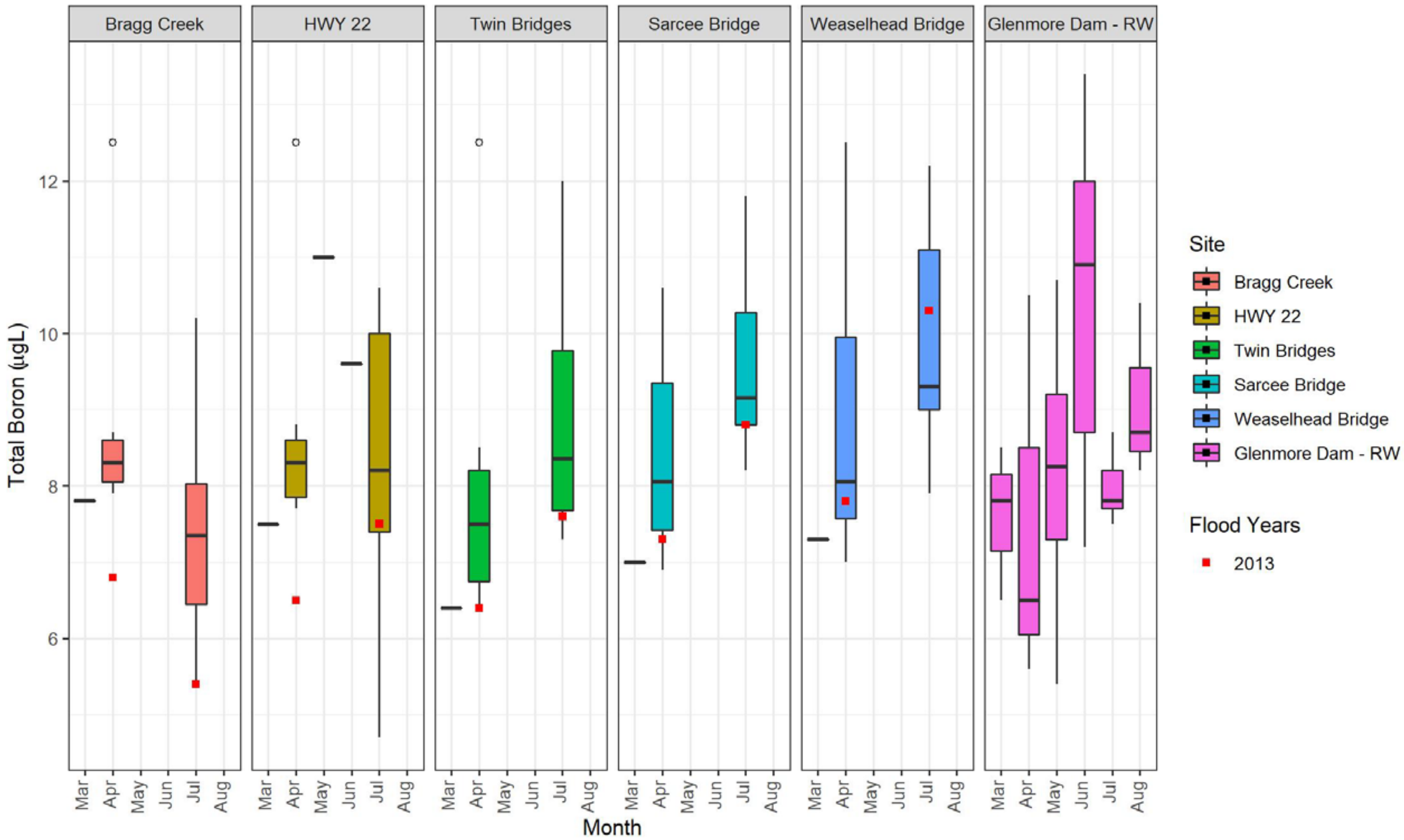
NOTE: red symbols represent maximum concentrations during the 2013 flood year; the black line represents the CCME guideline, CCME 2018a

Figure IR308-8 Total Aluminum in the Upper Elbow River Mainstem Sites and at Glenmore Dam from 1979 to 2016



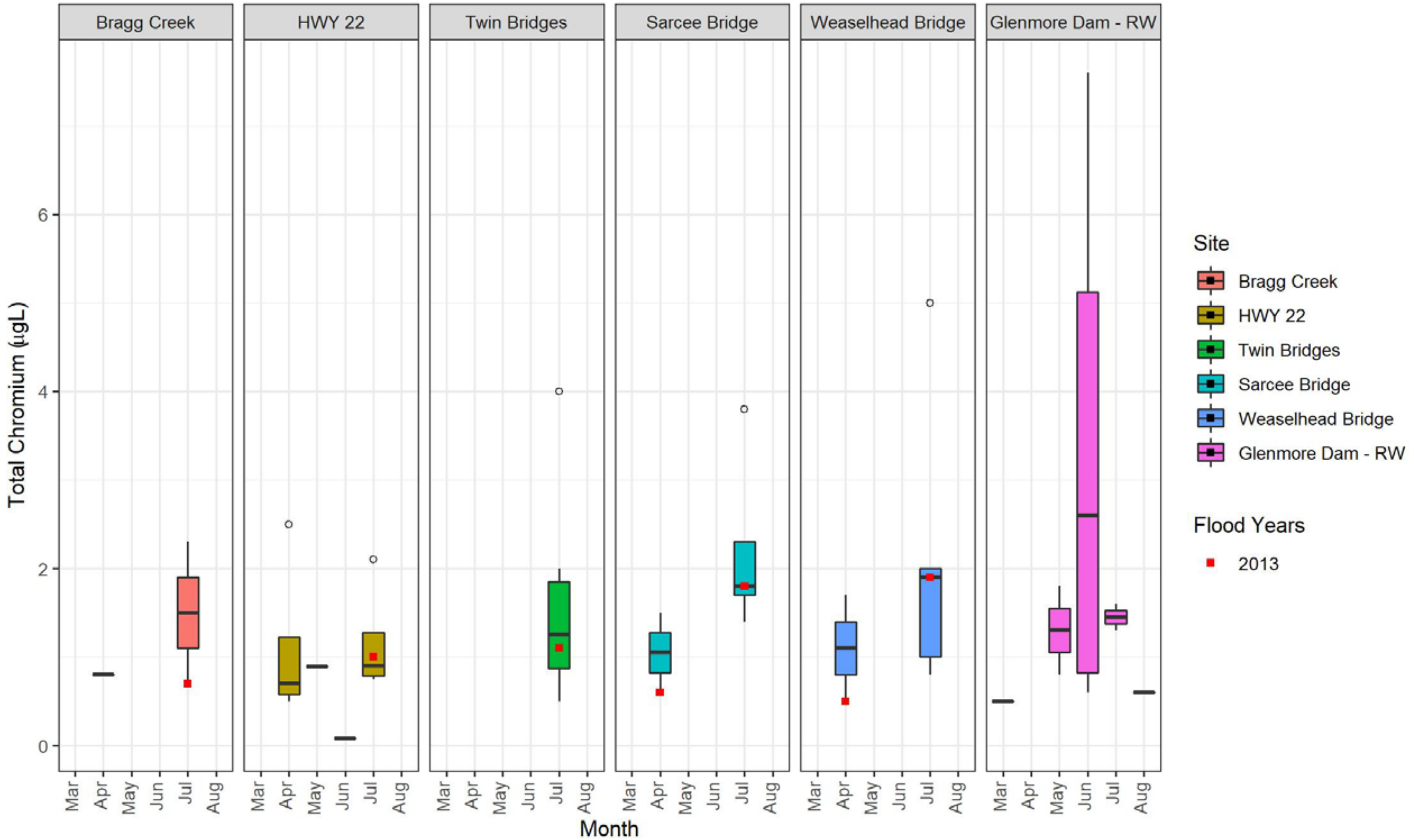
NOTE: red symbols represent maximum concentrations during the 2013 flood year; the black line represents the CCME guideline, CCME 2018b

Figure IR308-9 Total Arsenic in the Upper Elbow River Mainstem Sites and at Glenmore Dam from 1979 to 2016



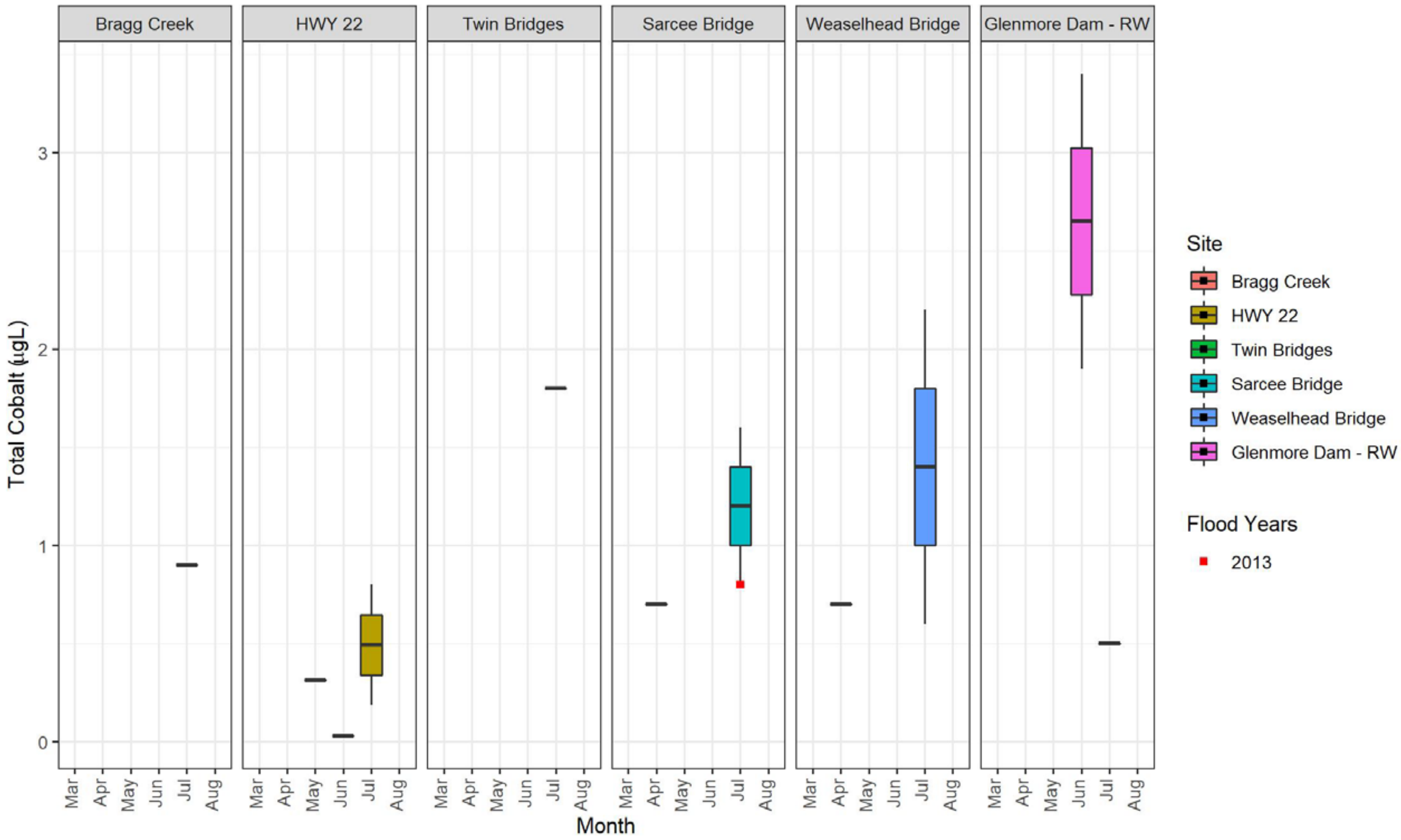
NOTE: red symbols represent maximum concentrations during the 2013 flood year

Figure IR308-10 Total Boron in the Upper Elbow River Mainstem Sites and at Glenmore Dam from 1979 to 2016



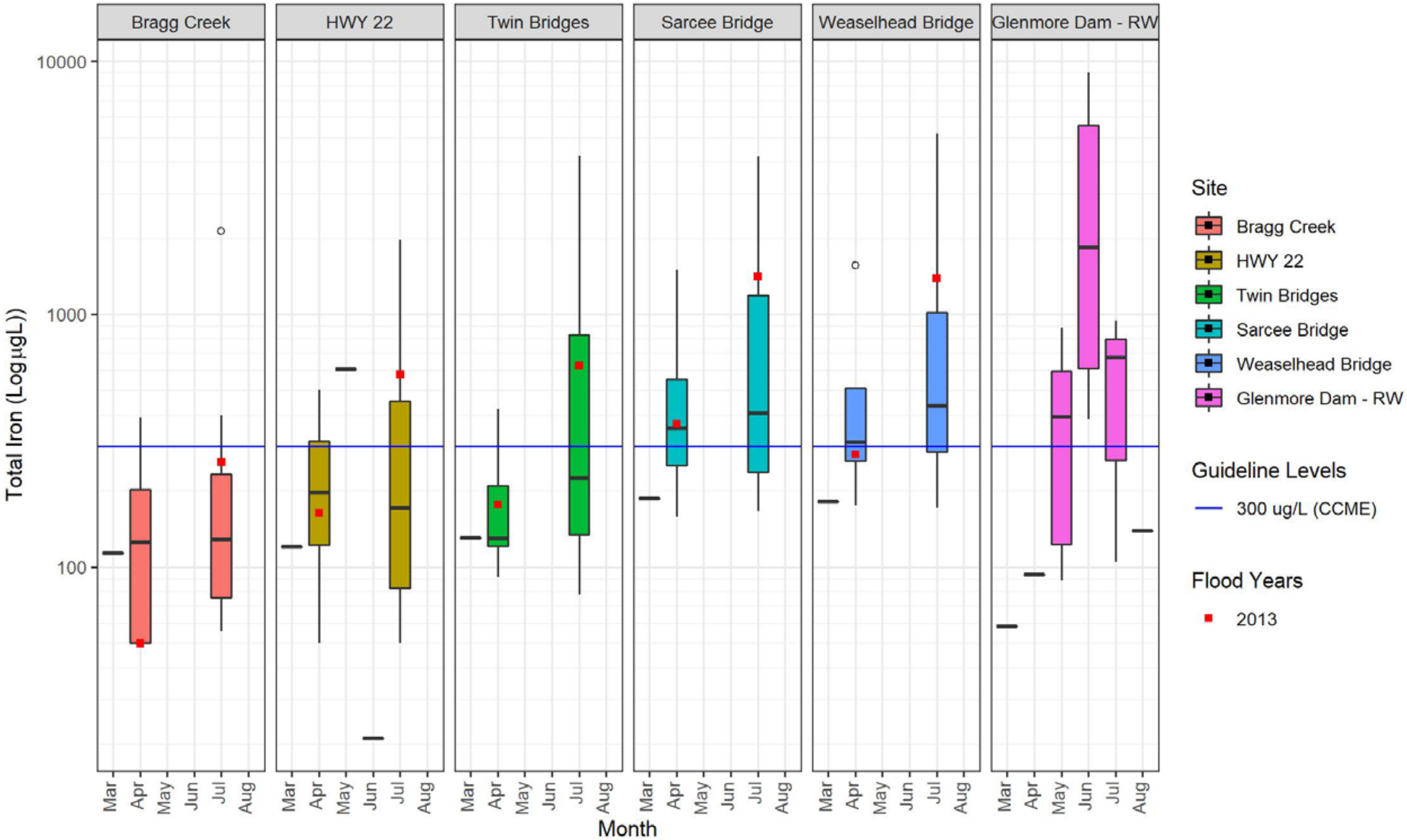
NOTE: red symbols represent maximum concentrations during the 2013 flood year

Figure IR308-11 Total Chromium in the Upper Elbow River Mainstem Sites and at Glenmore Dam from 1979 to 2016



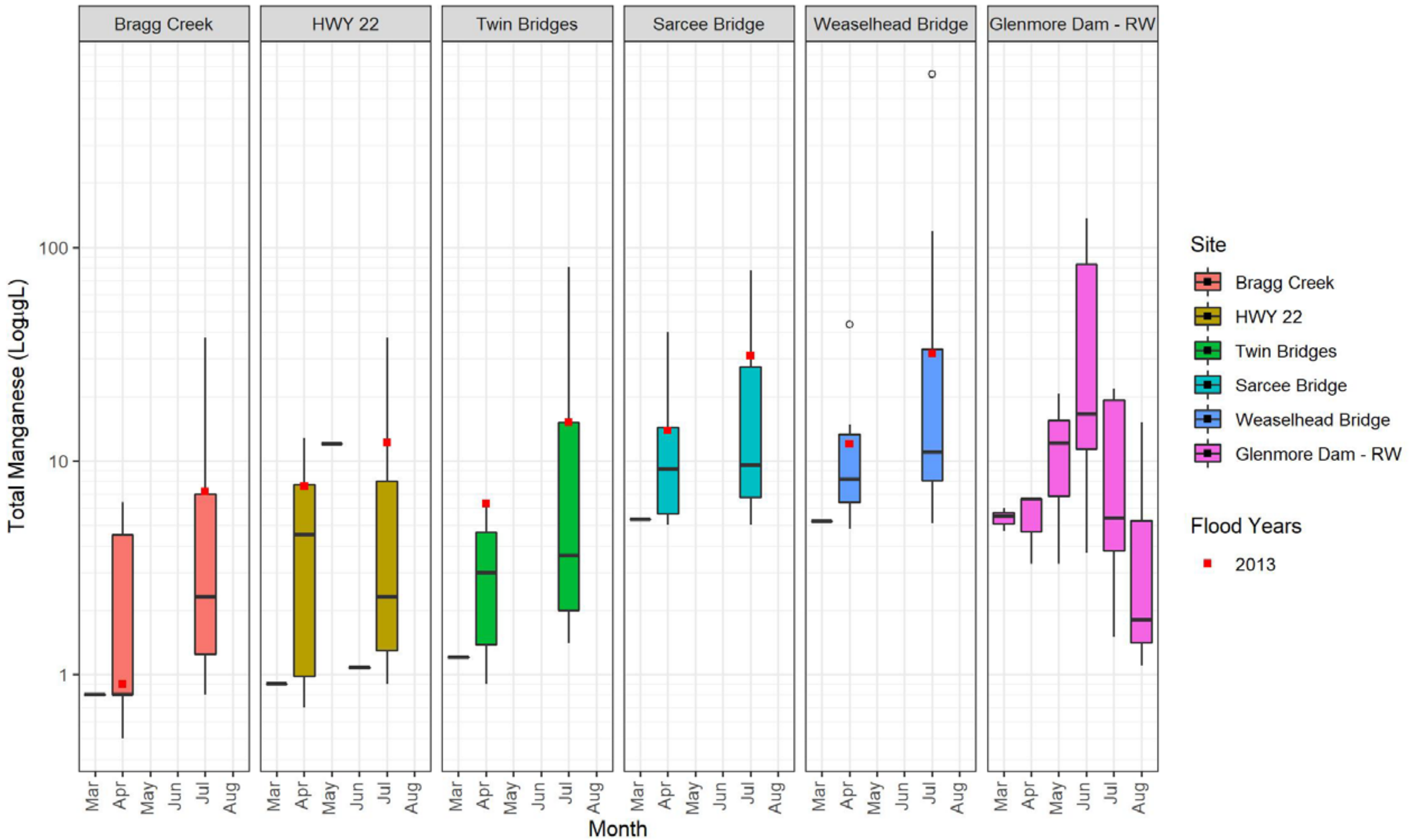
NOTE: red symbols represent maximum concentrations during the 2013 flood year

Figure IR308-12 Total Cobalt in the Upper Elbow River Mainstem Sites and at Glenmore Dam from 1979 to 2016



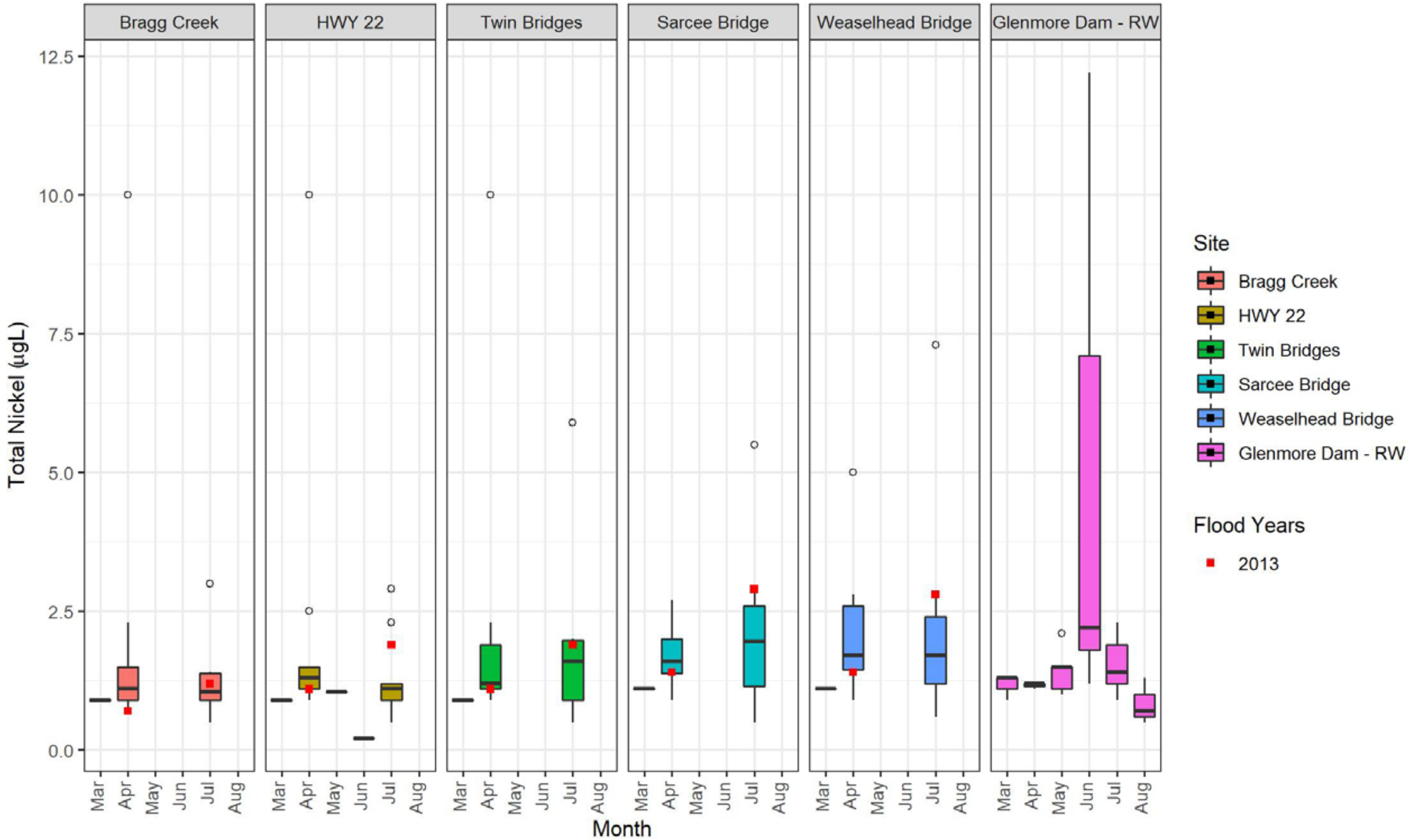
NOTE: red symbols represent maximum concentrations during the 2013 flood year

Figure IR308-13 Total Iron in the Upper Elbow River Mainstem Sites and at Glenmore Dam from 1979 to 2016



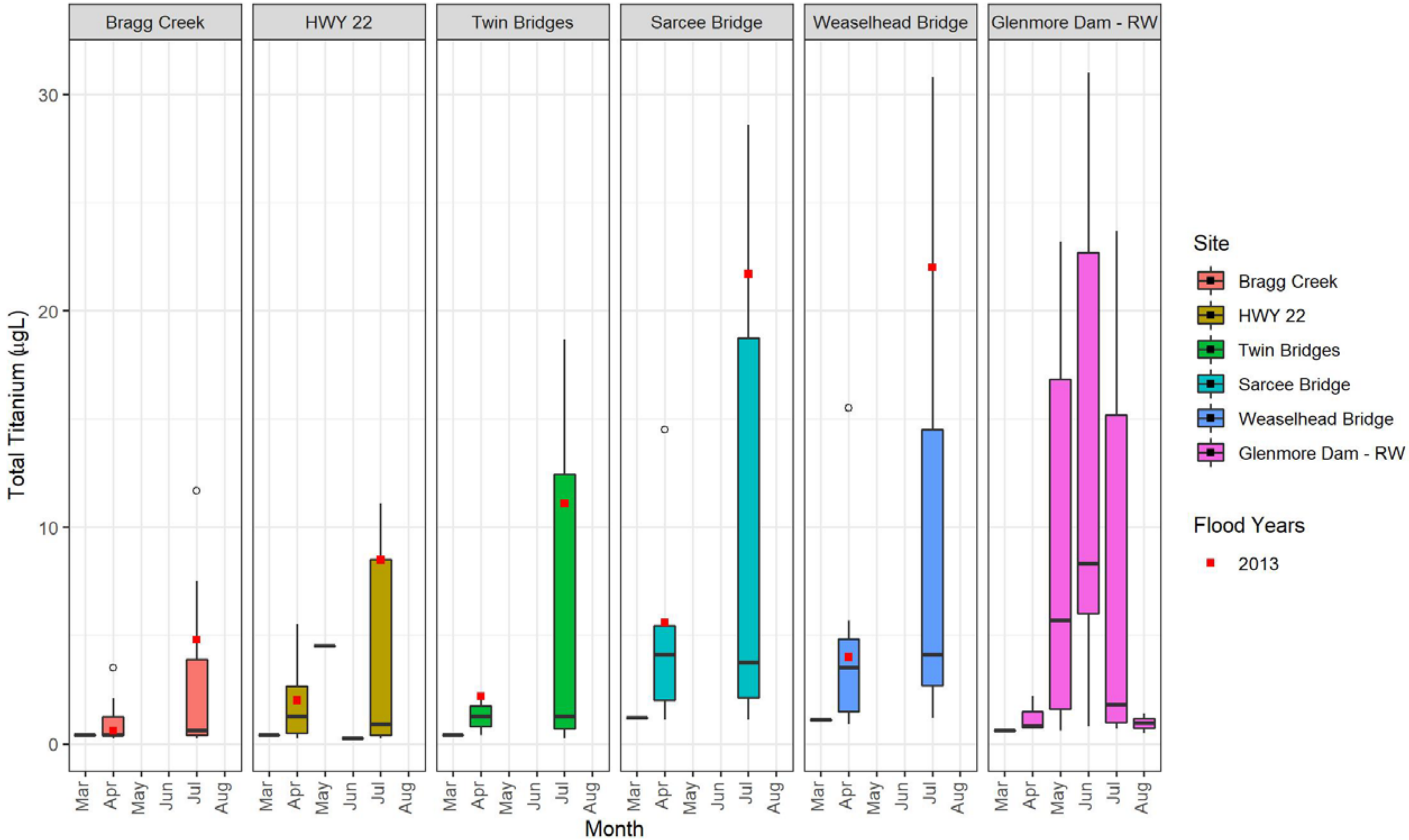
NOTE: red symbols represent maximum concentrations during the 2013 flood year

Figure IR308-14 Total Manganese in the Upper Elbow River Mainstem Sites and at Glenmore Dam from 1979 to 2016



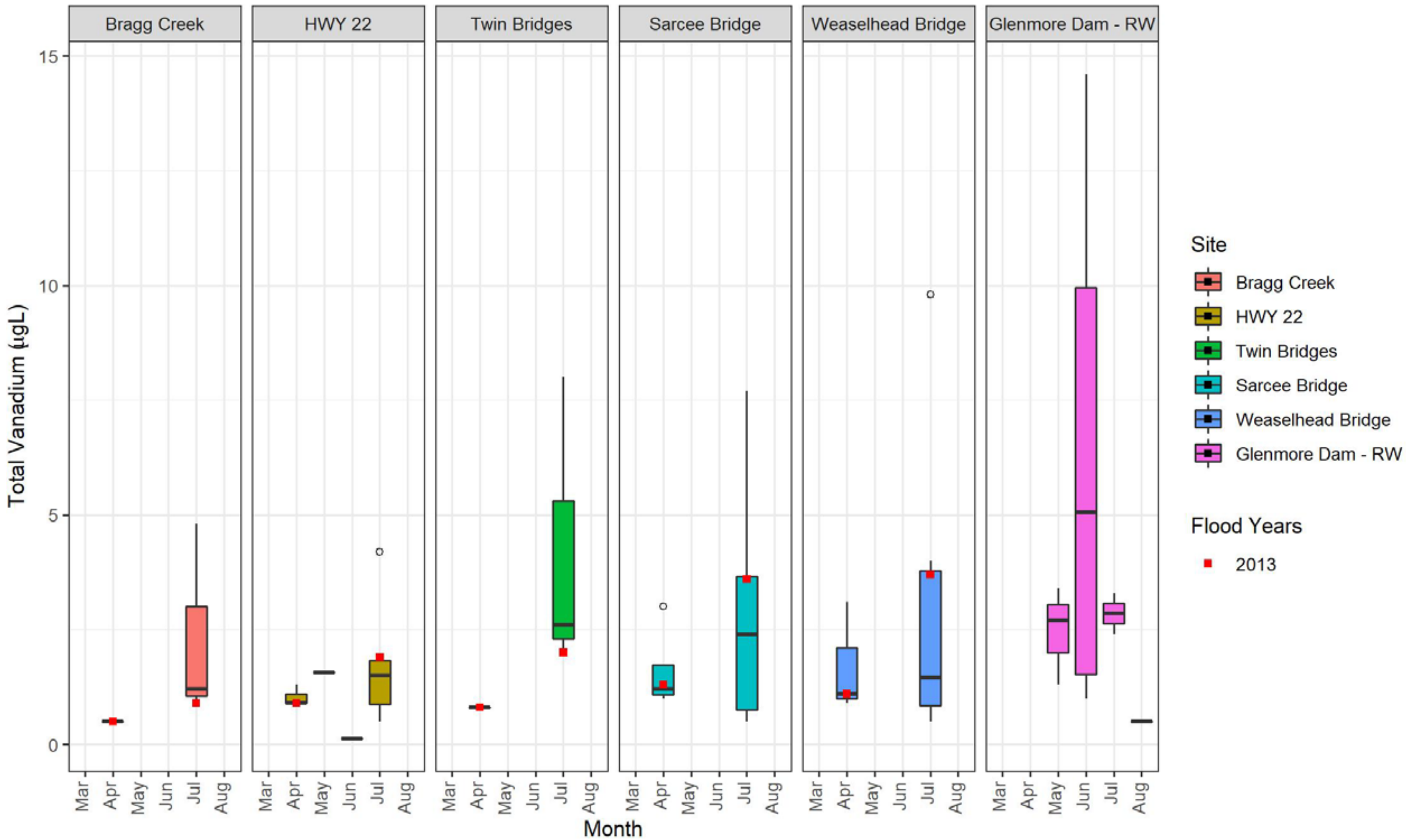
NOTE: red symbols represent maximum concentrations during the 2013 flood year

Figure IR308-15 Total Nickel in the Upper Elbow River Mainstem Sites and at Glenmore Dam from 1979 to 2016



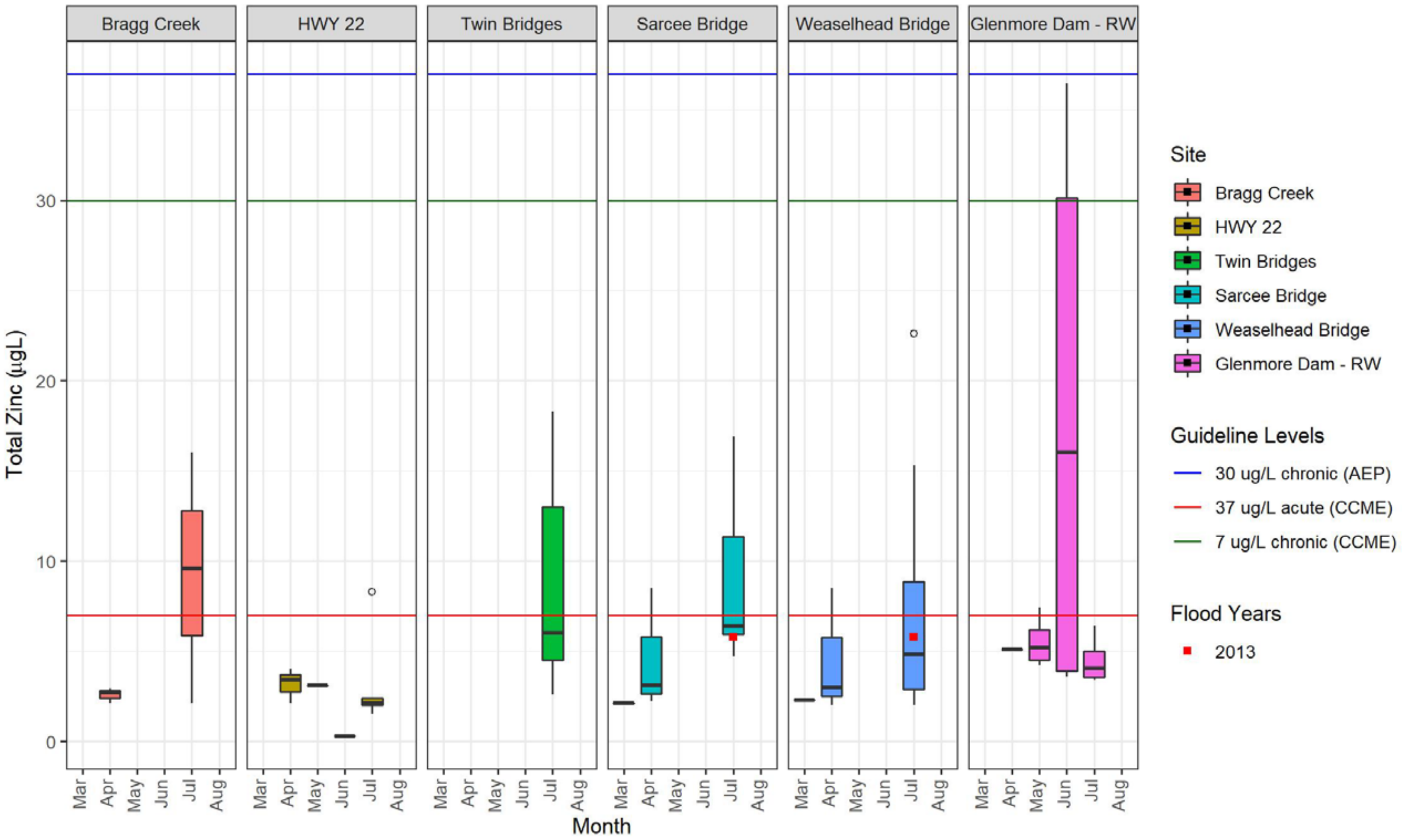
NOTE: red symbols represent maximum concentrations during the 2013 flood year

Figure IR308-16 Total Titanium in the Upper Elbow River Mainstem Sites and at Glenmore Dam from 1979 to 2016



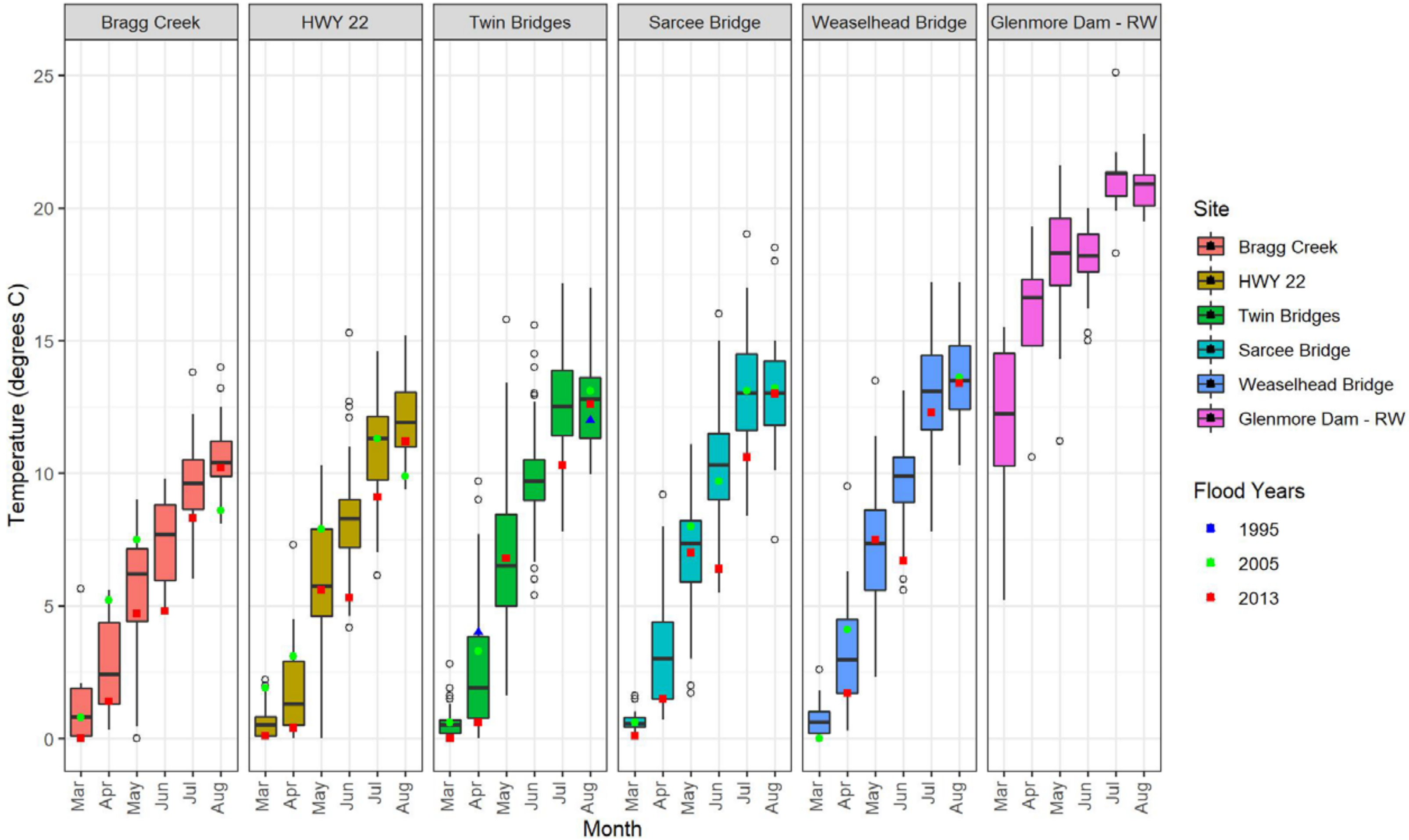
NOTE: red symbols represent maximum concentrations during the 2013 flood year

Figure IR308-17 Total Vanadium in the Upper Elbow River Mainstem Sites and at Glenmore Dam from 1979 to 2016



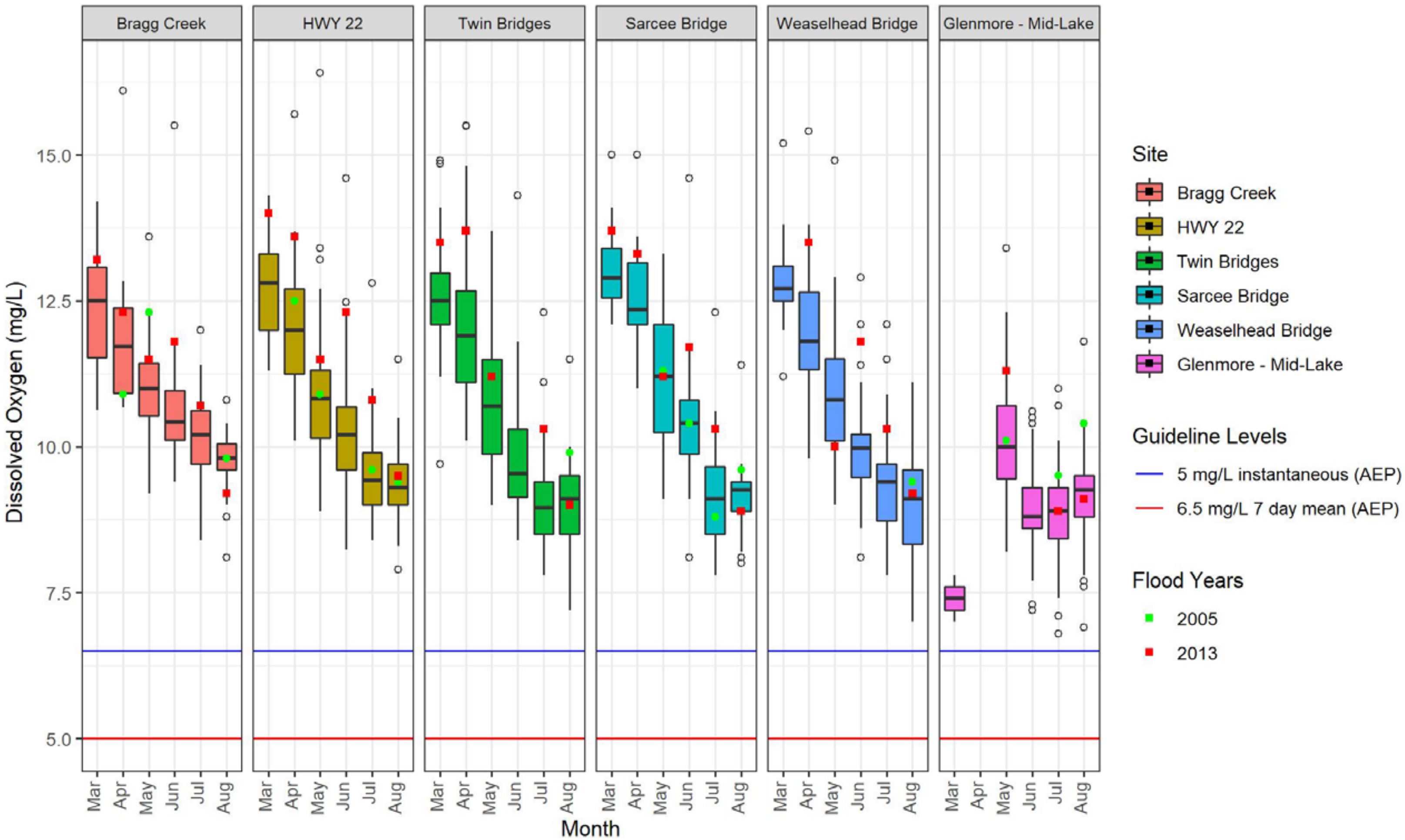
NOTE: red symbols represent maximum concentrations during the 2013 flood year

Figure IR308-18 Total Zinc in the Upper Elbow River Mainstem Sites and at Glenmore Dam from 1979 to 2016



NOTE: blue, green and red symbols represent maximum concentrations during 1995, 2005 and 2013 flood years

Figure IR308-19 Temperature in the Upper Elbow River Mainstem Sites and at Glenmore Dam from 1979 to 2016



NOTE: green and red symbols represent maximum concentrations during 2005 and 2013 flood years

Figure IR308-20 Dissolved Oxygen in the Upper Elbow River Mainstem Sites and at Glenmore Dam from 1979 to 2016

REFERENCES

CCME (Canadian Council of Ministers of the Environment). 2018a. Canadian Water Quality Guidelines for the Protection of Agriculture: Irrigation and Livestock. Website accessed October 2018. http://st-ts.ccme.ca/en/index.html

CCME. 2018b. Canadian Water Quality Guidelines for the Protection of Aquatic Life. Website accessed October 2018. http://st-ts.ccme.ca/en/index.html

Question 309

Volume 3B, Section 7.4.2, Page7.21

Alberta Transportation stated that *It is anticipated that these suspended sediment concentrations during the last few days of the discharge can be controlled with the low-level outlet gate operation (i.e. reducing flow rate) and, possibly, also with sediment and silt fences. Without further mitigation the resulting increase in the Elbow River of suspended sediment concentrations is likely to exceed the Canadian Water Quality Guideline.*

a. What is the level of reduction that the mitigation controls have to accomplish to avoid exceeding the guidelines and the level that would be achieved by proposed controls?

b. What is the uncertainty of meeting those reductions?

Response 309

a. Upon release of retained water from the off-stream reservoir, predicted total suspended solids (TSS) concentrations will range from 1,798 mg/L (1:10 year flood) to 20,692 mg/L (1:100 year flood); however, this is well below the predicted peaks for floods that occur without the Project in place: 4,818 mg/L (1:10 year flood), 77,649 mg/L (1:100 year flood), and 139,682 mg/L (design flood).

   Water will be released from the off-stream reservoir after the water flow in Elbow River has subsided; predicted peak and average TSS concentrations at the confluence of the unnamed creek with Elbow River and 1 km downstream (the extent of modelling) of the confluence are presented in Table IR309-1, which is a summary of key information from Volume 3B, Section 6, Table 6-7, Table 6-8 and Table 6-9).

   The assessment of Project residual effects on surface water quality is based on the release of water from the reservoir without mitigation measures. The assessment concluded that effects from the predicted sediment concentrations are not significant. Given that significant effects are not predicted, the primary sediment control measure is to control the release rate through the outlet gates; other measures are not necessary.

A general description of the release criteria is in Volume 3B, Section 6.4.1.4, page 6.17.

Table IR309-1 Total Suspended Sediment Concentrations at the End of the Release Period of Water from the Off-Stream Reservoir

	At the Confluence of Elbow River and the Unnamed Creek		Elbow River 1 km Downstream from the Confluence with the Unnamed Creek	
Flood	**Peak**	**Average**	**Peak**	**Average**
1:10 year flood	1,798 mg/L	1,657 mg/L	99 mg/L	81 mg/L
1:100 year flood	20,692 mg/L	7,285 mg/L	4,704 mg/L	1,576 mg/L
Design flood	17,955 mg/L	2,173 mg/L	5,666 mg/L	754 mg/L

b. There will be uncertainty around the effectiveness of the mitigation due to the variability in site-specific conditions in the off-stream reservoir and in the river at the time of a particular release (e.g., weather, concentrations of TSS in the river, flow rate in the river, deposition pattern of sediments in the reservoir, sediment particle size and erosion locations). These site-specific conditions will also determine when water will be released from the reservoir and back into the river.

Table IR309-2 lists the applicable guidelines that will be used in controlling the outlet gate to manage suspended sediments in the receiving waters of Elbow River.

Table IR309-2 Water Quality Guidelines for the Protection of Aquatic Life

Parameter	Guideline Value
Suspended Sediments: Clear Flow	• Maximum increase of 25 mg/L form background levels for any short-term exposure (e.g., 24-hour period). • Maximum average increase for of 5 mg/L from background levels for longer term exposure (e.g., inputs lasting between 24 h and 30 d).
Suspended Sediments: High Flow	• Maximum increase of 25 mg/L from background levels at any time when background levels are between 25 and 250 mg/L. • Should not increase more than 10% of background levels when background is greater than 250 mg/L.
SOURCES: GoA 2018; CCME 1999	

REFERENCES

CCME (Canadian Council of Ministers of the Environment). 1999. Canadian Water Quality Guidelines for the Protection of Aquatic Life: Total Particulate Matter. Updated 2002. Winnipeg.

GoA (Government of Alberta). 2018. Environmental Quality Guidelines for Alberta Surface Waters. Water Policy Branch, Alberta Environment and Parks, Edmonton.

Question 310

Volume 3B, Section 7.4.3, Page 7.24
Volume 4J, Section 2.4.2, Page 2.37

Alberta Transportation states that in the proposed reservoir *Dissolved oxygen can be consumed by retained water because of organic matter decomposition, if the residence time and weather conditions create suitable conditions for decomposition to occur.* In addition Alberta Transportation states that *flows in the Elbow River needed to be less than 20 m3/s before release could occur. This threshold was based on a maximum design release rate of 27 m3/s and the effective discharge for suspended sediment transport of between 35 and 50 m3/s.* Given the potential for lengthy detention in the reservoir that could include summer there is a potential for an anoxic water condition to be created that could promote the release of metals and nutrients from the bottom sediments.

a. **Explain how anoxic conditions might affect water quality in the reservoir and further downstream during post flood release into the Elbow River.**

Response 310

a. Due to low biochemical oxygen demand (BOD), low sediment oxygen demand (SOD) and the influence of wind mixing and shallow water levels, oxygen concentrations in the off-stream reservoir are not predicted to become anoxic; changes in dissolved oxygen are expected to be smaller than currently observed in Glenmore Reservoir (Volume 3B, Section 7.4.3).

   If low oxygen conditions in the off-stream reservoir occur prior to release of water from the reservoir, these levels will be attenuated as water is released into the unnamed creek, which has a gradient of greater than 0.8 % over the lower 2 km before the confluence with the Elbow River (Volume 4, Appendix J, Section 3.3, Page 3.5). Turbulence—generated by energy dissipater blocks and stream channel roughness through the unnamed creek—is predicted to aerate water as energy is dissipated before it enters the river.

   Median summer dissolved oxygen concentrations in Elbow River are just above and below aquatic life guideline levels (9.5 mg/L, CCME 2018) at Highway 22 and Twin Bridges, respectively. Effects in Elbow River from low oxygen are predicted to be localized and temporary because of rapid aeration of water in the river.

REFERENCES

CCME (Canadian Council of Ministers of the Environment). 2018. Canadian Environmental Quality Guidelines website. Accessed September 2018 at http://ceqg-rcqe.ccme.ca/en/index.html

Question 311

Volume 3B, Section 7.4.3, Page 7.24

Alberta Transportation indicated that *The amount of organic material available for decomposition is lower than in many studied wet reservoirs and shallow lakes.*

a. What, specifically, is the amount of organic material used for this comparison?

Response 311

a. The sentence quoted (Volume 3B, Section 7.4.3, page 7.24) in the preamble, "The amount of organic material available for decomposition is lower than in many studied wet reservoirs and shallow lakes" should be revised to read: "The amount of organic material available for decomposition is lower than in two studied wet reservoirs and shallow lakes."

   The wet reservoirs and shallow lakes include reported research literature on a prairie chained river-lake system in the Qu'Appelle River watershed, Saskatchewan (i.e., Terry et al. 2017; Akomeah and Lindenschmidt 2017). Specific organic matter levels were not reported in these studies; however, the system has organic inputs not found in Elbow River, including two upstream municipalities with sewage discharges (Moose Jaw and Regina). Based on these inputs and that the shallow lakes in the Qu'Appelle River watershed were reported to be hyper-eutrophic, organic material would be expected to be comparably higher than found in the Elbow River.

   As stated, the studies referred to above refer to wet reservoirs, whereas the off-stream reservoir will only hold water temporarily and infrequently (approximately 1:10 year). Therefore, effects of organic material on water quality in the off-stream reservoir are not expected.

REFERENCES

Akomeah, E. and K.E. Lindenschmidt. 2017. Seasonal Variation in Sediment Oxygen Demand in a Northern Chained River-Lake System. Water, 9(4), p.254.

Terry, J.A., A. Sadeghian and K.E. Lindenschmidt. 2017. Modelling Dissolved Oxygen/Sediment Oxygen Demand under Ice in a Shallow Eutrophic Prairie Reservoir. Water, 9(2), p.131.

Question 312

Volume 3B, Section 8.2.2.1, Page 8.6

Alberta Transportation states *The increase in bed stability and stable flows can result in the growth of aquatic macrophytes, which can improve habitat.*

a. Provide support for your statement that an increase in aquatic macrophytes can improve habitat (in the Elbow River). Or remove if unsupportable in regard to the Elbow River.

Response 312

a. The statement in the preamble is missing the original context provided in Volume 3B, Section 8.2.2.1:

> "Lateral channel migration promotes habitat diversity and can be negatively affected by flow impoundment (Sheilds et al. 2000), as might occur upstream of the diversion structure during diversion. This could affect shallow side-channel and nearshore rearing habitats. The increase in bed stability and stable flows can result in the growth of aquatic macrophytes, which can improve habitat, but can also restrict fish spawning habitat, and fish and invertebrate access to clean substrates."

To further clarify, changes in local hydrology near the diversion structure may constrain lateral channel movement and decrease habitat variability. Altered stream flows and a subsequent reduction in bed scouring during post-flood conditions may allow macrophytes and aquatic vegetation to root in localized low flow and backwater areas. Aquatic vegetation may provide habitat not commonly found in Elbow River; cover and shade are provided around the margins of vegetated patch's where dissolved oxygen (DO) and temperatures are suitable and thus have a positive effect. However, as stated in Section 8.2.2.1, macrophytes and aquatic vegetation can also have negative effects when they alter existing habitat and features important for resident species (i.e., spawning gravels).

High and low flow velocity patterns near the diversion structure will remain similar with upstream and downstream sections of the river. Affected habitat is mostly run habitat with some riffle and pool habitat. Reach 2 has primarily run habitat (85% R3 channel unit with depths between 0.3 and 0.75 m, 12% R2 channel unit with depths between 0.75 and 1.0 m, and a few small shallow pools). Reach 3 has continuous run habitat (45% R2 channel unit, 40% R3 channel unit and 10% riffle channel unit and 5% small shallow pools). The habitat in this reach does not appear to be limiting habitat and is common in the river. Any changes that result in the growth of vegetation will be localized, small in magnitude and not result in habitat changes that would cause an effect on resident fish populations.

Question 313

Volume 3C, Section 2.6, Page 2.7

Alberta Transportation identified that *Following a flood that results in the diversion of water to the reservoir and prior to discharge from the reservoir, water samples will be collected at the low-level outlet channel and analyzed….*

a. Approximately how many samples will be taken?

b. Will samples also be taken periodically from the outflow during post-flood discharge from the reservoir? If so, explain whether a datasonde might be installed for continuous monitoring of turbidity; pH, conductivity, DO, and temperature.

c. The parameter list for water sample analysis is missing TKN.

Response 313

a-c. Water quality monitoring will be done in the off-stream reservoir prior to the release of water and in the unnamed creek. Details of the monitoring plan are provided the Surface Water Monitoring Plan (see the response to IR302, Appendix IR302-1; refer to Section 9.3.3 [Turbidity and Suspended Solids] and Section 9.3.7 [Water Quality]).

Question 314

Volume 3D, Section 3-1, pg. 3.16

Alberta Transportation stated that *The magnitude of the effect is anticipated to be from low to high. The high magnitude effect is related to high suspended sediment concentrations in the Elbow River at the end water release.*

a. Comment on whether this also applies to the parameters that behave in similar fashion to TSS.

b. Comment on the potential implications of the high magnitude effect on downstream water users.

Response 314

a. The quote in the preamble states that increasing suspended sediments at the end of water release is predicted to be of high magnitude effect on water quality. However, the effect on water quality is expected also to be reversible and short-term. The Project will result in a high magnitude reduction in sediment loading on Elbow River and Glenmore Reservoir; consequently, there will be a similar reduction in the loading of sediment associated parameters.

The high magnitude effect for sediment is short term and reversible during the "end water release" described in Volume 3B, Section 6.4.3, page 6.25 through page 6.51. The sediment loading associated with this short-term increase will be small because most of the sediment will settle and remain in the off-stream reservoir as follows:

- For the design flood, 98% of sediments will settle and remain in the reservoir and not return to the river; approximately 2% of the sediment will return to the river.
- For the 1:100 year flood, 88% of sediments will settle and remain in the reservoir and not return to the river; approximately 12% of sediment will return to the river.
- For the 1:10 year flood, 95% of sediment will settle and remain in the reservoir and not return to the river; approximately 5% of sediment will return to the river.

Parameters associated with suspended sediments are predicted to have a small, short-term increase in concentration when water is released back into Elbow River (Volume 3B, Section 7.4.2., pages 7.22 to page 7.23). Metals and nutrient loading associated with suspended sediments will increase with TSS; however, based on the small proportion of sediment returning to the river, the loading of these associated parameters is predicted to be equally small. These parameters are attached to sediment, which means they will not be readily bioavailable.

The magnitude of effect from parameters associated with suspended sediment is considered low (Volume 3B, Section 7.4.2., page 7.22 to page 7.23); duration is short and infrequent, limited to a flood periodicity of 1:10 year and reversible.

b. The Project will have a substantial benefit, during and after diversion, to the quality of the drinking water supplied to the City of Calgary during a flood by reducing the total suspended solids (TSS) load entering the Glenmore water treatment plant (Volume 3B, Section 15.4.2.3, page 15.20).

There are no effects predicted on downstream water users. During the 2013 flood in Calgary, boil-water advisories were avoided for municipal waters from the Glenmore Reservoir due to earlier investments in water treatment infrastructure. Therefore, a flood similar in magnitude to the 2013 flood in Calgary would have a very low probability of needing mitigation to protect drinking water quality (Volume 3B, Section 15.4.2.2, page 15.19).

The Project will result in a substantial decrease in TSS load (i.e., volume of sediment) entering Glenmore Reservoir and the Glenmore water treatment plant during flood (see Table IR314-1) and post-flood conditions. For example, without diverting the flood water to the off-stream reservoir (i.e., without the Project), water from Elbow River entering Glenmore Reservoir would contain unmitigated concentrations of TSS. However, with the Project (during flood operations) most of the TSS in the off-stream reservoir would settle to the bottom and only a fraction of the sediment would resuspend and re-enter Elbow River.

Table IR314-1 Mass of Suspended Sediments Diverted during each of the Three Flood Scenarios (from Table 6-6; Volume 3B, Section 6.4)

Flood	Diversion time	Elbow River TSS mass without diversion (kt)	Accumulated TSS in Reservoir with diversion (kt)	Elbow River TSS mass reduction (%)	TSS mass released into Elbow River (kt)
Design	3.75 days	4,819	2,389	50	90
1:100 year	1.80 days	1,943	1,268	65	220
1:10 year	0.38 days	24	1.3	5	1.1

Question 315

Volume 4, Appendix K, Section 3.2.2.2, Figure 3-24, Pages 3.34. and 3.35

Alberta Transportation stated that *Temperature COVs were generally greatest during the winter months [...] temperatures are most variable during the winter.* However, the figure shows a lower variability during winter. The COV could be affected by the mean temperature close to zero during winter.

a. Confirm that winter is the season with highest temperature variability.

Response 315

a. It is correct that the coefficient of variation (COV) appears to be affected by the mean temperature close to zero during winter. Variability is relative to the mean and, at low temperatures, small variations in measurements due to equipment or environmental factors can be relatively large, as a percentage change, but small in absolute terms.

Variability presented as COV is greatest at lower temperatures during the winter (i.e., winter was defined as December through February when water temperatures are lowest). Variability in absolute terms (i.e., change in temperature in degrees Celsius) is greatest in spring and fall. Median, mean and standard deviations for monthly temperature at three locations in Elbow River closest to the Project are provided in Table IR315-1. Temperatures are lowest during the three winter months and, with the exception of March at Sarcee Bridge, standard deviations are lowest in winter months as well.

Table IR315-1 Monthly Temperature Values (Median, Mean and Standard Deviation) for Elbow River at Bragg Creek, Highway 22 and at Sarcee Bridge.

Site	Month	Number of Measurements	Median	Mean	Standard Deviation
Bragg Creek	Jan	14	0.2	0.3	0.30
	Feb	11	0.2	0.3	0.36
	Mar	15	0.8	1.2	1.46
	Apr	37	2.4	2.9	1.78
	May	128	6.2	5.5	2.23
	Jun	120	7.7	7.4	1.54
	Jul	93	9.6	9.7	1.56
	Aug	24	10.4	10.6	1.44
	Sep	20	8.5	8.3	1.83
	Oct	14	5.7	5.2	1.77
	Nov	11	3.0	2.4	1.49
	Dec	11	0.4	0.5	0.42
HWY 22	Jan	32	0.3	0.3	0.35
	Feb	33	0.2	0.3	0.36
	Mar	39	0.5	0.6	0.60
	Apr	68	1.3	1.9	1.71
	May	142	5.8	6.0	2.47
	Jun	141	8.3	8.2	2.08
	Jul	112	11.3	11.1	2.02
	Aug	43	11.9	12.1	1.50
	Sep	40	8.9	8.9	1.98
	Oct	41	5.6	5.3	2.25
	Nov	31	1.2	1.6	1.41
	Dec	29	0.2	0.3	0.37

Table IR315-1 Monthly Temperature Values (Median, Mean and Standard Deviation) for Elbow River at Bragg Creek, Highway 22 and at Sarcee Bridge.

Site	Month	Number of Measurements	Median	Mean	Standard Deviation
Sarcee Bridge	Jan	17	0.1	0.3	0.39
	Feb	17	0.0	0.4	0.60
	Mar	79	0.6	0.6	0.44
	Apr	117	3.0	3.3	2.17
	May	117	7.4	6.9	1.99
	Jun	147	10.3	10.4	2.24
	Jul	145	13.0	13.1	2.18
	Aug	139	13.0	13.1	2.05
	Sep	113	9.3	9.3	2.45
	Oct	111	6.0	5.5	2.02
	Nov	78	1.9	2.1	1.78
	Dec	31	0.3	0.4	0.53

Question 316

Volume 4, Appendix K, Section 3.2.2.3, Page 3.37.

Alberta Transportation states that *dissolved ortho phosphate…and dissolved sodium concentrations have no apparent seasonal patterns…these parameters are, therefore, the most different from TSS.* However, dissolved phosphorus was found to behave similar to TSS.

a. Discuss this apparent inconsistency and the confidence of each result based partially on the number of samples.

Response 316

a. The statement in Volume 4. Appendix K, page 3.37 is not correct that dissolved orthophosphate has a seasonal pattern different than total suspended solids (TSS). In fact, data for dissolved orthophosphate showed no seasonal or spatial pattern, as shown in Volume 4, Appendix K, Section 3.2.2, Table 3-1.

The high seasonal variation metric for dissolved orthophosphate is an artifact of unique limitations in the dataset for this parameter. Table 3-1 Identifies how closely parameter variability is associated with TSS variability (i.e., variation pattern [seasonal variability metric (SVM) distance from TSS]), seasonal pattern and spatial pattern.

Historical dissolved orthophosphate data for Elbow River are limited to samples analyzed in 1979, from two locations (Highway 22 and Twin Bridges). The analytical results for these samples were either below the method detection limit or within five times the detection limit (i.e., the practical quantitation limit [PQL]). A single analysis had a higher value result from a sample collected on March 3, 1979 from Elbow River and Highway 22.

A parameter in a water quality sample will be reported as present if the concentration is at or above the analytical method detection limit; however, the parameter data distribution cannot reasonably be understood until the concentration is at or above the PQL. Consequently, data less than the PQL generally has low variability (i.e., analytical results appear to reflect the detection limit rather than a natural distribution), has high uncertainty and has an ambiguous distribution. This can result in bias (i.e., the tendency to imply the concentration is higher than is actually occurring), which will influence subsequent calculations or statistical results using this data.

Historical data for dissolved phosphorus was collected from more sites, covered a longer time period, and was more variable than data for orthophosphate (Volume 4, Appendix K, Section 3.2.2, Figure 3-5, page 3.15). Seasonal dissolved phosphorus data is available from the City of Calgary from between 1993 and 2015 and AEP between 1988 and 2015. The data are available from samples collected at six sites. Therefore, the results for the seasonal variation metric for dissolved phosphorus are more reliable than orthophosphate.

In summary, orthophosphate data appeared to be influenced by a large number of censured data (i.e., analytical water quality results at or below detection limits) and the seasonal variation metric seems to be an anomaly.

However, the seasonal variation metric result for dissolved phosphorus is based on a robust dataset and confidence in this result is high.

Question 317

EIS Summary, Section 6.6.2.1, Page 6.29

Alberta Transportation identified that *Construction activities could change sediment concentrations, water temperatures, […], nutrient concentrations.*

a. Missing is a comment on water temperature and nutrient concentrations; only sediment concentration was provided. Provide this missing comment.

Response 317

a. The discussion in the EIS Summary, Section 6.6.2.1, page 6.29 is complete.

As discussed in Volume 3A, Section 8.4.4.1 (Permanent Alteration of Fish habitat, page 8.56 and page 8.57), construction-related temperature and nutrient effects will be mitigated and not cause a residual effect. Therefore, the pathway that includes temperature and nutrients is not in the list of considerations.

Question 318

Volume 1, Section 3.6.1, Table 3-10, Page 3.37

Alberta Transportation indicates the plans for sediment removal as *Off-stream reservoir - partial removal of sediment so that water flow is not blocked Low level outlet works - removal of debris and sediment from the outlet components to the degree required to maintain optimal functionality.*

a. How would the remaining sediment be flushed under non-extreme peak flows and affect water quality downstream?

Response 318

a. Post-flood maintenance activities will not include flushing sediment from the off-stream reservoir into Elbow River. Sediment will be left in-place in the off-stream reservoir but moved or recontoured in the reservoir so that the functionality of water flow into and out of the reservoir is maintained and also to maintain the integrity of the off-stream dam.

Question 319

<u>Volume 3A, Section 7.1.4, Page 7.6</u>

Alberta Transportation indicated that *The regional assessment area is used to evaluate potential cumulative changes to watercourses resulting from the Project and other development in the watershed; it encompasses the Elbow River watershed from its headwaters to Glenmore Dam.* The RAA does not include the Bow River but Section 3.5.2 [H] of the terms of reference states *Describe any potential cumulative effects in the Bow River and the implications to the WQMF and regional initiatives such as the Bow River Phosphorus Management Plan.*

a. Describe any potential cumulative effects in the Bow River as required by the Terms of Reference.

Response 319

a. Cumulative effects on surface water quality are described in Volume 3C (Section 1.2.3, page 1.22 and Section 1.3.4., page 1.78). In those sections, it is shown that Project residual effects on water quality in Elbow River and Glenmore Reservoir are negligible and will not extend beyond the RAA. During a flood, a large proportion of sediment originating in Elbow River will be retained in the off-stream reservoir (Volume 3B, Section 7.4.2, page 7.23); consequently, sediment bound nutrients and related parameters will also remain in the reservoir. This will reduce the overall load on Elbow River downstream of the Project and Glenmore Reservoir. Changes in Elbow River and Glenmore Reservoir are not predicted and, therefore, pathways for effects further downstream in the Bow River are not valid.

   Interactions between residual effects from the Project and residual effects from other proposed activities in the RAA are not predicted. Changes to water quality trigger levels, including phosphorus, as described in ESRD (2014), and the Bow River Phosphorus Management Plan (GOA 2014) are not predicted to occur.

   Therefore, the Project will not affect how the Water Quality Management Framework and the Bow River Phosphorus Management Plan will be implemented.

REFERENCES

GOA (Government of Alberta). 2014. Bow River Phosphorus Management Plan. Edmonton, AB. 42 pages

ESRD (Alberta Environment and Sustainable Resource Development). 2014. South Saskatchewan Region: Surface Water Quality Management Framework for he Mainstem Bow, Milk, Oldman and South Saskatchewan River (Alberta). Edmonton, AB. 66 pages.

Question 320

Volume 3A, Section 7.4.2.1, Page 7.14

Alberta Transportation states that *Water withdrawals for dust suppression and other construction needs can be required and can affect downstream water quality by decreasing assimilative capacity. Volumes for these withdrawals are not known yet. Given that any water withdrawal during construction will be short term and of relatively small quantity, no effects to downstream assimilative capacity are anticipated, and therefore, this effect pathway is not discussed further.*

a. Indicate what a relatively small quantity means.

b. What are potential implications if the construction happens during a drought year?

Response 320

a-b. Initial plans suggested sourcing water from Elbow River for dust suppression and construction needs as a possible option; however, this option for sourcing water is no longer included. The preferred option to source water for dust suppression and other construction needs will be to have it hauled in from a third-party local permitted supply.

Question 321

Volume 3A, Section 7.4.2.2, Page 7.15

Alberta Transportation states that *Suspended sediment concentrations will be monitored upstream and downstream of instream construction activities. […] Should an unacceptable increase in suspended sediment concentrations occur, it would be mitigated immediately or the work halted until mitigation is in place.*

a. What would be considered an unacceptable increase in suspended solids?

Response 321

a. Unacceptable increase in suspended solids will be as described in *Clause 1.7- Compliance Criteria of the Turbidity Barriers and Monitoring, Section 02242* of the Civil Works Master Specifications for Construction of Provincial Water Management Projects (Volume 4, Supporting Documentation, Document 9). These criteria are set by GoA (2018), which are based on CCME (2002, 2018), and are listed in Table IR321-1.

Table IR321-1 Suspended Sediment Criteria

Site Conditions (Background TSS)	Exceedance Levels (TSS in Excess of Normal Background Levels)
TSS < 25 mg/L	• A maximum instantaneous increase of 25 mg/L over background levels at any time. • An average increase of >5 mg/L over background levels for more than 24 hours.
TSS 25 mg/L – 250 mg/L	• A maximum instantaneous increase of 25 mg/L from background levels at any time.
TSS > 250 mg/L	• A maximum instantaneous increase of 10% of background levels at any time.

REFERENCES

CCME (Canadian Council of Ministers of the Environment). 2002. Canadian water quality guidelines for the protection of aquatic life: Total particulate matter. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

CCME. 2018. *Canadian Environmental Quality Guidelines website*. Available at: http://ceqg-rcqe.ccme.ca/en/index.html. Accessed November 2018.

GoA (Government of Alberta). 2018. Environmental Quality Guidelines for Alberta Surface Waters. Water Policy Branch, Alberta Environment and Parks, Edmonton, Alberta.

Question 322

<u>Volume 3A, Section 7.6, Page 7.18</u>

Alberta Transportation indicated that *Prediction confidence in the effect of herbicide application during dry operations on water quality is moderate.*

a. Describe the herbicides monitoring plan.

Response 322

a. Details of herbicide monitoring as it pertains to surface water monitoring are provided the Surface Water Monitoring Plan (See the response to IR302, Appendix IR302-1; Section 9.3.5, Page 9.12 [Herbicide Monitoring]).

Question 323

Volumes 3A, Section 7.2.2, Pages 7.10
Volume 3B, Section 7.5, Page 7.10
Volume 4, Appendix K, Section 3.1, Page 3.1
Volume 4, Appendix K, Section 2.2.4.4, Page 2.18

Alberta Transportation states that *Concentrations of some parameters increased between 1979 and 1997.*

Alberta Transportation also states that *A statistical trend analysis of long-term water quality patterns was not completed because the data available was not appropriate for this type of analysis.*

This trend analysis uses data over 20 years old. The City of Calgary has up to date water quality data.

a. Are there any new water quality trends in this watershed?

b. Are the concentrations increasing at similar rates?

Response 323

a. The statement, "Concentrations of some parameters increased between 1979 and 1997" is based on Sosiak (1999). For clarification, Alberta Transportation has used water quality data sourced from the AEP water quality database and the City of Calgary (the City) water quality database, which includes data up to 2015 (see Volume 4, Appendix K, Section 2.2.1).

   Water quality data for the upper Elbow River mainstem and Glenmore Reservoir were not statistically analyzed to identify trends. Determining a statistically reliable long-term trend and characterize variability requires the availability of continuous sampling data. Such data are not available from AEP or City water quality databases. These databases, rather, are characterized by irregular sampling and small sample sizes. Thus, the available data are snapshots of variability and are not suited to determined long term trends. However, a seasonal variation metric (SVM) is calculated for parameters with sufficient site data: monthly water quality data at a sufficient number of sample sites to calculate 20 coefficients of variation used to derive the SVM (Volume 4, Appendix K, Section 3.2, page 3.7).

   The seasonal variation metric results for 30 parameters are compared with total suspended solids (TSS) to determine how closely these parameters reflected TSS seasonal patterns. The results for this analysis are provided in Table 3-1 (Volume 4, Appendix K, Section 3.2.2).

Water quality is visually displayed using box and whisker plots to identify spatial patterns from upstream to downstream, and interpretations of the visual assessment are provided in Volume 4, Appendix K, Section 3, Table 3-1.

b. Sosiak (1999) discussed temporal trends observed for dissolved phosphorus, turbidity, fecal and total coliforms. Data from the City of Calgary is included in the dataset and the surface water quality analysis; however, the long-term dataset is considered not suitable to determine if trends identified by Sosiak (1999) have continued to the present (Volume 4, Appendix K, Section 2.2.4.4 page 2.18). The available data is not continuous, is highly variable and subject to complex hydrological processes; irregularly sampled and small datasets are not suitable for long-term trend analysis.

Based on the SVM assessment (Volume 4, Appendix K, Section 3, Table 3-1), dissolved phosphorus had a seasonal pattern similar to TSS (increasing in spring and summer), but it did not appear to exhibit a spatial pattern from upstream to downstream. Total coliforms appeared to have a seasonal pattern similar to TSS, as well increasing in spring and summer and showing an increase in concentrations from upstream to downstream. The fecal coliform seasonal variation only moderately reflected the TSS seasonal pattern, but fecal coliform does increase from upstream to downstream.

REFERENCES

Sosiak, A. 1999. Evaluation of recent trends in water quality in the Elbow River upstream from Glenmore Reservoir. Water Sciences Branch, Water Management Division, Natural Resources Service, Alberta Environment. W9907.

Question 324

Volumes 3A, Section 7.2.2, Page 7.10
Volume 3B, Section 7.2.2, Page 7.5

Alberta Transportation states that *These changes were potentially related to runoff from livestock wintering areas and seepage from septic fields. And -non-point source runoff from agriculture, recreation and residential development upstream of the City of Calgary; - urban runoff that is conveyed to the Elbow River and Glenmore Reservoir.*

a. Provide a map of current land uses.

b. Identify and map the main non-point sources in the RAA.

Response 324

a. A map of current land uses in the RAA is presented in Volume 3A, Section 6.2.2.3, Figure 6-7. A map of current land uses near the PDA is presented in Volume 1, Section 1.3.2.1, Figure 1-7.

b. A discussion of non-point sources in the RAA is provided in Volume 3A, Section 7.2.2 and Volume 4, Appendix K, Section 3.1. Volume 3A, Figure 6-7 shows a map of land uses in the RAA and identifies areas where non-point source runoff such as agricultural or urban runoff are likely to occur; however, no specific map of non-point source locations in the RAA is provided.

Question 325

Volume 3B, Section 7.4.1.1, Page 7.19
Volume 3B, Section 7.1.1.5; Table 7.1, Page 7.4

Alberta Transportation stated that *The assessment of change in suspended sediment associated parameter concentration is based on existing conditions data analysis on which parameters behave like suspended sediment and the sediment transport modeling results.*

Table 7-1 indicates that the measurable parameters to assess potential environmental effects is relevant water quality and sediment quality parameters such as total phosphorus in mg/L; however, the assessment did not report the effects on the sediment related parameters on those terms.

a. Report the effects on sediment related parameters as the potential increase in concentration (e.g. mg/L) due to the Project and implications for the water uses.

Response 325

a. Data is not available to quantitatively predict an increase in concentration of sediment-related parameters; however, parameters associated with suspended sediments are predicted to increase in value, similar to total suspended solids (TSS) when water is released back into Elbow River (Volume 3B, Section 7.4.2, page 7.22 and page 7.23) and loading into the river will be small.

Most sediments and, consequently, sediment-related parameters, will settle into the bottom of the off-stream reservoir and only a small portion will be returned to the river, as follows:

- design flood, 1.8% of suspended sediment will be returned to the river
- 1:100 year flood, 11.7% of suspended sediment will be returned to the river
- 1:10 year flood, 4.6% of suspended sediment will be returned to the river

Any sediment-related parameters that are released with suspended sediments will be equally small. Furthermore, these constituents will be sediment bound (i.e., meaning they will not be readily bioavailable) and, therefore, effects will be minimal (Volume 3B, Section 7.4.2, page 7.23).

Effects on drinking water are not predicted. During the 2013 flood in Calgary, boil-water advisories were avoided for municipal waters from the Glenmore Reservoir due to earlier investments in water treatment infrastructure. Therefore, a flood similar in magnitude to the 2013 flood in Calgary would also have a very low probability of requiring mitigation to protect the drinking water quality (Volume 3B, Section 15.4.2.2, page 15.19).

The magnitude of effect from parameters associated with suspended sediment is considered low (Volume 3B, Section 7.4.2., pages 7.22 and 7.23), duration is small and infrequent and limited to the flood periodicity greater than 1:10 year flooding, and reversible.

Question 326

Volume 3B, Section 7.4.1.3, Page 7.20

Alberta Transportation indicated that *Methylmercury concentration in diverted water into the reservoir is assumed to be zero because methylmercury concentrations during a flood are not known and existing conditions data indicates that total and dissolved mercury concentrations in the river are low.* A methylmercury concentration equal to zero is an inappropriate assumption.

a. Estimate the median methylmercury background concentration at high flows and recalculate the effects using that concentration.

Response 326

a. Mercury data from Elbow River was collected by the following:

- Samples collected in 2016 at Highway 22 and Elbow River were analyzed for total and dissolved mercury; reported concentrations were below analytical detection limits (Volume 4, Appendix K, Attachment A, Table A-1).
- Total mercury analysis in historical data from AEP was limited to a single value from 1988.

Water data distributions are assumed to be lognormal (Helsel and Hirsch 2002). Depending on how water chemistry data are distributed, the shape and symmetry of the lognormal curve can vary. However, based on how data are distributed above the reported detection limit, the distribution of censured data (i.e., values below the analytical detection limit) can be inferred.

When most, or all, of the data are censured, it is assumed the distribution will still be lognormal. Due to the potential flexibility in the curve, mean and standard deviation will be impossible to infer. However, if it is assumed the distribution is symmetrical, arranged between zero and the reported detection limit. Percentiles can be estimated and the median will be roughly half the detection limit.

Total mercury analysis results for samples collected from the Elbow River (ER H22) in 2016 were below detection limit of 0.005 µg/L. Using the logic described above, a lognormal distribution for data from the Elbow River between 0 and 0.005 µg/L implies that the median value is approximately 0.003 µg/L.

Because there are no total mercury analysis results above the reported detection limit, the assumption is that the maximum value in the distribution is conservative. Thus, the median total mercury values estimated here are likely higher than actual values.

In surface water, methylmercury is generally an order of magnitude lower in concentration than total mercury. Ratios of methylmercury to total mercury reported by Balogh et al. (2005), Dittman et al. (2010), Schuster et al. (2008) and Shanley et al. (2008) ranged between 1% and 15%. Higher ratios are associated with watersheds having a higher proportion of landcover in wetland habitat. Using a conservative methylmercury-to-total mercury ratio of 15%, and median total mercury concentrations estimated as 0.003 µg/L, the estimated methylmercury concentration in the Elbow River is 0.0004 µg/L.

Based on predictions in Volume 3B, Section 7.4.4, page 7.29 regarding methylmercury flux between soil and off-stream reservoir water, and a starting water concentration of 0.0004 µg/L, updated predictions for methylmercury concentrations in the reservoir associated with the three floods are as follows:

- design flood, 0.00068 to 0.0017 µg/L
- 1:100 year flood, 0.0008 to 0.0024 µg/L
- 1:10 year flood, 0.00085 to 0.0024 µg/L

These estimated low and high methylmercury concentrations are conservative and the potential upper limits of these concentration are based on analytical detection limits. The upper limits for the 1:100 year and 1:10 year floods are above the Alberta Environmental Quality guidelines (0.001 µg/L [chronic] and 0.002 µg/L [acute]; GoA 2018); however, these estimated concentrations are below the Canadian Council of Ministers of the Environment (CCME) Canadian Water Quality Guideline for the Protection of Aquatic Life (0.004 µg/L, CCME 2003).

REFERENCES

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Question 327

Volume 3B, Section 7.4.2, Page 7.23

Alberta Transportation indicated that *The extent of nutrient release from the reservoir is dependent on water residence time [...]*

a. Provide the residence time used for this assessment and justify why that number was chosen.

Response 327

a. The residence times for retained flood water in the off-stream reservoir are presented in in the response to IR 283, Table IR283-1. Flow in Elbow River must be less than 20 m^3/s to accept a maximum release rate from the reservoir of 27 m^3/s and have flows in the river remain below 47 m^3/s. This operational condition will minimize sediment resuspension in Elbow River downstream of the unnamed creek.

The time it takes for Elbow River flow to decrease to 20 m^3/s depends on the shape of the river's hydrograph; the greater the declining slope after the peak, the faster the river returns to a flow of 20 m^3/s. The hydrographs used to model each flood are derived as follows (Volume B, Appendix J, Section 2.4.2, Page 2.31):

- The design flood scenario is derived from the 2013 flood and seasonal flow hydrograph.
- The 1:100 year flood is modelled using the Hydrologic Engineering Center Hydrological Modeling System (HEC-HMS) model and the 1:100 year precipitation and runoff excess as a volumetric time series.
- The 1:10 year flood is based on the 2008 flood and seasonal flow hydrograph.

Figure IR327-1 presents the hydrographs. The 2013 hydrograph used to model the design flood is more "peaky" than the hydrograph used to model 1:100 year flood. In other words, flows in Elbow River return to normal much faster for the design flood than for the 1:100 year flood. Therefore, for a design flood, water can be released back to Elbow River in 20 days rather than the 43 days needed for the 1:100 year and 1:10 year floods.

The actual operational release rates from the off-stream reservoir will vary depending on the circumstances at the time of the diversion and the release, such as the flow conditions in Elbow River. Release rates can be managed to minimize mobilization of sediment in the unnamed creek and remobilization of sediment in Elbow River.

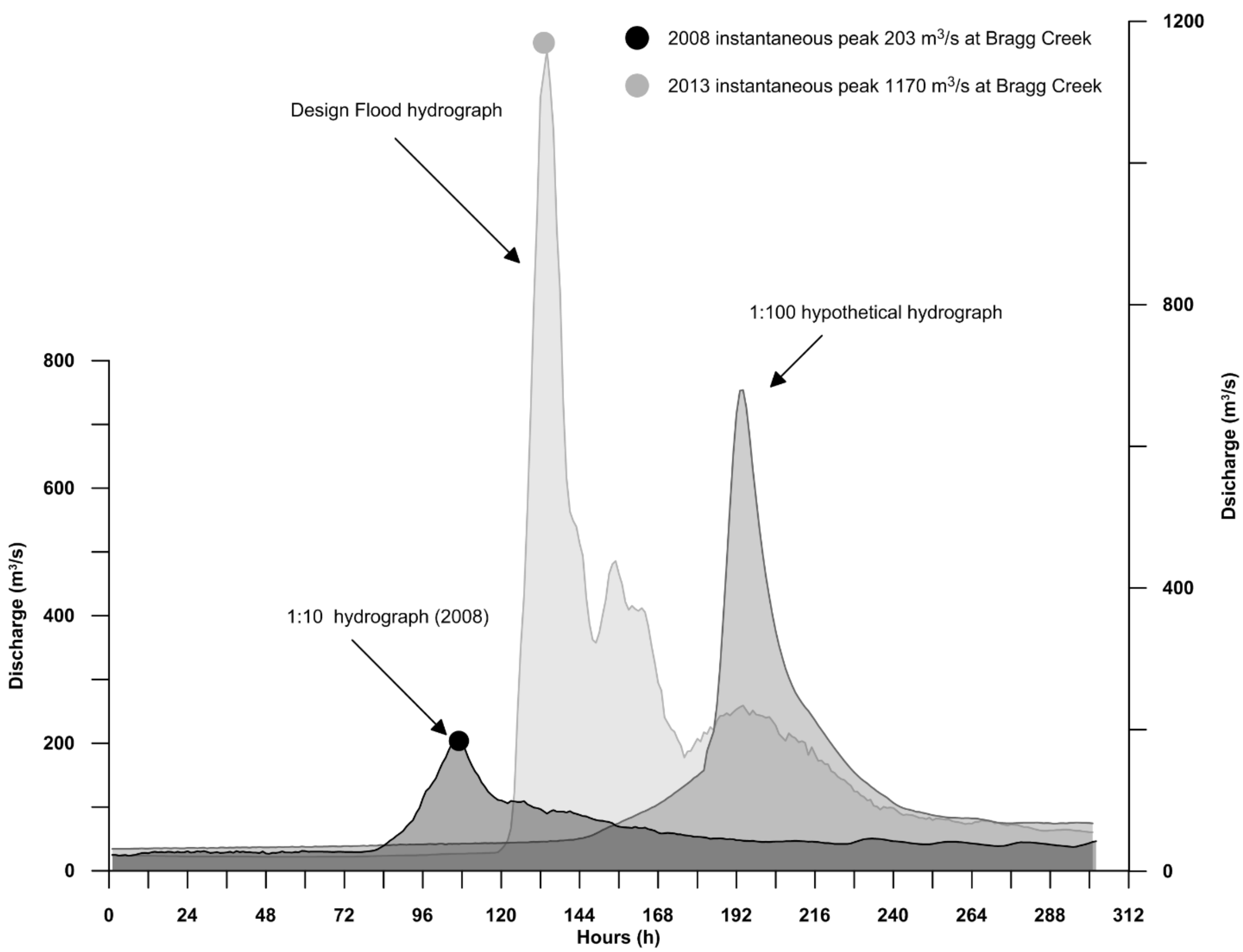

Figure IR327-1 The 1:10 Year, 1:100 Year and Design Flood Hydrographs used in Modelling (from Volume B, Appendix J, Section 2, Figure 2-4)

Question 328

Volume 3B, Section 7.4.2, Page 7.23

Alberta Transportation states that *Metals and nutrients that are associated with particles through ion exchange are less available to biota than dissolved forms.*

However, total dissolved phosphorus was very similar to suspended sediment in data patterns. This may mean that the concentration in the reservoir (spring freshet) would be higher than the concentration at lower flows.

a. Discuss the effects on water quality due to dissolved constituents that increase in concentration at high flows.

Response 328

a. Flows in Elbow River have a quick response time; runoff is delivered to the river rapidly where the rising limb of the hydrograph increases rapidly. The initial peak in a flood can happen in a matter of hours (Volume 4, Appendix J, Section 2.4.2, Figure 2-4).

When water is delivered rapidly to the river channel, dissolved constituents increase in concentration with the initial rise in the water flow. However, the supply of available solutes is exhausted and the maximum river solute concentration is reached before the peak in flow rate. As river flow increases, solute concentrations become diluted. Therefore, the discharge–solute concentration relationship on the rising and decreasing limbs of the hydrograph (water flow) are different. This has been shown to hold for watersheds with rapid runoff (e.g., the Elbow River watershed) (House and Warwick 1998; Bowes et al. 2005; Bieroza and Heathwaite 2015).

Nutrient and solute concentrations in Elbow River are expected to increase as water levels increase. Due to the quick response time and nature of the Elbow River hydrograph discussed above, dissolved constituents will quickly be diluted and concentrations will decrease. Nutrient and solute concentrations are expected to be close to their peak during the initial flood stage and solutes are presumed to be diluted at higher flows. The concentration of solutes in the off-stream reservoir will be variable and dependent on dilution in the diverted water.

The operation of the reservoir is not expected to affect dissolved parameters and will reduce or not change the total load of parameters that are associated with suspended solids. No increase in loads are expected and no adverse effect on water quality is expected (Volume 3B, Section 7.4.2., page 7.23).

REFERENCES

Bieroza,M.Z., and A.L. Heathwaite. 2015. Seasonal variation in phosphorus concentration-discharge hysteresis inferred from high-frequency in situ monitoring. Journal of Hydrology. Volume 524, page 333-347.

House, W.A., and M.S. Warwick. 1998. Hysteresis of the solute concentrations/discharge relationship in rivers during storms. Water Resources. Volume 32 (8). Page 2279-2290.

M.J. Bowes, W.A. House, R.A. Hodgkinson, and D.V. Leach. 2005. Phosphorus-discharge hysteresis during storm events along a river catchment: the River Swale, UK. Water Research. Volume 39, page 751-762.

Question 329

Volume 3B, Section 7.4.3, Page 7.25
Volume 3B, Section 7.4.3, Figure 7-11, Page 7.26

Alberta Transportation states that *For the design flood, the release of retained water from the reservoir would contribute 29% to 59% of total flow in Elbow River downstream of the low-level outlet. For the 1:100 year flood, the release of retained water from the reservoir would contribute 5% to 34% of total flow in Elbow River downstream of the low-level outlet. For the 1:10 year flood, the released water would contribute less than 5% of the total flow in the Elbow River.*

a. What is the temperature, DO and nutrient concentrations expected in the water released from the reservoir?

b. Figure 7-11 shows an outlet channel flow % of total during discharge never below 20% for the 1:100 flood. Clarify the statement that says 5% to 34%.

Response 329

a. Factors that affect water temperature and dissolved oxygen (DO) in waterbodies (i.e., ambient air temperature, local weather patterns, barometric pressure) are variable. It is not possible to predict water temperature and DO in the off-stream reservoir. Water temperatures in the off-stream reservoir will increase over time, as will the temperatures in Elbow River. The effects of mixing between the two is predicted to be localized and temporary (Volume 3B, Section 7.4.3, page 7.24).

   Water released from the off-stream reservoir will be aerated as it flows through the energy dissipater blocks and before the water re-enters the river. Due to low amounts of available organic carbon, low biochemical oxygen demand and low sediment oxygen demand, wind mixing, and shallow water levels, it is predicted that DO levels will be similar to the DO levels in Elbow River (Volume 3B, Section 7.4.3, page 7.24 and 7.25). Changes in dissolved oxygen are expected to be smaller than currently observed in Glenmore Reservoir (Volume 3B, Section 7.4.3).

Changes to water quality in Elbow River due to temperature and DO changes in water released into Elbow River from the off-stream reservoir are not predicted (Volume 3B, Section 7.4.2 page 7.22 and page 7.23).

Data to estimate inflow concentrations during a flood are not available and, therefore, off-stream reservoir nutrient concentrations and subsequent outflow concentrations cannot be estimated or modelled. Concentrations of nutrient water quality parameters in the off-stream reservoir will be dependent on the inflow concentrations under flood conditions as the reservoir fills.

Nutrient levels in the river during the summer are low. The responses to IR83b and IR308 demonstrate that median phosphorus concentrations in the river, upstream of Calgary, are at levels within oligotrophic conditions (i.e., below 10 µg/L). Total nitrogen concentrations are low and below 1.0 mg/L (Volume 4, Appendix K, Section 3.2.2.3, Figure 3-27, page 3.40). Dissolved nutrients released from the off-stream reservoir are predicted to not change water quality and nutrient loading into Elbow River nor into Glenmore Reservoir (Volume 3B, Section 7.4.2, Page 7.23).

As stated in response IR328, during a flood, nutrient and solute concentrations in Elbow River are expected to increase as water levels increase. Due to the quick response time and nature of the Elbow River hydrograph discussed in the response to IR328, dissolved constituents will quickly be diluted and concentrations will decrease. Nutrient and solute concentrations are expected to be close to their peak during the initial flood stage and solutes are presumed to be diluted at higher flow. The concentration of solutes in the off-stream reservoir will be variable and dependent on dilution in the diverted water.

Most sediments, and consequently sediment-related nutrients, will settle and remain in the reservoir as follows and not be released into the river:

- design flood, 1.8% of suspended sediment will be returned to the river
- 1:100 year flood, 11.7% of suspended sediment will be returned to the river
- 1:10 year flood, 4.6% of suspended sediment will be returned to the river

Particulate forms of nutrients, and those bound to suspended sediments, may temporarily increase in Elbow River during the last few days of release of water from the reservoir because suspended sediments in the release water increase in concentration. However, particulate-bound nutrients are generally not available for uptake and growth in plants or algae in Elbow River (Volume 3B, Section 7.4.2, page 7.23).

b. There is an incorrect statement in Volume 3B, Section 7, page 7.25 (in the first full paragraph), which should be corrected as follows, “For the 1:100 year flood, the release of retained water from the reservoir would contribute ~~5%~~ 25% to 34% (Figure 7-11) of total flow in Elbow River downstream of the low-level outlet.”

Question 330

Volume 3B, Section 7.4.4, Page 7.29

Alberta Transportation indicates that *water would be in the reservoir from the start of diversion to the end of emptying for the following durations: design flood 62 days, 1:100, 84 days; 1:10, 74 days.* This is assuming that the design flood starts in late June and not in May as the other floods.

a. Provide analysis of the probability of having different start times for the flood and indicate how this might affect the duration of water in the reservoir.

b. What is the maximum time that the water would be in the reservoir assuming and early flood?

Response 330

a. Diversion time as well as water residence and release times for the three floods are summarized in Volume 3B, Section 6, Table 6-4. The release times for these events are based upon real event hydrographs from 2013 (design flood) and 2008 (1:10 year flood), and a modelled hydrograph (1:100 year flood). The release time was modelled to begin release of water from the reservoir on the receding limb of the hydrograph, once the peak river flow had passed. This results in a combined diversion time, reservoir residence time, and water release time for the 1:10, 1:100, and design floods of 74, 84, and 62 days, respectively. These hydrographs are independent of any specific time period and the results would not change, regardless of what time of year they occur.

b. The length of time water is retained in the reservoir and the length of time for the reservoir to be emptied are not related to the time of year when flooding occurs.

Question 331

Volume 3B, Section 7.4.4, Figures 7-14 to 7-16, Pages 7.30-7.31

Figure 7-16 has a smaller inundated area and a shorter retention time than the scenarios in Figures 7-14 and 7-15 yet the methylmercury concentrations are very similar.

a. Explain why the methylmercury concentration is very similar in all three flood scenarios.

Response 331

a. As described in the response to IR326, methylmercury concentrations in the reservoir for the three floods are as follows.

- design flood, 0.00068 µg/L to 0.0017 µg/L
- 1:100 year flood, 0.0008 µg/L to 0.0024 µg/L
- 1:10 year flood, 0.00085 µg/L to 0.0024 µg/L

The ratio of off-stream reservoir volume to surface area is linear for lower magnitude floods, such as the 1:10 year flood and the 1:100 year flood. Thus, the capacity for dilution and flux of methylmercury between soil and water remains constant and is similar for these two flood magnitudes and methylmercury concentrations will be similar.

During the design flood, a larger area of landcover in the reservoir would be inundated (Volume 3B, Section 7.4.4, Figures 7-14, 7-15, and 7-16); however, because the reservoir water release time would be shorter and the residence time for water in the reservoir shorter, the methylmercury flux would also be lower than for the 1:100 and 1:10 year floods:

- design flood, reservoir is inundated for 62 days
- 1:100 year flood, reservoir is inundated for 84 days
- 1:10 year flood, reservoir is inundated for 74 days

Additionally, the data used to predict methylmercury concentrations in the reservoir include very low concentrations (i.e., nanograms/L). Consequently, the differences in the predicted concentrations among the three floods are also small, within rounding error.

Question 332

Volume 3B, Section 7.7, Page 7.34
Volume 3B, Section 6.4.3.2, Table 6-7, Page 6.35

Alberta Transportation identified that *During the last few days of water release back into the Elbow River, suspended sediment concentrations are expected increase and cause a short-term peak.* Table 6-7 identifies an average TSS concentration during release of 754 g/m³ at 1 km downstream of the low level outlet confluence with the Elbow River.

a. Estimate the concentrations in the Elbow River near the Glenmore Reservoir.

b. Identify any potential water quality impacts.

Response 332

a. Volume 3B, Section 6.4.3.2, Table 6-7 shows suspended sediment concentrations (SSC) for the whole release period of the design flood (38 days). Therefore, the average SSC concentration (754 g/m³) at 1 km downstream of the unnamed creek channel confluence with Elbow River shown in Table 6-7 is not the average concentration of SSC at the end of the release period, but the average SSC concentration for the whole release period.

   "During the last few days", which is the period from 9 to 21 Aug 2013 (Volume 3B, Section 6.4.3.2, Figure 6-15), the average SSC is 2,204 g/m³ in Elbow River at 1 km downstream from the low-level outlet channel (unnamed creek) and 2,061 g/m³ at Sarcee Bridge chosen as the site near the Glenmore Reservoir. In Volume 3B, Section 6.4.3.2, page 6.32, it is stated that "…average concentrations show a slight increase of 0.5% between Highway 22 and Twin Bridges versus a 7% decrease between Twin Bridges and Sarcee Bridge." Therefore, a total decrease of 6.5% is used to calculate the average SSC at Sarcee Bridge (2,016 g/m³) using the average SSC (2,204 g/m³) in Elbow River at 1 km downstream from the low-level outlet channel (unnamed creek)

b. Water quality was assessed for potential effects from increased suspended sediments released during the last days that water is released from the off-stream reservoir. Total suspended sediments and TSS associated parameters including nutrients, ions, and metals (Volume 3B, Section 7.4.2, page 7.20) were assessed to determine the potential for changes in water quality. Effects on water quality from the predicted sediment concentrations are "not significant because the change in water quality is not anticipated to cause acute or chronic toxicity to change the trophic status of the Elbow River of Glenmore Reservoir" (Volume 3B, Section 7.5, page 7.34).

In Volume 3B, Section 6.4.3.1, it is stated "For the design flood, approximately 50% of the suspended sediment that would have been transported downstream without the Project would be diverted into the reservoir. The mass diverted is estimated at 2,389 kilotonnes (kt). After 20 days of retention, approximately 90 kt of suspended sediment would be released into the low-level outlet." The mass of 90 kt of suspended sediment is only 3.8% of the total suspended sediment mass settling in the reservoir.

Question 333

<u>Volume 3D, Section 3.0, Table 3-1, Page 3.15</u>

Alberta Transportation states *The following potential project effects are assessed for surface water quality: change in surface water quality.* This statement does not adequately list the potential effects assessed.

a. Indicate in more detail which potential effects were assessed (refer to the reporting method used for Aquatic Ecology, same table).

Response 333

a. The surface water quality assessment is structured differently than the aquatics assessment and examined one effect (i.e., change in surface water quality) with multiple effects pathways, while the aquatics assessment examined multiple effects.

The assessment of effects on changes in surface water quality examined different effects pathways that could affect surface water quality. These effects pathways are considered for 1) construction and dry operations (Volume 3A, Section 7.1.3) and 2) flood and post-flood operations (Volume 3B, Section 7.1.1.5):

- change in herbicide concentration (Volume 3A, Section 7.4.2.1)
- change in suspended sediment concentration (Volume 3A, Section 7.4.2.1; Volume 3B, Section 7.4.2)
- change in suspended sediment related parameters including metals, nutrients, and carbon (Volume 3B, Section 7.4.2)
- change in water temperature and dissolved oxygen (Volume 3B, Section 7.4.3)
- change in methylmercury concentration (Volume 3B, Section 7.4.4)

Question 334

Volume 4, Appendix K, Section 2.2.4.1, Page 2.17

Alberta Transportation states that *In case where a parameter was associated with comparable observations that used more than one method, each observation was compared to the median observation. Observations that differed from the median by more than 50% were removed. The median of the remaining observations was then used as the parameter value.*

a. **Explain whether, following this methodology, it is possible that peak concentrations representative of high flows could have been deleted from the dataset.**

b. **Provide a list of the parameters and samples that followed this method.**

Response 334

a. Yes, a number of extreme values from samples collected in May and June were removed from the data set. These were from dates when Elbow River had elevated flows (i.e., 1:2 year flood levels). As stated in response IR336a:

> "values that were removed were considered extreme values and potentially not comparable among all data points due to method consolidation as discussed in Volume 4, Appendix K, Section 2.2.4.1, page 2.16. Where data is evenly distributed, extreme values have the potential to introduce bias in the data distribution (i.e., skewing the data distribution to the right) resulting in elevated median values."

b. Table IR334-1 lists the parameters that had one or more extreme value(s) removed from the dataset.

Table IR334-1 Parameters Sets with Extreme Values Removed

Parameter	Spring	Summer	Fall	Winter
Total suspended sediments	• Highway 22 • Weaselhead Bridge	• Bragg Creek • Highway 22 • Twin Bridges	--	--
Total coliforms	• Glenmore Dam	• Twin Bridges • Glenmore Dam	--	--
Dissolved phosphorus	• Twin Bridges • Glenmore Dam	--	--	• Bragg Creek • Twin Bridges

Table IR334-1 Parameters Sets with Extreme Values Removed

Parameter	Spring	Summer	Fall	Winter
Total phosphorus	• Highway 22 • Twin Bridges	• Bragg Creek • Highway 22 • Weaselhead Bridge	• Highway 22 • Twin Bridges • Sarcee Bridge	• Highway 22 • Twin Bridge
Total Kjeldahl nitrogen	--	• Bragg Creek	--	--

Question 335

<u>Volume 4, Appendix K, Section 2.2.4.6, Page 2.29</u>

Alberta Transportation identified that *Non-essential metals that can be of particular concern because of toxicity include cadmium, chromium, mercury, lead, arsenic and antimony.* The EIA identified that over 70% of the arsenic and chromium have been found to be associated with suspended sediment (Section 3.2, Page 3.2).

a. Assess the potential project impacts on the concentration of these metals downstream of the release.

Response 335

a. Volume 4, Appendix K, Section 3.2 states that "the majority (over 70%) of aluminum, arsenic, barium, chromium, copper, iron, manganese, nickel, zinc, and phosphorus have been found to be associated with suspended sediment particles in major United States (US) rivers (Horowitz 2004)."

Sediment-bound metals will largely be deposited in the off-stream reservoir, which will reduce the load in Elbow River and Glenmore Reservoir. However, suspended sediment concentrations are predicted to increase due to resuspension temporarily during the last few days that water is released from the off-stream reservoir; but, these resuspended sediments (and associated metals bound to them) are comparatively small compared to the overall amount of sediment entering the off-stream reservoir. Most of the suspended sediments that enter the reservoir will remain there (rather than be released to Elbow River). Sediment entering the reservoir as total suspended solids (TSS) will deposit and remain in the reservoir (and the associated sediment bound metals) as follows (Volume 3B, Section 7.4.2, page 7.23):

- design flood, 98.2% of suspended sediment remains at the bottom of the drained reservoir

- 1:100 year flood, 88.3% of suspended sediment remains at the bottom of the drained reservoir
- 1:10 year flood, 95.4% of suspended sediment remains at the bottom of the drained reservoir

Downstream effects to water quality are not expected. The overall effect of the off-stream reservoir will be to reduce or not change the total load of parameters that are associated with suspended solids by 88 to 98%. Therefore, no increase in loads to Elbow River are expected.

REFERENCES

Horowitz, A.J. 2004. Monitoring suspended sediment and associated trace element and nutrient fluxes in large river basins in the USA. Sediment transfer through the fluvial system (Proceedings of a symposium held in Moscow, August 2014). IAHS Publ 288, 2004.

Question 336

Volume 4, Appendix K, Section 3.2, Figure 3-1, Page 3.4

One or more extreme values were removed for seven box charts.

a. Further justify this as a reasonable approach.

Response 336

a. The values removed were extreme values and potentially not comparable among all data points due to method consolidation as discussed in Volume 4, Appendix K, Section 2.2.4.1, page 2.16. Where data is evenly distributed, extreme values have the potential to introduce bias in the data distribution (i.e., skewing the data distribution to the right) resulting in elevated median values. Therefore, a judgement must be made as to whether showing the extreme values or the central tendency value (i.e., median or mean) is more suited to meet the objective of the assessment.

   Because the objective of using box and whisker plots was to demonstrate the distribution of the data around the median and extreme values that may not be comparable to the whole dataset were removed.

Question 337

Volume 4, Appendix K, Section 3.2.2.2, Figure 3-25, Page 3.36

The effect of extra nutrients and changes in concentration may need more resolution on the changes in DO during the retention-release period.

a. Assess how, during a two month period of total flood operation there would be an increasing likelihood of critical DO issues due to a change in the timing of nutrient loading.

Response 337

a. A change in timing to release water from the off-stream reservoir is not predicted to change the results of the water quality assessment or increase the likelihood of a critical dissolved oxygen (DO) issue. The 50th percentile (i.e., median) and 75th percentile dissolved oxygen levels in Elbow River, upstream of Calgary, during July and August, have historically remained above 9.0 mg/L and 8.5 mg/L, respectively, as explained in the response to IR308a. Water temperatures in Elbow River during late summer and fall generally begin to decrease while DO levels increase (Volume 4, Appendix K, Section 3, Figure 3-24 and Figure 3-25).

   Nutrients are predicted to deposit in the off-stream reservoir during flood operations and result in limited downstream loading during flows in July and August (Volume 3B, Section 7.4.2, page 7.20-7.23). Nutrient levels in Elbow River during the summer are low. The responses to IR83b demonstrates that median phosphorus concentrations in Elbow River, upstream of Calgary, are at levels indicative of oligotrophic conditions (i.e., below 10 µg/L). Total nitrogen concentrations are low and below 1.0 mg/L (Volume 4, Appendix K, Section 3.2.2.3, Figure 3-27). Any dissolved nutrients released from the off-stream reservoir are predicted to not change water quality and nutrient loading of Elbow River or Glenmore Reservoir (Volume 3B, Section 7.4.2, page 7.23). During the fall, nutrient levels in Elbow River generally remain similar, or decrease, from summer levels (Volume 4, Appendix K, Section 3, Figure 3-5 to Figure 3-8, and Section 3.2.2.3, Figure 3-26 and Figure 3-27), thus increasing the capacity for the river to assimilate dissolved and particulate forms of nutrients.

   Particulate forms of nutrients, and those bound to suspended sediments, may temporarily increase in Elbow River during the last few days of release of water from the off-stream reservoir because suspended sediments in the release water increase in concentration. However, particulate bound nutrients are generally not available for uptake and growth in plants or algae downstream of the Project (Volume 3B, Section 7.4.2, page 7.23).

The water released from the off-stream reservoir will contribute to the total flow in Elbow River (but release of water would not occur if the river flow is over 20 m^3/s) below the unnamed creek:

- design flood, release of water contributes 29% to 59% of total flow in Elbow River
- 1:100 year flood, release of water contributes 25% to 34% of total flow in Elbow River
- 1:10 year flood, release of water contributes less than 5% of total flow in Elbow River

The absolute amount of dissolved nutrients in Elbow River downstream of the unnamed creek may increase as a result water released from the off-stream reservoir. But, due to the large volume of water, the dissolved nutrient concentrations contributed by the off-stream reservoir will be diluted. Thus, the reservoir is expected to have no effect on dissolved nutrient concentrations, not contribute to additional plant and algae growth, and not result in changes to DO levels in Elbow River (Volume 3B, Section 7.4.2, page 7.23).

The Alberta long-term guideline (GOA 2018) for DO is a 7-day mean of 6.5 mg/L. During May through the end of June, the guideline is 8.3 mg/L to protect emerging mayflies; however, this guideline will not apply at the time water is released between July and August.

A guideline of 9.5 mg/L (GOA 2018, CCME 1999) is applied for areas and times where larval fish are developing within gravel beds. Rainbow trout and rainbow–cutthroat hybrids are spring-spawning resident fish that build nests, where embryo and juvenile fish remain in gravel during July. During a flood without the Project, most of the spawning habitats, potential redds, and juvenile fish within the river would be disturbed and potentially lost (Warren et al. 2009).

Therefore, a direct critical DO issue due to release of water from the reservoir would not occur. Effects to juvenile fish and aquatic life from changes resulting in release water from the reservoir are not predicted.

REFERENCES

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Warren, D.R., A.G., Ernst, and B.P. Baldigo. 2009. Influence of spring floods on year-class strength of fall- and spring-spawning salmonids in Catskill Mountain streams. Transactions of the American Fisheries Society. Vol 138: 200-210.

Question 338

Volume 4, Appendix K, Section 3.3, Page 3.48

Alberta Transportation identified that *Compared to other tributaries, the low-level outlet is associated with low oxygen, high temperature, high conductivity, and high nutrient concentrations.*

a. Discuss any implications of the low-level outlet showing, in general, poorer water quality than other tributaries.

Response 338

a. Poor water quality in the unnamed creek (low-level outlet channel) has no implications for the Project. Stream flows in the creek are low and intermittent throughout the year (Volume 4, Appendix J, Section 3.3.1, page 3.18, Figures 3-10 and 3-11) and appear to largely be driven by precipitation. Groundwater may contribute baseflow in the creek; dilution of electrical conductivity during rainfall events suggests that baseflow in the unnamed creek is, in part, maintained by springs. However, because flows are intermittent, the volume of groundwater contribution is low. The average flow in the creek is approximately 0.03 m^3/s, however, flows were intermittent throughout the year. The peak flow measured was 0.79 m^3/s during a high rain event.

The average but intermittent flow of 0.03 m^3/s is small compared to the potential amount of water that would be released from the off-stream reservoir. It is approximately 11.0% of the modelled release rate from the reservoir for a 1:10 year flood (0.275 m^3/s) and only 0.15% of the modelled release rate from the reservoir for a design flood (20 m^3/s; Volume 3B, Section 6.4.1, Figure 6-7).

Flows in the unnamed creek are intermittent and only for a period of several days at a time. The magnitude and timing of potential changes in water quality will not be sufficiently high, or last long enough, to alter water quality in water released from the reservoir or further downstream in the river.

Question 339

Volume 4, Appendix J, Section 2.3.1, Page 2.19

Alberta Transportation monitored the low-level outlet (TR1 site) during June 2016 to May 2017. Different conclusions were drawn from this data.

a. Discuss if the monitored period represents typical conditions and any implications.

Response 339

a. Flows for the unnamed creek is provided between June 2016 and July 2017 (Volume 4, Appendix J, Section 3.3.1.2, page 3.18 and page 3.19). The date of May 2017 stated in the EIA is not correct. The monitoring period is greater than a year and represents typical conditions in the creek. Generally, flows at the TR1 site (in the unnamed creek) are intermittent in spring and summer while having no flow from fall through winter. Based on site characteristics, conditions do not vary greatly from year to year.

   The mean flow in the unnamed creek is approximately 3 x 10^{-2} m^3/s with peak flow measured as 0.79 m^3/s after a period of prolonged rainfall (Volume 3B, Appendix J, Section 3.3.1.2, page 3.18). Bankfull flow is approximately 1.0 m^3/s. These natural flows in the unnamed creek are much smaller than the water released from the reservoir (approximately 20 m^3/s for the design flood, 11 m^3/s for the 1:100 year flood, and 4.7 m^3/s for the 1:10 year flood). Years where conditions vary considerably at the unnamed creek (e.g., high annual runoff or drought conditions) have no implication for predictions associated with the Project (Volume 3B, Section 6.4.3 and 6.4.4.). Regardless of how natural conditions change from year to year, these predicted changes remain the same.

Question 340

Volume 4, Appendix J, Section 2.3.2, Page 2.20

Alberta Transportation indicated *that a minimum of 10 flow measurements across a range of flows are required to establish a stable stage-discharge relationship.* However, only six measurements were used to establish the rating curve for TR1.

a. Explain why only six flow measurements were used and any implications.

Response 340

a. Based on the flow regime and intermittent nature of flows in TR1, the unnamed creek, only six flow measurements could be taken. The natural flow in the tributary is intermittent,

   The range of baseline flows, even with uncertainty, is much lower that the predicted flows from the release of water from the reservoir. The uncertainty in the very small baseline flows of TR1 does not have an effect on the prediction of effects on the environment.

Question 341

Volume 3B, Section 6.4.3.2, Figure 6-15, Page 6.36
Volume 3B, Section 6.4.3.3, Figure 6-20, Page 6.45

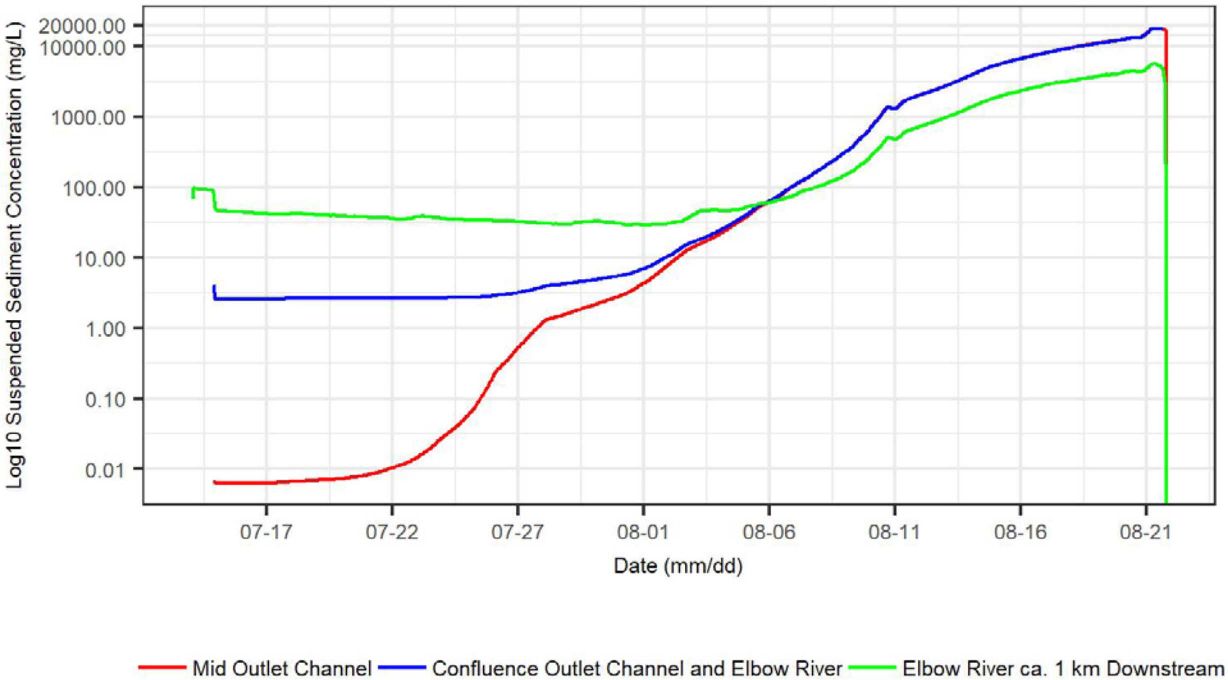
The suspended sediment concentration for these figures does not clearly show the concentration for the initial stage of the discharge.

a. Provide a visual representation of the suspended solids concentration that antecedes the peak at the end of the release.

Response 341

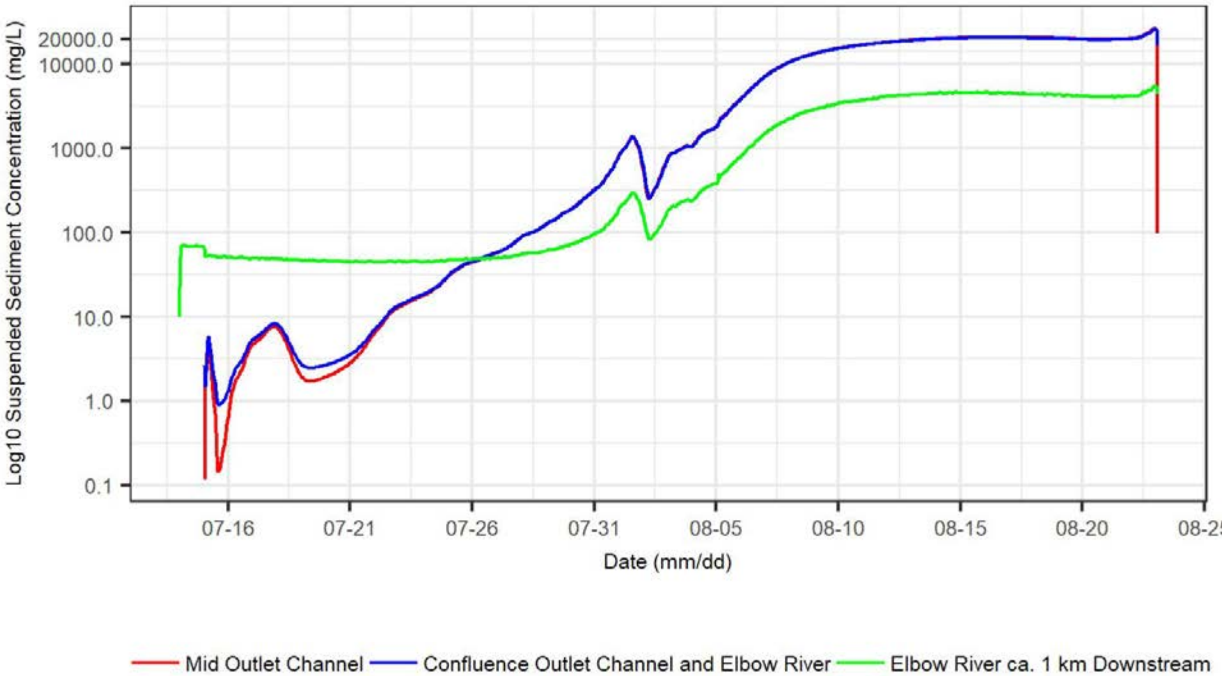
a. The suspended sediment concentrations in Elbow River at the end of the release period from the reservoir are shown in Figure IR341-1 (design flood) and Figure IR341-2 (1:100 year flood). These figures reflect the information in Figure 6.15 and Figure 6-20 (Volume 3B, Section 6.4.3); however, the figures here are presented in logarithm scale to clearly show the lower concentrations during the period prior to the last few days of release of water. The suspended sediment concentrations drop off during the later dates in August at the time when the water release is over.

   The average suspended sediment concentrations in Elbow River (approximately 1 km downstream from the confluence with the unnamed creek) are predicted to be 754 mg/L (associated with the design flood) and 1,576 mg/L (associated with the 1:100 year flood). However, these suspended sediment levels are averages for the complete release period, while the absolute concentrations for this period are much lower and only increase at the end of the release period of water.



NOTE: channel refers to the unnamed creek.

Figure IR341-1 Suspended Sediment Concentrations Associated with Release of Design-Flood Waters



NOTE: channel refers to the unnamed creek

Figure IR341-2 Suspended Sediment Concentrations Associated with the Release of 1:100 Year Flood Waters

5.5 AQUATICS

Question 342

Volume 3A, Section 8.2.1.1, Page 8.16

Alberta Transportation states *The review of aquatic resources was used to identify species composition, species at risk, distribution, relative abundance, status, movements, habitat use and life history parameters.*

a. Describe how quantitative population estimates of fish resources have been assessed.

b. Provide quantitative population estimates for the fish species found within the Elbow River.

Response 342

a. Surveys to generate quantitative population level estimates of fishery resources were not conducted as part of the assessment. Quantitative population studies require multiple seasons and multiple years of accurate data collection. Instead, the aquatic ecology assessment uses relative abundance for assessing effects on fish habitats and populations. Relative abundance is also the assessment method used by AEP to assess species status within the region (e.g., bull trout (*Salvelinus confluentus)* andwestslope cutthroat trout (*Oncorhynchus clarki*)).

The aquatics ecology assessment is based on information from AEP's online Fisheries and Wildlife Management Information System (FWMIS) database (AEP 2017). Site-specific habitat assessments and fish density estimates were completed to support and confirm the desktop review of existing fisheries data (Volume 4, Appendix M, Aquatic Ecology TDR).

The Province of Alberta has identified several focal fish species requiring additional management attention. The Fish Sustainability Index (FSI) was developed to provide a consistent province-wide assessment process to evaluate fish stocks (MacPherson et al. 2014). Bull trout, westslope cutthroat trout, mountain whitefish (*Prosopium williamsoni*), burbot (*Lota lota*) and northern pike (rivers; *Esox lucius*) have been identified as priority fish species to be assessed by FSI. Currently, the province has only provided FSIs for bull trout and westslope cuthroat trout; this includes FSI maps depicting current adult density maps (see Table IR342-1). These two species in Alberta are sensitive and sentinel fisheries species and are a commercial, recreation and Aboriginal fisheries species as defined under the federal *Fisheries Act.*

Table IR342-1 Fish Sustainability Index (FSI) for Bull Trout and Westslope Cutthroat Trout in the Elbow River Watershed

FSI – Maps	Bull Trout FSI	Westslope Cutthroat FSI
Current adult density	*Very low* - *Upper and lower reaches*	*Very low* in upper reaches adjacent to the diversion structures Functionally *extirpated* in lower reaches.
Historic adult density	*Moderate* *Upper and lower reaches*	*Very high to high* *Upper and lower reaches*
Habitat protection need	*High* *Upper and lower reaches*	*low* to *moderate* in Upper reaches none identified in lower reaches
Overharvest protection need	*Very high* *Upper and lower reaches*	*very high* to *high* in upper reaches. none in lower reaches
SOURCE: *AEP 2018: http://aep.alberta.ca/fish-wildlife/fisheries-management/fish-sustainability-index/fsi-species-maps/default.aspx		

FSI is applied in Alberta to provide consistent fish stock assessments, at a provincial scale, which are used to compare stocks, areas, and time periods (MacPherson et al. 2014). Individual assessments evaluate population integrity (e.g., population density, genetic integrity and ecological integrity), productive potential, and threat mitigation. Using the FSI measure, the majority of bull trout watersheds in Alberta are assessed as having either low or very low abundance of adult fish, with the lowest densities assessed in the most heavily developed watersheds (AEP 2018). Monitoring of bull trout has focused on relatively few, high-profile watersheds; a more consistent and widespread Alberta monitoring program is required (AEP 2018). These assessments have not been conducted regularly in the Elbow River watershed (Hydrologic Unit (HUC) 04021001), which has been identified as having a low relative abundance index and a decreasing population trajectory with a poor population status for bull trout (DFO 2017). Best available population estimates from DFO (2017) for bull trout adults in the Elbow River watershed are presented in Table IR342-2.

Population estimates for fish species other than trout are also limited in the Elbow River watershed. Given lack of population information, relative abundance, based on presence records, is used for the aquatic ecology assessment.

Table IR342-2 Population Estimates for Bull Trout

Waterbody	Hydrologic Unit Code 8	Life history Type	Estimated Abundance (Adults)[1]	Occupancy (stream km)	Relative Abundance Index	Population Trajectory	Population Status*
Lower Elbow River	04021001	fluvial resident	105 (50-250)	40-200	*low*	decreasing	*poor*
Canyon Creek	04021001	resident	20 (1-50)	4-40			
Upper Elbow River	04021001	resident	115 (50-250)	40-200			

*SOURCE: DFO 2017 (Table 2 and Table A1)

NOTE:
[1] Assessment was completed by the Fish and Wildlife Division of Alberta Sustainable Resource Development. Estimated adult population abundance (using quantitative data and/or expert opinion) are accompanied by appropriate NatureServe Range Categories in parentheses.

b. Population level fisheries data was not collected in the Elbow River. Quantitative annual population estimates for resident fish populations in Elbow River are limited to qualitative relative abundance. Current population estimates for bull trout and westslope cutthroat trout are listed in Table IR342-2. Selected Elbow River fish inventory and fish habitat survey data were collected and used—with the regional FSI assessments for the Elbow River—to support environmental planning. Further field collection to determine quantitative population estimates were not conducted.

The population estimates that have been conducted are not recent (the data is more than five years old), short in duration, not seasonal or multiyear, and are often limited to the upper tributaries of the Elbow River (e.g., Canyon and Prairie Creeks). When using these estimates, the population level estimates of trout exhibit high variability between years (e.g., Applied Aquatic Research 2008; Stelfox 2004; Fitzsimmons 2008; DFO 2014).

REFERENCES

Applied Aquatic Research Ltd. 2008. Fluvial Bull Trout Redd Surveys on the Elbow, Sheep and Highwood Rivers, Alberta – Trout Unlimited Canada. Submitted by R. Popowich and G. Eisler, Applied Aquatic Research Ltd. Calgary, Alberta

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AEP. 2017. Fish and Wildlife Management Information System (FWMIS) Internet Mapping Tool. Available at: https://maps.srd.alberta.ca/FWIMT_Pub/Viewer/?Viewer=FWIMT_Pub

DFO (Fisheries and Oceans Canada). 2014. Recovery Strategy for the Alberta populations of Westslope Cutthroat Trout (Oncorhynchus clarkii lewisi) in Canada [Final]. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. iv + 28 pp + Appendices. Available at: http://www.sararegistry.gc.ca/virtual_sara/files/plans/rs_truite_fardee_wstslp_cutthroat_trout_0314_e.pdf

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Fitzsimmons, K. 2008. Monitoring bull trout and cutthroat trout populations in Canyon Creek and Prairie Creek drainages, Elbow River, Alberta, 2005. Data Report, D-2008-010, produced by the Alberta Conservation Association, Cochrane, Alberta, Canada. 27 pp + App.

MacPherson, L., M. Coombs, J. Reilly, M.G. Sullivan, and D.J. Park. 2014. A Generic Rule Set for Applying the Alberta Fish Sustainability Index, Second Edition. Environment and Sustainable Resource Development, Edmonton, Alberta, Canada. 51 pp.

Stelfox, J, 2004. Summary of upper Elbow River electrofishing survey on 29 August 2002.

Question 343

<u>Volume 3A, Section 8.2.2.3, Table 8-5, Page 8.30</u>

Alberta Transportation presented the upstream migration times of various fish species in Table 8-5.

a. How were migration patterns of fish species in the Elbow River determined apart from general life history patterns?

b. Describe which of these species moves through the area of the diversion structure where migration may be affected during the times described in the table.

Response 343

a. Migration patterns were determined for each species from known patterns of life history, biology and behaviour. No additional information sources were used.

b. Elbow River fish species (see Table IR343-1) can only migrate during seasonal periods when flow and water depths are adequate for movement for each species. Migratory fish species in the Elbow River near the diversion structure primarily include bull trout and cutthroat trout (hybrids) (e.g., Fitzsimmons 2008).

Table IR343-1 Fish Species in the Elbow River near the Diversion Structure

	BSP[1]-1 April 2-June 15	BSP-2 June 16-Sept 25	BSP-3 Sept 26-Dec 1	BSP-4 Dec 2-April 1
Flow Period				
$3Q10_{min}$ (m^3/s)	2.8	3.47	2.38	0.8
$3Q10_{max}$ (m^3/s)	75.7	69.5	15	9.81
Upstream Migration Period				
Burbot	-	-	-	Dec-Jan
Northern pike	April	-	-	-
Rainbow trout	March-May	-	-	-
Cutthroat trout (hybrids)	April-June	-	-	-
Brown trout	-	-	October	-
Bull trout	-	July-August	-	-
Brook trout	-	September	-	-
Mountain whitefish	-	September	-	-
NOTE: [1] BSP-biologically significant period (upstream migration times)				

The construction and operation of the diversion structure will not change the natural duration and extent of river floods and seasonal opportunities for fish migration and movement. Elevated river flows are not predicted to result in water velocities that are a barrier to fish passage. Adequate water levels will be maintained during operations above thresholds needed to facilitate fish passage (see the response to IR91) and summarized in Table IR343-1.

REFERENCES

Fitzsimmons, K. 2008. Monitoring bull trout and cutthroat trout populations in Canyon Creek and Prairie Creek drainages, Elbow River, Alberta, 2005. Data Report, D-2008-010, produced by the Alberta Conservation Association, Cochrane, Alberta, Canada. 27 pp + App.).

Question 344

<u>Volume 3A, Section 8.4.2.1, Page 8.49</u>
<u>Volume 3A, Section 8.4.4.2. Page 8.59</u>

Alberta Transportation states on page 8.49 that *During dry operations, the physical structure may be a barrier to upstream fish migration for large fish by creating an area of shallow water over the concrete gates, with depths shallower than 18 cm, that may impede the upstream movement of large fish such as bull trout, brown trout, or mountain whitefish, during late summer spawning migrations.* Subsequent mitigations in sections 8.4.4.2 describe measures to keep velocities from exceeding small fish swim speeds, but depth is only referred to during higher flows (0.75m/s) where depth is described as exceeding 20cm.

a. **Describe mitigation measures taken to address low water depth passage restriction to large fish such as Bull trout during low flow periods.**

Response 344

a. Fish passage during low water periods will be maintained through several design and mitigation measures. These have been consolidated into Appendix IR91-1 for the response to IR91. These measures are designed to mimic the existing thalweg of the Elbow River channel, including its geometry and intermittent bedrock grade control.

   In summary, during low flow conditions, the right gate will be raised in order to increase river flows through the left bay, thus simulating the effect of the existing point bar on the right bank where the diversion structure is located. Hydraulically, this measure has the same depth and velocity characteristics as the existing thalweg, upstream and downstream of the diversion structure and, therefore, will allow passage of large fish such as bull trout. This is described in Appendix IR91-1 (Attachment IR91-1A and Attachment IR91-1B). Because geometry of the flow through the diversion channel and the thalweg are similar, the hydraulic characteristics are similar at flows lower than those evaluated in the Volume 3A, Section 8.

   The modelled flow rate of 0.8 m^3/s (0.75 m^3/s) is the 3-day, 10-year minimum daily-mean flow ($3Q10_{min}$) for the biologically sensitive period (BSP) (December 02 – April 01) (Appendix IR91-1, Attachment IR91-1A). The design mitigation provides for 18 cm of water depth during this BSP with this flow rate, which is the lower limit flow condition under which fish can pass the structure without a three-day delay in their migration. This three-day delay condition has an annual exceedance probability of 0.1, which was the basis of the design to maintain fish passage at these potential low flow periods. Elbow River flows have only been lower than this for one day of the record during this BSP (based on daily mean flows for Elbow River at Bragg Creek hydrometric station); excluding winter conditions. When groundfast and interbedded ice create passage barriers, the Elbow River has had flow rates of less than 0.8 m^3/s for less than 0.005% of its entire hydrometric record (1934 – 2015).

Question 345

<u>Volume 3A, Section 8.4.3.2, Page 8.51</u>

Alberta Transportation describes measures to avoid introducing invasive species by cleaning equipment prior to arrival during construction of the project.

a. **Describe measures to ensure aquatic invasive species do not occupy or establish in the project infrastructure. Will any testing be completed to check for the presence of invasive species? Explain why or why not.**

b. **Describe measures to remove aquatic invasive species should they be found.**

Response 345

a. AEP has published a *Decontamination Protocol for Watercraft and Equipment* (GOA 2017) to provide methods for inspecting and cleaning of vehicles, watercraft and water-based equipment. The protocol is primarily aimed at controlling the spread of whirling disease but is also intended to address other aquatic invasive species of concern. Methods used to decontaminate equipment from whirling disease are considered adequate for addressing contamination from other aquatic invasive species. The Project is wholly located within the yellow risk zone (high to moderate risk) for whirling disease. Alberta Transportation is committed to following the *Decontamination Protocol for Watercraft and Equipment* (GOA 2017).

Invasive species control measures during construction will be the responsibility of construction contractors and will follow these measures (Volume 1, Attachment A, Section A.2.2.5):

- Before arriving on site, equipment will be cleaned of mud and debris, and disinfected following Alberta Environment and Parks' disinfection procedures found at: http://aep.alberta.ca/fish-wildlife/wildlife-diseases/whirling-disease/stop-the-spread.aspx.
- Machinery on site will be in a clean condition and maintained free of fluid leaks, invasive species, and noxious weeds.
- Site-specific procedures to prevent the invasion or spread of undesirable non-native vegetation (e.g., purple loosestrife, Eurasian milfoil) will be developed.
- Disinfection stations will be established to clean equipment before it leaves the site.

Construction equipment that may have contact with water on the construction site will be inspected, cleaned and dried, consistent with AEP protocols. If the protocols are followed, no other testing is required. Compliance of the protocol will be monitored by the environmental inspector on site. Hand tools used instream and water protection clothing (i.e., waders, rubber boots) will not be used if previously used in the red zone unless cleaned in a hot water wash, decontaminated with 1,500 ppm solution of quaternary ammonium compounds (QUAT), rinsed and dried.

Project components will be monitored for invasive species during maintenance activities. Testing for invasive species is not planned. Proactive measures to prevent the spread of invasive species such as the implementation of decontamination protocols and monitoring will be used in place of testing.

b. Project construction, operational and maintenance managers will be provided with management plans and guidance for identification of aquatic invasive species. Response protocols for removal of invasive species is dependent on the individual species, time of year and extent of each species distribution. Alberta identified the removal of different types of aquatic invasive species such as mussels, goldfish, black bullhead, flowering rush, whirling disease and others (GOA 2018). Removal methods can range from capture of fish by electrofishing or nets to physical removal of plants and mussels. AEP will be notified if any invasive species have been observed and of the proposed removal method.

REFERENCES

GOA (Government of Alberta). 2017. Decontamination Protocol for Watercraft & Equipment. Alberta Environment and Parks. 45 pp.

GoA. 2018. Accessed October 2018. https://open.alberta.ca/dataset/ecf3f1b1-152e-45ea-8599-f4140087c5da/resource/a5fa98ea-e2d8-4b18-bce6-650edd5249b6/download/aquaticinvasivespecies-2017annualrpta-june2018.pdf

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Question 346

Volume 3A, Section 8.4.4.1, Page 8.58.

Albert Transportation states that *large wood debris that builds up at the structure should be manually moved to downstream of the diversion structure to maintain a natural amount of woody debris in the river channel.*

a. How often will such debris be removed and relocated downstream of the structures?

b. Describe where and how debris will be located downstream of the structure so as to maintain a natural distribution pattern.

Response 346

a. Debris will be removed from the debris deflector, intake structure and gates prior to spring freshet annually in May or June, to ensure the structure is operating properly when river flow increases and the likelihood of flooding is highest (see Volume 3A, Section 6.2.2.4). Maintenance (see Table IR346-1) to clear large woody debris from the intake structure, debris deflector and gates will happen when conditions are safe to so do in April and again when river flow has receded in the summer.

Table IR346-1 Maintenance Schedule for the Diversion Structure

Annual Maintenance Schedule	Function
April	Remove winter debris to prevent interference with intake structure and gate equipment to prepare for elevated river discharge during freshet.
July	Remove large woody debris resulting from spring freshet.
October	Remove debris in preparation for ice formation and prevent interference with intake structure and gate equipment.

b. The text in Volume 3A, Section 8.4.4.1 relating to the placement of wood debris downstream of the diversion structure, post-flood is not correct. Large woody debris taken from the debris deflector, intake structure, and gates will be removed from the beds and shores and will not be introduced downstream in the River.

Question 347

Volume 3A, Section 8.4.4.2, Page 8.58
Volume 3C, Sec 01, Section 1.2.4.2, Page 1.27

The diversion of the unnamed tributary (ID 1350) into the constructed diversion channel is an example where habitat may require offsetting which was briefly described. 1,854m^2 of fish habitat for the diversion structure and 900m^2 of habitat for the debris deflector was calculated to be destroyed as a result of the construction of this project (Volume 3C, Sec 01, Section 1.2.4.2, Page 1.27).

a. Identify plans to offset losses in the productivity of the fish habitat identified.

b. Indicate how environmental protection plans address applicable provincial and federal policies on fish habitat including the development of a “No Net Loss” fish habitat objective.

Response 347

a. Potential habitat offset gains will be addressed as part of the *Fisheries Act* authorization process for the Project: a habitat offset plan will be developed and submitted for review and will take into consideration input from Indigenous groups, Fisheries and Oceans Canada (DFO) and stakeholders. It will also align with local fish management objectives. It is anticipated the habitat offset will be planned to directly enhance and create habitats adjacent. The area around Reach 3 and planned footprint for the diversion structure may benefit from enhanced pool and side areas to support spawning and rearing habitats for salmonids.

b. The environmental protection plans for the Project identify mitigation measures and best practices to avoid or minimize potential effects, including to fish and fish habitat from Project activities. Potential losses in fish habitat productivity will be further addressed in the offset plan which will meet the “No Net Loss” fish habitat guiding principle through DFO. The plan, once completed, will be submitted to DFO for review and input.

Question 348

Volume 3B, Section 8.2.2.3, Page 8.10
Volume 3B, Section 8.2.2.3, Page 8.12

Alberta Transportation states on page 8.10 that *Increased turbidity and the deposition of sediment on substrates could affect the quality of fish habitat in the low-level outlet channel and in Elbow River downstream of the low-level outlet*. On page 8.12 Alberta Transportation states *the potential change in sediment and turbidity that may result downstream is not anticipated to result in residual effects on aquatic ecology, given the slow rate of draining of the reservoir*.

a. Discuss the impacts to fish resulting from the slow rate of release of turbid water over an extended period of time. Consider the severity of ill effects (SEV) dose-response curve which indicates elevated negative impacts to fish with increasing duration of high sediment events.

b. Discuss the elevated turbidity levels and increased duration and the resulting impact to any spring spawning species potentially using the portion of the Elbow below the outlet structure for spawning during post-flood reservoir draining.

Response 348

a. Suspended sediment concentration in the water from the off-stream reservoir is predicted to increase during the last few days. As discussed in Volume 3B, Section 7.4.2, page 7.22:

> "It is anticipated that these suspended sediment concentrations during the last few days of the discharge can be controlled with the low-level outlet gate operation (i.e., reducing flow rate) and, possibly with physical sediment barriers. Without these mitigation measures, the resulting increase in the Elbow River of suspended sediment concentrations is likely to exceed the Canadian Water Quality Guideline (Canadian Council of Ministers of the Environment"

During a 1:10 year flood, suspended sediment in water released would decrease by approximately 95% between the confluence of the unnamed creek (the low-level outlet channel) with Elbow River and 1 km downstream of the confluence (Volume 3B, Section 6.4.3.4). During a 1:100 year flood, suspended sediments would decrease by 31% over the same distance (Volume 3B, Section 6.4.3.3). Suspended sediment in water from the reservoir would be expected to further decrease with distance downstream in river and, thus, there will be a decreased potential effects on fish from suspended sediment. Fish species within the river experience natural seasonal and prolonged fluctuations in suspended sediment related to river flow and where they are in the river, mostly during episodic floods.

The assessment approach acknowledges CCME (2002) "Canadian Water Quality Guidelines for the Protection of Aquatic Life: Total Particulate Matter", which was derived so as to consider aquatic effects across a suspended sediment gradient; this guideline will inform the reservoir operator how suspended sediments are to be released from the off-stream reservoir.

A discussion of the risk to this species from water release and associated suspended sediment is provided in the response to IR100c. As stated in Volume 3B, Section 8.5.1, page 8.20:

> "Given infrequency of diversion and with the implementation of mitigation measures, the potential change in suspended sediment concentrations downstream is not anticipated to result in residual effects on aquatic ecology. This indicates that the effects on fish habitat are not significant."

b. Flooding in Calgary typically occurs in June (e.g., 2005 and 2013). Because holding time of water in the off-stream reservoir for 1:10 year and 1:100 year floods is approximately 43 days (Volume 1, Table 3-3, page 3.12), and subsequent release of that water would be approximately 30 and 39 days, respectively, release of water from the reservoir would begin in July or August and continue into August or September if a flood occurred in June. The release of flood water from the reservoir during August and September would not coincide with known fish spring spawning timing (see Volume 3A, Section 8, Table 8-5)

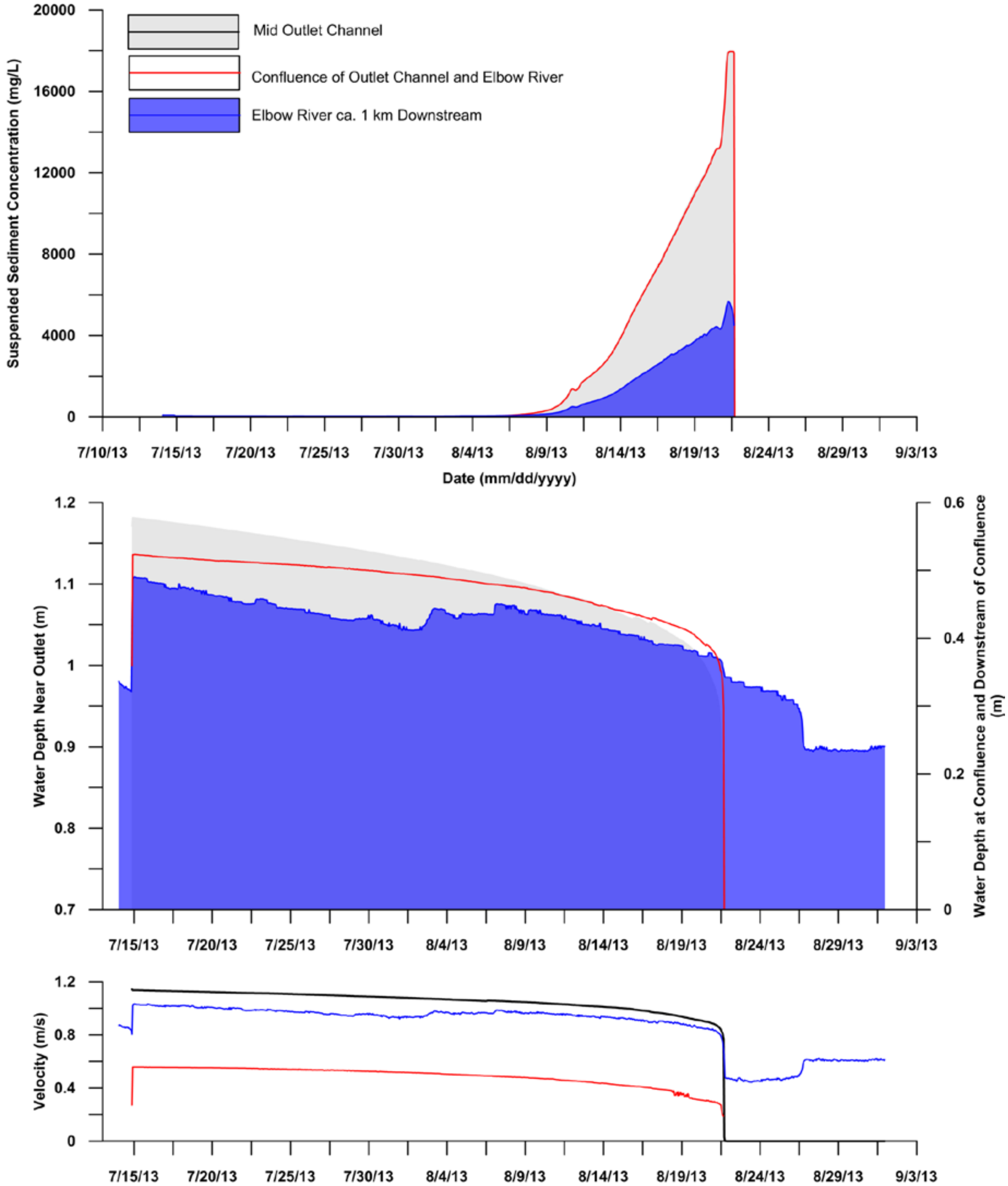
Spring spawners such as rainbow trout and white sucker will have completed spawning and fry emerged prior to release of flood water from the reservoir. After emergence, fry move to slower water and areas of cover that are likely to have lower levels of suspended sediment. Adults are more resilient to suspended sediment levels and better able to move to areas of lower suspended sediment. The diversion of water during a flood may benefit survival of fish eggs and fry by reducing the amount of sediment and destructive powers of floods during this critical period of fish life history.

Predicted peak and average suspended sediment concentrations for the water released from the reservoir, the confluence of the unnamed creek with Elbow River, and in Elbow River 1.0 km downstream of the confluence with the unnamed creek are provided in Table IR348-1 and shown graphically in Figure IR348-1, Figure IR348-2 and Figure IR348-3.

Table IR348-1 Suspended Sediment Concentrations in Released Flood Water at Three Locations

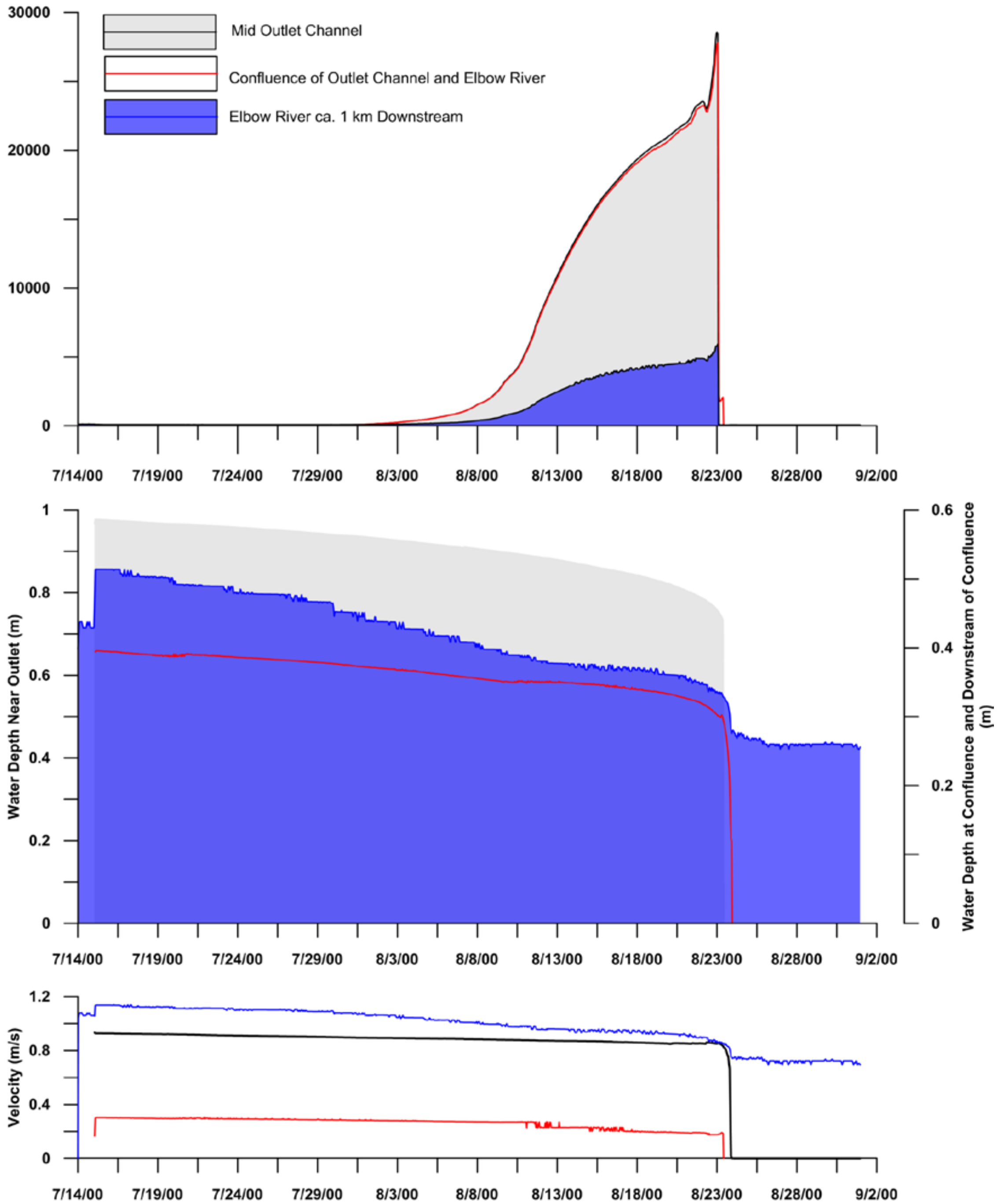
Location	Design Flood Suspended Sediment Concentration (mg/L)			1:100 Year Flood Suspended Sediment Concentration (mg/L)			1:10 Year Flood Suspended Sediment Concentration (mg/L)		
	Peak	Average	Release Time (days)	Peak	Average	Release Time (days)	Peak	Average	Release Time (days)
Unnamed creek	17,961	2,188	38	20,789	7,333	39	1,798	1,656	30
Confluence with Elbow River	17,955	2,173	38	20,692	7,285	39	1,798	1,657	30
Elbow River 1.0 km downstream of confluence	5,666	754	38	4,704	1,576	39	99	81	30
Background Elbow River [1]	50	16	--	50	16	--	50	16	--

NOTES:
-- no data
[1] Historical monthly suspended concentration in August without the 2013 data at highway 22



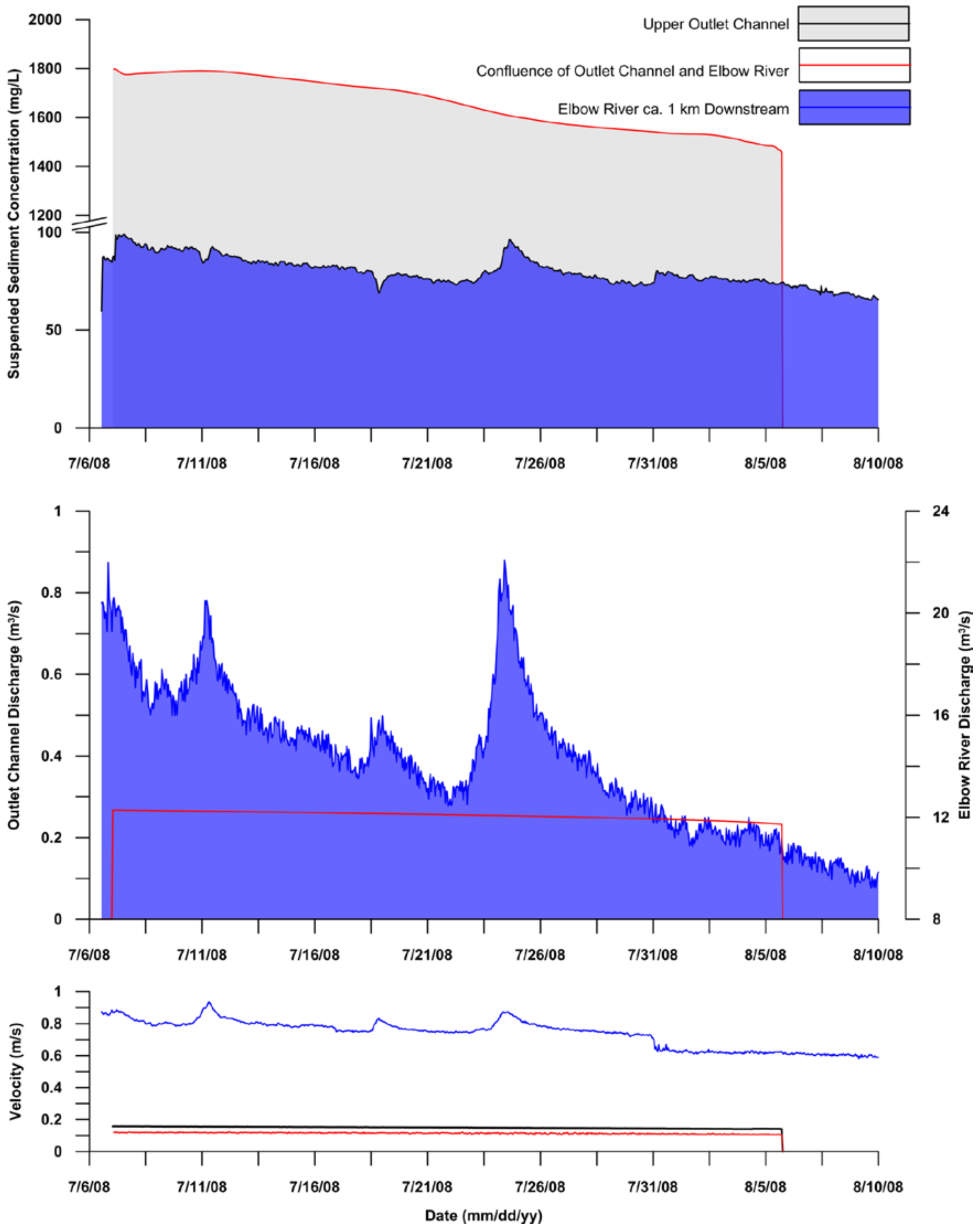
NOTE: channel refers to the unnamed creek

Figure IR348-1 Suspended Sediment Concentration in Released Flood Water at Three Locations, after a Design Flood



NOTE: channel refers to the unnamed creek

Figure IR348-2 Suspended Sediment Concentration in Released Flood Water at Three Locations, after a 1:100 Year Flood



NOTE: channel refers to the unnamed creek

Figure IR348-3 Suspended Sediment Concentration in Released Flood Water at Three Locations, after a 1:10 Year Flood

REFERENCES

CCME (Canadian Council of Ministers of the Environment). 2002. Canadian water quality guidelines for the protection of aquatic life: Total particulate matter. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

Question 349

Volume 3B, Section 8.2.2.3, Page 8.11

Alberta Transportation states that flows over 160 m^3/s *are considered channel forming and would shift bed materials which would maintain overwintering and spawning habitat and shallow side-channel and nearshore rearing habitats*.

a. Provide evidence to support this assertion.

Response 349

a. Bankfull flow was used to determine the threshold for river channel forming flows (i.e., discharge and flow are used interchangeably). Bankfull discharge is the maximum amount of water that can flow through a river or stream channel (i.e., measured as m^3/s) before flows spill out into the river's floodplain. This rate is also highly associated with the flow rate that can suspend and carry the greatest amount of bedload sediments (i.e., termed the effective discharge) and exert the greatest erosional force on the river channel (Wolman and Miller 1960).

The greater the flow rate, the larger bedload sediment particles (e.g., gravel and cobble size) that can be moved. Therefore, the flows that are at the incipient point of flooding are also associated with the forces that effectively modify the river channel form. Because bankfull discharge can be directly measured in the field, while effective discharge is usually based on indirect measurements and calculations, bankfull flow is often the preferred river flow used to describe channel forming processes. The bankfull flow downstream of the diversion structure ranges from 40 m^3/s to 60 m^3/s.

Channel forming flows can be assessed by the relative mobility of the bed material to the forces acting on them by flow in the river. Velocity can be used as a measure for determining the erodibility of bed sediment to velocity. Velocity maps were extracted from hydrodynamic model developed for used in the assessment of hydrology and aquatic ecology. Hjulström (1935) developed a curve defining the relationship between erosion and deposition and threshold velocities. The curve is a relationship between flow velocity and grain size and provides domains of a critical erosion velocity curve, transport, and a settling velocity curve.

Figure IR349-1 shows the modelled velocity distribution for the section of the Elbow River provided in the figure at a flow of 50 m^3/s. The velocity range of 1.5 m/s to 2.0 m/s accounts for the higher velocity areas in the model domain. Using the Hjulström curve within this velocity range, sediment sizes of 18 mm to 30 mm would be eroded. The average surface D_{50} (i.e., median sediment particle size, as 50th percentile of sediment particle size) of field-sieved samples in Elbow River was found to range between 32 mm and 42 mm. The surface D_{90} (i.e., 90th percentile sediment particle size) ranged between 57 mm and 82 mm.

Hollingshead (1971) found that the point of incipient motion in Elbow River is around 23 m^3/s. During bankfull flows, it is assumed that bedload transport is occurring over bars and not necessarily for more armoured deposits located in the thalweg of the river channel. Figure IR349-2 shows the modelled velocity distribution for the same reach in the Elbow River at a flow of 160 m^3/s (this is when a partial diversion of flood waters begins). Velocities, and therefore erosive forces, are greater. Selecting a proportionally similar velocity range as was done for Figure IR349-1, the velocity range of 2.5 m/s to 3.0 m/s was selected. Referring to the Hjulström curve and identifying the grain sizes that intersect the critical erosion velocity curve, sediment sizes of 40 mm to 80 mm would be eroded.

This suggests that at flows equal to or greater than 160 m^3/s, velocities are sufficiently high that sediment as large as the D_{90} can be eroded. Mackenzie and Eaton (2017) propose that their experiments support the notion that the stability of a river channel is more dependent on whether the D_{90} is mobile, rather than the D_{50}.

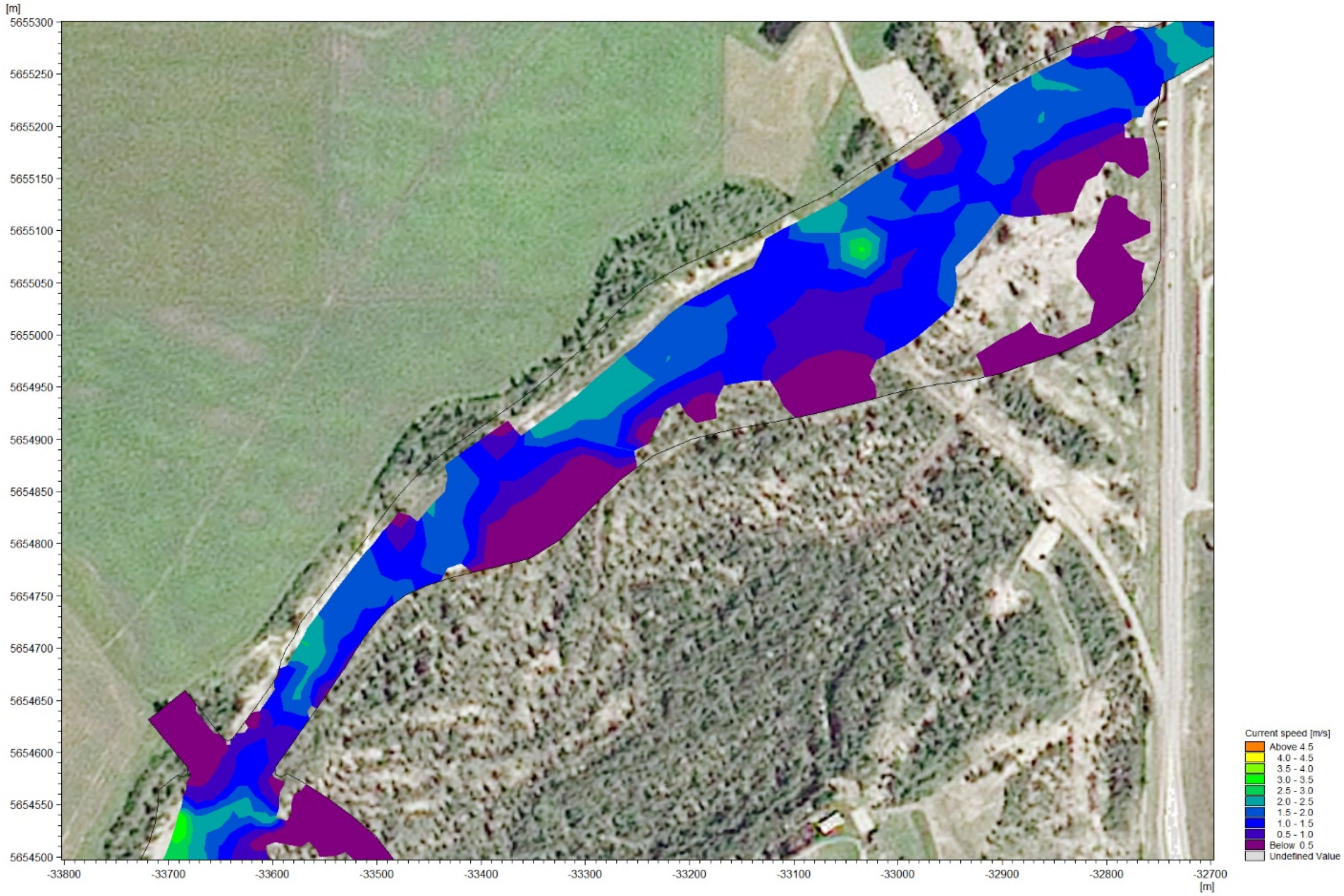


Figure IR349-1 Elbow River Velocity Distribution at 50 m³/s

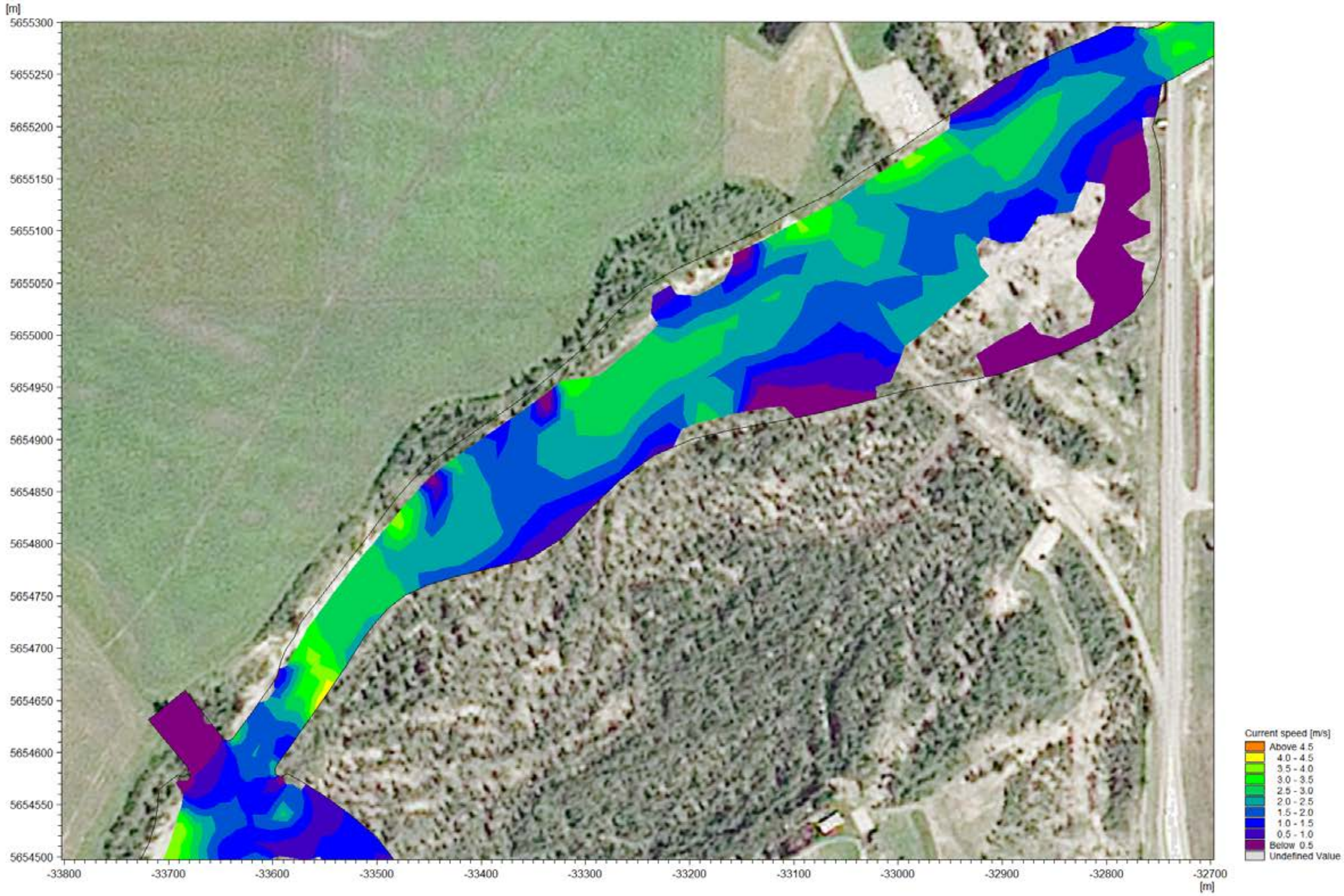


Figure IR349-2 Elbow River Velocity Distribution at 160 m³/s

REFERENCES

Hjulström, F. 1935. Studies of the morphological activity of rivers bends as illustrated by the River Fyris. *Bulletin of the Geological Institute University of Uppsalla*, 25, pp. 221-527.

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Question 350

Volume 3B, Section 8.2.4.1, Page 8.14

Alberta Transportation states at peak design diversion capacity that *up to approximately 80% of the flow could be going into the diversion canal during a design flood*, potentially resulting in *the entrainment of 80% of the fish that are upstream and near the diversion structure or being swept downstream during flooding*. No further estimates of fish numbers potentially entrained are presented.

a. Discuss the potential to model fish entrainment at varying diversion rates to reduce uncertainty of this significant risk factor.

Response 350

a. The entrainment of 80% of fish near the diversion structure is based on the conservative assumption that there is a linear relationship between diversion rates into the diversion structure and fish being swept into the diversion channel. This linear relationship assumption suggests that varying percentages of diversion rates will result in similar population percentages of fish entrainment (i.e., 80% diversion will result in 80% fish entrainment; alternatively, when 15% of the river is diverted during a smaller flood event, the linear assumption would predict only 15% of the fish being entrained).

   Modelling to confirm this assumption must account for numerous factors: site specific habitat and flood streamflow conditions; fish distribution and habitat use; behavior during flooding (such as movement into the flood fringe); use of refuge habitat; and fish moving away from the maximum channel flows (i.e., the thalweg) that will be directed into the diversion structure. Uncertainty in these parameters will add or compound uncertainty in model results.

Because of the unique nature of the Project design, and uncertainties regarding fish displacement and entrainment in the diversion structure, modelling would not provide meaningful results because it would have large uncertainties for how fish will be affected by the diversion structure.

Upon closer review of the prediction regarding the potential for fish to be displaced from the Elbow River and swept into the diversion structure during a flood (Volume 3B, Section 8.2.4, page 8.14), the potential for 80% of fish being displaced is considered conservative and high. It is likely that fish response to rising water levels and flows will reduce the percentage of fish being entrained when flood waters are diverted. Based on literature reviews of fish behavior during flooding, most of the resident fish population upstream of the diversion would find refuge and not be swept downstream and, therefore, would not be at risk of entrainment: larval fish and eggs would still be displaced downstream. However, these life stages would likely have a high mortality rate during the flood itself regardless of the diversion. Fish respond to environmental cues (e.g., rising stream flows and velocities, changes in temperature) that trigger a behavioral response including searching out refuge (e.g., channel margin habitat; floodplain habitats' point bars; concave-bank benches; deflection eddies; and expansion eddies) (Schartz and Harricks 2005; Bolland et al. 2015; Lytle and Poff 2004). Rather than downstream displacement of fish, flooding resulted in upstream dispersal into local refugia habitats (Franssen et al. 2006).

For example, Hog sucker (*Hypentelium nigricans*) in the Current River, Missouri moved into the inundated riparian areas and remain in the same stream reach as prior to flooding (Matheney and Rabeni 1995). Hog sucker are related and belong to the same family of sucker species resident in Elbow River (i.e., Catastomidae). *Galaxias argenteus* is a New Zealand salmoniform gamefish that generally grows to 40 cm and inhabits slow, lowland streams. This fish exhibits an adaptive response by remaining in the same stream habitat or moving upstream during flood events, rather than being displaced downstream (David and Gloss 2002). Large woody debris, boulders and habitat variability provide refugia from high water velocity from bankfull flood stage for coastal cutthroat trout in California (Harvey et al. 1999).

In some river systems, refugia may be limited causing fish to be more susceptible to downstream displacement. Young et al. (2010) estimated that brown trout experienced a 60% to 70% mortality during a flood in a New Zealand river where habitats were dominated by large mobile substrates. The cause of mortality was unclear, but Young et al. (2010) speculate that fish mortality may have been due to physical substrate and bedload movement. Abundance of the endangered diamond darter (*Crystallaria cincotta*) in West Virginia was reduced after a high magnitude 1:200 year flood, but local resident populations were not strongly impacted. The author's conclusion was that this species was able to withstand high stream velocities and downstream displacement (Rizzo et al. 2018).

Small-sized fish such as minnows, shiners and salmonid fry are at the highest risk of displacement during high water events (George et al. 2015). Weaker swimming capabilities of small-sized fish may make these fish more susceptible to displacement during higher flows, in channelized watercourses (Bolland et al. 2015). Fish larvae (including centrarchids [sunfish *Lepomis* sp.] and largemouth bass [*Micropterus salmoides*]) in an Oklahoma river were displaced by flooding; however, their ability to withstand flooding increased with their size (Harvey 1987).

In summary, adult fish can largely deal with high stream flow events and withstand downstream displacement. However, smaller fish may be susceptible to downstream displacement and being swept into the diversion structure. Even though smaller sized fish, such as salmonid fry in Elbow River, may be susceptible to displacement through the diversion structure during floods, the relationship between fish displaced and percent flow diverted is likely less than 1:1 (i.e., less than 80% fish displaced when 80% of the flow is diverted). Due to the uncertainty in how fish will behave during a flood, a model that can reflect site-specific entrainment conditions during flood events is not available. The development of a new model would not reduce uncertainty in the assessment.

REFERENCES

Bolland, J.D., A.D. Nunn, M.C. Lucas, and I.G. Cowx. 2015. The Habitat Use of Young-of-the-Year fishes During and After Floods of Varying Timing and Magnitude in a Constrained River. Ecological Engineering. Vol. 75: 435-440.

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Lytle, D.A., and N.L. Poff. 2004. Adaptation to Natural Flow Regimes. Trends in Ecology and Evolution. Vol 19(2): 94-100

Matheney IV, M.P. and C.F. Rabeni. 1995. Patterns of Movement and Habitat Use by Northern Hog Suckers in an Ozark Stream. Transactions of the American Fisheries Society. Vol. 128:886-897.

Rizzo, A.A., C.T. Rota, P.A. Thompson, D.J. Brown, an S.A. Welsh. 2018. Effects of an Extreme flood event on federally endangered Diamond Darter Abundances. American Midland Naturalist. Vol:180, 108-119

Schwartz, J.A., and E.E. Herricks. 2005. Fish use of Stage-specific fluvial habitats as refuge patches during a flood in a low gradient Illinois stream. Canadian Journal of Fisheries and Aquatic Sciences. Vol 62: 1540-1552.

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Question 351

<u>Volume 3B, Section 8.2.5, Table 8-2 Page 8.18</u>
<u>Volume 3B, Section 8.4, Page 8.19</u>

Alberta Transportation states in table 8-2 under residual effects that the magnitude of fish mortality resulting from post-flood stranding is high, and subsequently in section 8.4 that confidence on the effects of fish mortality during post-flood operations is lower than for other effects because of several unpredictable factors related to rate of fish entrainment and escape during draining.

a. Explain how this mortality risk can be classified as not significant given that mitigation relies on locating and rescuing an unknown number of fish by hand with an unspecified work force capacity working in a short time window during which reservoir water quality and capacity will support fish.

Response 351

a. As stated in Volume 3B, Section 8.3, Page 8.19, a residual effect that results in a “significant adverse environmental effect” caused by fish mortality is where:

> “Residual serious harm to fish due to fish mortality occurs when fishery productivity or sustainability is adversely affected and where recovery to baseline levels is uncertain.”

The predicted effects on fish will not meet the threshold considered serious harm and, therefore, effects are not significant: "The residual serious harm to fish due to fish mortality from entrainment and stranding in the off-stream reservoir is likely not significant if fish rescues are undertaken to relocate stranded fish" (Volume 3B, Section 8.5, page 8.21).

Fish that become entrained will enter the diversion channel where they may experience bodily harm (Volume 3B, Section 8.2.4, page 8.16) while going through the intake structure (i.e., through physical contact with the structure and debris). Fish that end up in the off-stream reservoir may be at risk of stranding during release of water from the reservoir. However, as discussed in the response to IR350, the fish entrainment rate predicted is conservative and the estimates are precautionary. Actual fish entrainment rates will likely be lower, as stated in the response to IR350:

> "the potential for 80% of fish being displaced is considered conservative and high. It is likely that fish behavior (i.e., fish response to rising water levels and flows) will reduce the percentage of fish being entrained when flood waters are diverted. Based on literature reviews of fish behavior during flooding, most of the resident fish population upstream of the diversion would find refuge and not be swept downstream and therefor would not be at risk of entrainment – larval fish and eggs would still be displaced downstream. However, these life stages would likely have a high mortality rate during the flood event itself regardless of the diversion. Fish respond to environmental cues (e.g., rising stream flows and velocities, changes in temperature) that trigger a behavioral response including searching out refuge (e.g., river channel margin habitat; floodplain habitats' point bars; concave-bank benches; deflection eddies; and expansion eddies) (Schartz and Harricks 2005; Bolland et al. 2015; Lytle and Poff 200]). Rather than downstream displacement of fish, flooding resulted in upstream dispersal into local refugia habitats (Franssen et al. 2006)."

The following is a correction (in red text) to Volume 3B, Section 8.2.4.2, page 8.16 regarding the release of water from the off-stream reservoir:

"The water flows in the canal will be gradually reduced and the reservoir slowly drained to facilitate the movement of fish from the reservoir, back to the Elbow River with the receding water. The outlet will be designed and operated in a manner that allows fish egress out of the reservoir, downstream into the outlet channel. Drainage areas within the reservoir will be graded to provide positive drainage and reduce stranding of fish during release of stored flood water from the reservoir").

AEP will develop a fish monitoring program to identify isolated pools and other locations where fish may be stranded as water levels decrease in unnamed creek and reservoir. A draft plan is provided in the response to IR302, Appendix 302-1. The fish rescue plan will include the use of teams of fisheries biologists led by qualified aquatic environmental specialists that will be on hand to capture fish as water levels decrease and safely relocate them to Elbow River. Indigenous groups have offered to participate and assist in the fish rescue efforts.

The overall productivity of the Elbow River fishery is not expected to be adversely affected by fish mortality in the Project components (diversion inlet, off-stream reservoir, and unnamed creek). The fishery is predicted to remain sustainable and any changes to baseline population levels are reversible and will return to existing conditions. Thus, residual effects are not significant.

REFERENCES

Bolland, J.D., A.D. Nunn, M.C. Lucas, and I.G. Cowx. 2015. The Habitat Use of Young-of-the-Year fishes During and After Floods of Varying Timing and Magnitude in a Constrained River. Ecological Engineering. Vol. 75: 435-440.

Franssen, N.R., K.B. Gido, C.S. Guy, J.A. Tripe, S.J. Shrank, T.R. Strakosh, K.N. Bertrand, K.M. Franssen, K.L. Pitts, and C.P. Paukert. 2006. Effects of floods on fish assemblages in an intermittent prairie stream. Freshwater Biology, Vol 51: 2072-2086

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Question 352

Volume 3C, Section 2.6.3, Page 2.6

Alberta Transportation states that following a flood that results in the diversion of water to the reservoir and prior to discharge from the reservoir, water samples will be collected at the low-level outlet channel and analyzed for various parameters and those results will be provided to the City of Calgary water services department.

a. **Which test results will be used by Alberta Transportation to make decisions regarding water release from the reservoir?**

b. **Describe the duration and frequency of monitoring.**

c. Describe any thresholds for measured concentrations or levels of total suspended sediment, temperature, and dissolved oxygen that may trigger actions or notification to compliance or resource management departments due to potential harm caused to fish or other aquatic life.

d. Will any monitoring of background concentrations of the same various parameters listed above in c be used for the Elbow River near the low level outlet be undertaken so as to determine if release of reservoir water and subsequent mixing would have negative impacts to aquatic ecology? If so, describe the monitoring plan that will be used to monitor background concentrations. If no monitoring will be conducted justify and explain the rationale behind not monitoring any of the listed parameters.

e. Will sampling results be made available to groups other than the City of Calgary (for example fisheries management)? If not why not.

Response 352

a-b. Water quality monitoring will be conducted in the off-stream reservoir prior to release of water. Details of the monitoring plan are provided in the Surface Water Monitoring Plan (see the response to IR302, Appendix IR302-1; in particular, refer to Section 9.3.3 [Turbidity and Suspended Solids] and Section 9.3.7, [Water Quality]).

Table IR352-1 lists the parameters that will be monitored for determining operational procedures. The release period is estimated to be between 30 and 40 days (Volume 3B, Section 6.4.2, Table 6-4, page 6.20).

Table IR352-1 Water Quality Parameter Frequency and Location Monitoring

Monitoring Parameter	Unit	Frequency	Location[1]
Total Suspended Sediments (TSS) and Turbidity	mg/L; NTU	Daily	Res, O-C and u/s
Temperature	°C	Daily	O-C and u/s
Dissolved Oxygen	mg/L; % saturation	Daily	O-C and u/s
Conductivity	µS/cm	Daily	O-C and u/s
pH	-	Daily	O-C and u/s
Discharge (Flows in the channel)	m^3/s	Daily	O-C and u/s
Major ions	mg/L	Weekly	Res, O-C
Total and Dissolved Metals	µg/L	Weekly	Res, O-C
Nutrients	mg/L	Weekly	Res, O-C

Table IR352-1 Water Quality Parameter Frequency and Location Monitoring

Monitoring Parameter	Unit	Frequency	Location[1]
Methyl Mercury	µg/L	Weekly	Res, O-C
Hydrocarbons	mg/L	Weekly	Res, O-C

NOTE:
[1] O-C – outlet channel (includes the unnamed creek); u/s – Elbow River upstream of the intake structure and diversion channel;
Res – off-stream reservoir.

c-d. Total suspended sediment (turbidity), dissolved oxygen and temperature levels will be sampled/measured during release back into the river. Results will be compared with background levels in Elbow River upstream from the intake structure at the time samples are taken. If mass balance calculations indicate levels exceed regulatory guidelines at full mixing, then AEP fisheries managers will be notified, and additional downstream monitoring of these parameters will occur.

Guideline threshold levels are provided in Table IR352-2 (from Volume 4, Appendix K, Section 2, Table 2-8).

e. Results will be provided to the City of Calgary and AEP fisheries managers.

REFERENCES

GOA (Government of Alberta). 2018. Environmental Quality Guidelines for Alberta Surface Waters. Water Policy Branch, Alberta Environment and Parks, Edmonton, Alberta

CCME (Canadian Council of Ministers of the Environment). 2016. Canadian Environmental Quality Guidelines website. Accessed December 2016

ERWP (Elbow River Watershed Partnership). 2009. Elbow River Basin Water Management Plan: a decision support tool for the protection of water quality in the Elbow River Basin. May 2008 (revised January 16, 2009).

Table IR352-2 CCME and Alberta Water Quality Guidelines for the Protection of Aquatic Life and Elbow River Water Quality Objectives (From Volume 4, Appendix K, Section 2, Table 2-8)

Parameter	Unit	CWQG acute	CWQG chronic	AB WQG short-term	AB WQG long-term	ER WQO central reach
Physical parameters						
Temperature	˚C	-	Narrative	Narrative	Narrative	18
pH	S.U.	-	6.5-9.0	-	6.5-9.0	-
Alkalinity (as $CaCO_3$)	mg/L	-	-	-	Minimum 20	-
Dissolved oxygen (cold water biota)	mg/L	-	Minimum 6.5	Minimum 5	Minimum 6.5	Minimum 6.5
Total suspended sediment	mg/L	-	Narrative	Narrative	Narrative	Narrative
Total coliforms (irrigation guideline)	CFU/100 mL	-	1,000	-	-	20,000
Fecal coliforms (irrigation guideline)	CFU/100 mL	-	100	-	100	100
Ions and ion balance						
Chloride	mg/L	640	120	640	120	-
Fluoride	mg/L	-	0.12	-	-	-
Sulphate	mg/L	-	-	-	Varies[a]	-
Sulphide	mg/L	-	-	-	0.0019	-
Nutrients and carbon						
Nitrate (as N)	mg/L	124	3.0	124	3.0	-
Nitrite (as N)	mg/L	-	0.06	Varies[a]	Varies[a]	-
Nitrate+nitrite (as N)	mg/L	-	-	-	-	0.267
Nitrogen (total)	mg/L	-	Narrative	-	-	Narrative
Ammonia (total as N)	mg/L	-	Equation[b]	-	Equation[b]	0.04
Total dissolved phosphorus	mg/L	-	-	-	-	0.009

Table IR352-2 CCME and Alberta Water Quality Guidelines for the Protection of Aquatic Life and Elbow River Water Quality Objectives (From Volume 4, Appendix K, Section 2, Table 2-8)

Parameter	Unit	CWQG acute	CWQG chronic	AB WQG short-term	AB WQG long-term	ER WQO central reach
Phosphorus (total)	mg/L	-	-	-	Narrative	-
Total organic carbon	mg/L	-	-		-	5.0
Metals (dissolved)						
Aluminium	mg/L	-	-	0.1 or equation[b] when pH <6.5	0.05 or equation[b] when pH <6.5	-
Iron	mg/L	-	-	-	0.3	-
Metals (total)						
Aluminum	mg/L	-	0.005 at pH≤6.5; 0.1 at pH≥6.5	-	-	-
Arsenic	mg/L	-	0.005	-	0.005	-
Boron	mg/L	29	1.5	29	1.5	-
Cadmium	mg/L	Equation[b]	Equation[b]	Equation[b]	Equation[b]	-
Chromium (trivalent)	mg/L	-	0.0089	-	0.0089	-
Chromium (hexavalent)	mg/L	-	0.001	-	0.001	-
Cobalt	mg/L	-	-	-	0.0025	-
Copper	mg/L	-	Equation[b]	Equation[b]	0.007	-
Iron	mg/L	-	0.3	-	-	-
Lead	mg/L	-	Equation[b]	-	Equation[b]	-
Mercury	mg/L	-	0.000026	0.000013	0.000005	-
Methylmercury	mg/L	-	0.000004	0.000002	0.000001	-

Table IR352-2 CCME and Alberta Water Quality Guidelines for the Protection of Aquatic Life and Elbow River Water Quality Objectives (From Volume 4, Appendix K, Section 2, Table 2-8)

Parameter	Unit	CWQG acute	CWQG chronic	AB WQG short-term	AB WQG long-term	ER WQO central reach
Molybdenum	mg/L	-	0.073	-	0.073	-
Nickel	mg/L	-	Equation[b]	Equation[b]	Equation[b]	-
Selenium	mg/L	-	0.001	-	0.001	-
Silver	mg/L	-	0.00025	-	0.0001	-
Thallium	mg/L	-	0.0008	-	0.0008	-
Uranium	mg/L	0.033	0.015	0.033	0.015	-
Zinc	mg/L	-	0.03	-	0.03	-
Pesticides						
2,4-D	mg/L	-	0.004	-	-	Should not exceed lower of <1/10 of federal drinking water guidelines or < CCME guidelines for aquatic life
Mecoprop (MCPP)	mg/L	-	-	10	0.013	

Table IR352-2 CCME and Alberta Water Quality Guidelines for the Protection of Aquatic Life and Elbow River Water Quality Objectives

NOTES:

CWQG = Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life by Canadian Council of Ministers of the Environment (CCME 2016).

AB WQG = Environmental Quality Guidelines for Alberta Surface Waters (GOA 2018).

ER WQO central reach = water quality objectives developed by the Elbow River Watershed Partnership for the central reach of the Elbow River (ERWP 2009)

- = no guideline

[a] Guidelines that vary based on other parameters were determined as per GOA0 (2018) and CCME (2016):

- Sulphate guideline varies based on hardness from 128 mg/L to 429 mg/L
- Nitrite-N ABWQG varies based on chloride concentrations from 0.02 mg/L to 0.20 mg/L

[b] Equations were used to calculate hardness, pH, and temperature-dependent guidelines as per ESRD (2014) and CCME (2016).

- Ammonia CWQG and AB WQG: guideline for total ammonia is based on temperature and pH, see table for values in CCME (2016).
- Dissolved aluminum AB WQG (µg/L) = $\{e^{(1.6-3.327(pH)+0.402(pH)^2)}\}$
- Total cadmium chronic/long-term CWQG and AB WQG: At hardness ≥ 17 mg/L and ≤ 280 mg/L (µg/L) = $10^{\{0.83[\log10(hardness)-2.46]\}}$
- Total cadmium acute/short-term CWQG and AB WQG: At hardness <5.3 mg/L, the guideline is 0.00011 mg/L. At hardness ≥ 5.3 mg/L and ≤ 360 mg/L (µg/L) = $10^{\{1.016[\log10(hardness)-1.71]\}}$. At hardness >360 mg/L, the guideline is 0.0077 mg/L.
- Total copper chronic CWQG: When the water hardness is 0 to < 82 mg/L, the CWQG is 0.002 mg/L. At hardness ≥82 to ≤180 mg/L the CWQG is calculated as CWQG (µg/L) = 0.2 * $e^{\{0.8545[\ln(hardness)]-1.465\}}$. At hardness >180 mg/L, the CWQG is 0.004 mg/L. If the hardness is unknown, the CWQG is 0.002 mg/L.
- Total copper short-term AB WQG (µg/L) = $(e^{\{0.979123[\ln(hardness)]-8.64497\}})$*1000
- Total lead CWQG and AB WQG: When the hardness is 0 to ≤ 60 mg/L, the guideline is 0.001 mg/L. At hardness >60 to ≤ 180 mg/L the guideline is calculated as (µg/L)= $e^{\{1.273[\ln(hardness)]-4.705\}}$. At hardness >180 mg/L, the guideline is 0.007 mg/L. If the hardness is unknown, the guideline is 0.001 mg/L.
- Total nickel CWQG: When the water hardness is 0 to ≤ 60 mg/L, the CWQG is 0.025 mg/L. At hardness > 60 to ≤ 180 mg/L the CWQG is calculated as CWQG (µg/L) = $e^{\{0.76[\ln(hardness)]+1.06\}}$
- Total nickel long-term AB WQG (µg/L) = $e^{\{0.846[\ln(hardness)]+0.0584\}}$
- Total nickel short-term AB WQG (µg/L) = $e^{\{0.846[\ln(hardness)]+2.255\}}$

Question 353

Volume 3C, Section 2.7.3.2, Page 2.8

Alberta Transportation states that follow-up monitoring during dry operations will include monitoring of fish passage over the diversion structure, and that details of fish passage success criteria will be developed with regulatory agencies.

a. **Describe what monitoring will entail including frequency, time of year, and techniques.**

b. **Describe how Alberta Transportation will contribute to current and proposed regional monitoring programs.**

Response 353

a. Conditions and engineering criteria for fish passage are well understood (Katopodis 2003; Katopodis and Gervais 2016) and are incorporated into the service spillway structure design. Fish passage and structural design details are provided in the response to IR91, Appendix IR91-1.

   A permanent gauging station with a pressure transducer will be established on the diversion gate structure to continuously measure Elbow River water levels and calculate river flow. The service spillway and v-weir dimensions are known, therefore, water levels and flow velocities can be deduced from the water level and river discharge data. Low thresholds for water level, as indicated by the pressure transducer, will indicate when volumes of water over the diversion gates and v-weirs are inadequate for fish passage and gate operations are required. For instance, during river low flow, the right gate of the service spillway will be raised. This will force the flow of the river through a smaller area to increase water depths and facilitate movement of fish upstream and downstream of the river.

   Manual river depth and velocity measurements will also be taken as required during the summer when conditions permit for calibrating water levels to flow rate and flow velocity.

b. The *Fisheries Act* authorization and offsetting plan will require post construction monitoring to assure regulators that offsetting measures compensate for alterations to fish habitat. The monitoring data will provide ongoing information on local fish habitat and resident populations. As stated in Volume 3C, Section 2.7.3.2, fish and fish habitat will be assessed in the Elbow River at sampling reaches 1 through 12 for the following:

   - fish habitat, abundance, distribution, and benthic invertebrate monitoring
   - location and measurements of required fisheries offsetting measures

The results of this work will build upon baseline data for Elbow River providing resource managers with a better understanding of fisheries in Elbow River and benchmarks for future monitoring.

Consultations with fisheries regulators will occur during the approvals process and details on how the monitoring program can best contribute to regional monitoring programs will be discussed at that time.

REFERENCES

Katopodis, C. 2003. Case Studies of Instream Flow Modelling for Fish Habitat in Canadian Prairie Rivers. Canadian Water Resources Journal. 28:2, 199-216

Katopodis, C. and R. Gervais. 2016. Fish swimming performance database and analyses. DFO Can. Sci. Advis. Sec. Res. Doc. 2016/002. vi + 550 p.

Question 354

Volume 3C, Section 2.7.3.3, Page 2.9-2.10

Alberta Transportation describes post flood monitoring during dewatering for stranded fish in isolated pools and their subsequent salvage. In addition to measures described:

a. **Will monitoring be undertaken at the low level outlet to determine if fish in the reservoir are avoiding the outlet current or exhibiting signs of stress from overcrowding or deteriorating water quality? If monitoring is to be undertaken describe the monitoring plan that will be in place. If no monitoring is to be undertaken justify and explain the rationale behind not monitoring fish at the low level outlet for signs of stress from overcrowding or deteriorating water quality.**

b. **Will any monitoring be undertaken in the Elbow River to ascertain whether fish swimming out of the reservoir are exhibiting signs of stress or mortality after returning to the flowing watercourse? If monitoring is to be undertaken describe the monitoring plan that will be in place. If no monitoring is to be undertaken justify and explain the rationale behind not monitoring fish in the Elbow River to determine if fish are exhibiting signs of stress or mortality after returning to the flowing watercourse.**

c. **Confirm there will be a qualified aquatic environment specialist (QAES) responsible for the assessment of fish stranding. Will there be multiple aquatic environment specialists involved considering the size of the reservoir? Provide the rationale behind how the number of aquatic environmental specialists involved in considering the size of the reservoir was selected.**

d. Describe the level of manpower available to perform salvage operation as directed by the QAES.

Response 354

a-c. Post-flood operations will include monitoring fish in the off-stream reservoir during the release of water. The outlet structure will be operated so that allows fish egress from the off-stream reservoir and into the unnamed creek and to the river. Fish monitoring will be necessary to identify shallow areas in the reservoir that become isolated and strand fish as the water levels drop. This monitoring will be done to inform fish rescue activities. Monitoring for fish rescue activities will include the following:

- During release of water from the off-stream reservoir, isolated pools will be identified and the potential for fish to become stranded will be assessed.
- Monitoring in and around the outlet structure will observe if and how fish congregate around the outlet and if conditions permit their movement out of the reservoir. Visual monitoring will also include assessing for potential harm or mortality of fish caused by movement through the outlet.
- Water quality in the off-stream reservoir will be monitored using hand held meters to assess water temperature and dissolved oxygen to inform fish capture and handling methods. If conditions in the reservoir become unfavorable (i.e., low oxygen and elevated temperatures), additional fish rescue crews and equipment will be mobilized.
- When the water has been fully drained, the unnamed creek will also be surveyed to identify isolated pools where fish might be stranded.
- Fish will be handled according to conditions set out in the Fish Research License.
- Monitoring will be undertaken at a frequency that allows for successful fish rescue based on environmental conditions, including ambient air temperature and the rate of the receding water level.
- Shoreline surveys in Elbow River immediately downstream of the unnamed creek confluence with the Elbow River will be completed periodically to assess if potentially translocated fish show signs of stress or mortality. Adjustments in returning fish to Elbow River will be made, as needed, to mitigate stress to fish (e.g., increase acclimation time).

Further details on post-flood monitoring for the Project can be found in the response to IR302, Appendix IR302-1, Section 9.5.

d. The level of manpower will be determined by the size and number of pools where stranding of fish may occur. The off-stream reservoir operator (AEP Operations) will assess and determine the number of personnel required to conduct the fish rescue. Fish rescue activities will be conducted by a qualified company. The company will be vetted for capability to perform all required scale fish rescue and monitoring programs, and for capability to adjust crew sizes as needed. Indigenous groups have offered to participate and provide workers to assist in the fish rescue efforts.

Question 355

Volume 3D, Section 3.0, Table 3-1 Page 3.16

Alberta Transportation states in Table 3-1 that *During post-flood cleanup, it is not anticipated that the Project would measurably affect water quality in Elbow River or Glenmore Reservoir.*

a. Describe changes to hydrology on the Elbow River below Glenmore Reservoir due to all aspects of water operations.

Response 355

a. Changes to hydrology on the Elbow River associated with the Project are described in Volume 3A, Section 6 and Volume 3B, Section 6 for all Project activities where a valid effects pathway was identified.

   As discussed in Volume 3B, Section 6.4, the primary purpose of the Project is to mitigate downstream flood hazard to the City of Calgary by modifying the hydrology of the Elbow River during a high flow by temporarily diverting water. Because the Project is a mitigation for downstream flood damage, this modification of river hydrology is intentional. However, the modification is short-term in the larger context of the Elbow River flow regime where the probability of the Project operating in any given year decreases with larger magnitude.

   Effects on hydrology of the Elbow river below Glenmore Reservoir are not expected because outflows from Glenmore Reservoir will be controlled by the operation of the Glenmore Dam. The operation of the Project will reduce the peak flows entering Glenmore Reservoir.

   Overall changes to hydrology on the Elbow River associated with the Project are positive (see the response to IR62).

   With respect to post-flood cleanup, sediment and debris moving within the off-stream reservoir and contouring will occur so as to maintain water flow into and out of the reservoir (for the next flood operations event) and maintain dam integrity. These activities will be infrequent.

With the implementation of sediment and erosion control measures and flow isolation (if needed for sediment and debris removal in the channel of the river), the hydrology of Elbow River will not be affected in post-flood operations.

Question 356

Volume 3D, Section 3.0, Table 3-1 Page 3.18

Alberta Transportation states in the summary table in volume 3D under Aquatic Ecology that *The residual effects on fish habitat, as a function of bedload movement in Elbow River and low-level outlet during the post-flood phase are of a high magnitude, short-to-long term duration.* The column describing the overall magnitude of the various potential effects only lists those effects as low or negligible.

a. Provide an update to the summary table which shows the full range of magnitude for potential effects.

Response 356

a. Table 3-1 (Volume 3D, Section 3.0, page 3.18) as it pertains to magnitude of effect to aquatic ecology is incorrect. The full range of magnitude and potential effects have been corrected (as shown with strikethrough and red text) in Table IR356-1.

Table IR356-1 includes only the relevant aquatic ecology section of Volume 3D, Section 3 Table 3-1 and not the whole table.

Some mitigation measures in Table 356-1 are relevant for more than one effect and, therefore, redundant mitigation measures are removed (by strikethrough) in Table IR356-1.

Table IR356-1 Summary of Environmental Effects Assessment (revision to Volume 3D, Section 3, Table 3-1)

Valued Component (VC) Affected	Area of Federal Jurisdiction	Project Phase		Potential Effects	Key Mitigation Measures	Residual Effect(s)	Direction*	Magnitude*	Geographic Extent*	Duration*	Frequency*	Reversibility*	Ecological and Socio-economic Context*	Timing	Significance of Residual Effect (s)
		Construction and Dry Operation	Flood and Post-Flood Operation												
Aquatic Ecology	√ Fish species at risk and navigable waters	√	√	The following potential project effects are assessed for Aquatic Ecology: • Permanent alteration of fish habitat • Destruction of fish habitat • Death of Fish • Change in Sediment • Change in Fish Passage • Entrainment and Stranding of Fish	• Building material used in watercourses, including concrete, silt fences, turbidity barriers, and containment berms will be used to prevent the release or leaching of substances that may be deleterious to fish into the water. • Activities near water will be planned and completed in the dry and isolated from watercourses to prevent materials such as paint, primers, blasting abrasives, rust solvents, degreasers, grout, other chemicals or other deleterious materials do not enter the watercourse. • The top substrate from a wetted channel will be stripped and stockpiled for later use as the top layer of reclaimed instream substrate to improve the recolonization rate and maintain average mobile substrate sizes. • Rootwads and large boulders that must be removed will be stored on-site for subsequent placement on reclaimed instream cover or for bank protection. • Fertilization of reclaimed areas in the immediate vicinity of a watercourse	The residual effect of construction on causing a permanent alteration to fish habitat is adverse in direction, low in magnitude, restricted to the PDA, permanent in duration, and a single event in frequency. Due to the permanence of the project structures in the river, the effect is irreversible. The residual effect of construction on causing the destruction of fish habitat is adverse in direction, low in magnitude, restricted to the PDA, permanent in duration, and as a single event in frequency. Due to the permanence of the structure in the river, the effect is irreversible. The residual effect of construction causing death of fish is ~~adverse~~neutral in direction, ~~low~~ negligible in magnitude, restricted to the PDA, and as an irregular event in frequency. Given the low potential and the small portion of the fish population that could be affected, the effect is reversible. The effect of dry operation on aquatic ecology through a destruction of fish habitat is ~~adverse~~Neutral in direction, low in magnitude, extends to the Elbow River through the LAA, permanent in duration, and would occur during spawning migrations at an irregular, but continuous	A/N	~~L/N~~ N/H	PDA/ LAA	P/ST/ LT	S/IR/C	I/R	U/D	S/R	The residual effects on fish habitat, fish mortality, sedimentation and fish passage are unlikely to pose a long-term threat to the persistence or viability of a fish species, including SAR, in the RAA. With the application of mitigation measures, residual effects on aquatic ecology are predicted to be not significant.

Table IR356-1 Summary of Environmental Effects Assessment (revision to Volume 3D, Section 3, Table 3-1)

Valued Component (VC) Affected	Area of Federal Jurisdiction	Project Phase: Construction and Dry Operation	Project Phase: Flood and Post-Flood Operation	Potential Effects	Key Mitigation Measures	Residual Effect(s)	Direction*	Magnitude*	Geographic Extent*	Duration*	Frequency*	Reversibility*	Ecological and Socio-economic Context*	Timing	Significance of Residual Effect (s)
					will not be allowed unless approved by DFO and AEP. • Streambanks and approach slopes will be revegetated using an appropriate native seed mix or erosion control mix. • Boulders will be added to increase the bed roughness of the channel immediately downstream of the diversion structure, which will increase water depths and reduce velocities. • Boulder V-weir structures will be constructed in the channel downstream of the gates to provide slower velocity and deeper resting zones. • A monitoring program will be undertaken to identify if fish passage is impeded for migratory salmonids or other fish species. • Structures will be designed so that storm water runoff and wash water from the access roads, decks, side slopes, and approaches will be directed into a retention pond or vegetated area to remove suspended solids, dissipate velocity, and prevent sediment and other deleterious	frequency. Due to the permanence of the structure in the river, the effect is irreversible. The residual effects on fish habitat, as a function of bedload movement in Elbow River and low-level outlet during the post-flood phase are of a high magnitude, short-to-long term duration. The release of water from the reservoir through the low-level outlet will temporarily increase localized suspended sediment concentrations and turbidity in the Elbow River. Increased turbidity and the deposition of sediment on substrates could affect the quality of fish habitat in the low-level outlet channel and in Elbow River downstream of the low-level outlet. Upstream movement of fish during post-flood operations would not differ from upstream movement during dry operations. During post-flood operations, stranding in the reservoir is expected to cause mortality of fish that do not swim out of the reservoir during post-flood draining. The diversion structure and reservoir are planned and designed as mitigation measures to limit the effects of floods in the Elbow River									

Table IR356-1 Summary of Environmental Effects Assessment (revision to Volume 3D, Section 3, Table 3-1)

Valued Component (VC) Affected	Area of Federal Jurisdiction	Project Phase: Construction and Dry Operation	Project Phase: Flood and Post-Flood Operation	Potential Effects	Key Mitigation Measures	Residual Effect(s)	Direction*	Magnitude*	Geographic Extent*	Duration*	Frequency*	Reversibility*	Ecological and Socio-economic Context*	Timing	Significance of Residual Effect (s)
					substances from entering the watercourse. • ~~Activities near water will be planned and completed in the dry and isolated from watercourses to prevent materials such as paint, primers, blasting abrasives, rust solvents, degreasers, grout, other chemicals or other deleterious materials do not enter the watercourse.~~ • The cleaning and removal of debris and sediment from sediment and erosion control devices will be conducted in a manner that will prevent materials from entering the water body. • Large woody debris pieces such as rootballs and logs over 50 cm in diameter, will be retained and relocated in the river downstream of the structure. • Where debris removal from the structures is required, debris removal will be timed to avoid disruption to sensitive fish life stages (i.e., outside the RAP), unless the debris and its accumulation is immediately threatening to the integrity of the structure or relates to an										

Table IR356-1 Summary of Environmental Effects Assessment (revision to Volume 3D, Section 3, Table 3-1)

Valued Component (VC) Affected	Area of Federal Jurisdiction	Project Phase: Construction and Dry Operation	Project Phase: Flood and Post-Flood Operation	Potential Effects	Key Mitigation Measures	Residual Effect(s)	Direction*	Magnitude*	Geographic Extent*	Duration*	Frequency*	Reversibility*	Ecological and Socio-economic Context*	Timing	Significance of Residual Effect (s)
					emergency (i.e., risk of structure failure). • Works in water will be timed with respect to the restricted activity periods (RAPs) wherever possible. For the Elbow River, the RAP is May 01 – July 15 and September 16 – April 15. Condition and use of restricted activity periods will be provided within further project permitting and authorization under the Fisheries Act. For planning purposes, the Elbow River RAP will be applied as an avoidance and mitigation measure. • Building material used in watercourses, including concrete, will be handled and treated in a manner that prevents the release or leaching of substances that may be deleterious to fish into the water. • ~~Activities near water will be planned and completed in the dry and isolated from watercourses to prevent materials such as paint, primers, blasting abrasives, rust solvents, degreasers, grout, other chemicals or other deleterious materials do not enter the watercourse.~~ • ~~Activities near water will be planned such that~~										

Table IR356-1 Summary of Environmental Effects Assessment (revision to Volume 3D, Section 3, Table 3-1)

Valued Component (VC) Affected	Area of Federal Jurisdiction	Project Phase: Construction and Dry Operation	Project Phase: Flood and Post-Flood Operation	Potential Effects	Key Mitigation Measures	Residual Effect(s)	Direction*	Magnitude*	Geographic Extent*	Duration*	Frequency*	Reversibility*	Ecological and Socio-economic Context*	Timing	Significance of Residual Effect (s)
					~~materials such as paint, primers, blasting abrasives, rust solvents, degreasers, grout, or other chemicals do not enter the watercourse.~~ • Erosion and sediment control measures will be installed before starting work to prevent sediment from entering the water body. • Erosion and sediment control measures will be regularly inspected daily and maintained during construction. • Erosion and sediment control measures will be repaired immediately if damage occurs. • Non-biodegradable erosion and sediment control materials will be removed once the site is stabilized. • Measures for managing water flowing onto the site, as well as water being pumped/diverted from the site will be implemented such that sediment is filtered out before the water enters a waterbody (e.g., silt fences, turbidity barriers, pumping/diverting water to a vegetated area, constructing a settling basin, or other filtration system). • TSS levels will be controlled and reduced										

Table IR356-1 Summary of Environmental Effects Assessment (revision to Volume 3D, Section 3, Table 3-1)

Valued Component (VC) Affected	Area of Federal Jurisdiction	Project Phase: Construction and Dry Operation	Project Phase: Flood and Post-Flood Operation	Potential Effects	Key Mitigation Measures	Residual Effect(s)	Direction*	Magnitude*	Geographic Extent*	Duration*	Frequency*	Reversibility*	Ecological and Socio-economic Context*	Timing	Significance of Residual Effect (s)
					using silt fences and turbidity barriers to ensure the water quality from care of water system discharges is made equal to or better than the initial water quality. TSS levels will be monitored by carrying out frequent water quality testing. • Excavated materials and debris will be stockpiled above the highwater mark and in such a way as they do not enter the watercourse. Silt fences will be used to contain soil erosion. • Clearing of riparian vegetation will be kept to a minimum. • Herbicide use in the immediate vicinity of a watercourse will not be allowed unless approved by DFO and AEP. Weeds will be controlled during construction through multiple measures, such as herbicide, mowing, wicking, and hand picking. After construction, disturbed areas will be stabilized and reclaimed. • Erosion and sediment control measures will be maintained monitored until vegetation has become sufficiently reestablished.										

Table IR356-1 Summary of Environmental Effects Assessment (revision to Volume 3D, Section 3, Table 3-1)

Valued Component (VC) Affected	Area of Federal Jurisdiction	Project Phase: Construction and Dry Operation	Project Phase: Flood and Post-Flood Operation	Potential Effects	Key Mitigation Measures	Residual Effect(s)	Direction*	Magnitude*	Geographic Extent*	Duration*	Frequency*	Reversibility*	Ecological and Socio-economic Context*	Timing	Significance of Residual Effect (s)
					• To allow for fish passage and construction of the structures in the dry, the Elbow River will be diverted, and flows will be maintained downstream by the construction of a temporary bypass channel. • Sediment laden dewatering discharge will be pumped into a vegetated area or settling basin to allow sediment to settle out before returning it to the water body. Silt fences, turbidity barriers and clean granular berms will be used to contain the sediment and other deleterious substances and to prevent it from entering a watercourse or water body. • Energy dissipaters will be used at pump outlets to prevent erosion. • The location of any in-stream works will be isolated from the watercourses using silt fences, turbidity barriers and clean granular berms. • Isolation materials will be designed to minimize disturbance of the bed and banks of the Elbow River and other watercourses.										

Table IR356-1 Summary of Environmental Effects Assessment (revision to Volume 3D, Section 3, Table 3-1)

Valued Component (VC) Affected	Area of Federal Jurisdiction	Project Phase: Construction and Dry Operation	Project Phase: Flood and Post-Flood Operation	Potential Effects	Key Mitigation Measures	Residual Effect(s)	Direction*	Magnitude*	Geographic Extent*	Duration*	Frequency*	Reversibility*	Ecological and Socio-economic Context*	Timing	Significance of Residual Effect (s)
					• Clean granular fill with less than 5% fines passing the 80um sieve size will be used for instream work such as cofferdams, causeways, access ramps, Bailey bridges, river channel diversions. Fine grained soils may be used, provided only clean granular fill is exposed to the river at any time during construction and restoration operations. • Sediment and erosion control devices will be constructed to withstand anticipated flows during construction. If necessary, the outside face of granular berms may be lined with heavy poly-plastic to make them impermeable to water. • Before isolation and dewatering works commence, a qualified environmental professional (QEP) will be retained to obtain applicable permits for relocating fish and to capture any fish trapped within an isolated/enclosed area at the work site and safely relocate them to an appropriate location in the same waters. • Pump discharge area(s) will be isolated to prevent erosion and the										

Table IR356-1 Summary of Environmental Effects Assessment (revision to Volume 3D, Section 3, Table 3-1)

Valued Component (VC) Affected	Area of Federal Jurisdiction	Project Phase		Potential Effects	Key Mitigation Measures	Residual Effect(s)	Direction*	Magnitude*	Geographic Extent*	Duration*	Frequency*	Reversibility*	Ecological and Socio-economic Context*	Timing	Significance of Residual Effect (s)
		Construction and Dry Operation	Flood and Post-Flood Operation												
					release of suspended sediments downstream. Any sediment build-up will be removed when the work is completed. • Water intakes pipes will be screened to prevent entrainment or impingement of fish. Entrainment occurs when a fish is drawn into a water intake and cannot escape. Impingement occurs when an entrapped fish is held in contact with the intake screen and is unable to free itself. Screens are to comply with DFO's "Freshwater Intake End-of-Pipe Fish Screen Guidelines". • Accumulated sediment and spoil build up within the isolated areas will be removed prior to removal of the isolation barriers. • When removing the isolation barriers, the downstream isolation barriers will be gradually removed first, to equalize water levels inside and outside of the isolated area and to allow suspended sediments to settle prior to removing the upstream isolation materials. • ~~Boulders will be added to increase the bed roughness of the channel immediately~~										

Table IR356-1 Summary of Environmental Effects Assessment (revision to Volume 3D, Section 3, Table 3-1)

Valued Component (VC) Affected	Area of Federal Jurisdiction	Project Phase: Construction and Dry Operation	Project Phase: Flood and Post-Flood Operation	Potential Effects	Key Mitigation Measures	Residual Effect(s)	Direction*	Magnitude*	Geographic Extent*	Duration*	Frequency*	Reversibility*	Ecological and Socio-economic Context*	Timing	Significance of Residual Effect (s)
					~~downstream of the diversion structure, which will increase water depths and reduce velocities.~~ • ~~Boulder V-weir structures will be constructed in the channel downstream of the gates to provide slower velocity and deeper resting zones.~~ • ~~A monitoring program will be undertaken to identify if fish passage is impeded for migratory salmonids or other fish species.~~ • Works in water will be timed with respect to the restricted activity periods (RAPs) wherever possible. For the Elbow River, the RAP is May 01 – July 15 and September 16 – April 15. Condition and use of restricted activity periods will be provided within further project permitting and authorization under the Fisheries Act. For planning purposes, the Elbow River RAP will be applied as an avoidance and mitigation measure. • Machinery will arrive on site in a clean condition and be maintained free of fluid leaks, invasive species, and noxious weeds. • Equipment will be inspected, maintained,										

Table IR356-1 Summary of Environmental Effects Assessment (revision to Volume 3D, Section 3, Table 3-1)

Valued Component (VC) Affected	Area of Federal Jurisdiction	Project Phase: Construction and Dry Operation	Project Phase: Flood and Post-Flood Operation	Potential Effects	Key Mitigation Measures	Residual Effect(s)	Direction*	Magnitude*	Geographic Extent*	Duration*	Frequency*	Reversibility*	Ecological and Socio-economic Context*	Timing	Significance of Residual Effect (s)
					and repaired immediately, to prevent leaks. • Use construction equipment that is mechanically sound with no oil leaks, fuel or fluid leaks. Inspect equipment daily and immediately repair any leaks. • Employ persons qualified to handle Construction Equipment fuels and lubricants to perform repairs. • Service vehicles to carry fuel spill clean-up materials. • Use containment berms and impermeable liners around fuel and lubricant storage tanks. • Maintain a minimum 100 metre setback between stored fuels and lubricants and rivers, streams and surface water bodies. • Stream bank and bed protection methods (e.g., swamp mats, pads) will be used if rutting is likely to occur during access to the bed and shore. Temporary access structures will be used where steep and highly erodible banks are present. • Whenever possible, machinery will be operated on land above the high-water mark in a										

Table IR356-1 Summary of Environmental Effects Assessment (revision to Volume 3D, Section 3, Table 3-1)

Valued Component (VC) Affected	Area of Federal Jurisdiction	Project Phase: Construction and Dry Operation	Project Phase: Flood and Post-Flood Operation	Potential Effects	Key Mitigation Measures	Residual Effect(s)	Direction*	Magnitude*	Geographic Extent*	Duration*	Frequency*	Reversibility*	Ecological and Socio-economic Context*	Timing	Significance of Residual Effect (s)
					manner that minimizes disturbance to the banks and bed of the watercourses. • Where instream works are required, non-toxic and biodegradable hydraulic fluids will be used in machinery. • ~~Erosion and sediment control measures will be installed before starting work to prevent sediment from entering the water body.~~ • ~~Erosion and sediment control measures will be regularly inspected daily and maintained during construction.~~ • ~~Erosion and sediment control measures will be repaired immediately if damage occurs.~~ • ~~Non-biodegradable erosion and sediment control materials will be removed once the site is stabilized.~~ • ~~Measures for managing water flowing onto the site, as well as water being pumped/diverted from the site will be implemented such that sediment is filtered out before the water enters a waterbody (e.g., silt fences, turbidity barriers, pumping/diverting water to a vegetated area, constructing a settling~~										

Table IR356-1 Summary of Environmental Effects Assessment (revision to Volume 3D, Section 3, Table 3-1)

Valued Component (VC) Affected	Area of Federal Jurisdiction	Project Phase: Construction and Dry Operation	Project Phase: Flood and Post-Flood Operation	Potential Effects	Key Mitigation Measures	Residual Effect(s)	Direction*	Magnitude*	Geographic Extent*	Duration*	Frequency*	Reversibility*	Ecological and Socio-economic Context*	Timing	Significance of Residual Effect (s)
					~~basin, or other filtration system).~~ • Excavated materials and debris will be stockpiled above the highwater mark and in such a way as they do not enter the watercourse. Silt fences will be used to contain soil erosion. • Clearing of riparian vegetation will be kept to a minimum. • ~~Herbicide use in the immediate vicinity of a watercourse will not be allowed unless approved by DFO and AEP. Weeds will be controlled during construction through multiple measures, such as herbicide, mowing, wicking, and hand picking. After construction, disturbed areas will be stabilized and reclaimed.~~ • After construction, disturbed areas will be stabilized and reclaimed. • ~~Erosion and sediment control measures will be monitored until vegetation has become sufficiently reestablished~~ • • Flows in the Elbow River will be maintained downstream of the project (e.g., bypass channel). • ~~Sediment laden dewatering discharge will be pumped into a~~										

Table IR356-1 Summary of Environmental Effects Assessment (revision to Volume 3D, Section 3, Table 3-1)

Valued Component (VC) Affected	Area of Federal Jurisdiction	Project Phase: Construction and Dry Operation	Project Phase: Flood and Post-Flood Operation	Potential Effects	Key Mitigation Measures	Residual Effect(s)	Direction*	Magnitude*	Geographic Extent*	Duration*	Frequency*	Reversibility*	Ecological and Socio-economic Context*	Timing	Significance of Residual Effect (s)
					~~vegetated area or settling basin to allow sediment to settle out before returning it to the water body. Silt fences, turbidity barriers and clean granular berms will be used to contain the sediment and other deleterious substances and to prevent it from entering a watercourse or water body.~~ • ~~Energy dissipaters will be used at pump outlets to prevent erosion.~~ • Sediment and erosion control devices will be constructed to withstand anticipated flows during construction. If necessary, the outside face of granular berms may be lined with heavy poly-plastic to make them impermeable to water. • Drainage areas within the reservoir will be graded to reduce stranding of fish during release of stored flood water from the reservoir.										

Table IR356-1 Summary of Environmental Effects Assessment (revision to Volume 3D, Section 3, Table 3-1, page 3-17)

Direction: P: Positive A: Adverse N: Neutral ***Magnitude:*** N: Negligible L: Low M: Moderate H: High	***Geographic Extent:*** PDA: Project Development Area LAA: Local Assessment Area RAA: Regional Assessment Area ***Duration:*** ST: Short-term LT: Long-term ***Timing:*** T: Time of Day S: Seasonality R: Regulatory N/A: Not applicable	***Frequency:*** S: Single event IR: Irregular event R: Regular event C: Continuous ***Reversibility:*** R: Reversible I: Irreversible ***Ecological/Socio-Economic Context:*** U: Undisturbed D: Disturbed

Question 357

<u>Volume 4, App M Aquatic Ecology, Section 3.1.1, Page 3.3</u>

While describing Bull Trout in the desktop review section, Alberta Transportation states *Fisheries surveys indicate that bull trout in the mid-reach of the Elbow spawn in the area upstream of Bragg Creek from Gooseberry Campground up to Elbow Falls.*

a. Map existing critical or sensitive areas used by Bull Trout including migration and spawning routes.

b. Describe and map existing critical or sensitive areas such as spawning, rearing, and overwintering habitats, seasonal habitat use including migration and spawning routes for other fish species.

Response 357

a. There are no listed Schedule 1 species within the aquatic ecology LAA under the *Species at Risk Act* (SARA) and, therefore, there is no critical habitat as defined by SARA. Bull trout are considered *'threatened'* under *Alberta Wildlife Act* and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

   Redd surveys completed by Applied Aquatic Research in 2002, 2003, 2004, and 2006 (AAR; 2008) were reviewed and referenced in Section 3.1.1 of Volume 4, Appendix M. The redd surveys were completed for three consecutive years, the final year completed was in September of 2006 along a reach of the Elbow River in the aquatic ecology LAA. The reach assessed by Applied Aquatic Research was completed in two sections: Elbow Falls (11U 6559331E, 5637338N) to the downstream (east) end of Paddy's Flat Campground (11U 660811E, 5638200N); and the east end of Paddy's Flat Campground to Gooseberry Campground (11U 666149E, 5643072N). Results of the Applied Aquatic Research redd survey found the area between Elbow Falls and the (east) end of Paddy's Flat Campground consistently and exclusively encompassed spawning areas used by bull trout.

   Bull trout are not expected to spawn in the portion of the Elbow River that is in the PDA or downstream of the PDA; however, they may migrate upstream through the PDA to upstream spawning locations and downstream after spawning, but this is not confirmed. Applied Aquatic Research provided maps showing the locations of the survey locations and found bull trout spawning areas consistently within the segment of the Elbow River between Elbow Falls and Paddy's Flat Campground upstream of the PDA (these are provided as Appendix IR357-1).

b. Figure 357-1 provides the fish and fish habitat reaches assessed within the LAA in 2016 (this figure is a copy of Figure 2-1 in the Aquatic Ecology TDR Volume 4, Appendix M). These reaches were selected based on distances from the proposed diversion structure and to correspond with all 10 benthic invertebrate sampling sites and five sites sampled for sediment quality. The 12 assessed reaches, identified within the Aquatic Ecology TDR (as referenced in Volume 4, Appendix M, Section 3.1.1), were assessed for sensitive fish habitat. Four of these assessed reaches (Reaches 4, 5, 6, and 7) are in the PDA; Reaches 4 and 5 are downstream of the proposed diversion structure and Reaches 6 and 7 are the two nearest assessed river reaches downstream of the unnamed creek.

No spawning evidence for fish was observed in these reaches. Based on physical parameters such as substrate, cover, and flows, Reaches 4, 5, and 6 could provide good habitat for all life history components of forage fish (fathead minnow, lake chub, longnose dace, pearl dace, spottail shiner, brook stickleback, and trout-perch). Reach 7 could provide moderate to good spawning and overwintering habitat, moderate rearing habitat and good migration habitat for forage fish.

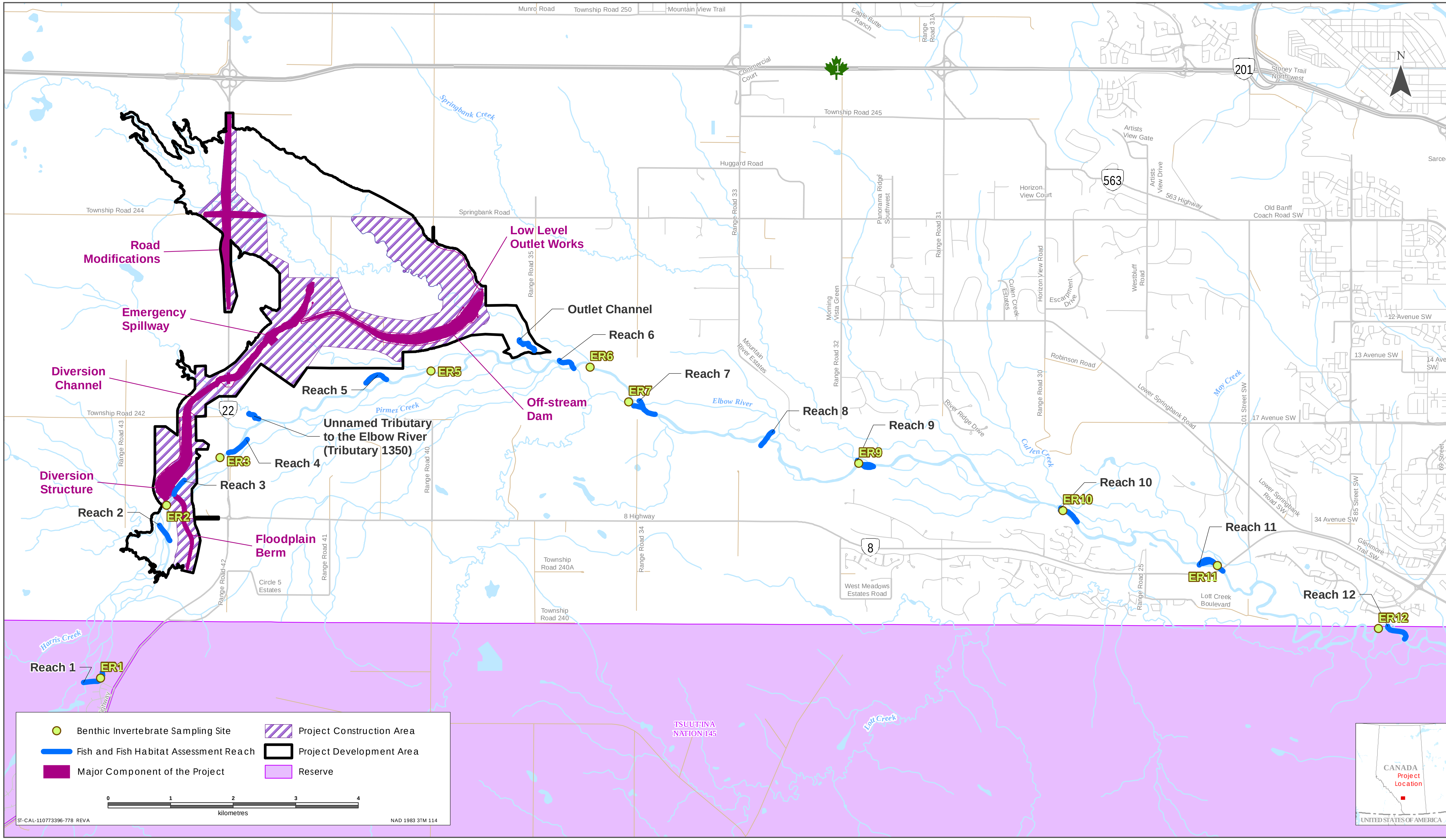
The fish habitat of these four assessed reaches are discussed in greater detail in Volume 4, Appendix M, Sections 3.1.6 to 3.1.9, pages 3.16 to 3.25. The following provides a summary.

For coarse fish (longnose sucker, mountain sucker, and white sucker), spawning habitat is rated as moderate in Reach 4 and good in Reaches 5, 6 and 7. Rearing habitat is rated as moderate in Reaches 4 and 7 and good in Reaches 5 and 6. Migration habitat is rated good for all four reaches. Overwintering habitat is rated as moderate in Reach 4, moderate to good in Reach 7 and good in Reaches 5 and 6.

Three species of sport fish (brown trout, brook trout, and rainbow trout) were captured in Reaches 4 and 5. Historically, sport fish in the area include northern pike, burbot, yellow perch, brook trout, brown trout, bull trout, rainbow trout, westslope cutthroat trout, and mountain whitefish. Fish habitat ratings for sport fish spawning are moderate in Reach 4 and good in Reaches 5 to 7. Rearing is rated as moderate for Reaches 4 and 7 and good for Reaches 5 and 6. Migration habitat is rated good for all four reaches. Overwintering habitat is rated as moderate for Reach 4, moderate to good for Reach 7 and good for Reaches 5 and 6. Brown trout may migrate through the aquatics RAA either to move to upstream spawning areas or downstream after spawning, rearing or overwintering. Much of Elbow River, from the Elbow River falls to Glenmore Reservoir, could be used for migration during various life history stages. Because brown trout could migrate through any portion of the river that is within the RAA, specific migration mapping is not provided.

REFERENCES

Applied Aquatic Research Ltd. 2008. Fluvial bull trout redd surveys on the Elbow, Sheep and Highwood Rivers, Alberta. Report prepared for Trout Unlimited Canada.



Sources: Base Data - Government of Alberta, Government of Canada. Thematic Data - Stantec Ltd.

Stantec

ALBERTA TRANSPORTATION SPRINGBANK OFF-STREAM RESERVOIR PROJECT ENVIRONMENTAL IMPACT ASSESSMENT

Fish and Fish Habitat Assessment Reaches and Benthic Invertebrate Sampling Sites

Figure IR357-1

Question 358

Volume 4, App M Aquatic Ecology, Attachment A, Section A-1 Table A1, Page A.3-4

Alberta Transportation provides a summary table of the 14 surveyed reaches of the Elbow and tributaries. Reach lengths do not appear to be listed.

a. **Provide the lengths of the reaches assessed.**

b. **Discuss the resulting ratio of assessed habitat area to total habitat area in the local assessment area and the applicability of using those measurements to determine characteristics of unassessed habitat.**

Response 358

a. Table IR358-1 below is a reproduction of Table A-1 with the addition of reach length.

b. Reach-based assessments are used to assess fish habitat in a segment of a watercourse, to define the structure of the stream reaches, the pattern, the forming features, and the dimensions of the habitat. Detailed habitat information was collected along the length of each reach. This is a standard approach when conducting environmental assessments in watercourses.

   Length of river was used in determining the ratio of habitat assessed as accurate measurements of area within the river are difficult to calculate. The length of Elbow River within the PDA is approximately 2.4 km with 25% of the length assessed. The length of Elbow River within the LAA is approximately 84 km with 6% of the length the assessed. Because the selected reaches are representative of Elbow River, these percentages are considered sufficient for the assessment.

Table IR358-1 Summary of Fisheries Reaches

Reach	Date Surveyed	Channel Width (m)	Maximum Depth (m)	Length of Reach (m)	Fish Captured (n)	Fish Range of Lengths (mm)	Water Quality at Time of Sampling	Spawning Habitat Rating	Overwintering Habitat Rating	Rearing Habitat Rating	Migration Habitat Rating	Comments
1: Elbow River	Sep 21, 2016	26-100	0.9	404.44	BKTR (1) BNTR (9)	132 54-330	8.6 °C 9.91 mg/L 400 µs/cm 8.0 pH 0.91 NTU	Poor - moderate	Poor - moderate	Poor - moderate	Good	Filamentous algae present. Spawning habitat limited for forage fish. Overwintering habitat limited by lack of depths. Rearing habitat is limited by lack of bank features.
2: Elbow River	Sep 22, 2016	13-34	1.0	297.64	LNDC (1) BNTR (7) MNWH (1)	59 420-480 97	8.8 °C 9.40 mg/L 415 µs/cm 8.0 pH 0.31 NTU	Poor - moderate	Poor - moderate	Poor - moderate	Good	Filamentous algae present. Spawning habitat limited for forage fish. Overwintering habitat limited by lack of depths. Rearing habitat is limited by lack of bank features.
3: Elbow River	Sep 22, 2016	16-39	0.8	283.46	BKTR (2) BNTR (5)	127-136 64-86	8.4 °C 9.68 mg/L 417 µs/cm 7.9 pH 0.01 NTU	Moderate	Moderate	Moderate - good	Good	Filamentous algae present.
4: Elbow River	Sep 21, 2016	28-60	0.8	379.91	BKTR (1) BNTR (6)	184 64-238	9.0 °C 10.86 mg/L 370 µs/cm 8.1 pH - NTU	Moderate - good	Moderate - good	Moderate - good	Good	Filamentous algae present.
5: Elbow River	Sep 26, 2016	15-39	1.0	401.36	BNTR (7) RNTR (1)	72-146 observed	8.2 °C 10.41 mg/L 326 µs/cm 7.8 pH 0.46 NTU	Good	Good	Good	Good	Filamentous algae present.
6: Elbow River	Sep 19, 2016	25-38	1.0	311.48	Not sampled due to elevated velocities	Not sampled	9.1 °C 12.50 mg/L 469 µs/cm 7.1 pH 0.42 NTU	Good	Good	Good	Good	Filamentous algae present.

Table IR358-1 Summary of Fisheries Reaches

Reach	Date Surveyed	Channel Width (m)	Maximum Depth (m)	Length of Reach (m)	Fish Captured (n)	Fish Range of Lengths (mm)	Water Quality at Time of Sampling	Spawning Habitat Rating	Overwintering Habitat Rating	Rearing Habitat Rating	Migration Habitat Rating	Comments
7: Elbow River	Sep 19, 2016	24-46	1.2	528.78	LNDC (2) WHSC (1)	< 20-47 < 20	12.5 °C 11.50 mg/L 416 µs/cm 8.0 pH 0.56 NTU	Moderate - good	Moderate - good	Moderate	Good	Filamentous algae present.
8: Elbow River	Sep 23, 2016	21-36	1.0	290.63	Not sampled due to elevated velocities	Not sampled	9.8 °C 9.88 mg/L 427 µs/cm 8.0 pH 0.03 NTU	Moderate - good	Good	Moderate - good	Good	Filamentous algae present.
9: Elbow River	Sep 23, 2016	21-31	1.2	486.48	Not sampled due to elevated velocities	Not sampled	11.7 °C 11.02 mg/L 429 µs/cm 7.8 pH 0.00 NTU	Poor-moderate	Poor-moderate	Moderate	Good	Filamentous algae present. High velocities limit spawning and overwintering habitat.
10: Elbow River	Sep 21, 2016	24-52	1.0	459.73	Not sampled due to elevated velocities	Not sampled	13.2 °C 9.80 mg/L 435 µs/cm 7.8 pH - NTU	Poor-moderate	Poor-moderate	Poor-moderate	Good	Filamentous algae present. High velocities limit spawning and overwintering habitat. Rearing habitat is limited by lack of habitat diversity and complexity.
11: Elbow River	Sep 22, 2016	21-31	>1.0	712.31	LNDC (2) BKTR (1)	70-86 183	10.6 °C 9.48 mg/L 435 µs/cm 8.1 pH 0.01 NTU	Moderate	Moderate - good	Moderate	Good	Filamentous algae present.
12: Elbow River	Sep 21, 2016	18-29	>1.0	417.69	LNDC (3) LNSC (3)	46-89 59-86	10.9 °C 9.38 mg/L 442 µs/cm 8.1 pH 0.14 NTU	Moderate	Good	Moderate - good	Good	Filamentous algae present.
Unnamed tributary	Sep 20, 2016	0.5-1	0.10	217.94	BRST (2)	55-57	Not taken	None	None	None-poor	Poor	Standing pooled water with no flow.

Table IR358-1 Summary of Fisheries Reaches

Reach	Date Surveyed	Channel Width (m)	Maximum Depth (m)	Length of Reach (m)	Fish Captured (n)	Fish Range of Lengths (mm)	Water Quality at Time of Sampling	Spawning Habitat Rating	Overwintering Habitat Rating	Rearing Habitat Rating	Migration Habitat Rating	Comments
Unnamed creek	Sep 19, 2016	5-13	0.40	362.66	WHSC (3) BRST (15)	Not measured	11.0 °C 9.50 mg/L 1,333 µs/cm 7.9 pH 5.15 NTU	None	Non-poor	None-poor	Poor	Standing pooled water with no flow.

Key to species codes for fish captured:
BKTR: brook trout
BNTR: brown trout
BRST: brook stickleback
LNDC: longnose dace
LNSC: longnose sucker
MNWH: mountain whitefish
RNTR: rainbow trout
WHSC: white sucker

Question 359

Volume 4, App M Aquatic Ecology, Section 3.1.1, Page 3.5

Alberta Transportation states *Mountain whitefish spawn over gravel and cobble substrates at moderate gradients in the Athabasca River*.

a. Confirm if the watercourse is supposed to be the Athabasca River. If the Athabasca River is incorrect then update the watercourse name so the correct one is referenced.

b. If the Athabasca River is correct then explain why the spawning habitat requirements for a different watercourse in a different part of the province was provided rather than for the Elbow River.

Response 359

a. The Athabasca River is the correct watercourse name.

b. The Sheep River mountain whitefish spawn in substrates of "rock and rubble (5 to 50 cm diameter)" (R.L. & L. Environmental Services Ltd. 1996). The Sheep River mountain whitefish is the closest population in proximity and with habitat characteristics (i.e., within a similar sized watercourse) to Elbow River and, therefore, this information is considered the most relevant representative available outside of Elbow River. Whitefish general habitat requirements are expected to be similar or comparable among watersheds within the Bow River basin.

   AMEC (2017) completed habitat surveys on the Elbow River near Bragg Creek and noted that the area was characterized by riffle/run sequences with predominately clean, coarse substrates. These findings are consistent with the reaches assessed for the Project in 2016.

   In the Bragg Creek area, large numbers of mountain whitefish were documented (AAR 2008) and broadcast spawners, such as mountain whitefish, prefer to spawn over clean cobble substrate in shallow waters (R.L. and L. 1997; Roberge et al. 2012), which is consistent with the assessed habitat in the Elbow River.

   The preferred spawning depths for mountain whitefish are between 0.1 m and 1.0 m (Ford et al. 1995; Langhorne et al. 2001; Roberge et al. 2002). Clipperton et al. (2002) determined a habitat suitability of 1.0 for mountain whitefish in depths of 0.61 m and greater, along with velocities between 0.533 to 1.06 m/s (1.75 to 3.5 feet per second). These findings are consistent with Katopodis and Gervais (2016), who identified velocities for salmonids in Appendix 1 of the J5b series, which suggests that the majority of individuals can successfully migrate upstream between velocities of 0 to 1.6 m/s. Based on these depths and velocities, as well as the abundant run habitat assessed in the river, mountain whitefish could successfully spawn within Elbow River.

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Roberge, M., J.M.B. Hume, C.K. Minns, and T. Slaney. 2002. Life history characteristics of freshwater fishes occurring in British Columbia and the Yukon, with major emphasis on stream habitat characteristics. Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 2611

Question 360

Volume 4, App M Aquatic Ecology, Attachment A, Section A-2 Habitat Survey Sheets, (Page 158-159 PDF)

The first two habitat survey sheets describe an Unnamed tributary to the Elbow River (Tributary 1350). These two habitat surveys appear to be assessments of separate locations but contain identical information including site name, photographs, and some data.

a. Clarify if these are separate sites. Provide the corrected and updated data for each site.

Response 360

a. The field data sheet in Volume 4. Appendix M, Attachment A, pdf page 158 identifies an unnamed tributary to the Elbow River; however, incorrect information was identified on pdf page 158. Appendix IR360-1 provides a replacement page to reflect data captured at the unnamed tributary to Elbow River during the fish and fish habitat assessment. Pdf page 159 was submitted in error and can be considered a deletion from Volume 4, Appendix M, Attachment A.

Question 361

Volume 4, App M Aquatic Ecology, Section 3.1.3 – 3.1.14

Alberta Transportation describes fish habitat assessed at 12 reaches and as relative percentages of the reach.

a. Provide mapping of fish habitat and aquatic resources of the Elbow River and tributaries affected by the project and all ancillary project components.

Response 361

a. Mapping of fish habitat within the Elbow River is presented in Appendix IR361-1, Figures IR361-1 to IR361-14. Mapping was completed through the analysis of imagery available from ESRI that was collected between 2014 and 2016. The information contained within these habitat maps was corroborated with field observations. The habitat maps were prepared to demonstrate fish habitat features at a scale of 1:2,500 and focused on the main channel of the Elbow River. The reaches assessed in September of 2016 (see Volume 4, Appendix M) are also presented in this mapping. These reaches, however, were mapped based on the ESRI imagery and not the 2016 collected field data in order to maintain consistency while mapping at the 1:2,500 scale. Detailed habitat information of the assessed reaches is provided in the Volume 4, Appendix M, Attachment A.2.

Water
May 2019