COUGAR CREEK
DEBRIS FLOOD RETENTION STRUCTURE

Supplemental Information Request Round 1

SUBMITTED TO:
Alberta Environment and Parks
and Natural Resources Conservation Board

SUBMITTED BY:
Town of Canmore

June 2017

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2D	two dimensional
AAAQO	Alberta Ambient Air Quality Objectives
AAF	Alberta Agriculture and Forestry
ACO	Aboriginal Consultation Office
AEP	Alberta Environment and Parks
ALARP	as-low-as-reasonably practicable
AQMG	Air Quality Model Guideline
asl	above sea level
AT	Alberta Transportation
BGS	BGC Engineering Ltd.
BMA	bear management area
BMP	best management practices
BRBC	Bow River Basin Council
CCME	Canadian Council of Ministers of the Environment
CDA	Canadian Dam Association
COPC	chemicals of potential concern
CPESC	certified professional in erosion and sediment control
CPR	Canadian Pacific Railway
EAP	Enhanced Approval Process
ECO	environmental construction operations
EIA	environmental impact assessment
EPP	emergency preparedness plan
ERBC	Elk Run Boulevard culvert
ERP	emergency response plan
ESC	erosion and sediment control
LDOF	landslide dam outbreak flood
LiDAR	Light Detection and Ranging
LSA	local study area
MD	Municipal District
MEMP	municipal emergency management plan
NO_2	nitrogen dioxide
NO_X	oxides of nitrogen
NRCB	Natural Resources Conservation Board
OMS	Operation, Maintenance and Surveillance
$PM_{2.5}$	fine particulate matter less than 2.5 µm in diameter
ppm	parts per million
RSA	regional study area
SIR	supplemental information requests
SLHHRA	screening level human health risk assessment
SO_2	sulphur dioxide
SSRP	South Saskatchewan Regional Plan
TOR	terms of reference
TMP	Traffic Management Plan
USBR	United States Department of the Interior, Bureau of Reclamation
Waterline	Waterline Resources Inc.

1 INTRODUCTION

The Town of Canmore submitted the environmental impact assessment and Natural Resources Conservation Board (NRCB) application summary for the Cougar Creek Debris Flood Retention Structure (the Project) in July 2016. First round of supplemental information requests (SIRs) were received from Alberta Environment and Parks and the NRCB in December 2016. Responses to the first round of SIRs are provided in this submission dated June 2017.

2 NATURAL RESOURCES CONSERVATION BOARD

2.1 General

1	**Volume 1, Section 3.2.1, Page 3-3** The Town of Canmore states *the Stoney Nakoda have received the Project notification and information package, and requested additional information from the Town of Canmore that was provided on November 11, 2015. A Stoney Nakoda consultation representative did indicate that they were interested in meeting to discuss the Project, but as of the date of EIA submission a meeting had not yet been scheduled.* a. Provide an update on consultation efforts with the Stoney Nakoda. Has the Town of Canmore followed up regarding a meeting to discuss the Project? b. Did the Stoney Nakoda provide the letter of non-objection? If not, is it an issue for future project development?

Response:

a. The Town of Canmore met with consultation representatives from the Stoney Nakoda on November 15, 2016. The Town of Canmore provided: an overview of the Project including its purpose, design and location; a history of Cougar Creek and its development; and information about wildlife corridor use and protection. No specific concerns about the Project or any potential adverse effects on First Nations rights were expressed by representatives of the Stoney Nakoda Nation at this meeting.

   A site visit was conducted with Stoney Nakoda representatives on December 2, 2016. Specific items discussed at the site visit included: an interest in an opportunity to harvest usable medicinal or ceremonial plants before construction; concerns regarding graffiti and other evidence of human use within the creek; and a desire to hold a ceremony on the site before construction begins.

b. The Town of Canmore has not received a letter of non-objection from the Stoney Nakoda First Nation; however, Stoney Nakoda consultation representatives have indicated that a letter regarding the Project will be provided. The Stoney Nakoda First Nation has requested an opportunity to harvest traditionally used plants and to hold a pre-construction ceremony on the site and the Town of Canmore fully supports both of these requests. The Town of Canmore will continue to work with the Stoney Nakoda to obtain a letter of non-objection and does not consider this to be a risk for Project development.

2

Volume 1, Section 4.2.1, Page 4-10

The Town of Canmore states that *the hazard and risk assessments prepared by BGC Engineering Ltd. (BGC 2014b) indicated that individual risk of loss of life and group risk of loss of life are very high and outside of generally accepted thresholds.* Provide information to support the following:

a. Probabilities for the risk of loss of life and group risk of loss of life absent the Project.

b. The probability of loss of life and group loss of life for an event similar to the 2013 flood (absent the project).

Response:

a. Probabilities for the risk of loss of life and group risk of loss of life absent the Project can be estimated from the baseline risk assessment (BGC 2014a). The response below is based on this assessment, and also considers the estimated level of risk reduction achieved by short term mitigation measures not accounted for in the baseline assessment. More details on these measures are provided below.

The BGC Engineering Ltd. (BGC) baseline risk assessment (BGC 2014a) considered six debris flood scenarios across the range of return periods listed in Table 2-1.

Table 2-1 Summary of Debris Flood Scenarios

ID	Frequency Interval (1:years)	Sediment Volume Estimate (m^3)	Sediment Concentration (%)	Peak Flow[1] (m^3/s)	Hydro-Geomorphic Processes	Model Runs and Assumptions
2	1:30 to 1:100	40,000	20	50	Debris flood	ERBC[2] performs to capacity
3a	1:100 to 1:300	60,000	20	60	Debris flood/LDOF[3]	ERBC performs to capacity
3b						ERBC is blocked
4	1:300 to 1:1,000	160,000	30	700	LDOF	ERBC is blocked
5	1:1,000 to 1:3,000	260,000	30	1,000	LDOF	ERBC is blocked
6	1:400[4]	90,000	20	80	Debris flood	ERBC performs as it is kept open artificially

Source: BGC 2014a, 2014b

Notes:

1. Peak flow as reported here is the total discharge including the sediment in transport.
2. ERBC = Elk Run Boulevard culvert
3. LDOF = landslide dam outbreak flood
4. Scenario with peak discharge similar to that estimated for the June 2013 event

BGC's baseline risk assessment (BGC 2014a) identified 181 parcels exceeding the individual risk tolerance standard of 1:10,000 risk of fatality per year and group safety risk fell within the "Unacceptable" range when compared to international risk tolerance standards (BGC 2014a). The baseline assessment was subsequently updated to 193 parcels based on revised assessment data provided by Alberta Municipal Affairs (BGC 2015a). This corresponds to an exceedance of 193 parcels for the completely unmitigated scenarios.

Following the June 2013 event, Canmore implemented several short-term mitigation measures that were not included in the baseline risk assessment, including:

- Restoring the creek channel to the pre-event channel geometry.
- Enlarging the channel cross-section further and placing articulated concrete mats on the channel banks (from the upstream end of development downstream to the Trans-Canada Highway).
- Constructing a debris net in a narrow and bedrock-confined section of the creek above the alluvial fan apex. This net is designed to retain approximately 18,000 m^3 of debris and be overtopped by sediment and debris once filled. The net is not designed to withstand impacts due to LDOFs.

BGC estimated residual debris flood risk for modelled debris flood scenarios that considered several different long-term mitigation options proposed for Cougar Creek (BGC 2015b). This work was done to support selection of the Structure. As part of the modelling completed for this assessment, BGC merged the short-term mitigation works channel geometry data processed on June 24, 2014 with the previous 2013 Light Detection and Ranging (LiDAR) data in the models developed for the Project. This assessment did not consider the debris storage capacity of the debris net.

While none of the mitigated scenarios considered exactly resembled the short-term mitigation measures constructed, BGC could comment on their effectiveness to reduce risk by examining the most comparable option which considered a debris flood retention structure capable of retaining 175,000 m^3 of material (Mitigation Option C1 in BGC 2015b).

With the debris flood retention structure (Mitigation Option C1), BGC identified 139 parcels that still exceeded the individual risk tolerance standard of 1:10,000 and group safety risk fell within the “Unacceptable” range when compared to Canmore’s risk tolerance standards. Given the debris net is designed to retain an order of magnitude less debris than the considered debris flood retention structure above, the existing short-term mitigation measures are believed to provide very little life loss risk reduction benefit.

b. Safety risk estimates typically do not consider single return period events because they consider the total risk across all scenarios considered. However, BGC did model one scenario (Scenario 6, BGC 2014a) representing a similar magnitude debris flood to the one that occurred in June 2013 with an estimated annual probability of 1:400. The partial risk associated with this scenario is estimated to exceed the individual risk tolerance standard of 1:10,000 for approximately six parcels.

For group loss of life, BGC (2014a, 2015b) estimated one fatality for Scenario 6, whereas no lives were lost in the June 2013 event. BGC considers this estimate to be credible; that no lives were lost during the June 2013 event is no guarantee that lives could not be lost by an unmitigated event of similar magnitude in the future. While the short-term mitigation works reduce life loss risk for the lower return period events, as stated above they are not considered to be sufficient.

References:

BGC Engineering Inc. (BGC), 2015a. Cougar Creek Baseline Debris-Flood Risk Assessment Update. *Letter Report prepared for* the Town of Canmore dated May 21, 2015.

BGC Engineering Inc. (BGC), 2015b. Cougar Creek Debris-Floods: Risk Reduction Optimization. *Final Report prepared for* the Town of Canmore dated February 2, 2015.

BGC Engineering Inc. (BGC). 2014a. *Town of Canmore, Cougar Creek Debris Flood Risk Assessment – Final Revised*. Report prepared for the Town of Canmore. Vancouver, British Columbia. June 11, 2014.

BGC Engineering Inc. (BGC). 2014b. *Town of Canmore, Cougar Creek Debris Flood Hazard Assessment - Final*. Report prepared for the Town of Canmore. Vancouver, British Columbia. March 7, 2014.

3	**Volume 1, Section 4.2.1, Page 4-10** The Town of Canmore indicated that design options were derived with the project goal to *reduce the probability of death of an individual to less than 1 in 10,000 years for each of the 181 properties that exceed this threshold; and reduce risk of group loss of life into the as-low-as –reasonably-practicable zone.* a. Provide a reference for generally acceptable risk of death to be less than 1 in 10,000 years. b. Provide details supporting a definition of *as-low-as-reasonably practicable zone*.

Response:

a. For clarification, the individual risk tolerance standard is not "less than 1 in 10,000 years." It corresponds to a maximum 1:10,000 risk of fatality per year. This risk tolerance threshold is consistent with individual risk tolerance thresholds formally adopted in Hong Kong (Government of the Hong Kong 1998), by the District of North Vancouver (Dercole 2009), and the Town of Canmore (2016), and informally applied to previous landslide risk assessments in Australia (AGS 2007) and several other municipal jurisdictions in British Columbia. For a summary of risk tolerance thresholds, refer to Porter et al. (2008), Porter and Morgenstern (2013), and Tappenden (2014).

b. Ale (2005) provides a definition of as-low-as-reasonably practicable (ALARP) based on comparison of risk regulation in the United Kingdom and the Netherlands. The definition of ALARP was first made explicit by Lord Justice Asquith in England (Judge Asquith 1949). This legal case established that a computation could be made between a quantum of risk and the effort (financial, time, or other sacrifice) required to reduce the risk. If it is shown that one is in gross disproportion to the other, e.g., that the effort required to reduce risk is grossly disproportionate to the additional level of risk reduction achieved, then there should be no additional burden placed to reduce the risk (technically, the burden of proving that compliance was not reasonably practicable is discharged). Since then, the principle has been applied in the United Kingdom to define societal risk tolerance for nuclear power stations (HSE 1988), and as part of group risk tolerance criteria adopted for dam safety by the United States Department of the Interior, Bureau of Reclamation (USBR 2003), International Commission on Large Dams, Australian National Committee (2003), New South Wales Government (2006), and Canadian Dam Association (CDA 2013) for landslide risk assessments in Australia (AGS 2007) and the District of North Vancouver (Dercole 2009), and for steep creek geohazards in North Vancouver and the Town of Canmore (Town of Canmore 2016). For a summary of the ALARP principle, refer to Porter et al. (2009) and Porter and Morgenstern (2013).

References:

Ale B.J.M. 2005. "Tolerable or acceptable: A comparison of risk regulation in the United Kingdom and the Netherlands." *Risk Analysis 25(2):* 231-241.

Australian Geomechanics Society (AGS). 2007. "A national landslide risk management framework for Australia." Extract from Landslide Risk Management. *Australian Geomechanics 42(1)*: 1-12.

Canadian Dam Association (CDA). 2013. *Dam Safety Guidelines 2007.* 2013 Edition. 88 pp.

Dercole F. 2009. *Natural Hazards Risk Tolerance Criteria*. District of North Vancouver, Report to Council. November 10, 2009.

Health and Safety Executive (HSE). 1988. *The Tolerability of Risk from Nuclear Power Stations.* London: HMSO. Produced by a working group under the chairmanship of Mr. J.D. Rimington CB, Director General of HSE.

International Commission on Large Dams, Australian National Committee. 2003. *Guidelines on Dam Safety Management*. Rev. ed. Australian National Committee on Large Dams. Australia.

Judge Asquith. 1949. *Edwards v. The National Coal Board.* All England Law Reports, 1, 747.

New South Wales Government. 2006. *Risk Management Policy Framework for Dam Safety*. Dam Safety Committee. Endorsed by Cabinet on August 22, 2006.

Porter et al. 2009. *Proposed Landslide Risk Tolerance Criteria.* BGC Engineering Inc. Vancouver, British Columbia.

Porter M. and N. Morgenstern. 2013. *Landslide Risk Evaluation - Canadian Technical Guidelines and Best Practices Related to Landslides: A National Initiative for Loss Reduction*. Geological Survey of Canada Open File 7312. 21 p.

Tappenden K.M. 2014. “The district of North Vancouver’s andslide management strategy: ole of public involvement for determining tolerable risk and increasing community resilience.” *Natural Hazards 72:* 481.

The Government of the Hong Kong Special Administrative Region. 1995. *Guide to Slope Maintenance.* Geoguide 5. Geotechnical Engineering Office, Civil Engineering Department. Homantin, Kowloon, Hong Kong. July 1995. http://www.cedd.gov.hk/eng/publications/geo/doc/eg5.pdf

Town of Canmore. 2016. *Canmore Municipal Development Plan*. Bylaw 2016-03. Canmore, Alberta. September 13, 2016.

United States Department of the Interior, Bureau of Reclamation (USBR). 2003. *Guidelines for Achieving Public Protection in Dam Safety Decision Making*. 38 p.

4	**Volume 1, Section 9.2.6.1, Page 9-8** **Volume 1, Section 9.2.6.2, Page 9-9** a. Explain the relationship of the emergency response program (page 9-8) to the Municipal Emergency Management Plan (MEMP, page 9-8), the Emergency Preparedness Plan (EPP, page 9-9) and the Emergency Response Plan (ERP, page 9-9).

Response:

a. The relationship between the municipal emergency management plan (MEMP), emergency preparedness plan (EPP), and emergency response plan (ERP) is defined in the *Dam Safety Guidelines 2007* (CDA 2013) under Section 4: Emergency Preparedness (page 39 of the guidelines):

> *"Effective emergency management relies on establishment of a clear emergency response structure that is understood by all responders, supported by the following four components:*
>
> - *An internal, dam-specific emergency response plan (ERP), including actions the dam owner will take in response to unusual or emergency conditions*
> - *An emergency preparedness plan (EPP), developed by the dam owner for external use, defining the hazards posed by the dam, the roles and responsibilities of all parties, and notifications to be made*
> - *Municipal, community, or regional emergency plans, developed by responding agencies for their own use to warn and evacuate residents within the floodplains (MEMP)*
> - *A maintenance, testing, and training program to ensure that the processes are effectively integrated and kept up to date (OMS manual)"*

In this specific case, the ERP is similar to any other specific plans that the Town of Canmore has for other emergencies (wildfire, Bow River flood, steep creek flood, etc.). It is specific to the Structure and the MEMP will refer to the ERP after the Project approval.

The EPP will inform external agencies of the hazards posed by the Structure. In this case, the Town is the owner and the main agency that would be affected by a Structure malfunction. The Town has prepared the EPP following the dam safety guidelines but is currently looking at integrating most of the information in the MEMP and keep the EPP for distribution to external agencies (Dam Safety branch of Alberta Environment and Parks, Alberta Emergency Management Agency, downstream municipalities, etc.).

References:

Canadian Dam Association (CDA). 2013. *Dam Safety Guidelines 2007.* 2013 Edition. 88 pp.

5	**Volume 1, Section 9.2.6.2, Page 9-9** **Volume 1, Section 9.2.6.2, Page 9-10** **Volume 1, Section 13, Page 13-1** The Town of Canmore is developing an EPP (Emergency Preparedness Plan) and an ERP (Emergency Response Plan) (page 9-9). The development of these plans is not specifically listed in the Commitments section (section 13). a. Confirm if the development of an Emergency Preparedness Plan and an Emergency Response Plan are a commitment from the Town of Canmore, and if they are, indicate the timeline for meeting this commitment.

Response:

a. The emergency preparedness plan and emergency response plan have already been submitted to the Dam Safety branch of Alberta Environment and Parks through the *Water Act* application process.

6 **Volume 1, Section 4D, Appendix 4D, Table 25, Page 26**

The Town of Canmore states that *the permeability coefficient for the alluvium is ranging between 2*10-5 m/s and 4*10-4 m/s* (hydraulic conductivity values for all wells are shown in Table 25).

a. Confirm that the hydraulic conductivity (K) values in Table 25 are correct. Calculations using the formula T(transmissivity) = k(hydraulic conductivity) b(saturated thickness) and transmissivity information from Table 25 and saturated thickness information from Table 22 suggests that the hydraulic conductivity values in Table 25 may be one order of magnitude too low.

b. If the hydraulic conductivity values are underestimated, what are the impacts on the geotechnical modeling of the structure?

Response:

a. In Appendix 4D, Table 21 on page 24 shows values for the permeability coefficient K, ranging from 2E-04 m/s (high) and 4E-05 m/s (low), from in situ slug tests. Appendix 4D, Table 25 on page 26 shows values ranging from 4E-04 m/s and 2E-05 m/s. The Table 25 values result from a more detailed geo-hydraulic investigations by Waterline Resources Inc. (Waterline) These values are in a plausible range for well graded alluvial deposits. Permeability coefficients with an order of magnitude higher (4E-03 m/s) could be expected for a washed, uniformly graded drainage material. However, these conditions are not expected in Cougar Creek, regardless of the existence of anisotropic conditions in the alluvial deposits.

   The referenced values were estimated and derived by Waterline after reliable hydraulic tests were done. More information on tests and results can be found in Section 04.01.02 of Appendix 4D of the environmental impact assessment (EIA).

b. If the hydraulic conductivity values were underestimated, which is not the case, the existing seepage calculation would indicate the wrong conditions. A possible change in the design to compensate for this would be to remove the drainage layer at the footprint of the downstream embankment, which is for discharging uprising seepage water. High quality drainage material has permeability values in the range of 5E-03 when washed. But generally, the drainage layer is an important design feature for such structure.

   Moreover, the Structure design, including Appendix 4D of the EIA (Geotechnical Design Basis Memorandum), is currently being reviewed by the Dam Safety branch of Alberta Environment and Parks (AEP). The Town has been working closely with AEP and no issues have been raised regarding the hydraulic conductivity or other results from the geotechnical investigation undertaken by the Town of Canmore.

7

Volume 1, Appendix 8A, Section 3.1, Page 4
Volume 1, Section 5.2, Page 10
Volume 1, Section 5.3, Page 12

The Town of Canmore states that *due to the large size of the study area and the density of vegetation within the study area, vegetation sound absorption was included in the model. A ground absorption coefficient of 0.5 was used…. … trees were also included in the noise model. (s 3.1)*

The Town of Canmore also states that *those receptors with increases greater than 1.0 dBA are all located directly adjacent to the [proposed] site access road and the increased noise levels will be the result of haul trucks using the site access road*. *(s 5.2 and 5.3).*

a. Why is it appropriate to use trees and a ground absorption coefficient of 0.5 for modelling the noise from the haul trucks using the site access road to the receptors located adjacent to the site access road?

b. If not appropriate, then provide noise calculations for some receptors located adjacent to the site access road using a ground absorption coefficient for residential areas and no trees for the baseline, construction and maintenance cases. (R-093 and R-120 may be appropriate receptors to use as the modelling shows they will have the greatest increase in noise.)

Response:

a. The ground absorption value of 0.5 is appropriate throughout the entire study area. For those receptors directly adjacent to the site Access Road, the ground absorption value has little effect due to the close proximity. Therefore, there is no need to adjust this value. Trees were included in the model only in locations at which there actually are trees. Trees were not included at locations for receptors directly adjacent to the Access Road, which have direct line-of-sight to the Access Road. Therefore, there is no need to update the noise model.

b. Refer to the response to part a) above.

8	**Volume 1, Section 8.2.4.1, Page 8-3** **Volume 1, Section 8.2.4.5, Page 8-8** The Town of Canmore states *the Lafarge monitoring station is an industrial site that monitors air quality from the operations of the Lafarge Exshaw Cement Plant, a limestone quarrying operation; elevated* $PM_{2.5}$ *is common at such industrial sites (s. 8.2.4.5).* The Town of Canmore also states *The Lafarge monitoring station, located approximately 12 km southeast of the Project, was used as it is the closest ambient air quality monitoring station that monitors* NO_2 *and* $PM_{2.5}$*. (s. 8.2.4.1).* a. Why is it appropriate to use the Lafarge monitoring station data (that is suspected to have elevated $PM_{2.5}$) as ambient air quality data at the site of the Project?

Response:

a. It is appropriate to use the Lafarge monitoring station as it is the closest available data to the Town of Canmore, it is located within the same valley, and is downwind of Canmore. Table 8-1 (expanded Table 8.2.4 from the environmental impact assessment [EIA]) presents the maximum ambient concentrations for relevant averaging period for nitrogen dioxide (NO_2) and fine particulate matter less than 2.5 µm in diameter ($PM_{2.5}$) and the 98th percentile 24-hour average $PM_{2.5}$ for comparisons between the Lafarge station and monitoring stations in other mountain communities (Hinton, Alberta and Golden, British Columbia). As described in the EIA, the 24-hour averaging period for $PM_{2.5}$ can be expected to be elevated at the Lafarge site as this site is associated with mining and cement manufacturing processes; however, the EIA also provided the 98th percentile $PM_{2.5}$ as per the Canadian ambient air quality standards for $PM_{2.5}$ (CCME 2012). The 98th percentile $PM_{2.5}$ concentration at Lafarge is comparable to the $PM_{2.5}$ levels at Golden, British Columbia and Hinton, Alberta (Table 8-1). Using the 98th percentiles removes the outliers associated with the site-specific industrial activity (as is the case with Lafarge) and provides a more representative background air quality in the valley; therefore, the use of data from the Lafarge monitoring station is appropriate for this assessment.

Table 8-1 Ambient Concentration at Lafarge, Hinton and Golden Monitoring Stations

Station	Substance	Averaging Period	Ambient Monitoring ($\mu g/m^3$)	Ambient Air Quality Objectives	
				$\mu g/m^3$	Guideline
Lafarge[1]	Nitrogen Dioxide (NO_2)	1 hour	68	300	AAAQO
		Annual	16	45	AAAQO
	Fine Particulate Matter ($PM_{2.5}$)	24-hour	173	30	AAAQO
	Fine Particulate Matter ($PM_{2.5}$)[a]	24-hour (98th percentile of 24-hour average)	22	28	CCME
	Fine Particulate Matter ($PM_{2.5}$)[2]	24-hour (99.9th percentile)	170	28	CCME
	Fine Particulate Matter ($PM_{2.5}$)[2]	24-hour (98th percentile of 99.9th percentile)	22	28	CCME
	Fine Particulate Matter ($PM_{2.5}$)[2]	24-hour (90th percentile)	10	28	CCME
	Fine Particulate Matter ($PM_{2.5}$)[2]	24-hour (98th percentile of 90th)	8	28	CCME
Hinton[2]	Nitrogen Dioxide (NO_2)[b]	1 hour	82	300	AAAQO
		Annual	13	45	AAAQO
	Fine Particulate Matter ($PM_{2.5}$)[b]	24-hour	37	30	AAAQO
	Fine Particulate Matter ($PM_{2.5}$)[a, b]	24-hour (98th percentile of 24-hour average)	18	28	CCME
	Fine Particulate Matter ($PM_{2.5}$)[3]	24-hour (99.9th percentile)	25	28	CCME
	Fine Particulate Matter ($PM_{2.5}$)[3]	24-hour (98th percentile of 99.9th percentile)	18	28	CCME
	Fine Particulate Matter ($PM_{2.5}$)[3]	24-hour (90th percentile)	13	28	CCME
	Fine Particulate Matter ($PM_{2.5}$)[3]	24-hour (98th percentile of 90th)	11	28	CCME
Golden Helipad[3]	Nitrogen Dioxide (NO_2)	1 hour	-	300	AAAQO
		Annual	-	45	AAAQO
	Fine Particulate Matter ($PM_{2.5}$)[c]	24-hour	23	30	AAAQO
	Fine Particulate Matter ($PM_{2.5}$)[4] (TEOM)	24-hour	14	30	AAAQO
	Fine Particulate Matter ($PM_{2.5}$)	24-hour	23	28	CCME
	Fine Particulate Matter ($PM_{2.5}$)[a,c]	24-hour (98th percentile of 24-hour average)	18	28	CCME

a. CCME 2012
b. Temporary Scotford Station Data for 2016 (AEP 2016)
c. Province of British Columbia 2017
1. Data from the LaFarge Canada Inc. Lagoon Monitoring station in Exshaw for the year 2015. The station is 12 km East of Canmore.
2. Data from the Hinton Monitoring station for the year 2016. Hinton is located 300 km north of Canmore.
3. Data from the Golden Helipad for the year 2016. The station is 1,115 km west of Canmore.
4. Data from Calgary NW station for the year 2015. The station is 80 km east of Canmore.

References:

Alberta Environment and Parks. (AEP). 2016. *Data Reports*. Accessed on February 24, 2017. http://airdata.alberta.ca/aepContent/Reports/DataReports.aspx

Canadian Council of Ministers of the Environment (CCME). 2012. *Guidance Document on Achievement Determination Canadian Ambient Air Quality Standards for Fine Particulate Matter and Ozone.* Winnipeg, Manitoba. http://www.ccme.ca/files/Resources/air/aqms/pn_1483_gdad_eng.pdf

Province of British Columbia. 2017. *BC Air Data Archive Website*. Accessed on February 3, 2017. https://envistaweb.env.gov.bc.ca/

9	**Volume 1, Section 8.2.1 to 8.2.4.5, Pages 8-1 to 8-8** **Volume 1, Section 4.2.3, Page 4-12** a. Explain how the construction and operation of this Project is affected by the South Saskatchewan Region Air Quality Management Framework for NO_2 and $PM_{2.5}$.

Response:

a. The South Saskatchewan Region *Air Quality Management Framework* applies at the regional scale and was not intended for individual project permitting purposes; therefore it is not appropriate to consider the Framework for this Project.

10 **Volume 1, Section 8.2.6.4, Tables 8.2-9, Page 8-14**
Volume 1, Section 8.2.6.4, Table 8.2-10, Page 8-14
Volume 1, Section 8.2.6.5, Page 8-15; Air Quality Spreadsheet « Scaling of Modelling

The Scaling of Modelling spreadsheet indicates that road dust was included in the modelling, but at a 30% suppression of the total release amount of PM$_{2.5}$ in Table 8.2-9. In the footnote to Table 8.2-9, the Town of Canmore states *the total release takes into account the natural mitigations and any other applied dust control methods.* Table 8.2-10 indicates that the largest source of PM$_{2.5}$ is road dust. Section 8.2.6.5 includes the modelling assumption from the Town of Canmore that *road dust was not included as it will be mitigated with water as dust suppression.*

a. In the air quality modelling, why is it appropriate to further suppress the road dust source amount after mitigation measures?

Response:

a. An error was made in displaying the fine particulate matter less than 2.5 µm in diameter (PM$_{2.5}$) total for road dust. Table 8.2.10 of the environmental impact assessment has been revised and provided below as Table 10-1. Road dust emissions are the smallest source of PM$_{2.5}$ for the Project.

Table 10-1 Total Criteria Air Contaminants Emissions for the Construction Phase of the Project

Source[1]	**Emissions (kg)**	
	NO$_X$[2]	**PM$_{2.5}$**
Equipment	1.75E+05	1.84E+03
Blasting	2.49E+01	6.79E+01
Road Dust	-	1.04E+04
TOTAL	**1.75E+05**	**1.23E+04**

1. Project duration assumed 27 months.
2. NO$_X$ - oxides of nitrogen

In the Scaling of Modelling spreadsheet an approximate 30% suppression was used as adjusting the emissions to account for equipment that may not be continually operating at the construction site.

11	**Volume 1, Section 8.2.6.4, Tables 8.2-9, Page 8-14** **Volume 1, Section 8.2.6.4, Table 8.2-10, Page 8-14** Road dust amount of $PM_{2.5}$ in Table 8.2-10 does not match any of the $PM_{2.5}$ numbers in its source, Table 8.2-9. a. What is the correct value for $PM_{2.5}$ in Table 8.2-10?

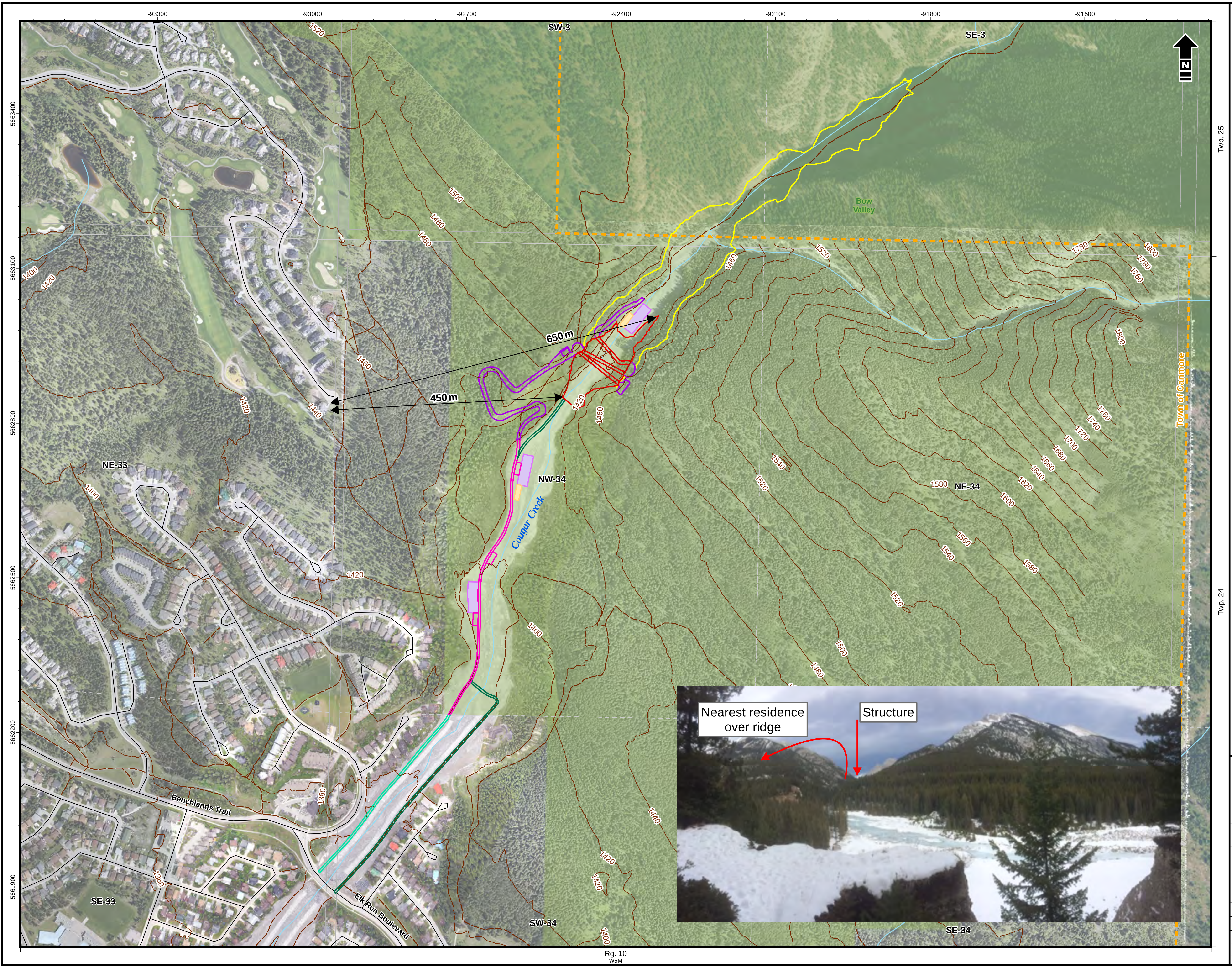
Response:

a. Table 8.2-9 of the environmental impact assessment (EIA) is correct for the total release value for fine particulate matter less than 2.5 µm in diameter of 10.4 tonnes. Table 8.2.10 of the EIA has been revised and provided in the response to SIR 10 (Table 10-1). This update does not change the conclusions of the original assessment.

12	**Volume 1, Section 8.2.6.5, Page 8-15** For air quality modelling, the Town of Canmore assumes *the closest residence is 450m from the construction of the Structure;* however, there are multiple receptors located adjacent to the site access road. a. How has the actual distance from the haul route to the receptor (not the distance from the structure) been considered regarding the air quality effects of the haul route on the receptors adjacent to the haul route?

Response:

a. While construction activities will include hauling of materials to the site, the bulk of the construction activities and emissions will occur at the site of the Structure. For this reason, the closest residence to the primary construction emissions was measured to be 450 m away. The emissions associated with hauling will be transient in nature as the vehicles move through and for comparison will be similar to the emission that occurred during the post flood restoration and installation of the articulated concrete mats. Another point of comparison that was considered to determine if modelling of the haul road was needed was the volume of traffic along the haul road versus traffic in the area. Vehicle counts along the haul road are expected to average four vehicles per hour, which is insignificant when compared to the adjacent Trans-Canada Highway with 105,000 (Table 8.5-6 of the environmental impact assessment) vehicle movements per day. Furthermore, dust along the haul road will be mitigated with dust suppression. In summary, while combustion emissions and road dust were calculated along the whole length of the Access Road, the air screening assessment focused on the main construction portion of the Project to which the nearest receptor is approximately 450 m (Figure 12-1), as the emissions and road dust outside the main construction area are considered low.



- Town of Canmore Municipal Boundary
- 🟩 Wildland Provincial Park
- Watercourse
- Elevation Contour (20 m)
- ◄► Distance to Nearest Residence from Flood Retention Structure
- Road
- Trail

Proposed Footprint

- Debris Flood Retention Structure
- Access Road
- Inundation

Proposed Construction Footprint

- Stockpile
- Laydown

Site Access

- Construction
- Operations and Construction
- Paved Footpath

Note: Paved footpath to be used for operations and construction access.

Reference: Data obtained from AltaLIS © Government of Alberta and Alberta Parks (all rights reserved) used under license. GDM transportation infrastructure data provided by IHS © 2015 used under license. Imagery (2009, 2013 and 2014) obtained from client used under license.

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Metres

NAD 1983 3TM 114

Town of CANMORE

Cougar Creek Debris Flood Retention Structure

Distance to Nearest Residences From Flood Retention Structure

Date: 01 Mar 2017	Project: 20746-514	
Technical: K. Onder	Reviewer: J. Barbier	Drawn: K. Andruchow

Figure
12-1

I:\TownOfCanmore\20746\FiguresAndTables\EIA_SIR1\2017\Report\AEP_Response\Figure-12-1-Distance_to_Nearest_Residences_from_Flood_Retention_Structure.mxd

13	**Volume 1, Section 8.2.7.1, Table 8.2-12, Page 8-17** a. Confirm if 6 excavators are required to fill 6 tandem trucks during maintenance of rock and woody debris removal.

Response:

a. Up to six excavators will be needed during the removal of rock and woody debris during a post-flood maintenance event. One or two excavators will be needed to fill the tandem trucks and the remaining excavators are required to create access for the trucks, sort out the debris into separate piles and to reshape the creek channel.

14	**Volume 1, Section 8.2.7.1, Table 8.2-15, Page 8-18**
	Equipment emissions in Table 8.2-15 (NOx and $PM_{2.5}$) do not match the totals in Table 8.2-13 (p8-17).
	a. What are the correct values for NOx and $PM_{2.5}$ in Table 8.2-15?
	b. How do these NOx and $PM_{2.5}$ values change the *Summary of Criteria Air Contaminants Emissions for Maintenance Case of the Project* in section 8.2.7.1?

Response:

a. Table 8.2-13 of the environmental impact assessment (EIA) is correct for the total release value for fine particulate matter less than 2.5 µm in diameter ($PM_{2.5}$) of 22.85 kg. Table 8.2.15 of the EIA has been revised and provided below as Table 14-1.

Table 14-1 Total Criteria Air Contaminants Emissions for the Maintenance Case of the Project

Source	**Emissions (kg)**	
	NO_X[1]	**$PM_{2.5}$**
Equipment	6.1	22.9
Road Dust	-	3,500.0
TOTAL	**6.1**	**3,522.9**

b. The total values in the *Summary of Criteria Air Contaminants Emissions for Maintenance Case of the Project* change from 3,500.1 to 3,522.9 kg, a revised summary table is provided above (Table 14-1). It is still well below the construction phase emissions; therefore, the conclusions of the original assessment do not change.

2.2 Water

15	**Volume 1, Section 6.5.1.1, Page 6-10** The Town of Canmore states *precipitation and temperature in the surface water RSA and LSA were estimated using…and is based on data from 1961 to 1990.* a. Provide justification and support that 30-year normal averages remain precise and accurate in 2016.

Response:

a. Minor changes to climate in the study areas may have occurred since the 1961 to 1990 period as a result of climate change. These potential changes are discussed in detail in the *Cougar Creek Forensic Analysis, Hydroclimatic Analysis of the June 2013 Storm – Final* report (BGC 2014). However, the purpose of this information is to provide a general indication of the climate of the study areas for context. The climate of the study areas will not change as a result of the Structure and the best way to provide a general overview of climate is with long-term climate normals. Updating the climate estimates using more recent local data gathered near or within the study areas would not affect the findings of the environmental impact assessment.

References:

BGC Engineering Inc. (BGC). 2014. *Cougar Creek Forensic Analysis, Hydroclimatic Analysis of the June 2013 Storm – Final*. Report prepared for the Town of Canmore. Vancouver, British Columbia. August 1, 2014.

16	**Volume 1, Section 6.5.1, Page 6-13** The Town of Canmore states that the baseline case includes the debris net installed after the 2013 debris flood event. a. Clarify why it is appropriate to include the debris net in the baseline case when estimates for flow regimes, debris and sediment yield, transport, and deposition, peak discharges, and meteorological conditions are based on data prior to installation of the debris net (i.e., 2013 or earlier) and given that the debris net will be removed if the debris retention structure is constructed.

Response:

a. The debris net was considered to be part of the baseline case for the following reasons:

- if the Project is not approved or constructed, the debris net will remain in place; therefore, forming part of the baseline condition;
- transport and deposition of fine sediment remains the same with or without the debris net as this material passes freely through the net;
- as described in the response to SIR 95, the contribution of woody debris from Cougar Creek downstream to Policeman Creek and the Bow River is considered sporadic and insignificant;
- all groundwater and surface water data collected by the Town of Canmore and used in the environmental impact assessment was collected after the debris net, and associated grouting within the creek bed, was installed; and
- all geotechnical investigations, including the pumping and slug tests, were conducted after the debris net, and associated grouting within the creek bed, was installed.

With respect to other data collected before the debris net was installed:

- the rainfall runoff models prepared by Canadian Hydrotech Corporation address design flows, the rates of which do not change with or without the debris net since the net does not affect or impede the passage of water;
- debris and sediment yields determined by BGC Engineering Ltd. are modelled for peak flows over millennia and the analysis is not affected by the presence or absence of the debris net; and
- meteorological conditions are not affected by the presence or absence of the debris net.

17	**Volume 1, Section 6.6.3.2, Page 6-50** The Town of Canmore states *cumulative effects between the operation of the Structure and existing channel improvements are not anticipated.* a. Explain how increased or maintained flow velocities and decreased sediment contributions from bank erosion as a result of the combination of concentrated flow from the outlet structure and articulated concrete mats may result in changes on Cougar Creek interactions with the Fan, Policeman Creek or the Bow River.

Response:

a. The assessment of impacts of the Structure on flow, debris, and sediment was presented for peak flow conditions only because normal and low flows (and associated debris and sediment transport) would not be impacted by the Structure. Therefore, the following response focusses on cumulative effects during peak flow events.

The key impact of the Structure on interactions between Cougar Creek and the Fan, Policeman Creek, and the Bow River is a reduction in peak flow rates and associated geomorphic changes because of the following:

- The baseline case includes the existing debris net, which will prevent debris and coarse sediment from reaching the Cougar Creek Fan during a flood event. Therefore, the Structure will not impact debris and coarse sediment transport compared to baseline conditions.
- Flow travelling through the Structure discharges to the stilling basin on the downstream side. The downstream cross-section of the stilling basin mimics a typical creek cross-section: there is a 5 m wide, 1.5 m deep low flow channel with the rest of the cross-section being flat for the remaining width so water can spread out over the entire cross-section during peak flow events. Given that the flow capacity of the low water channel is low relative to estimated peak flow rates, water will be dispersed across the entire channel width in a similar distribution as the baseline case during peak flow events. Therefore, the Structure will not concentrate flow at its outlet more than the baseline case.

As described in the environmental impact assessment (EIA), the key impact of the articulated concrete mats on interactions between Cougar Creek and the Fan, Policeman Creek, and the Bow River is a reduction in geomorphic changes within the extents of the articulated concrete mats due to the following:

- increasing channel velocities; therefore, reducing deposition rates
- decreasing erosion rates by protecting the channel banks from increased velocities

The geomorphic impact of the Structure due to reduction in extreme peak flow rates and associated geomorphic changes was described in the EIA. In comparison, the geomorphic impacts from the articulated concrete mats (slightly changing erosion and deposition rates within the Lower Cougar Creek reach) are a much smaller impact over the long-term and are limited to the extents of the articulated concrete mats.

Considering that the above described impacts are limited to rare peak flow events (i.e., once or a few times in every 100 years), cumulative effects of the Structure and the articulated concrete mats on Cougar Creek geomorphology will be medium in magnitude, but rare in frequency. The Town of Canmore recognizes this is a change to the EIA cumulative effects assessment.

18

Volume 1, Section 6.6.3.2, Page 6-51

The Town of Canmore states *during normal and low-flow conditions, streamflows in Cougar Creek will effectively be the same in both Baseline and Application cases.*

a. Explain how the cut-off wall will change surface water discharge at the structure during normal and low flow conditions as a result of shallow groundwater interception and release at the outflow.

b. Provide surface water discharge estimates at the structure for the Baseline and Application cases (i.e., without the cut-off wall and with the cut-off wall and outflow).

c. Explain if increased shallow groundwater inputs during peak flows or flood events have been taken into consideration when estimating surface water volumes at the structure during the operational phase.

Response:

a. The cutoff wall will change surface water flows in the immediate vicinity of the Structure by forcing groundwater from the gravel bed to the surface and through the Structure before it is returned to the gravel bed downstream via the low water channel in the stilling basin (refer to the response to SIR 162). Therefore, surface water flows will generally increase in the immediate vicinity of the Structure as a result of the Structure but will be unchanged outside of the immediate vicinity of the Structure.

b. Total flow at the Structure is separated into surface water and groundwater. Generally speaking, water will flow as groundwater at low flows and as flows increase, water levels will increase to the gravel channel bed resulting in surface water flow. Total flow will vary throughout the year but, as discussed in the environmental impact assessment, the magnitude and variability of normal and low-flows was not the focus of the assessment because these conditions will not be affected by the Structure. The distribution of total flow between surface water and groundwater is not considered relevant to the impact assessment because all flow will return to baseline conditions a short distance downstream of the Structure.

   A conceptual groundwater model was created to quantitatively illustrate the potential changes to groundwater flux as a result of the Structure (Appendix 60-1). This report includes a rough estimate of average groundwater flow near the Structure within the Cougar Creek gravel bed of 265 m^3/day based on historical groundwater well data and hydraulic conductivity of the gravel bed. The groundwater flow through the gravel bed will vary greatly from this estimate based on the seasons and weather patterns.

   In the baseline case, surface water flows will be as low as 0 m^3/s (when all water is flowing as groundwater). Upper estimates of normal surface water flows are not provided because these conditions will not be affected by the Structure.

   In the application case, all groundwater will be forced to surface, so that normal surface water flows will likely be above 0 m^3/s and upper estimates of normal flow surface water flows will be the baseline case values plus 265 m^3/day or greater from groundwater.

c. The hydrologic studies completed for the Structure design estimated total flows generated within the Cougar Creek watershed. These total flows originate at the surface and continue downstream eventually passing the Structure as both surface water and groundwater. Therefore, increased shallow groundwater inputs during peak flows or flood events are inherently included in the surface water volume estimates used for the Structure design.

2.3 Terrestrial

19	**Volume 1, Section 3.3.3, Page 3-7** **Volume 1, Section 4.5, Page 4-47** **Volume 1, Section 4.6, Page 4-48** **Volume 1, Section 8.3.5, Page 8-25** **Volume 1, Section 11, Page 11-5** The Town of Canmore is considering paving the access road on the east side of Cougar Creek, but this was not confirmed at the time the EIA was submitted. a. Has the Town of Canmore made a decision on paving the access road on the east side of Cougar Creek? b. If yes, provide the decision, any relevant explanation, and a description of changes required to any portion of the EIA as a result of the decision. c. If no, provide the expected timeline and considerations for making this decision.

Response:

a. Access on the east side of the creek will not be paved and will be left as gravel.

b. The pathway on the east side of the creek has never been paved. It has always been a gravel recreational pathway that provides access to the Bow Valley Wildland Provincial Park. If the Town of Canmore was to pave it before the construction of the Structure, it would need to remove the asphalt at the end of the Project construction, which would increase the cost to finish the current rehabilitation project of Cougar Creek through the residential area. Therefore it has been decided to finish the landscaping rehabilitation, downstream of the Bow Valley Wildland Provincial Park boundary, to pre-flood conditions.

   The tender and contract will stipulate dust suppression requirements for access on all unpaved roads or pathways. If the contractor determines that a more effective dust suppressant than water is available, the Town of Canmore will review the proposed product with the Parks Division of Alberta Environment and Parks to confirm that the product is appropriate for use adjacent to Cougar Creek.

   Changes to the environmental impact assessment are not required as a result of this decision. All modelling and analysis done were based on the east trail not being paved.

c. Refer to the response to part b) above.

20	**Volume 1, Section 4.9.5.4, Page 4-57** The Town of Canmore states it *will work with AEP to identify areas within No Man's Land for selective revegetation* but this is not considered part of the project. a. Clarify why this work is being included in the EIA if it is not part of the Project.

Response:

a. The partial revegetation of No Man's Land downstream of the Structure was included in the environmental impact assessment (EIA) even though it is not part of the Project. The partial revegetation of No Man's Land is a separate project that the Town of Canmore is undertaking with Alberta Environment and Parks (AEP) to restore important wildlife habitat post-flood. A discussion of this revegetation work is included in the EIA to illustrate how all of the Town of Canmore's activities will be used to meet overall reclamation objectives in Cougar Creek.

The Town of Canmore will work with AEP to identify areas within No Man's Land for selective revegetation (refer to the response to SIR 108). The objective of revegetating selected areas within No Man's Land is to create an aesthetically pleasing environment consistent with surrounding undisturbed areas, to provide habitat for wildlife, and to reclaim along-channel and across-channel wildlife movement routes.

21	**Volume 1, Section 7.2, Page 7-2** The Town of Canmore states that *selected areas within No Man's Land downstream of the structure will also be revegetated.* a. What criteria will be used to determine which sections of No Man's Land will be revegetated?

Response:

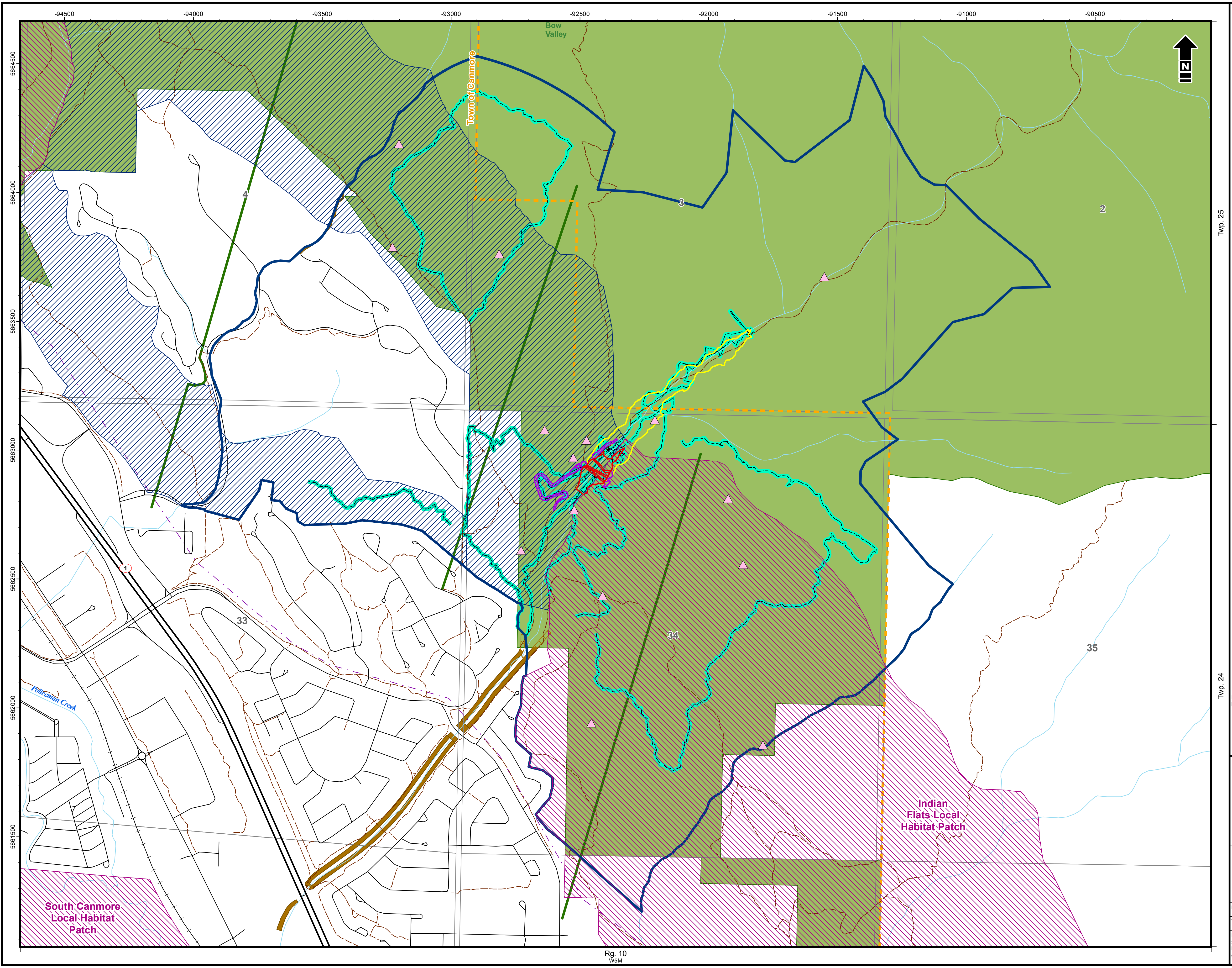
a. The Town of Canmore has developed a plan with Alberta Environment and Parks (AEP) for revegetating parts of No Man's Land within the Bow Valley Wildland Provincial Park (refer to the response to SIR 108. AEP has jurisdiction over the bed and shore of Cougar Creek through the Bow Valley Wildland Provincial Park.

The overall objective of reclamation within No Man's Land is the creation of an aesthetically pleasing environment consistent with the surrounding areas, while adding low maintenance cover for wildlife. The proposed reclamation in No Man's Land will involve reclamation of scattered small patches, or islands. The islands will be teardrop-shaped, 5 m wide by 7 m long on average, but variable in size. Islands will be scattered across No Man's Land with a minimum distance of 5 m from the edge of the creek channel and locations will be selected so that there is no interference with creek hydrology or flow paths. Final placement of the islands will be decided by the Town of Canmore and the Parks Division of AEP after the results from wildlife monitoring are reviewed and understood. Wildlife tracking data and use of the area, as well as the location of the Structure and the Access Road will be taken into consideration. In total, the vegetated islands may comprise approximately 5% to 8% of the surface area of No Man's Land.

22	**Volume 1, Section 7.3.3.3, Page 7-12** The Town of Canmore provides wildlife habitat use transect survey information. a. Provide an overlay of the wildlife habitat corridors as delineated in the Wildlife Habitat Patch Guidelines for the Bow Valley.

Response:

a. The wildlife habitat corridors were shown on Figures 7.2-1 and 7.2-2 of the environmental impact assessment. The overlay of the wildlife habitat corridors on the wildlife habitat use transects can now be seen on Figure 22-1.



- Wildlife Local Study Area
- Bow Valley Wildlife Corridor
- Habitat Patch
- Town of Canmore Municipal Boundary
- 🟩 Wildland Provincial Park
- Highway
- Road
- Railway
- Trail
- Powerline
- Watercourse
- △ Remote Camera Location

Articulated Concrete Mats

- Above Ground
- Below Ground

Proposed Footprint

- Debris Flood Retention Structure
- Access Road
- Inundation Area

Wildlife Survey Transects

- Wildlife Habitat Use Transect
- Winter Tracking Transect

Reference: Data obtained from AltaLIS © Government of Alberta used under license. Data provided by Alberta Parks (all rights reserved) used under license. GDM transportation infrastructure data provided by IHS © 2015 used under license.

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NAD 1983 3TM 114

Town of CANMORE

Cougar Creek Debris Flood Retention Structure

Remote Camera and Winter Tracking Transect Locations for Long-Term Monitoring

Date: 07 Jun 2017
Project: 20746-514
Technical: C. Corbett
Reviewer: R. Lauzon
Drawn: K. Andruchow

Disclaimer: Prepared solely for the use of the Town of Canmore as specified in the accompanying report. No representation of any kind is made to other parties with which the Town of Canmore has not entered into contract.

Figure
22-1

I:\TownOfCanmore\20746\FiguresAndTables\EIA_SIR1\2017\Report\AEP_Response\Figure-22-1-Remote_Camera_and_Winter_Tracking_Transect_Locations_for_Long_Term_Monitoring.mxd

23	**Volume 1, Appendix 7C, Section 7C.3.2.2, Page 7C-16** The Town of Canmore states that the findings of the remote camera survey from the first year of work were unavailable for the environmental impact assessment. Further the Town states that preliminary findings from *Alberta Environmental and Parks (AEP) indicate very high numbers of humans detected within the local study area relative to animals.* a. When will the results of the AEP camera survey results be available? b. If available, provide the results.

Response:

a. The Alberta Environment and Parks camera survey is part of a greater human use management review, which should be completed at the end of June 2017. A draft, 2-year data summary report, is anticipated to be ready by September 2017. Further analyses and publications are expected in the following months.

b. Refer to the response to part a) above.

2.4 Approvals

24	**Volume 1, Section 4.2.2, Page 4-12** The Town of Canmore states *AEP will establish a number of conditions for the land sale that will preserve the values of the surrounding wildland park.* a. Describe the park values being preserved and the nature of any conditions that will ensure preservation.

Response:

a. Alberta Environment and Parks (AEP) notified the Town of Canmore on March 29, 2017 (Appendix 24-1) that the South Saskatchewan Regional Plan (SSRP) was amended in January 2017 to allow the Minister of AEP to approve the construction and maintenance of an access road within a wildland provincial park if it is in the interest of public safety. Alberta Parks concluded that the SSRP amendment pursuant to the *Alberta Land Stewardship Act* supersedes the *Provincial Parks Act Dispositions Regulation* and that the land sale was no longer required. If the Project is approved, Alberta Parks will issue a disposition to the Town of Canmore and will maintain jurisdiction over all activities within the Bow Valley Wildland Provincial Park.

25	**Volume 1, Section 4.2.5, Page 4-13** **Volume 1, Section 7.2.5.2; Page 7-4** The Town of Canmore makes reference to the Bow Corridor Ecological Advisory Group – Wildlife Corridor Habitat Patch Guidelines for the Bow Valley (updated 2012). a. Provide specific information and analysis as to implications, compatibility and residual effects relevant to guidelines as set in the Habitat Patch Guidelines.

Response:

a. The intent of the *Wildlife Corridor Habitat Patch Guidelines for the Bow Valley* (referred to in this supplemental information request [SIR] response as the guidelines) is to protect corridors and habitat patches and provide guidance for land managers with development applications. Additionally, the guidelines provide standards for the design of wildlife corridors and habitat patches. Specifically, they provide:

- *"guidelines that identify a consistent set of ground rules for land management agencies to apply when dealing with new development applications and human use activities within and adjacent to wildlife corridors and habitat patches;*
- *standards for wildlife corridor and habitat patch design including size, topography, cover and vegetation characteristics; and*
- *guidelines and best practices for proposed and existing developments and activities that will identify compatible uses within and adjacent to wildlife corridors and habitat patches, as well as measures to lessen their impacts on the viability of wildlife corridors and habitat patches."*

As this Project does not seek to change the design of the corridors or habitat patches, this response focusses on the guidance to land managers and best practices for proposed developments.

The Project is not anticipated to have a long-term impact on wildlife movement along the corridor or between habitat patches. Revegetation work planned for No Man's Land (refer to the response to SIR 108) is anticipated to mitigate the impacts of the Project and potentially increase connectivity relative to baseline conditions by increasing the extent of hiding cover in locations deemed to be of high value to connectivity. Additionally, the top of the Structure may allow easier access across Cougar Creek between the canyon edges facilitating movement across the corridor in an area where movement is currently difficult.

The trail system that currently goes through the wildlife corridor and the Indian Flats Habitat Patch is relatively dense compared to other areas of the Bow Valley and as a result, the area is known to have high human use. Alberta Environment and Parks (AEP) is currently working on evaluating and discouraging use on non-designated trails to minimize human impacts. Trail structure and location associated with the Project is being coordinated with AEP. Similarly, appropriate trail and educational signage will be discussed and coordinated with AEP.

Long-term monitoring work is being coordinated between the Town of Canmore and AEP to obtain baseline conditions and evaluate changes in habitat use through the construction and operations phases of the Project. Data is being collected by AEP in a way that is consistent with other regional monitoring initiatives. The guidelines recommend that 1 year of baseline data is collected followed by 3 years of monitoring post-development. Data from the monitoring work will inform AEP if additional mitigation measures are needed to maintain the effectiveness of the wildlife corridor and the Indian Flats Habitat Patch. The need for and design of a post-construction monitoring program will be determined by AEP and it is expected that any post-construction monitoring will be incorporated into AEPs regional monitoring efforts.

The best practices within wildlife corridors and habitat patches section offer recommendations related to linear density, development footprints in habitat patches, recreational trail protocol, creation of new trails, educational signage and maintaining hiding cover. Many of the best practices fall outside of the jurisdiction of the Town of Canmore or will be carried out in consultation and cooperation with AEP.

The guidelines recommend that to reduce linear density, crossings in the wildlife corridor should be perpendicular to the corridor and spaced at not less than 1 km intervals. Due to terrain constraints, the Access Road winds its way up the embankment to the top of the Structure; however, the overall movement of vehicles is roughly perpendicular to the wildlife corridor (refer to Figure 4.4-2 of the environmental impact assessment [EIA]). There are no other perpendicular crossings of the wildlife corridor within 1 km. Although the Structure overlaps with the edge of the Indian Flats Local Habitat Patch, the Structure is unlikely to cause any long-term decrease in functional habitat patch size. The grassy slope design of the Structure should allow continued movement and habitat use by wildlife.

Amenities such as benches, tables, garbage receptacles and lighting will not be permanent features of the Project during operations but some of these features will be available to work crews during construction and are necessary for human and wildlife safety. The Town of Canmore has satisfied requirements of the Bow Corridor Ecosystem Advisory Group (BCEAG 2012) by providing detailed maps that identify footprint relative to the corridor and habitat patch and conducting an EIA. The Town will require contractors to prepare an environmental construction operations (ECO) plan in accordance with the Alberta Transportation (AT) *Environmental Construction Operations (ECO) Plan Framework: Instructions for preparing ECO Plans for Alberta Transportation, City of Calgary and City of Edmonton Construction Projects* (ECO Plan Framework; AT, City of Calgary, City of Edmonton 2014). The ECO plan will address site-specific environmental sensitivities and features that require additional protection and education including wildlife and wildlife habitat. All workers at the construction site will be required to take a wildlife awareness program that the Town of Canmore has reviewed and sent to AEP Parks Division for comment before construction (refer to the response to SIR 139).

References:

Alberta Transportation, City of Calgary, City of Edmonton. 2014. *Environmental Construction Operations (ECO) Plan Framework: Instructions for preparing ECO Plans for Alberta Transportation, City of Calgary and City of Edmonton Construction Projects.* January 1, 2014. http://www.transportation.alberta.ca/Content/docType245/Production/EcoPlan.pdf

Bow Corridor Ecosystem Advisory Group (BCEAG). 2012. *Wildlife Corridor and Habitat Patch Guidelines for the Bow Valley.* Updated 2012. Town of Canmore, Town of Banff, Municipal District of Bighorn, Banff National Park, and Government of Alberta.

26	**Volume 1, Section 4.9.2.2, Page 4-53** The Town of Canmore states it will follow AEP direction guidelines for managing woody debris and merchantable timber and will follow the Town of Canmore's FireSmart strategy. a. Clarify the manner in which these guidelines will be incorporated into the Project given the applicable regulations apply to Crown land and may not be applicable if the Project land is sold to the Town. b. Describe any implications related to adherence to FireSmart guidelines on Project construction and operation.

Response:

a. Alberta Environment and Parks (AEP) notified the Town of Canmore on March 29, 2017 (Appendix 24-1) that the South Saskatchewan Regional Plan (SSRP) was amended in January 2017 to allow the Minister of AEP to approve the construction and maintenance of an access road within a wildland provincial park if it is in the interest of public safety. Alberta Parks concluded that the SSRP amendment pursuant to the *Alberta Land Stewardship Act* supersedes the *Provincial Parks Act Dispositions Regulation* and that the land sale was no longer required. If the Project is approved, Alberta Parks will issue a disposition to the Town of Canmore and will maintain jurisdiction over all activities within the Bow Valley Wildland Provincial Park.

   Refer to the responses to SIR 111b and SIR 111c for a discussion of how woody debris and merchantable timber will be managed.

   The Town of Canmore updated its *FireSmart Mitigation Strategy* in 2010 (Town of Canmore 2010) in accordance with the FireSmart guidelines. The strategy includes all lands within the Town of Canmore boundary and applies to all types of land ownership within the boundary including private deeded, municipal lands and crown lands (including Bow Valley Wildland Provincial Park lands managed by AEP). The strategy includes priority mitigation options for areas within the Town boundary based on a hazard and risk assessment and identifies responsible parties for vegetation management (e.g., AEP, Town of Canmore, developers). The entire Project site sits within the Town of Canmore boundary and the Town will manage vegetation on the site as appropriate based on the hazard and risk defined for Cougar Creek and in consultation with AEP. The Town of Canmore, AEP and Banff National Park have cooperated and coordinated fire risk management in the Bow Valley for many years.

b. Vegetation management, including adherence to FireSmart guidelines, will be incorporated into the construction plan and into the facility maintenance plan. The Town of Canmore considers FireSmart mitigation to be an important risk management practice and does not foresee any adverse implications of adherence to FireSmart guidelines on the construction or operation of the Structure.

References:

Town of Canmore. 2010. *FireSmart Mitigation Strategy*. December 2010. https://canmore.ca/documents/municipal-development-plan

2.5 Errata

27	**Volume 1, Section 8.2.6.3, Table 8.2-6, Page 8-10** Footnote on Power Rating is not listed at the bottom of the table. a. Provide footnote on Power Rating.

Response:

a. There is no footnote for the power rating column.

28	**Volume 1, Section 9.2.4.2, Page 9-6** **Volume 1, Section 11, Page 11-6** Confirm that the description of the third mitigation listed on page 11-6, *Maintaining access to the trails downstream*…., is consistent with the access description on page 9-6.

Response:

The third mitigation listed on page 11-6 - *Maintaining access to the trails downstream of the Structure that connect to both the east and west banks of Cougar Creek, and connect to backcountry trails (including Horseshoe Loop, Montane Traverse, and Mount Lady Macdonald)* – is consistent with the access description on page 9-6. Access to trails that begin downstream of the Structure will be maintained at all times; however, during periods of heavy traffic users might have to access those trails using existing alternate routes rather than directly from the Cougar Creek parking lot and trail head. The Town of Canmore will inform the public via signage, their website and social media about access restrictions and alternate routes. During construction planning, the Town of Canmore will work to minimize disruption to recreational users and will only restrict access to the Cougar Creek parking lot and trail head for short periods of time when it is necessary to protect public safety.

3 GENERAL

3.1 Public Engagement and Aboriginal Consultation

29	**Volume 1, Section 3.2.1, Page 3-2** The Town of Canmore indicates *no specific concerns regarding the Project were raised at any of the meetings.* That being said, there would have been other communication besides meetings. a. Provide a list of any concerns brought up at any time during consultation including any non-project specific concerns/issues.

Response:

a. No project-specific concerns were raised during First Nations consultation meetings. Other non-project specific concerns or issues that were raised during meetings or site visits were as follows:

- representatives from all First Nations expressed concerns regarding flooding and flood recovery in their own communities;
- a representative from the Stoney Nation raised a concern regarding proliferation of human use trails in the backcountry in general; and
- Stoney Nation representatives raised concerns regarding graffiti and other evidence of human use within Cougar Creek during their site visit.

30	**Volume 1, Section 3.2.1, Page 3-2** a. How were the notification letters and plain language information packages delivered to the First Nations? What type of delivery verification is available for this? b. The Town of Canmore indicates notification that the proposed TOR was provided to the First Nations. What type of delivery verification is available for this?

Response:

a. A notification letter and plain language information package was delivered to the consultation contacts at each First Nation community according to the community's preferred method of delivery and in accordance with Aboriginal Consultation Office (ACO) delivery verification requirements. A record of delivery verification has been filed with the ACO for each First Nation. In most cases verification is in the form of a return email or email read-receipt. If an email verification was not available, the documents were sent by registered mail and a tracking record was submitted to the ACO.

b. Notification of the proposed terms of reference (TOR) were delivered to the consultation contacts at each First Nation community according to the community's preferred method of delivery and in accordance with ACO delivery verification requirements. A record of verification has been filed with the ACO for each document. In most cases verification is in the form of a return email or email read-receipt. If an email verification was not available, the documents were sent by registered mail and a tracking record was submitted to the ACO. A public notice regarding the environmental impact assessment Proposed TOR was also posted in the Rocky Mountain Outlook, Alberta Native News, the Calgary Herald and the Edmonton Journal.

31	**Volume 1, Section 3.2.1, Page 3-2** **Volume 1, Section 8.7.4, Page 8-73** The Town of Canmore indicates *no specific TEK was provided by any of the First Nations consulted on the Project to date of the EIA submission.* a. Was there any TEK provided? If any TEK was provided by any of the First Nations describe the TEK that was provided.

Response:

a. The Town of Canmore asked representatives from each First Nation if they were interested in sharing traditional ecological knowledge (TEK); however, no TEK was provided by any of the First Nations consulted on the Project.

32	**Volume 1, Section 3.2.1, Page 3-3** **Volume 1, Section 8.7.4, Page 8-74** **Volume 1, Section 8.8.6, Page 8-77** The Town of Canmore indicates *Tsuut'ina Nation, Blood Tribe, Piikani Nation, and Siksika Nation have all provided the Town with letters of non-objection confirming that the Project is not expected to adversely affect TLU or Treaty rights.* This statement is more of an assumption. The letters submitted by these four Nations do not explicitly state this. a. Clarify what was indicated in the letters.

Response:

a. Each of the four letters received by the Town of Canmore confirmed that the First Nations noted above had conducted a traditional land use assessment and that there were no concerns with or objections to the Project. These letters did contain the following clarifications:

   - a statement of non-objection should not be interpreted as the abandoning, waiving or extinguishing of Aboriginal or Treaty Rights (Blood Tribe);
   - a statement of non-objection to the Project does not indicate a lack of concern regarding impacts to traditional use or heritage sites, wildlife or their habitat and vegetation in general (Siksika Nation); and
   - that communities maintain the right to amend their position or withdraw a letter of non-objection (Tsuut'ina Nation, Piikani Nation).

33	**Volume 1, Section 3.2.1, Page 3-3** The Stoney Nakoda requested additional information. a. What information was requested?

Response:

a. The Stoney Nakoda provided the Town of Canmore with a Stoney information letter form to fill out and return. The Stoney information letter is used to determine the level of involvement required from the Stoney First Nation regarding consultation on projects that they are asked to review. The form requests: general information about a proposed project; details on what environmental, cultural and archaeological work has been completed; details regarding the consultation plan, communication methods and emergency response planning; confirmation of whether or not a cultural awareness, safety and community orientation has been conducted; and employment and training opportunities associated with the Project. The Town of Canmore submitted a completed form to the Stoney Nation on November 10, 2015.

34	**Volume 1, Section 3.2.1, Page 3-3** a. Clarify why a meeting has not yet been scheduled with the Stoney Nakoda.

Response:

a. The Town of Canmore made several attempts to schedule a meeting with the Stoney Nation between October 2015 and the submission of the environmental impact assessment in July 2016. A meeting was held on November 15, 2016, with the Stoney Nation consultation manager and two consultation officers. A Stoney Nation site visit was conducted on December 2, 2016.

35	**Volume 1, Section 3.2.1, Page 3-2** Contradiction in statements regarding First Nation views on reclamation *no specific views on reclamation were provided on page 3-2 versus no specific views on reclamation were provided other than a preference for reclamation with native species* on pages 3-10 and 8-73. a. Clarify the inconsistent statements.

Response:

a. No specific views on reclamation were provided by First Nations during consultation meetings. A representative from the Blood Tribe expressed a preference for reclamation with native species during the Blood Tribe traditional use site visit.

36	**Volume 1, Section 7.4.4.3, Page 7-56** It was indicated that this project may result in direct and indirect mortality to wildlife populations. a. Were these potential affects discussed with First Nations? If so, was there any discussion about mitigation for these concerns? If not, justify why these potential effects were not discussed with First Nations.

Response:

a. Potential direct and indirect mortality to wildlife was not specifically discussed with First Nations. Wildlife known to use the wildlife corridor were discussed with each First Nation and no concerns regarding Project-related mortality were raised. With the exception of the Stoney Nakoda First Nation, consultation meetings and site visits occurred before the completion of the environmental assessment. No questions or concerns have been communicated to the Town of Canmore by First Nations regarding wildlife mortality since submission of the environmental assessment.

The environmental consequence ratings for direct wildlife mortality associated with site clearing and blasting and with the removal of nuisance wildlife and for indirect wildlife mortality were negligible, meaning that potential effects are not discernible above background. The environmental consequence rating for direct wildlife mortality associated with collisions with project vehicles is low, meaning that the measurable change is at or above levels of natural variability with no predicted measureable change in regional wildlife populations. The Town of Canmore will enforce a 20 km/hour speed limit on Project roads and will restrict vehicle traffic to 7 am to 7 pm and these mitigations are expected to substantially limit collisions. The Town of Canmore is working with Alberta Environment and Parks (AEP) to monitor wildlife and will work with AEP to identify adaptive management practices as warranted.

37	**Volume 1, Section 7.2.2, Page 7-3** **Volume 1, Section 7.3.2.3, Page 7-10** It was indicated that this project may result in direct loss of rare plants and traditionally used species. a. Were these potential effects discussed with First Nations? If so, was there any discussion about mitigation for these concerns? If not, justify why these potential effects were not discussed with First Nations.

Response:

a. With the exception of the Stoney Nakoda First Nation, consultation meetings and site visits occurred before the completion of the environmental assessment; however, the Town of Canmore prepared a summary of the vegetation field work that was conducted and provided it to First Nations who inquired about rare and traditionally used species (Piikani Nation and Tsuut'ina Nation). This summary included rare plant observations on the Project site. First Nations consultation representatives confirmed that they would assess traditionally used plant species during a site visit and inform the Town of Canmore of any concerns. Stoney Nakoda representatives inquired about an opportunity to harvest traditionally used plants before construction and the Town of Canmore committed to providing this opportunity.

38	**Volume 1, Section 3.2.2, Page 3-3** The Town of Canmore initiated public engagement activities on July 18, 2013 with a focus on residents directly affected by the 2013 flood. No other information on public consultation activities is provided. a. Provide a list of communities and stakeholders that were identified for public engagement activities. b. How were these specific groups chosen? c. What issues were presented to the Town of Canmore from public interest groups, stakeholders, etc.? How did the Town go about resolving these issues? Was any of the input received included in the EIA and if so what input?

Response:

a. There were four community and stakeholder groups identified by the Town of Canmore after the 2013 flood:

   1. Residents directly impacted by a mountain creek.

      All homeowners who back directly on to Cougar Creek were sent a letter inviting them and any tenants to be part of an email list. Approximately 70 group emails have been sent to this group since the flood. In addition, the Town has held meetings with this group to update them on recovery and to answer their questions. There were eight meetings in 2013, ten meetings in 2014, and two each in 2015 and 2016. Notes/minutes from each meeting were directly emailed to the group.

      Similarly, all homeowners who are in the hazard and risk zone for Stone Creek, Stoneworks Creek, and Three Sisters Creek have received a letter inviting them to be part of an email group. These groups have received fewer emails but are updated on any significant recovery information.

   2. All community members.

      Regular communication was provided to all residents after the 2013 flood through a weekly update from the Mayor that was shared via the Town's website and social media. The Mayor posted a total of 24 updates between July 16, 2013 and May 2014. Most of the Mayor's updates were also published in the Rocky Mountain Outlook. These updates were ultimately replaced by the mountain creek hazard mitigation pages of the Town's website at: http://canmore.ca/residents/mountain-creek-hazard-mitigation.

      The Town also held public open houses and information sessions for the entire community on June 30 and September 25, 2013. Dr. Matthias Jakob, from BGC Engineering Ltd., gave a presentation to Council on Stone Creek and Three Sisters Creek on February 10, 2014, that was advertised and open to the whole community. Another public information session on long term mitigation for Cougar Creek was held on October 6 and 7, 2014.

Four newsletters have been published to date and were made available at open houses, online, via email, and through social media.

Since the 2013 floods, multiple presentations have been made to Council at public meetings which are recorded and made available to the public. These meetings are also attended by the local press and every presentation made to Council has received media coverage.

3. Leading experts in the fields of geomorphology, mountain creek flood mitigation, hydrology, geotechnical engineering, and geology.
4. Agencies, governments, businesses, organizations, and land owners who would be part of the recovery process. These include but are not limited to Alberta Health Services, Alberta Transportation (AT), Alberta Environment and Parks (AEP), Canadian Pacific Railway (CPR), the Municipal District (MD) of Bighorn, Parks Canada, Town of Banff, Three Sisters Mountain Village, Stone Creek Resorts, Cross Zee Ranch, and New Life Church.

b. Immediately after the 2013 flood the Town began to identify two key groups: the community that needed to be kept updated; and key stakeholders that the Town needed to partner with in order to recover effectively.

It was clear that information needed be shared with the entire community. The Town also understood that those who live or own a business on or near a creek would need more in depth information than the general community. The targeted list of residents was chosen based on location of property and property ownership.

For stakeholders, the Town worked to develop a thorough list of anyone who would either be impacted or had key information/knowledge that could play a role in the recovery process. Key stakeholders included, among others, CPR, MD of Bighorn, AT, AEP, and leading experts (Dr. John Pomeroy, Dr. Norbert Morgenstern, Dr. Michael Church, and Dr. Matthias Jacob) who would inform and support the Town of Canmore flood mitigation efforts. The Town began meeting with those groups to share information, knowledge, and learnings, and to craft plans for moving forward. These meetings formed the basis for the working relationships the Town has today. The Town worked with stakeholders to develop a shared understanding of mountain creek behaviour and risks, the goals, schedule, decision points, and risks of the Town's Mountain Creek Hazard Mitigation Program, and how key stakeholders and decision makers would be engaged throughout the recovery process.

c. Concerns and issues raised during engagement activities were summarized in Section 3.2.2 (page 3-4) of the environmental impact assessment (EIA). This summary described the main concerns raised by residents immediately after the flood, during initial flood mitigation activities and during planning for the Structure. More specific issues raised by community groups and stakeholders are listed below.

- **From the Alpine Club of Canada, different groups representing climbers and AEP:** Access to Cougar Creek, upstream of the Structure, must be maintained during construction and operation. The Town has been working with AEP to build a new recreational trail to access the creek during and post construction – this has been discussed in Section 8.4.5.4 of the EIA.

- **From AEP and conservation groups:** Wildlife movement up and down the creek needs to be maintained. The Town has worked with its consultants to ensure that the slopes of the Structure, both upstream and downstream, are at a grade that is low enough that all wildlife can move over the Structure. Those slopes will also be topsoiled and seeded with native grass to enhance the visual look and provide a more natural environment for wildlife. The stilling basin will also be filled to ensure that there is not a large and deep gap or pool at the downstream side of the Structure. Refer to the response to SIR 108 for a description of reclamation plans, and the responses to SIR 134 and SIR 142 for a description of wildlife movement.

- **From AEP and conservation groups:** Wildlife movement across Cougar Creek should be maintained through the wildlife corridor and habitat patches restored. The Town has worked extensively with wildlife biologists to minimize disruption to wildlife movement due to the Structure and its appurtenant structures. The Town has also worked on a reclamation plan in No Man's Land with AEP to increase the efficiency of the wildlife corridor. Refer to the response to SIR 108 for a description of reclamation plans, and the responses to SIR 134 and SIR 142 for a description of wildlife movement.

- **From AEP:** Maintenance of the Structure, and clean out of debris and coarse sediment accumulation are key to the effectiveness of the Structure. The Town has committed to maintain and clean the debris from the Structure and has already started a fund reserve that its sole purpose will be for operation and maintenance of steep creek hazard mitigation measures.

- **From AT and CPR:** Ensure that any mitigation measures upstream of Highway 1 and the CPR bridge do not negatively affect them. The Structure will lower the maximum flow of water going through the Highway 1 culvert and under the CPR bridge. The amount of debris being transported to Highway 1 and the railway tracks should be lower to what they have previously experienced. The Structure therefore lowers risk to Highway 1 and CPR infrastructure and might also lower maintenance costs.

- **MD of Bighorn, Bow River Basin Council, other downstream stakeholders:** Ensure that the proposed mitigation measures will not negatively affect communities downstream of Canmore along the Bow River. The Project will lower the peak flow of water reaching the Bow River during large storm events. Instead of a surge of water, the Structure will slow down the release of water. This will in turn lower the risk of the Bow River surging through downstream communities during large storm events.

39 **Volume 1, Section 3.2.2, Page 3-3**

The Town of Canmore has accepted feedback from residents (both those directly affected and others) by e-mail, mail, online surveys, and in person at public meetings.

a. What specific issues were received by e-mail, mail, online surveys, and in person at public meetings?

b. What was the Town of Canmore's response to each type of issue?

c. Were any issues unable to be resolved and/or are still ongoing?

Response:

a. Throughout the process the community has provided input and asked questions that shaped the Project. In the years since the flood the Town has worked very closely with all residents backing on to Cougar Creek to address their issues and concerns through group meetings, individual meetings, onsite meetings, and through various contractors working in the creek.

The community, including the Cougar Creek resident group, was notified about the environmental impact assessment application and encouraged to submit their feedback directly to Alberta Environment and Parks.

The main issues raised by residents were related to funding and perceived lack of mitigation works on other creeks within the Town of Canmore.

1. Funding: People were worried that such a project would be too onerous for the Town of Canmore and that it would result in a large tax increase or a reduction of other services.

2. Mitigation works on other creeks: In the first few months following the flood, it appeared as if the Town was primarily focused on Cougar Creek and that the other creeks were not being studied which caused concerns in the wider community.

3. Timing and necessity of the project: several residents living in the Cougar Creek area have expressed concerns over the lengthy process to get the Structure designed, approved and constructed. They still feel unsafe with the short-term mitigation work done to date and want the Structure to be in place as early as possible.

4. Other issues were concerning the wildlife corridor and recreational access to Cougar Creek. These issues are discussed in the response to SIR 38c.

b. The issues were dealt with in the following way:

1. The Town made an early commitment to provide up to $4M for the Project. All other funds required to construct the Project will be provided by the Federal and Provincial Governments. Alberta Transportation has provided $1.37M, a $19M provincial grant has been in place since 2014 and the Town received $10.26M from the Alberta Community Resilience Program in May 2017. The Federal Government announced a $14.45M grant in October of 2016 for the Project. With this Provincial and Federal funding the Town of Canmore will only be responsible for a total of $4M. The financial impact of the Project is well within acceptable range for the Town of Canmore.

2. The Town demonstrated that all the other creeks were also being studied. However, Cougar Creek has been the top priority due to its high risks.
3. The Town has kept Council and residents informed through meetings and an email distribution list regarding scheduling and progress of the Project.
4. Refer to the response to SIR 38c.

c. The Town of Canmore believes that all of the issues raised by community members and stakeholders have been resolved with the exception of the concern raised by residents regarding their continued exposure to risk until the Structure is approved and constructed. The Town will continue to inform directly impacted residents, the broader community and other stakeholders regarding progress through the regulatory process.

3.2 Socio-Economic

40	**Volume 1, Section 3.3, Page 3-5** The Town of Canmore states that *detailed assessments, including the assessment of baseline conditions for each indicator, are included in Sections 6, 7, and 8.* a. Reference the specific areas in Sections 6, 7 where socio-economic effects are specifically addressed.

Response:

a. The statement was intended as a general one, to indicate that assessment of baseline conditions for each indicator were included in the appropriate aquatic environment, terrestrial environment and human environment sections. With respect to socio-economic effects this is covered in Section 8.5 of the environmental impact assessment.

41

Volume 1, Section 8.5.2, Page 8-45
Volume 1, Section 8.5.4.2, Table 8.5-2, Page8-48
Volume 1, Section 8.5.4.3, Page 8-50

The Town of Canmore states *other communities in the RSA include Exshaw, Lac de Arcs, Harvie Heights, and Dead Man's Flats.* However, on page 8-45 the Town of Canmore States *The RSA includes the Town of Canmore and the hamlets of Exshaw, Lac de Arcs, Harvie Heights, and Dead Man's Flats as well as parts of the MD of Big Horn No.8, the Kananaskis Improvement District and a small portion of Banff National Park.*

a. The hamlets of Exshaw, Lac de Arcs, Harvie Heights, and Dead Man's Flats are within the MD of Big Horn No.8. List what other parts of the MD of Big Horn No.8 the Town of Canmore is referencing on page 8-45.

b. On Page 8-45 the Kananaskis Improvement District and a small portion of Banff National Park is included in the RSA. However, these areas are not referenced on page 8-50 under *Section 8.5.4.3 Regional Socio-economic conditions*. Clarify if the Kananaskis Improvement District and a small portion of Banff National Park is included in the RSA. Update the required sections to reflect this so they are consistent.

c. The Kananaskis Improvement District and a small portion of Banff National Park are part of the RSA as stated on page 8-45. Update Table 8.5-2 so these areas are represented and include population numbers. If no population numbers are available indicate this in Table 8.5-2. In addition, if no population numbers exist explain how the socio-economic effects for these two areas were accounted for in the EIA and what the predicted effects to these areas might be.

Response:

a. The extent of the Municipal District (MD) of Big Horn No. 8 that is included in the regional study area (RSA) is shown on Figure 8.5-1 of the environmental impact assessment. The portion of the MD of Big Horn No. 8 that is included in the RSA contains the communities of Exshaw, Lac des Arcs, Harvie Heights and Dead Man's Flats, and portions of Highways 1 and 1A that will accommodate some construction traffic. The focus of the socio-economic assessment is on the Town of Canmore as a main service center but the assessment also includes communities within the MD (Exshaw, Harvie Heights, Dead Man's Flats and Lac Des Arcs).

b. Parts of the Kananaskis improvement District and Banff National Park are located within the boundaries of the RSA; however, there are no anticipated impacts to these areas as there are no population centres that fall within the RSA and there are no major transportation corridors that will be accessed by construction or operation traffic. Although the RSA focuses on a region, the impacts are assessed on the specific communities that could potentially be impacted.

c. Both Banff National Park and the Kananaskis Improvement District are accessed by the major transportation corridor of Highway 1, which may carry some construction traffic. Access to both regions is not anticipated to be affected by the Project because traffic influence is concentrated in the Town of Canmore and on Highway 1A between Exshaw and

Canmore. The Kananaskis Improvement District has no major transportation corridor that will be used by Project traffic. Although the Kananaskis Improvement District and Banff National Park have permanent populations, neither has a population centre located within the RSA; therefore, no impacts are expected due to the Project.

Table 8.5-2 has been updated to include Kananaskis Improvement District and Improvement District No. 9 (Banff) (Table 41-1). The Kananaskis Improvement District and Improvement District No. 9 (Banff) have 2011 population of 938 and 1,175 respectively.

Table 41-1 Population in Communities and Improvement Districts located in the Regional Study Area

Community/Improvement District	**2006**	**2008**	**2009[1]**	**2011**	**2014**
Canmore[2]	16,417	17,572	17,970	18,299	16,967
Permanent[2]	11,599	12,005	12,226	12,317	13,077
Non-permanent[2]	4,818	5,567	5,744	5,982	3,890
Exshaw[3]	382	-	-	362	-
Harvie Heights[3]	207	-	-	175	-
Lac des Arcs[3]	127	-	-	144	-
Dead Man's Flats[1]	-	-	-	121	-
Kananskis Improvement District[3]	429	-	-	249	-
Improvement District No. 9 (Banff)[3]	938	-	-	1,175	-

1. MD of Bighorn 2016, Statistics Canada 2015
2. Town of Canmore 2015
3. Statistics Canada 2015

- = Data not available.
Due to methodological differences and limitations of counts, Town of Canmore non-permanent population information for 2014 is considered "not comparable" to previous years.

The socio-economic impact assessment focused on the communities that are likely to be impacted by the Project due to population change or traffic. Due to the lack of population centres and accommodation in the portion of the Kananaskis Improvement District and Banff National Park that is located in the RSA and the lack of project-related traffic effects, the Project is not anticipated to affect these areas.

References:

Municipal District of Bighorn No. 8. 2016. *Community Profile*. Accessed in April 2016. http://mdbighorn.ca/ab-community-profile/

Statistics Canada. 2015. *NHS Profile, Canmore, CA, Alberta, 2011*. Last modified November 27, 2015. http://www12.statcan.gc.ca/nhs-enm/2011/dp-pd/prof/details/page.cfm?Lang=E&Geo1=CMA&Code1=828&Data=Count&SearchText=canmore&SearchType=Begins&SearchPR=01&A1=All&B1=All&Custom=&TABID=1

Town of Canmore. 2015. *2014 Municipal Census*. February 27, 2015. http://www.google.ca/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwia8vLtwKfLAhVX0mMKHUg2DYAQFggbMAA&url=http%3A%2F%2Fwww.canmore.ca%2Fcensus-documents%2F119-census-2014-final-report&usg=AFQjCNHwx6t8I5auc8CZPMG9ybnP0vRTow

42	**Volume 1, Section 8.2.5, Page 8-8**
	Section 8.5.5.4 points to section 8.2 for additional mitigation measures to manage dust. On page 8-8 the Town of Canmore states *Mitigation measures, including best practice standards, employed to reduce soil erosion and minimize the duration of soil exposure, will reduce the overall volume of airborne particulate matter.* a. Clarify if mitigation measures as it appears in the statement above is only referencing water as a dust suppressant. If there are other mitigation measures included explain them. b. What are the best practices the Town of Canmore is referencing? Are these best practices discussed in the EIA? If not, list the best practices and explain how these will be used to reduce soil erosion, minimize the duration of soil exposure, and reduce the overall volume of airborne particulate matter.

Response:

a. The Town of Canmore has committed to developing and implementing a dust control management plan (Section 4.9.3, Dust Suppression, page 4-55) and an erosion and sediment control (ESC) plan (Section 4.4.5.1, Construction Plan and Schedule, page 4-29) for the Project. Both of these plans will include mitigations aimed at reducing dust during construction and operation.

   The dust control management plan will be focused primarily on reducing dust from traffic travelling to and from the site, on movement and compaction of materials used to construct the Structure and on blasting activities. Specific mitigations include:

   - Road dust suppression up to four times per day during construction of the Project using water as a road dust suppressant. Water will also be used to suppress road dust during post-flood event maintenance activities. The tender and contract will stipulate dust suppression requirements for access on all unpaved roads. If the contractor determines that a more effective dust suppressant than water is available, the Town of Canmore will review the proposed product with the Parks Division of Alberta Environment and Parks to confirm that the product is appropriate for use adjacent to Cougar Creek.
   - Water will be used to maintain adequate moisture levels for compaction of materials used to construct the Structure; resulting in reduced airborne particulate matter from the construction site.
   - Qualified rock blasters will assess rock and site conditions to formulate an appropriate blast design in consultation with the Project engineering team. Blasting will be conducted in a manner that minimizes the disturbed area and reduces airborne rock, dust, and the potential for landslides or slope instability.
   - Matting will be used during blasting to minimize deposition of dust outside of the blasting area.

b. The Town of Canmore will require contractors to prepare an ESC plan in accordance with he *Erosion and Sediment Control Manual* (GoA 2011). The ESC plan will include appropriate best management practices identified in the manual and by the contractor to achieve the following objectives:

- minimize disturbance to vegetation and soil;
- prevent the loss of soil from the site due to precipitation, surface runoff, wind erosion and construction activities (this does not include fluvial debris deposits);
- prevent the movement of silt or sediment; and
- reduce dust and airborne particulate matter.

The Town will review and approve the ESC plan before construction and will require that it be developed, implemented and monitored by a certified professional in erosion and sediment control (CPESC). Specific practices will be determined by the CPESC during the development of the ESC plan; however, it is expected that at a minimum the ESC plan will include the following accepted, well-established and efficient measures:

- Pre-construction meetings with all onsite personnel to discuss ESC measures that have been put in place and the need for their continued maintenance during construction.

- Having ESC measures installed according to manufacturer’s instructions and under the guidance of the CPESC.

- Keeping sediment control materials (silt fence) in place in areas where the Project will disturb soils until vegetation is established.

- Completing ESC inspections of all measures.

- Installing wind barriers (slat fences, snow fences) as required.

- Maintaining vegetative buffer strips wherever possible, particularly along perimeters of construction areas.

- Grading disturbed surfaces to prevent increased runoff on slopes.

- Maintaining natural drainage patterns along the Access Road by ensuring appropriate size, spacing, location, and number of culverts.

- Providing ditch checks, where appropriate, to reduce runoff velocity, create storage, and reduce erosion potential in road ditches.

- Using flow obstacles (e.g., riprap, erosion control matting) on slopes that exceed 5% gradient to reduce water velocity.

The Town will also require contractors to prepare an environmental construction operations (ECO) plan in accordance with the Alberta Transportation ECO Plan Framework (AT, City of Calgary, City of Edmonton 2014). An ECO plan is a contractor’s plan for the identification and mitigation of potential environmental impacts that may occur as a result of their activities. The ECO plan will address environmental mitigation and protection issues relevant to the construction activities being performed on a specific project site.

The ECO plan will identify, among other things:

- potential environmental issues on the Project;
- mitigation measures to prevent or minimize environmental impacts (which includes ESC, as well as reduction of airborne particulates); and
- environmental emergency response procedures.

References:

Government of Alberta (GoA). 2011. *Erosion and Sediment Control Manual*. Government of Alberta. June 2011. http://www.transportation.alberta.ca/Content/docType372/Production/ErosionControlManual.pdf

Alberta Transportation, City of Calgary, City of Edmonton. 2014. *Environmental Construction Operations (ECO) Plan Framework: Instructions for preparing ECO Plans for Alberta Transportation, City of Calgary and City of Edmonton Construction Projects.* January 1, 2014. http://www.transportation.alberta.ca/Content/docType245/Production/EcoPlan.pdf

43	**Volume 1, Section 8.5.5.5, Page 8-60** The Town of Canmore states *rental housing continues to be a challenge in Canmore for both affordability and availability, and would likely not be the primary form of accommodation for the Project employees.* a. Confirm what the primary form of accommodation will be for the Project employees.

Response:

a. Based on current accommodation availability and occupancy rates, it is expected that short-term hotel and motel accommodation will be available for a potential temporary mobile construction workforce (Section 8.5.5.5, page 8-60). The maximum incremental temporary population change due in the regional study area during the construction period is 30 people. The Town of Canmore is accustomed to a non-permanent population and tourist industry, and is therefore expected to have the capacity to handle a temporary mobile workforce.

Operations of the Project requires one part-time position which is expected to be filled by an existing resident (Section 8.5.5.5, Socio-Economics, page 8-59) with no additional pressure on permanent accommodations.

44	**Volume 1, Section 8.5.5.5, Table 8.5-9, Page 8-62** The Town of Canmore does not indicate any passes for logging trucks in Table 8.5-9. a. Explain why no passes was recorded for logging trucks. Is it possible for this value to be estimated? If so, provide this value.

Response:

a. Based on the estimated volumes of merchantable (138 m^3) and non-merchantable (6 m^3) timber that will need to be removed from the site, the estimated number of passes for logging trucks is four of merchantable timber and one of non-merchantable timber. This estimate is based on a truck capacity of 40 m^3. The number of logging truck trips were not included in Table 8.5-9 of the environmental impact assessment because they are a small number of isolated passes and are not part of the daily construction traffic.

45	**Volume 1, Section 8.5.5.5, Page 8-62** The Town of Canmore states *it is expected that the mitigation measures provided will be able to accommodate the increased volume.* a. Reference in this statement where the provided mitigation measures can be found.

Response:

a. The Town of Canmore has proposed a number of project planning measures to mitigate the increased volume of traffic associated with the Project, including (with environmental impact assessment reference):

  - The Town of Canmore will implement a traffic accommodation strategy, including the installation of signage and the establishment of detours (Section 4.4.5).
  - Residents will be informed of work and traffic schedules, and signs will be in place to inform individuals that work is occurring within Cougar Creek (Section 8.5.5.4).
  - The Town of Canmore will mitigate traffic concerns by asking contractors to minimize the number of transportation trucks going in and out of site by maximizing the number of workers per truck and by providing a shelter for workers to have an onsite lunch (Section 8.5.5.4).
  - The existing public parking, which is used as a staging area for recreational users, will be maintained through most or all of the construction period. This parking area will be considered in the Project safety plan (Section 8.5.5.4).
  - Separate staging areas will be established for contractors from within Canmore and for contractors mobilizing from outside of the Town (Section 8.5.5.4).

- A traffic management plan (TMP) will be developed as a component of the Project health safety and environment plan. The TMP will focus on the safety of municipal road users, workers on the site, pedestrians and cyclists. Vehicles entering the Town of Canmore during construction will be subject to the requirements of the TMP. The TMP is expected to adequately mitigate safety risk related to additional traffic on municipal roads and within Cougar Creek. Speed limits will be strictly enforced both on municipal roads and within Cougar Creek (20 km/hour) (Section 9.2.4.3).

  The Town of Canmore has previous experience managing traffic during construction activities in and around Cougar Creek. During the 2014 to 2015 re-armouring and revegetation of the Cougar Creek banks, increased traffic was accommodated by maintaining access to residences through the two access points to the Project area and informing residents of timing of work and closures. Public traffic was directed and occasionally stopped to give construction vehicles priority. Occasionally, the construction traffic was restricted to accommodate short-term needs of adjacent landowners. Learnings from previous construction activities will be incorporated into construction management for the Project.

3.3 Emergency Response Plan

46	**Volume 1,Section 4.1.3, Page 4-2** **Volume 1, Section 4.9.4, Page 4-56** With reference to the following statement: *A small maintenance area with an impervious liner will be established on a dry area of the creek bed for use during construction (Section 4.1.3)* and Limiting maintenance and refueling to the designated maintenance area during construction. The designated maintenance area will have an impervious barrier to contain potential spills (Section 4.9.4). a. To avoid accidental product release, will refueling equipment have break-away couplings? If the equipment is not to have break-away couplings, provide rationale as to why this was not considered as a mitigation measure.

Response:

a. All refueling equipment working within the maintenance area will be equipped with break-away couplings to minimize the risk of accidental spillage during refueling. The Town of Canmore will include this requirement in the procurement and contract documents.

47 **Volume 1, Section 9.2.4.3, Page 9-6**

Provide a discussion on the risk assessment of the potential impact of the proposed structure to highway infrastructure.

a. Compare and quantify the existing risk (i.e. no structure) versus the addition of the proposed structure. Include in this discussion the likelihood of failure for the highway/bridge culverts with the proposed structure in place, and whether the consequence would be higher.

b. Provide a discussion on the Town's commitment related to maintenance of the proposed structure. Comment on how maintenance or lack of maintenance might impact highway/bridge infrastructure.

c. Provide a discussion on potential impacts to highway/bridge infrastructure under snow/ice conditions (aufeis).

d. Describe how the outlet under the dam will be cleaned of silt/small debris and whether this plan poses any risk to highway/bridge infrastructure.

Response:

a. With the Structure in place it is expected that substantially less debris will arrive at the Highways 1 and 1A culverts in a flood event. This reduction in debris load during extreme events (flows associated with greater than 14 m^3/s discharge), in combination with bank armouring via the articulated concrete mats installed in 2014, will decrease the potential blocking of the highway culverts. It is difficult to assign a numerical value to the decrease in probability as this depends, to some extent, on the frequency at which the highway culverts are being maintained and kept free of debris. The Town of Canmore's engineering consultant, BGC Engineering Ltd., is of the opinion that the consequences of highway failure with the Structure in place are less than with no Structure in place.

b. The Town is committed to the maintenance of the Structure. Council has approved a special reserve fund for flood mitigation works maintenance and inspection. The Town is putting aside money every year in this special reserve that will solely be used for this purpose. The yearly reserve contribution is based on an analysis of annual maintenance and inspection of the Structure, as well as an annualized cost of cleaning the debris accumulated behind the Structure. Moreover, the operation, maintenance and inspection of the Structure will be a key role for one Town of Canmore Engineering staff. The Manager of Protective Services will also be involved at a high level.

   Maintenance of the Structure will assure that it functions as designed over time. The Structure will withhold some debris; however, sediment and small debris will be allowed to pass through the Structure and be deposited along the downstream channel. Future flood/debris flood events can also mobilize debris along the channel reaches upstream of Highway 1. Debris deposition inside the Highway 1 box culverts during such an event could still lead to overtopping as the box culverts are not specifically designed for heavy debris loads. However, during extreme events, the Structure is designed to impound water and limit the volume of material passing the Structure. This, in turn, decreases the likelihood that the Highway 1 culvert will clog and be overtopped as was observed in June 2013.

In general, and independent on the maintenance of the Structure, it is important that Alberta Transportation (AT) regularly inspects the amount of debris accumulated in the box culverts and maintains maximum capacity. The Town of Canmore and AT have just completed a construction project at the Highway 1 culvert to reduce future blockage potential by improving the hydraulics of the inlet and outlet of the culvert.

c. For much of the year and particularly during the winter months, Cougar Creek runs dry at the surface with baseflow running through the subsurface alluvial material.

The Structure has no effect on the presence or absence of aufeis (icing). Aufeis will develop in times with streamflow followed by sudden cold spells which freeze the surface water. Cycles of rapid warming (Chinook) and rapid cooling could lead to an increase in the thickness of the ice layers should the warming period be of insufficient length to entirely melt it. The Town of Canmore is unaware of any aufeis problems at the Highway 1 culvert.

Similarly, snow accumulations are independent of an upstream Structure. Snow will accumulate independent of the Structure. Snow, if undergoing cycles of melt and refreeze could decrease the capacity of the culvert intake. However, during times of rapid runoff it is believed that snow and firn (old recrystallized snow) would rapidly melt. In this context, it is worthwhile remembering that the most damaging floods occur in early summer when snow or ice is rarely an issue.

d. Refer to the response to part b) above. Moreover, the bottom outlet structure has been designed to minimize debris and sediment accumulation in the outlet itself. One of the goals of the physical scale modelling (Hübl et. al 2016) was to reduce the maintenance requirements of the Structure (upstream, at the debris rake, and in the bottom outlet structure). The modelling showed that the outlet was mostly self-cleaning of silt/ small debris. The shape (semi-circle – promotes concentration of flows) and material (steel – low coefficient of friction to promote movement of water, sediment and debris) of the liner at the bottom of the outlet has been designed to maximize sediment and debris transport through the bottom outlet structure to minimize blockage and maintenance requirements. The bottom outlet structure is also big enough for a small excavator to go through to facilitate cleaning, if necessary.

The Town of Canmore does not consider the cleaning of the Structure's outlet to be a risk to the Highway 1 crossing.

References:

Hübl J. et al. 2016. *Physical Modelling of the Cougar Creek Debris Flood Retention Structure.* IAN Report 171, Department of Civil Engineering and Natural Hazards, University of Natural Resources and Life Sciences (unpublished).

3.4 Waste Management

48	**Volume 1, Section 4.1.7, Pages 4-3** **Volume 1, Section 4.1.7, Page 4-4** a. Explain what will be done with flood sediment that may build up behind or downstream (in the fan area) of the structure.

Response:

a. As described in the response to SIR 24, Alberta Environment and Parks (AEP) has confirmed that if the Project is approved, Alberta Parks will issue a disposition to the Town of Canmore and will maintain jurisdiction over all activities within the Bow Valley Wildland Provincial Park. AEP considers material that may build up in the inundation area or downstream of the Structure to be debris that will have no value as an aggregate material.

After a flood event, the Town of Canmore will remove debris from within the inundation area and downstream of the Structure as part of their operations and maintenance program. The Town of Canmore will hire a contractor through a tender process to remove and dispose of the debris.

49	**Volume 1, Section 4.4.7.4, Page 4-33** **Volume 1, Section 4.4.7, Page 4-34** a. Explain if sediment will have to be removed from behind the structure or in the inundation area.

Response:

a. As described in the response to SIR 24, Alberta Environment and Parks (AEP) has confirmed that if the Project is approved, Alberta Parks will issue a disposition to the Town of Canmore and will maintain jurisdiction over all activities within the Bow Valley Wildland Provincial Park. AEP considers material that may build up in the inundation area or downstream of the Structure to be debris that will have no value as an aggregate material.

Debris will need to be removed from behind the Structure after a flood event. Depending on the size of the event some material may also have to be removed from within the inundation area as well. The Town of Canmore will remove debris from within the inundation area and behind the Structure as part of their operations and maintenance program. The Town of Canmore will hire a contractor through a tender process to remove and dispose of the debris.

50	**Volume 1, Section 4.8, Table 4.8-1, Page 4-51** a. Clarify if drill cuttings generated during the grouting phase will be stable/solid enough for disposal at Francis Cook.

Response:

a. Drill cuttings generated during the grouting phase will be stable/solid enough for disposal at Francis Cook. The Town has had extensive discussion with several deep foundation specialists regarding the best drilling methods for the Project and an air driven system that uses no liquids or chemicals is the preferred method. Larger cuttings will be stockpiled before disposal at Francis Cook. Fine cuttings will be separated from the air stream in a manner determined by the drilling contractor based on their equipment specifications and site conditions, and transported to Francis Cook. Typical fine cutting (dust) control methods for air drilling include directing the air stream into a small cyclone separator unit, a dry receptacle for collection or an isolated decantation pond.

51	**Volume 1, Section 4.8, Page 4-50** **Volume 1, Section 4.8, Page 4-51** a. Explain what will be done with sediment that accumulates in the fan area after a flood event.

Response:

a. The Town of Canmore will maintain appropriate capacity in the Cougar Creek channel and culverts; however, less sediment and debris is expected within the fan area after a flood event once the Structure is in place. If sediment or debris removal is required within the fan area, the Town of Canmore will hire a contractor through a tender process to remove and dispose of the debris.

Any sediment or debris accumulation at the Canadian Pacific Railway (CPR) track and culverts will be handled by CPR, as it is currently the case.

3.5 Transportation

52	**Volume 1, Section 7.4.1.4, Page 7-18** a. How will a speed limit of 20 km/hr be enforced? Who will be responsible for overseeing this requirement?

Response:

a. The speed limit will be posted as per a standard road or street within the Town of Canmore. A penalty clause will be included in the contract whereby contractor and sub-contractors would be fined for speeding. The speed limit will be enforced by the contractor and the Town of Canmore project manager. If speeding is identified as a problem, random speed checks will be conducted with portable speed detection equipment by a Town of Canmore representative.

4 AIR

4.1 Emissions Management

53	**Volume 1, Section 8.2.6.4, Table 8.2-10, Page 8-14** Table 8.2-10 lists the total CAC emissions for the construction phase of the project; however, it does not outline the other source parameters required by the dispersion model. a. Provide an updated table listing the emission source parameters (i.e., flow rate, exit height, exit velocity etc.) used in the modelling for each source and all emission scenarios. b. Provide explanation and justification for the choice of model parameters. c. The model output files indicate that the model was run for a point source; however, the emissions from the project are non-point area or mobile sources. Provide justification for this approach.

Response:

a. Table 53-1 lists the emission parameters used in the modelling and the justification for those choices in the footnotes.

Table 53-1 Source Parameters for AERSCREEN

	Parameter	NO_2	$PM_{2.5}$
Stack Parameters	Source Emission Rate (g/s)	13.4[a]	1[b]
	Stack Height (m)	5[c]	5[c]
	Stack Inner Diameter (m)	0.5[d]	0.5[d]
	Plume Exit Temperature (K)	Ambient[e]	Ambient[e]
	Plume Exit Velocity (m/s)	20[f]	20[f]
	Rural or Urban	Rural	Rural
	NO_x to NO_2 Chemistry	OLM	n/a
	NO_2/NO_x In-stack Ration	0.1	n/a
	Ozone Background Concentration (ppm)	0.03[g]	n/a
Meteorology	Min/max Temperature (K)	250/310*	250/310*
	Minimum Wind Speed (m/s)	0.5*	0.5*
	Anemometer Height (m)	10*	10*
	Albedo	0.35[h]	0.35[h]
	Bowen Ratio	1.5[h]	1.5[h]
	Roughness Length (m)	1.3[h]	1.3[h]

* Default

a. Calculated emission rate.

b. AERSCREEN model was run with unit emission rate and the prediction was scaled by using the actual combustion and road dust fine particulate matter less than 2.5 µm in diameter ($PM_{2.5}$) emissions.

c. Approximate level of exhaust outlet at top of heavy equipment. Although not all equipment will have exhaust at this height, this estimate is conservative as higher predictions would be expected at the sensitive receptors with a higher exhaust. For comparison, AERSCREEN was run with a stack height of 3 m and resulting concentrations are lower than the original assessment as indicated in Table 53-2.

d. Conservative estimate; for comparison, AERSCREEN was run with a stack diameter of 0.2 m and resulting concentrations are lower than the original assessment as indicated in Table 53-2.

e. Conservative estimate; for comparison, AERSCREEN was run with an exit temperature of 150˚C (423 K) and resulting concentrations are lower than the original assessment as indicated in Table 53-2.

f. Conservative representative exit velocity for a diesel engine.

g. A screening assessment cannot use a monthly variable ozone list of values so an approximate average value of 0.03 parts per million (ppm) was used in the assessment (refer to the response to SIR 55).

h. Parameters for Albedo, Bowen Ratio and Roughness Length were chosen from the *Air Quality Model Guideline* (GoA 2013) surface characteristics for coniferous forests in winter months.

For comparison, AERSCREEN was re-run with more realistic stack parameters which are more representative of diesel exhaust emission characteristics (Table 53-2). The results show the overall revised predictions are significantly lower than the original modelling results as highlighted in the table below.

Table 53-2 AERSCREEN Model Re-runs with Stack Parameter Adjustments

Stack Parameter	Original Input	Revised Input	Original Results* (450 m) µg/m³		Original Results* (650 m) µg/m³		Revised Results* (450 m) µg/m³		Revised Results* (650 m) µg/m³	
			NO_2	$PM_{2.5}$	NO_2	$PM_{2.5}$	NO_2	$PM_{2.5}$	NO_2	$PM_{2.5}$
Stack Height (m)	5 m	3 m	140.7	62.9	103.2	35.0	139.8	62.3	102.0	34.0
Stack Inner Diameter (m)	0.5 m	0.2 m	140.7	62.9	103.2	35.0	84.5	63.0	47.0	35.0
Plume Exit Temperature (K)	AMBIENT	150°C (423 K)	140.7	62.9	103.2	35.0	31.0	23.0	22.6	16.8
Rerun with all revised stack parameters	n/a	as above	140.7	62.9	103.2	35.0	89.6	24.8	83.7	20.4

* Before scaling applied.

b. Refer to the response to part a) above.

c. The model was run for one point source and the results were distributed along the extent of the construction site as five separate point sources. This allows the emissions from individual construction equipment to be spread-out through the construction site as it is not possible to know exactly when and where the equipment will be operating. Modelling the construction equipment as point sources allows for accounting for the momentum and buoyancy flux associated with the exhaust characteristics. Area source is an approximate representation of multiple point source and it is not necessarily a better representation of construction equipment sources. In reality, emissions from construction equipment exhausts would disperse more like point source than an area source.

References:

Government of Alberta (GoA). 2013. *Air Quality Model Guideline.* Alberta Environment and Sustainable Resource Development, Air Policy Section. Edmonton, Alberta. Effective October 1, 2013. ISBN: 978-1-4601-0599-3. http://aep.alberta.ca/air/modelling/documents/AirQualityModelGuideline-Oct1-2013.pdf

54

Volume 1, Sections 8.2.6.4, Page 8-11
Volume 1, Section 8.2.6.5, Page 8-15 and supplemental info *PM25 Calculation.xlsx* spreadsheet and model output files

Section 8.2.6.4 describes how the emissions were calculated for the various scenarios and Section 8.2.6.5 presents the model results. *PM25 Calculation.xlsx* was provided as a supplement to the EIA report outlining post-processing of the model results. It is unclear what some of the assumptions were for deriving the calculations in the provided spreadsheet and how these relate to the emissions information provided in the EIA and the results of the model output files.

a. Connect the spreadsheet information back to the information in Section 8.2 of the EIA and clarify how these calculations are related to the output files.

b. Provide references or justification for any assumptions and scaling factors used in the calculations found in *PM25 Calculation.xlsx.*

c. The maximum predicted concentrations used for calculations in *PM25 Calculation.xlsx* were those predicted at distances of 450 m to 650 m rather than the maximum predicted concentrations. Provide justification for this approach.

Response:

a. AERSCREEN was modelled using unit emission rates. The calculations relate to the output files are:

   - Predicted nitrogen dioxide and fine particulate matter less than 2.5 µm in diameter (PM$_{2.5}$) concentrations were distributed among five distances (450, 500, 550, 600, and 650 m) by taking an average of these predictions at the closest residence.
   - Predictions at 450, 500, 550, 600, and 650 m from the construction site of the Structure are determined from the AERSCREEN output file.
   - For PM$_{2.5}$, the result associated with the above averaging is based on 1 g/s unit emission rate. Therefore, the resulting concentrations were scaled based on a combustion emission rate of 0.165 g/s, which is equal to 7.81 µg/m^3.
   - The 1-hour prediction of 7.81 µg/m^3 was converted to a 24-hour average based on AERSCREEN 24-hour/1-hour conversion ratio which equates to 4.69 µg/m^3.
   - The ratio of road dust/combustion emissions was applied to the predictions to account for the road dust, which equates to 13.11 µg/m^3.
   - The total of 4.69 µg/m^3 (combustion) and 13.11 µg/m^3 (road dust) equates to 17.80 µg/m^3 (total).

b. The approach described the response to part a) above provides a virtual source representation of the construction site by using the predictions at various distances. The scaling factors that were used in the calculations are:

  - Modelling based on unit emission rate of 1 g/s; therefore, predictions are directly multiplied by emission rate for the $PM_{2.5}$ predictions.
  - 24-hour/1-hour conversion ratio was based on AERSCREEN model output.
  - A road dust to combustion emission ratio, based on the Project emission estimation, was used to estimate the road dust component.
  - In the Scaling of Modelling spreadsheet a 30% suppression was used to account for the fact that equipment will not be continually operating at the construction site. This scaling factor of 30% was chosen as a reasonable assumption given that the actual operating times of individual pieces of equipment are not known.

c. Scaling was used because not all equipment will be located at the nearest point in the construction site and not all equipment will be operating at the same time and at the same exact location. Therefore, based on our professional judgement, the model was run for one point source and results were distributed along the extent of the construction site as five separate point sources. This allows the emissions from individual construction equipment to be spread-out through the construction site as it is not possible to know exactly when and where the equipment will be operating.

4.2 Dispersion Modelling

55	**Volume 1, Section 8.2.6.5, Page 8-15** The air dispersion modelling results are presented for NOx and compared to the AAAQO of 300 µg/m^3 for NO_2. a. Confirm the results presented and compared to the AAAQO are NO_2. b. What NOx to NO_2 conversion method was used for the modelling assessment? c. The submitted AERSCREEN model output file for NO_2 indicates the Ozone Limiting Method was applied for NOx to NO_2 conversion with an ozone background concentration of 0.03 PPM. Provide justification for the use of this value compared to the ozone time series for rural land use, provided in Appendix E of the Alberta Environment and Parks *Air Quality Model Guideline.*

Response:

a. Yes the results are nitrogen dioxide (NO_2).

b. The Ozone Limiting Method was used to convert oxides of nitrogen (NO_x) to NO_2 in the modelling assessment.

c. A time series cannot be used in a screening assessment so 0.03 parts per million (ppm) was used as an approximate average of rural ozone values. If a maximum ozone value of 0.042 ppm is used, as per Appendix E of the Air Quality Model Guideline (rural; GoA 2013), the predictions including background result in 221.6 µg/m^3 and 184.1µg/m^3 for 450 m and 650 m from the Structure, respectively, which is still below the Alberta Ambient Air Quality Objectives (AEP 2016) for NO_2. The output file for this comparison is available in Appendix 55-1.

References:

Alberta Environment and Parks (AEP). 2016. *Alberta Ambient Air Quality Objectives and Guidelines Summary.* Air Policy Branch. Government of Alberta. June 2016. ISBN: 978-1-4601-2861-9. 6 pp. http://aep.alberta.ca/air/legislation/ambient-air-quality-objectives/documents/AAQO-Summary-Jun2016.pdf

Government of Alberta (GoA). 2013. *Air Quality Model Guideline.* Alberta Environment and Sustainable Resource Development, Air Policy Section. Edmonton, Alberta. Effective October 1, 2013. ISBN: 978-1-4601-0599-3. http://aep.alberta.ca/air/modelling/documents/AirQualityModelGuideline-Oct1-2013.pdf

56	**Volume 1, Section 8.2.6.5, Page 8-15**
	The air dispersion modelling results are presented. As per the Alberta Environment and Parks *Air Quality Model Guideline,* a baseline value for the same substance must be added to the predicted value before comparison to the AAAQO. a. Do the results presented include the addition of baseline concentrations? Provide updated results, if necessary, of the maximum predicted concentrations with the addition of a representative baseline value.

Response:

a. The results presented in the environmental impact assessment (EIA) did not include the addition of baseline concentrations.

Table 56-1 below presents the maximum predicted concentrations after inclusion of a representative baseline value. The monitored baseline concentrations presented in Table 56-1 were calculated based on a reduced dataset of monitored values from the Lafarge station (12 km east of the Project), as per the *Air Quality Model Guideline* (AQMG; GoA 2013). The response to SIR 8 explains why Lafarge was chosen to represent baseline concentrations.

As described in the EIA, the 24-hour averaging period for fine particulate matter less than 2.5 µm in diameter ($PM_{2.5}$) is elevated at the Lafarge site as a result of the mining and cement manufacturing process. A screening level assessment, as per the AQMG (GoA 2013), requires 99.9th percentile of the hourly values to be considered; however, this would result in elevated background concentrations for $PM_{2.5}$ that may not be a representative of the impacts of the Project. Therefore, the background concentration based on the 90th percentile (Table 56-1) was calculated as per the AQMG for a refined assessment as "this allows for some variability in the baseline due to anthropogenic or unusual local sources" (GoA 2013).

Table 56-1 shows that the maximum predicted concentrations including background are in compliance with the applicable Alberta Ambient Air Quality Objectives.

Table 56-1 Monitored and Modelled Ambient Concentrations

Station	Substance	Averaging Period	Ambient Monitoring ($\mu g/m^2$)
Lafarge	Nitrogen Dioxide (NO_2)[a]	1 hour	33.0
		Annual	13.5
	Fine Particulate Matter ($PM_{2.5}$)[a]	24-hour	173.3
	Fine Particulate Matter ($PM_{2.5}$)[b]	24-hour (90th percentile)	10.1
Hinton[1]	Nitrogen Dioxide (NO_2)[c]	1 hour	29.9
		Annual	10.1
	Fine Particulate Matter ($PM_{2.5}$)[c]	24-hour	37.3
	Fine Particulate Matter ($PM_{2.5}$)[c]	24-hour (90th percentile)	12.5

Station	Substance	Averaging Period	Ambient Monitoring ($\mu g/m^2$)
Golden Helipad[2]	Nitrogen Dioxide (NO_2)[c]	1 hour	
		Annual	
	Fine Particulate Matter ($PM_{2.5}$)[c]	24-hour	
	Fine Particulate Matter ($PM_{2.5}$)[c]	24-hour (90th percentile)	

a. CCME 2012
b. Temporary Scotford Station Data for 2016 (AEP 2016)
c. Province of British Columbia 2017
1. Data from the LaFarge Canada Inc. Lagoon Monitoring station in Exshaw for the year 2015. The station is 12 km East of Canmore.
2. Data from the Golden Helipad for the year 2016. The station is 1,115 km west of Canmore.

References:

Alberta Environment and Parks. (AEP). 2016. *Data Reports*. Accessed on February 24, 2017. http://airdata.alberta.ca/aepContent/Reports/DataReports.aspx

Canadian Council of Ministers of the Environment (CCME). 2012. *Guidance Document on Achievement Determination Canadian Ambient Air Quality Standards for Fine Particulate Matter and Ozone.* Winnipeg, Manitoba. http://www.ccme.ca/files/Resources/air/aqms/pn_1483_gdad_eng.pdf

Government of Alberta (GoA). 2013. *Air Quality Model Guideline.* Alberta Environment and Sustainable Resource Development, Air Policy Section. Edmonton, Alberta. Effective October 1, 2013. ISBN: 978-1-4601-0599-3. http://aep.alberta.ca/air/modelling/documents/AirQualityModelGuideline-Oct1-2013.pdf

Province of British Columbia. 2017. *BC Air Data Archive Website*. Accessed on February 3, 2017. https://envistaweb.env.gov.bc.ca/

4.3 Air Quality Assessment

57	**Volume 1, Section 8.2.2, Page 8-2 and supplemental model output files** The Town of Canmore states, *potential Project effects on air quality are expected to be localized, and therefore the local and RSAs have been combined into a single 24 km x 24 km RSA. The RSA was chosen to include communities near the Project footprint.* However, the submitted AERSCREEN model output files indicate maximum predicted concentrations to a distance of 5000 m (5 km), which does not encompass the entire study area. a. Provide updated model results for the entire 24 km x 24 km study area using the receptor spacing outlined in the *Alberta Environment and Parks Air Quality Model Guideline.*

Response:

a. Based on the small scale of the Project's construction emissions, a screening assessment was selected, and it focused on the potential impacts within a relatively close proximity of the Project. However, it was recognized that selecting an regional study area(RSA) to match the screening assessment would have left the Lafarge emissions out of the baseline data review. As such the RSA was extended to include Lafarge (24 km × 24 km). The AERSCREEN model predictions at 5 km include:

- the 1-hour nitrogen dioxide (NO_2) prediction associated with the Project at 5 km is 63 µg/m³, which is well below the 1-hour NO_2 Alberta Ambient Air Quality Objectives (AAAQO) of 300 µg/m³; and
- the 24-hour fine particulate matter less than 2.5 µm in diameter ($PM_{2.5}$) prediction associated with the Project at 5 km is 3.0 µg/m³, which is well below the 24-hour AAAQO of 30 µg/m³.

The maximum predictions associated with the Project emissions at 5 km are already well below their respective AAAQOs (AEP 2016). As per the *Air Quality Model Guideline*, the standard practice is to determine the extent of the model domain based on the project-only emissions (GoA 2013). Therefore, completing the modelling exercise for the full RSA would result in lower predictions and not provide any additional value.

References:

Alberta Environment and Parks (AEP). 2016. *Alberta Ambient Air Quality Objectives and Guidelines Summary.* Air Policy Branch. Government of Alberta. June 2016. ISBN: 978-1-4601-2861-9. 6 pp. http://aep.alberta.ca/air/legislation/ambient-air-quality-objectives/documents/AAQO-Summary-Jun2016.pdf

Government of Alberta (GoA). 2013. *Air Quality Model Guideline.* Alberta Environment and Sustainable Resource Development, Air Policy Section. Edmonton, Alberta. Effective October 1, 2013. ISBN: 978-1-4601-0599-3. http://aep.alberta.ca/air/modelling/documents/AirQualityModelGuideline-Oct1-2013.pdf

4.4 Air Quality Assessment

58	**Volume 1, Section 8.2.4.3, Page 8-4** **Volume 1, Section 8.2.6.5, Page 8-15 and supplemental model output files** The Town of Canmore states in Section 8.2.4.3, *the Town of Canmore and the Project are located in the Canadian Rocky Mountains. The area surrounding the Project has significant changes in elevation with a downward slope from the northeast to the southwest. Additionally, it is stated in Section 8.2.6.5, AERSCREEN is able to generate site-specific worst-case data incorporating complex terrain algorithms.* However, the submitted AERSCREEN model output files indicate that the predicted concentrations were calculated assuming Flat Terrain. a. Provide updated model results using complex terrain mode incorporating digital elevation model (DEM) terrain information.

Response:

a. The sentence in the environmental impact assessment report is incorrect and should read: “Although AERSCREEN can handle some complex terrain situations with limitation it is not capable of handling the extreme complex terrain at the site; therefore a worst-case flat terrain approach was used.” Neighboring residences are located behind terrain features that would be extremely difficult to be resolved by AERSCREEN (or a more refined model such as AERMOD). The flat terrain approach is used to provide a conservative prediction as it assumes plumes disperse evenly across the flat terrain although, in reality, the dispersion of the plume would be limited by the terrain between the construction site and the homes (Figure 12-1).

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Volume 1, Section 8.2.4.1, Page 8-3
Volume 1, Section 8.2.4.5, Page 8-8

In Section 8.2.4.1 the Town of Canmore states, *the Lafarge Monitoring station, located approximately 12 km southeast of the Project, was used as it is the closest ambient air quality monitoring station that monitors NO_2 and $PM_{2.5}$.* In Section 8.2.4.5, it is stated, *the Lafarge monitoring station is an industrial site that monitors air quality from the operations of the Lafarge Exshaw Cement Plant, a limestone quarrying operation; elevated $PM_{2.5}$ is common at such industrial sites.* The Lafarge Monitoring station is not representative of ambient air quality conditions at the proposed Project and is inappropriate for determining baseline values of ambient concentrations for this assessment.

a. Provide updated baseline concentrations from a representative monitoring station, elsewhere in the province, determined using the procedure outlined in the Alberta Environment and Parks *Air Quality Model Guideline, Section 4.2.*

Response:

a. As described in the responses to SIR 8 and SIR 56, it is appropriate to use the Lafarge monitoring station as it is the closest available data to the Town of Canmore, it is located within the same valley, and is downwind of Canmore. Monitoring station data from two other mountain communities, Golden, British Columbia, (100 km west of the Project) and Hinton, Alberta (300 km north of the Project), were reviewed and compared to data from the Lafarge station to confirm the appropriateness of using Lafarge data for this assessment.

Table 59-1 presents the monitored baseline concentrations calculated as per the *Air Quality Model Guideline* (AQMG; GoA 2013) based on a reduced dataset of values (99.9th percentile for nitrogen dioxide (NO_2) and 90th percentile for fine particulate matter less than 2.5 µm in diameter ($PM_{2.5}$) as per the response to SIR 56; GoA 2013).

Table 59-1 Monitored Ambient Concentrations at Representative Stations

Station	Substance	Averaging Period (reduced dataset)	Ambient Monitoring (µg/m^3)
Lafarge[1]	Nitrogen Dioxide (NO_2)[a]	1 hour*	58.3
		Annual*	16.2
	Fine Particulate Matter ($PM_{2.5}$)[b]	24-hour**	10.1
Hinton[2]	Nitrogen Dioxide (NO_2)[c]	1 hour*	72.9
		Annual*	13.2
	Fine Particulate Matter ($PM_{2.5}$)[c]	24-hour**	12.5
Golden Helipad[3]	Nitrogen Dioxide (NO_2)[c]	1 hour*	-
		Annual*	-
	Fine Particulate Matter ($PM_{2.5}$)[c]	24-hour**	12

a. CCME 2012
b. Temporary Scotford Station Data for 2016 (AEP 2016)
c. Province of British Columbia 2017
1. Data from the LaFarge Canada Inc. Lagoon Monitoring station in Exshaw for the year 2015. The station is 12 km East of Canmore.
2. Data from the Hinton Monitoring station for the year 2016. Hinton is located 300 km North of Canmore.
3. Data from the Golden Helipad for the year 2016. The station is 1,115 km West of Canmore.
* 99.9th percentile (AQMG; GoA 2013)
** 90th percentile (AQMG; GoA 2013)

References:

Alberta Environment and Parks. (AEP). 2016. *Data Reports*. Accessed on February 24, 2017. http://airdata.alberta.ca/aepContent/Reports/DataReports.aspx

Canadian Council of Ministers of the Environment (CCME). 2012. *Guidance Document on Achievement Determination Canadian Ambient Air Quality Standards for Fine Particulate Matter and Ozone.* Winnipeg, Manitoba. http://www.ccme.ca/files/Resources/air/aqms/pn_1483_gdad_eng.pdf

Government of Alberta (GoA). 2013. *Air Quality Model Guideline.* Alberta Environment and Sustainable Resource Development, Air Policy Section. Edmonton, Alberta. Effective October 1, 2013. ISBN: 978-1-4601-0599-3. http://aep.alberta.ca/air/modelling/documents/AirQualityModelGuideline-Oct1-2013.pdf

Province of British Columbia. 2017. *BC Air Data Archive Website*. Accessed on February 3, 2017. https://envistaweb.env.gov.bc.ca/

5 WATER

5.1 Hydrogeology

60	**Volume 1, Section 6.5.2.2, Figures 6.5-8, Page 6-29** **Volume 1, Section 6.5.2.2, Figure 6.5-10, Pages 6-30** The Town of Canmore states *there are relatively steep hydraulic gradients down alluvial fans as indicated by the tight contour spacing (Figure 6.5-10). Near the Structure, the Cougar Creek Fan has a 4% to 6% hydraulic gradient.* a. What is the natural groundwater flux at the location of the Structure? b. Under the natural condition, approximately how much percent of recharge for LSA alluvial fan will the above flux count? Consider the majority of the LSA is urban area which means there will be a low recharge rate across the cement streets. c. Since the groundwater flow will be cut-off by the cement wall to prevent seepage under the dam, what will the contour (Figure 6.5-10) in LSA looks like after the Structure is constructed and the recharge to LSA alluvial fan groundwater is reduced? d. Similarly, how many meters will the groundwater levels drop in Figure 6.5-8 and Figure 6.5-9 after the Structure is constructed? e. Since the fresh water recharge to LSA alluvial fan aquifer will be reduced due to the project, groundwater quality will be degraded. What is the impact of groundwater level decrease and groundwater qualities degrade on existing groundwater users in LSA?

Response:

a. A reasonable estimate of natural groundwater flux is 265 m^3/day. The methodology for this estimate is discussed in a letter report provided as Appendix 60-1. Natural groundwater flux was considered in the Structure design and varies seasonally and year to year.

b. The percent of recharge for the local study area (LSA) alluvial fan via Cougar Creek Valley will vary season to season. During the coldest times of the year the percentage approaches 100%, during wetter times the relative percentage decreases. However, assigning an estimate of the percentage of recharge is unnecessary when assessing the Structure’s impact on the environment. As discussed in Section 6.6.6 of the environmental impact assessment (EIA) and quantitatively assessed in Appendix 60-1, groundwater flux to the Valley/Fan Aquifer will remain unchanged by the Structure. As such, the percentage of recharge to the Valley/Fan Aquifer via the Cougar Creek Valley will be unchanged regardless of season.

c. As discussed in Section 6.6.6 of the EIA, recharge to the Valley/Fan Aquifer is not reduced by the Structure as the Structure is specifically designed not to reduce flux or recharge.
A quantitative assessment of impacts on groundwater levels by the Structure is provided as Appendix 60-1. Groundwater levels (and contours) are estimated to decrease downgradient of the Structure and are limited to a very localized area between the seepage control structure (combination of the seal wall, cut-off wall and grout curtain) and the outlet.

d. Changes in groundwater levels below the Structure are estimated to be minimal (not on the order of metres) and very spatially limited (Appendix 60-1).

e. Fresh water recharge to LSA alluvial aquifer will not be reduced (Appendix 60-1); therefore, groundwater quality is not expected to be degraded. As discussed in Section 6.6.6 of the EIA, any impacts of the Structure (quantity and quality) will be limited to a small area around the Structure. As such, downgradient groundwater users in the LSA are not predicted to be impacted. Refer to the response to SIR 61 for further discussion on predicted impacts to groundwater quality and validation through monitoring.

61	**Volume 1, Section 6.6.6.2, Page 6-60** Town of Canmore states *the main source of potential long-term impact from the Structure to the groundwater system is from installation of a cut-off wall and grout curtain within the Valley/Fan Aquifer and uppermost bedrock. No impact on downstream groundwater quantity is anticipated. Impacts to groundwater quality due to long-term normal operation of the Structure are not anticipated.* a. Provide the basic calculation/simulation to support the no impact claims.

Response:

a. A quantitative assessment of the Structure's impact on groundwater quantity is provided as Appendix 60-1. The quantitative assessment illustrates that changes to groundwater heads from the Structure are limited to a localized area around the Structure and the total flux through the Structure will be unchanged from baseline conditions.

In terms of groundwater quality, the only change from baseline conditions are that there will be additional overland flow of groundwater routed through the Structure. Because the Valley/Fan Aquifer is an unconfined aquifer in direct communication with the atmosphere through coarse gravels, additional exposure to the atmosphere when flowing through the Structure are not anticipated to have a material impact on groundwater quality. This prediction will be verified by groundwater monitoring of the Valley/Fan Aquifer downstream of the Structure during operation (refer to the response to SIR 65).

62 **Volume 1, Section 6.9, Page 6-63**

Because the Structure is designed to allow groundwater flow to pass through, impacts are limited to the immediate vicinity of the Structure where water levels in the Valley/Fan Aquifer may be locally altered.

a. If the maximum groundwater level at the upstream side of the Structure is 1421.15 masl (Table 30, Appendix 4A), what is the average groundwater level at the downstream side of the Structure? What is the groundwater level difference between the two sides of the structure in no-flood condition?

Response:

a. Appendix 60-1 is a quantitative assessment of groundwater levels in no-flood conditions. Appendix 60-1,Figure 3 compares the groundwater levels before construction and post-construction. Downgradient of the Structure, a decrease in groundwater level is predicted to be limited to the very local area between the seepage control structure (combination of grout curtain, cut-off wall, and seal wall) and the outlet. The average groundwater level between the seepage control structure and outlet is simulated to be between 1,412.25 and 1,413.79 m above sea level (asl) at monitoring well locations TH15-11-V and TH14-5A, respectively. Assuming the maximum groundwater level at the upstream side of the Structure is 1,421.15 m asl, this equates to a 7 to 10 m difference between each side of the Structure. However, as stated in Appendix 60-1, downgradient of the outlet groundwater levels return to pre-construction levels within 200 m from the outlet. In other words, the quantitative assessment suggests the overall groundwater gradient in the Valley/Fan Aquifer is unchanged by the Structure.

63	**Volume 1, Section 3.3.1, Page 3-5** a. Provide rationale for not including river hydraulics as a consideration. b. How does removal of debris and aggregate change the hydraulic characteristics in Cougar Creek, Bow River and Policeman Creek?

Response:

a. River hydraulics (i.e., the behaviour of flowing water within a river with respect to velocity and water level) is a function of flow rates and depends on channel characteristics. Peak flow and level, and geomorphology were included as indicators in the environmental impact assessment (page 6-2); therefore, river hydraulics was considered in the assessment of the hydrology component.

b. The existing debris net is included in the baseline case. The debris net will remove debris and coarse sediment during an extreme peak flow event and the Structure is designed to do the same. Therefore, no measureable change to debris and coarse sediment transport between the baseline and application cases is expected. Accordingly, no changes to hydraulic characteristics as a result of debris and coarse sediment removal are anticipated.

64

Volume 1, Section 6.6.6.2, Page 6-61
Volume 1, Section 6.6.6.3, Page 6-62

With reference to the following statement: TOR (Section 3.2.2) *[C] Describe the nature and significance of the potential Project impacts on groundwater.*

The significance of potential effects and residual effects of the Project on groundwater is not provided.

a. Did the Town of Canmore conduct a significance evaluation? If so what were the results? If not, provide rationale for not providing this significance evaluation.

Response:

a. A quantitative assessment of the impacts of the Structure on groundwater quantity is provided as Appendix 60-1. Appendix 60-1 supports the Town of Canmore's significance evaluation that the Structure, as designed, will not have a significant impact on groundwater resources.

65	**Volume 1, Section 12, Page 12-1** The Town of Canmore states *samples will be taken once before construction, annually during construction and annually until the conclusions of the hydrogeology assessment are verified.* a. Justify why sampling would only occur *annually*. Monitoring of major construction projects normally occurs at a much greater frequency than one time per year.

Response:

a. Section 12 (Aquatics Monitoring) of the environmental impact assessment (EIA), describes monitoring of groundwater levels (quantity) and groundwater samples (quality). The purpose of this monitoring is verification of the EIA predictions during construction and operation.

The Town proposes to include monitoring of groundwater levels (quantity) using a dedicated instrument that collects data at a high frequency (more or less continuous monitoring). During subsurface construction phases (i.e., secant pile wall), groundwater sampling will be conducted twice per month to check field water quality parameters including pH, electrical conductivity, temperature and visual indicators. If any field samples are found to be out of established ranges, the Town of Canmore will investigate further and samples will be submitted to an accredited laboratory for analysis of routine parameters and metals.

As noted in the EIA, the Town proposes to continue monitoring groundwater levels with the dedicated instrument and to collect groundwater samples during operation as a means to verify the EIA predictions. Groundwater sampling (quality) is proposed to be only done annually because the Structure is designed not to have a significant impact on groundwater resources. Annual samples will be collected and assessed in early spring of each year for consistency and to avoid sampling in the creek during the potential flood season. If the EIA predictions are confirmed after 5 years of operations, the Town of Canmore will submit a summary to the regulators and discuss ending the groundwater monitoring program.

The response to SIR 85 includes a discussion on surface water quality monitoring and sampling frequency expected to be part of the construction monitoring proposal.

5.2 Hydrology

66	**Volume 1, Section 6.6.3.2, Page 6-51** The Town of Canmore states *coarse sediment (i.e., gravel to boulder size) that passes through the Structure will likely deposit upstream of the Cougar Creek and Bow River confluence, while the Structure will still allow normal stream bed load to reach the Bow River (BGC 2014f).* a. How will the bolder size sediment pass through the Structure if the Structure outlet and attached rake are limiting the debris and large bed load through the Structure? What is the size of the normal stream bed load?

Response:

a. There are two aspects that control bedload transport through the Structure: the spacing of the rake beams and the peak discharge at which the Structure starts to impound water. If impoundment takes place, gravel debris starts to aggrade at the apex of the inundation area. Discharge at the base of the Structure is controlled by a throttle located in front of the intake. The intake of the bottom outlet structure is protected by a rake, the principal function of which is to prevent woody and rock debris from clogging the outlet. The bottom outlet structure has a flow capacity of 45 m^3/s at full impoundment. The maximum peak discharge without any retention of water and gravel is approximately 14 m^3/s, according to simulation. Floods of less than 14 m^3/s, along with their respective bed load, are anticipated to be transported through the bottom outlet structure, as suggested by physical modelling conducted by the Institute of Mountain Risk Engineering (Hübl et al. 2016). That physical modelling included runs with sediment feed (i.e., bed load transport) scaled to Cougar Creek sediment.

The rake beams have a spacing of 0.5 m. Piton and Recking (2016) provide a summary of previous studies that assessed the probability of sediment clogging inlets similar to the Structure design. The metric commonly used is the relative opening:

$$Relative\ Opening = \frac{Opening\ Size}{D_{84}}$$

It is generally accepted that a relative opening of 3 is unlikely to be clogged, while a relative opening of 1.5 is likely to be clogged during full substrate mobilization. According to BGC Engineering Ltd. (BGC 2014), the material deposited on the fan is largely between 11 and 64 mm. Bulk sampling has been conducted for Cougar Creek and BGC has completed such sampling for a number of other creeks in the immediate area that are also prone to debris floods and which share similar watershed geological formations. Results of this sampling are shown on Figure 66-1. All the creeks sampled show similar grain size distributions, particularly for the coarser fraction with an average D_{84} of about 80 mm. Given a proposed rake opening of 500 mm and a D_{84} of 80 mm, the relative opening is equal to about 6. As such, the rake is unlikely to clog with sediment during bedload transport.

It is further noted that the proposed design includes a 0.5 m opening between the rake and the intake base plate, allowing bedload transport to occur along the channel substrate and not come into direct contact with the rake during low magnitude peak flow events. This configuration is similar to the current debris net configuration. When the debris net was initially installed, the base of the net was even with the channel substrate with no low flow opening. During the first spring after the net installation, the Town of Canmore had issues with debris accumulation, primarily due to small woody debris clogging the net, as demonstrated by Figure 66-2.

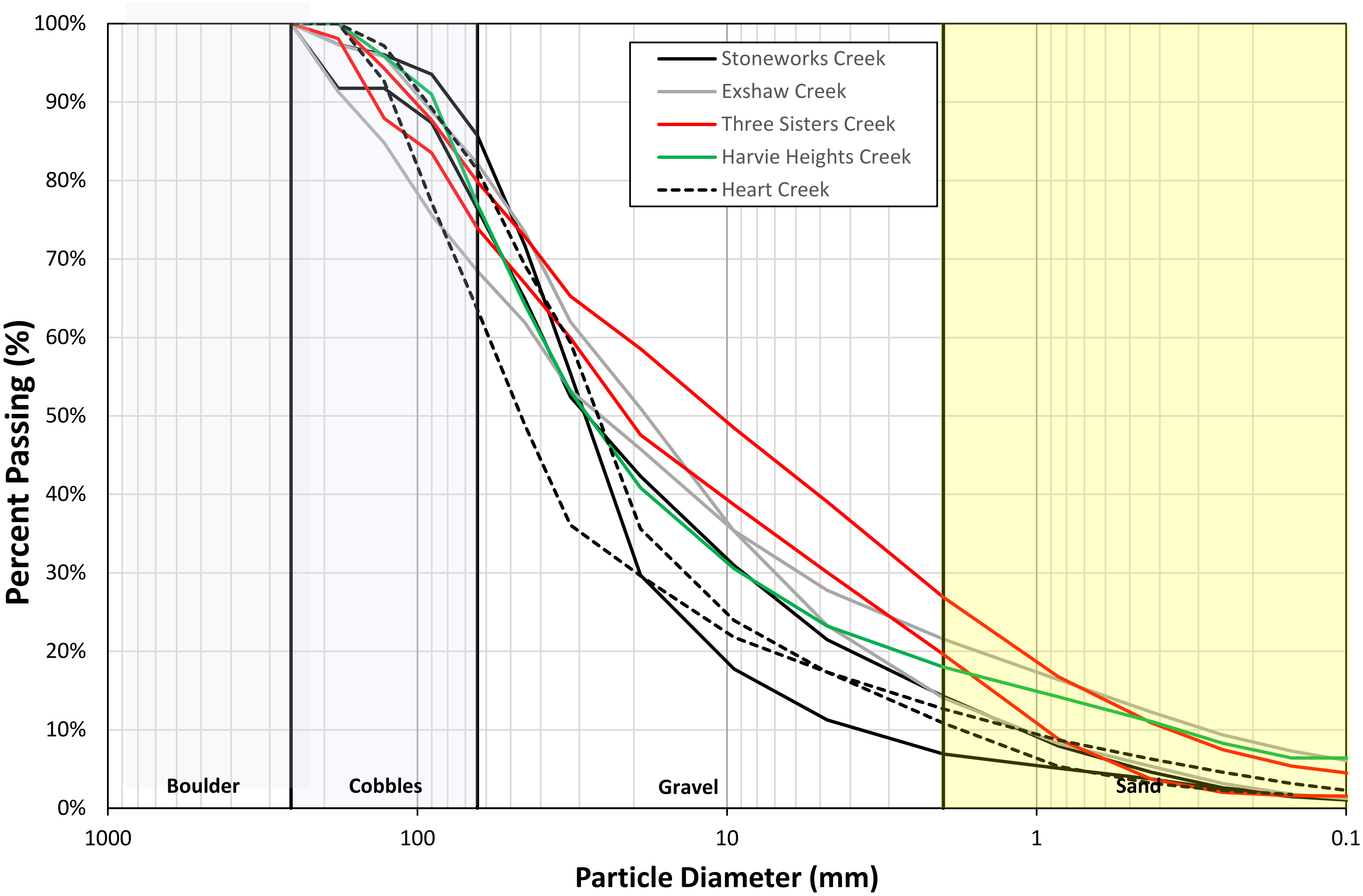


Figure 66-1 Bulk Sampling Results for Debris Flood Prone Creeks in the Vicinity of Canmore and Exshaw

Figure 66-2 **Debris Accumulation Upstream of the Debris Net**
(Town of Canmore photograph, May 2014)

The debris net was subsequently modified in two areas to allow for an approximate 0.6 m tall low flow opening (Figure 66-3). With this opening, no sediment or small woody debris has been captured by the debris net since June 2014.

Figure 66-3 **Downstream View of Modified Debris Net with low Flow Opening**
(Town of Canmore photograph, May 2014)

References:

BGC Engineering Inc. (BGC). 2014. *Bow River - Cougar Creek Sedimentation Considerations.* Memorandum prepared for the Town of Canmore. Edmonton, Alberta. October 14, 2014.

Hübl J. et al. 2016. *Physical Modelling of the Cougar Creek Debris Flood Retention Structure.* IAN Report 171, Department of Civil Engineering and Natural Hazards, University of Natural Resources and Life Sciences (unpublished).

Piton G. and A. Recking. 2016. “Design of Sediment Traps with Open Check Dams.” In: *Hydraulic and Deposition Processes*. American Society of Civil Engineers. Journal of Hydraulic Engineering. DOI: 10.1061/(ASCE)HY.1943-7900.0001048.

67	**Volume 1, Section 6.6.3.2, Page 6-52** The Town of Canmore states *while topsoil and underlining parent material will experience erosion during a flood event, impacts to slope stability are not anticipated due to the underlying bedrock that will experience minimal water erosion.* a. Was any investigation on the fracked bedrock within the inundation area performed? If so, what were the findings to support this conclusion, i.e. *impacts to slope stability are not anticipated*? If not, justify why no investigation was completed. b. Was any study on slope stability based on the investigation data completed for a potential slope slide into the inundation area for the flood events? If so, what were the findings to support this conclusion, i.e. *impacts to slope stability are not anticipated*? If not, justify why no such study was completed.

Response:

a. Yes, an investigation of bedrock within the inundation area was performed and is described fully in Appendix 4B, Section 18 of the environmental impact assessment. The key conclusions from this investigation included the following:

- the inundation area contains steep cliffs with local potential rock-fall detachments and numerous scree slopes;
- of the specific higher risk locations selected for detailed numerical slope instability assessments, none of these were identified as having a significant risk for major slope instability during an inundation event; and
- minor local slope instabilities are possible but do not affect the overall function of the Structure and its upstream storage.

These conclusions support that impacts to slope stability are not anticipated.

b. Refer to the response to part a) above.

68	**Volume 1, Section 6.6.3.3, Table 6.6-4, Page 6-53** Note 2 of the Table states *the Structure is intended to remain in place forever and as such assessing the reversibility, as is done with projects that are decommissioned and reclaimed, is not applicable for the Structure.* The term of “Irreversible” means “Baseline condition cannot be re-established upon reclamation” as stated in Table 6.6-1 on Page 6-46. a. Should “Irreversible’ be used for the indicators rather than “n/a” with Permanence of Criteria if we emphasize “Baseline condition cannot be re-established”? Discuss.

Response:

a. The rankings provided in the environmental impact assessment (EIA) are consistent relative to the effects criteria for each specific discipline. However, the aquatics disciplines ranked effects relative to “re-establishment of baseline conditions upon reclamation” whereas other disciplines ranked effects relative to “re-establishment of baseline conditions upon Structure construction.” The aquatics disciplines wish to revise the permanence ranking criteria to the following:

Permanence	Reversible	Baseline condition can be re-established upon construction
	Irreversible	Baseline condition cannot be re-established upon construction

Considering the revised ranking criteria, the Town of Canmore wishes to revise the following aquatics permanence rankings presented in the EIA:

- hydrology – “irreversible” for all indicators previously ranked as n/a;
- aquatic ecology – “irreversible” for all indicators previously ranked as n/a; and
- hydrogeology – “irreversible” for *Groundwater Levels in Valley/Fan Aquifer* previously ranked as n/a.

In addition to the revised rankings above, the Town of Canmore also wishes to clarify the following permanence rankings that were labelled incorrectly in the EIA:

- vegetation – “irreversible” for all indicators previously ranked as “permanent.”

None of the above changes to permanence rankings affect the overall final impact ratings presented in the EIA report.

69	**Volume 1, Section 6.2.1, Page 6-2** Justification of not providing mean and minimum flows analysis is understandable as mentioned in Article 6.2.1 *(typical EIA indicators (e.g., mean flows, minimum flows) for hydrology do not apply and have not been considered as part of the assessment).* a. Provide a description of the flow characteristics of Cougar Creek including seasonal variation of flow in Article 6.5.1 that will be valuable to understand the nature of the creek. b. Explain surface and subsurface flows observed along the Creek and when these flows (surface and subsurface) reach the Bow River. c. Explain past major flood events observed in Cougar Creek, when those events have occurred, and what were the flood magnitudes.

Response:

a. There has been no previous flow monitoring of Cougar Creek; therefore, the following discussion is based on a general understanding of hydrologic variability in these types of mountainous watersheds.

   Cougar Creek is a mountainous watershed that is subject to seasonal flow variation as a result of low temperatures and snow accumulation during the winter and the subsequent spring and summer freshet period. Flow during the winter is low and is mostly subsurface within the creek gravel bed. Flow during the spring and early summer increases substantially as temperatures rise and spring rains contribute to streamflow and increase snow melt rates. During late summer and fall, flow decreases as snow cover decreases and the frequency and intensity of rainfall events decrease.

   Because of the watershed's small size, high slope, and low permeability, Cougar Creek experiences extreme changes to flow rate as a result of rainfall events.

b. Total flow at the Structure is separated into surface water and groundwater. Generally speaking, water will flow as groundwater at low flows and as flows increase, water levels will increase to the gravel channel bed resulting in surface water flow. The explanation of flow of water in Cougar Creek can be separated in two areas:

   - The first area is in the Upper Cougar Creek Reach, which includes the upper watershed and Cougar Creek to the fan apex. In this area, the water is mostly confined within a bedrock lined channel that is quite narrow, especially at the fan apex where it is 40 to 100 m wide. The water in the Upper Cougar Creek Reach is mostly groundwater with a minimal surface flow that varies with the seasons and weather events.

   - The second area is the Lower Cougar Creek Reach, which includes the alluvial fan and extends downstream to Policeman Creek and the Bow River. In the Lower Cougar Creek Reach, the flow is not confined to a bedrock lined channel and therefore the vast majority of flow travels through the alluvial fan sediments as groundwater rather than surface water. When water does flow at the surface, it typically goes back subsurface before it reaches the Elk Run Boulevard culvert. Surface water will be present above-ground throughout the entire Lower Cougar Creek Reach only during high flow events (i.e., only a few times a year). As an example, since the flood of 2013, surficial water has reached the Bow River only four times in the span of 4 years (at the time of writing this response in May 2017): once in June of 2014, once in May of 2016, once in Aug of 2016 and once in May of 2017.

c. Extensive work has been completed to understand flood events in the Cougar Creek watershed. BGC Engineering Ltd. (BGC) has undertaken several studies and assessments for the Town of Canmore to assess flood events. Past major flood events observed in Cougar Creek are described in the 2014 BGC report titled *Town of Canmore, Cougar Creek Debris Flood Hazard Assessment - Final*. The conclusion is shared here but more information can be found in the 2014 BGC report (Section 4.2 and Appendix A, Table A-1; BGC 2014):

> "*Based on the above review of historical accounts, there were likely debris floods on Cougar Creek in 1948, 1956, 1967, 1974, 1980, 1990, 1995, 2003, 2005, and 2012. Including the most recent debris flood in 2013, there have been reports of 11 events in 66 years, giving a 6-year return period for events on Cougar Creek.*
>
> *The historical accounts do not provide a clear indication of the scale of each event relative to each other. More damage was reported in newspapers of the floods in the 1990s and 2000s, but this is likely due to increased local Canmore coverage, as well as increased development on the fan. The Town records and personal communications were similarly skewed as there was poor record-keeping prior to the 1980s and most people interviewed could only comment on the more recent events*."

References:

BGC Engineering Inc. (BGC). 2014. *Town of Canmore, Cougar Creek Debris Flood Hazard Assessment - Final*. Report prepared for the Town of Canmore. Vancouver, British Columbia. March 7, 2014.

70 **Volume 1, Section 6.3.1.1, Page 6-5**

The Town of Canmore states *the downstream portion of the surface water RSA includes any areas that may have been affected by Cougar Creek flows in the past or could potentially be affected if a flood event were to cause Cougar Creek to change its flow path.*

a. Explain how the potential changed flow path was determined, what can cause this change and show the location of this potential flow path.

Response:

a. The environmental impact assessment (EIA) does not describe one specific potential changed flow path. Rather, Sections 6.5.2.1 (page 6-28) and 6.5.1.1 (page 6-16) describe the geologic formation of the alluvial fan and the behaviour of flowing water as it travels down the alluvial fan. As described in those sections of the EIA, and as experienced during the 2013 flood, flow along the alluvial fan can spread or braid into several channels, and the main flow path can change substantially during a peak flow event.

   These discussions supported the delineation of the regional study area to the full downstream extent of the alluvial fan and any additional locations where water could flow as a result of a change to the flow path to any location along the alluvial fan.

71	**Volume 1, Section 6.5.1, Table 6.5-4, Page 6-15** a. Provide the peak discharge for 1-10 year return period flood.

Response:

a. Discharge estimates as listed in the referred table were provided by BGC Engineering Ltd. (BGC 2014) and no values for the 10-year return period were provided. Canadian Hydrotech Corporation estimates that the peak discharge for a return period of 10-year would be 18 m^3/s.

References:

BGC Engineering Inc. (BGC). 2014. *Town of Canmore, Cougar Creek Debris Flood Hazard Assessment - Final*. Report prepared for the Town of Canmore. Vancouver, British Columbia. March 7, 2014.

72	**Volume 1, Section 6.5.1.1, Page 6-16** a. Provide design flood/discharge information for the articulated concrete mats.

Response:

a. The articulated concrete mats have a design flow of 64 m^3/s and a design velocity of 4.1 m/s.

73	**Volume 1, Section 6.5.1, Page 6-27** The Town of Canmore states *for instance, following the June 2013 flood event, it was estimated that bed load transported to the Bow River was likely an order of magnitude less than what was deposited onto the Cougar Creek Fan (BGC 2014f).*However, the article does not provide any quantitative debris and sediment data. a. Provide data on debris and sediment yield.

Response:

a. The Cougar Creek fan has a total surface area of 3.1 km^2 and extends from the Structure, to approximately 150 m south of the Canadian Pacific Railway (CPR) culvert (Figure 73-1). The fan has been accumulating on the wide, relatively unconfined floodplain of the Bow River since deglaciation. As the Bow River floodplain is not confined, the Bow River migrates laterally across the floodplain without significantly eroding the toe of the Cougar Creek fan (BGC 2014). The key change to the natural morphodynamics on Cougar Creek fan was the construction of an artificial channel through confinement and deepening. This process has substantially reduced the long-term storage of debris on the fan. Nowadays (since the construction of a confined channel at the time of the subdivision construction in the early 1980s), substantially more debris is being delivered to the Bow River floodplain, as the chance of fan deposition has been drastically reduced, except from the largest event return periods (>300-year return period). The Structure is designed to further reduce the risk of fan surface deposition up to the 1,000-year event.

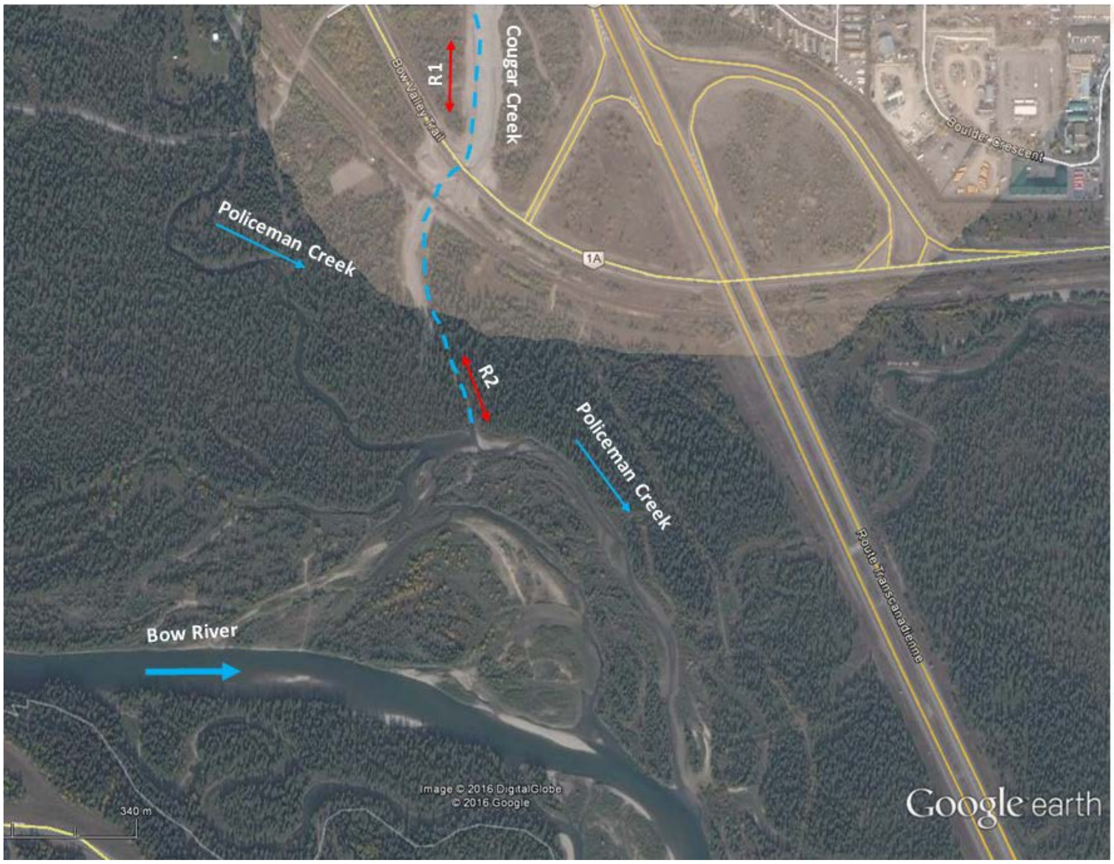


Figure 73-1 **Reach Overview of Cougar Creek up and Downstream of the Policeman Creek Confluence**
(R1 and R2 represent the lower fan and the area below the fan toe considered in the material transport analysis, and the brown polygon shows the fan boundary)

Through comparison of 2009 and 2013 Light Detection and Ranging (LiDAR), BGC Engineering Ltd. (BGC) estimated that approximately 90,000 m^3 of sediment and debris deposited on the Cougar Creek fan during the 2013 flood event. Comparison of 2009 and 2013 LiDAR for the floodplain portion of Cougar Creek fan from the CPR tracks to Policeman Creek (Figure 73-2) suggests that approximately 9,900 m^3 +/-2,700 m^3 of sediment and debris was deposited and approximately 400 m^3 was eroded, likely into the Policeman drainage.

Therefore, the portion of the total net sediment and debris deposition onto Cougar Creek fan that made it onto the Bow River floodplain during the 2013 event was approximately 10%, and only approximately 0.4% of the total load discharged into the Policeman Creek channel. During large floods on Bow River, portions of the material deposited during the 2013 event could be mobilized, the exact volume of which is currently unknown.

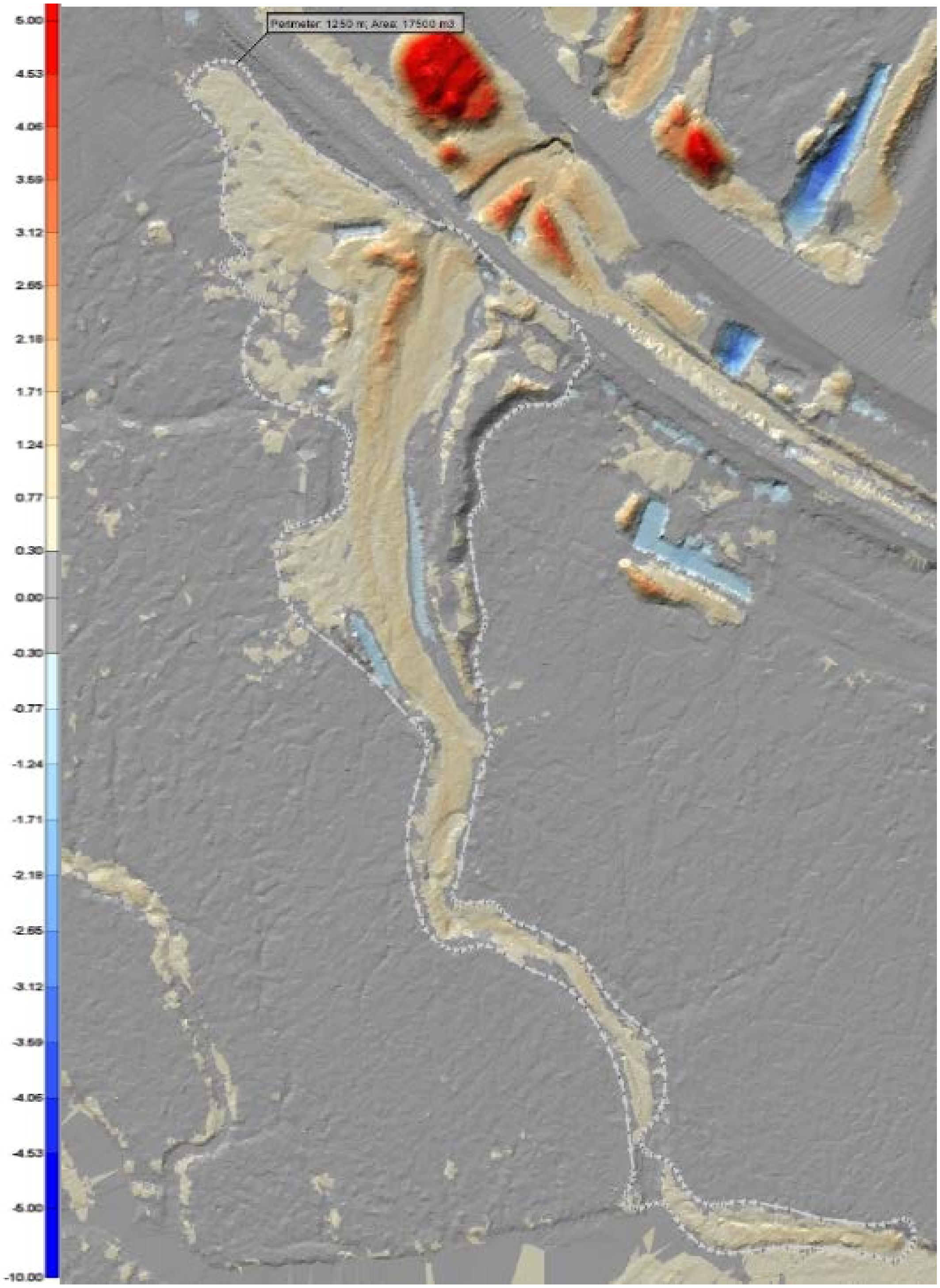


Figure 73-2 2009 and 2013 LiDAR Comparison for the Floodplain Portion of Cougar Creek Fan (from the railway to the confluence with Policeman Creek)

In order to demonstrate the impact of the decrease in channel gradient downstream of the fan (Reach 2 (R2); Figure 73-1) on the potential material transport during a flood event, BGC estimated the change in stream competence downstream of the fan boundary. Using 2013

LiDAR, BGC calculated a gradient of 3.6% in the constructed channel upstream of Highway 1 (Reach 1 (R1); Figure 73-1), and a gradient of 0.8% below the fan toe in a 60 m reach located directly upstream of the Policeman Creek confluence (R2; Figure 73-1). Flood hydraulics were simulated for five cross sections in each of these two reaches using the one dimensional software model HEC-RAS, developed by the US Army Corps of Engineers. Debris floods with peak discharges of 50, 60, and 80 m^3/s were modelled. The return periods associated with these flood magnitudes are provided in Table 73-1.

Table 73-1 Average Hydrogeomorphic Conditions for Five Cross-sections in the Lower Fan Reach and Five Cross-sections Downstream of the Fan Toe

Peak Flow (m^3/s)	Frequency Interval (1:years)	Hydraulic Depth (m)	Shear Stress (Pa)	Stream Power (W/m^2)	Size Entrained (mm)	Size Fully Mobilized (mm)
Reach 1 (R1): Lower Fan						
50	1:30 to 1:100	1.79	611	446	630	315
60	1:100 to 1:300	1.91	649	534	700	350
80	1:400	2.14	719	633	740	370
Reach 2 (R2): Below Fan Toe						
50	1:30 to 1:100	0.93	62	142	64	32
60	1:100 to 1:300	1.00	67	160	69	35
80	1:400	1.13	75	155	77	39

The values presented in Table 73-1 represent the average hydraulic conditions in the lower fan (R1), as well as downstream of the fan boundary (R2) during each of the debris flood scenarios considered. The results show that the reach-averaged shear stress acting on the channel bed – and the size of material that can be entrained and transported – is an order of magnitude greater on the lower fan (R1) compared to downstream of the fan toe (R2), as is the modelled stream power.

Stream competence (i.e., the size of material that can be transported by the flow) is linearly related to shear stress in gravel-bed streams, such that a decrease in shear stress produces a concomitant decrease in the size of material that can be entrained or fully mobilized. According to BGC (BGC 2014), the material deposited on the fan is largely between 11 and 64 mm. The results presented in Table 73-1 show that only the finer fraction of this material (i.e., up to 39 mm) is likely to be fully mobile downstream of the fan toe. As a result, material exceeding this size will deposit and remain within the constructed channel of Cougar Creek until excavated to maintain channel conveyance. It is unlikely to contribute significant bedload to stream reaches downstream of the fan toe.

Material transport rates are typically calculated as a nonlinear function of the excess stream power or shear stress, above a critical threshold for material mobilization (Meyer-Peter and Müller 1948). According to Eaton and Church (2011), for example, the rate of material transport (Q_b) is proportional to excess stream power:

$$Q_b \propto (\omega - \omega_c)^{3/2}$$

Where ω represents the stream power associated with a given flood event, and ω_c the critical stream power for grain movement. Therefore, in addition to decreasing the size of material transported downstream, the reduction in channel gradient downstream of the toe dramatically reduces the rate of material transport downstream of the fan.

References:

BGC Engineering Inc. (BGC). 2014. *Bow River - Cougar Creek Sedimentation Considerations.* Memorandum prepared for the Town of Canmore. Edmonton, Alberta. October 14, 2014.

Eaton B.C. and M. Church. 2011. “A rational sediment transport scaling relation based on dimensionless stream power.” *Earth Surface Processes and Landforms 36:* 901-910.

Meyer-Peter E. and R. Müller. 1948. “Formulas for Bed-load Transport.” In: *International Association of Hydraulic Structures Research 2nd Meeting*. Appendix 2. p. 39-64.

74	**Volume 1, Section 6.6.3.2, Page 6-50**
	a. Does Town of Canmore have any information (e.g. from modelling result, flood inundation study) on potential water levels, discharges, flood extents of Cougar Creek during floods larger than 1 in 30 year events for the with and without the Retention structure in place case to provide understanding on how the structure will help during those flood events? If yes, then provide comparisons of water levels, discharges and flood extents for with and without the Retention Structure cases. Provide this information for key locations on Cougar Creek (including the reach within the Town, at Highway crossing and Rail crossing) and at other points of interest within the Town/outside the Town that have potential to get flooded. b. If the above mentioned information is not available, describe how the Retention Structure will reduce the flooding in terms of water level, discharge, and flood extent, and how these impacts were estimated or predicted.

Response:

a. The Town of Canmore has a large amount of information regarding flood events on Cougar Creek. Most of the information is available in the *Town of Canmore, Cougar Creek Debris Flood Hazard Assessment – Final* report (BGC 2014). Some key information has been tabulated below and a few selected maps are presented in Appendix 74-1 to support this supplemental information request (SIR) response.

The primary difference between the mitigated and unmitigated cases is that avulsions occur in the residential area without the Structure in place, and do not occur with the Structure in place (Tables 74-1 to 74-3).

The unmitigated scenarios have the following peak flows (data provided in Appendix 74-1):

- 30 to 100 years – 50 m^3/s (Debris Flood);
- 100 to 300 years – 60 m^3/s (Debris Flood); and
- 300 to 1,000 years – 700 m^3/s (landslide dam outbreak flood; LDOF).

The Structure will reduce the peak flow to a maximum of 45 m^3/s, which will be contained in the Cougar Creek channel throughout the residential area. Moreover, the Structure will prevent the culverts from being blocked by rocks and woody debris.

Not all precipitation events in the 300 to 1,000-year return period are contained with the Structure (Appendix 4B, Section 09.01 and Section 4, Table 4.4-3 of the environmental impact assessment [EIA]). In such an event, the Structure spillway would be engaged and the resulting peak flow would be the 45 m^3/s from the bottom outlet structure plus additional flow from the spillway. As an example, a 12 hour rainfall duration for a 300-year event has a peak inflow of 64.8 m^3/s (Table 4.4-3 of the EIA) and is being attenuated with the Structure to a peak outflow of 58.6 m^3/s, where the spillway is contributing 13.6 m^3/s and the bottom outlet structure is contributing 45 m^3/s. This total outflow of 58.6 m^3/s would produce a downstream inundation area that would look very similar to the BGC Engineering Ltd. (BGC) modelled scenario for the 100 to 300-year return with a similar total peak discharge of 60 m^3/s (Run 3a and 3b, Table 2-1 in the response to SIR 2) and shown on Drawing 11 of the BGC hazard assessment report (provided in Appendix 74-1; BGC 2014).

However, the Structure would retain most of the debris and reduce the downstream impacts.

Furthermore, the Structure has been designed to contain the largest LDOF that has been modelled by BGC for the 300 to 1,000-year and the 1,000 to 3,000-year events. Unmitigated scenarios are highly disruptive and have high impact intensities due partly to the high amounts of entrained debris. Avulsions would happen on both sides of the creek and most of the Cougar Creek residential and industrial area would be affected. In the mitigated case, large and very infrequent events are retained by the Structure. The Structure reduces peak flows from 700 to 45 m^3/s and removes a high percentage of the debris. Figure 74-1 illustrates the difference between the unmitigated and mitigated case for a LDOF scenario.

Table 74-1 At Elk Run Boulevard

	Unmitigated/Without the Structure			Mitigated/With the Structure		
Return Period (years)	**Water Levels (m)**	**Peak Discharge (m^3/s)**	**Flood Extent**	**Water Levels (m)**	**Peak Discharge (m^3/s)**	**Flood Extent**
30-100	0.66	50	Contained in channel	0.62	45	Contained in channel
100-300	0.74	60	Contained in channel	0.62	45	Contained in channel
300-1,000	2+	160	Avulsion at Elk Run Boulevard	0.62	45	Contained in channel

Note: 160 m^3/s is the calculated capacity of Elk Run Boulevard culvert. The rest of the 700 m^3/s from a 300 to 1,000 return period is spreading through the residential area if the Structure is not in place.

Table 74-2 At Highway 1 and Canadian Pacific Railway Bridge

	Unmitigated/Without the Structure			Mitigated/With the Structure		
Return Period (years)	**Water Levels (m)**	**Peak Discharge (m^3/s)**	**Flood Extent**	**Water Levels (m)**	**Peak Discharge (m^3/s)**	**Flood Extent**
30-100	0.66	50	Contained in channel	0.62	45	Contained in channel
100-300	0.74	60	Contained in channel	0.62	45	Contained in channel
300-1,000	2+	64	Avulsion at Elk Run Boulevard and at Highway 1	0.62	45	Contained in channel

Note: 64 m^3/s is the calculated capacity of the Highway 1 culvert. The rest of the 700 m^3/s from a 300 to 1,000 return period spreads through the residential area if the Structure is not in place.

Table 74-3 Boulder Crescent & Glacier Drive Area

	Unmitigated/Without the Structure			Mitigated/With the Structure		
Return Period (years)	**Water Levels (m)**	**Peak Discharge (m^3/s)**	**Flood Extent**	**Water Levels (m)**	**Peak Discharge (m^3/s)**	**Flood Extent**
30-100	N/A	N/A	Area not affected Contained in channel	N/A	N/A	Area not affected Contained in channel
100-300	1+	30	Area affected due to avulsion at Elk Run Boulevard	N/A	N/A	Area not affected Contained in channel
300-1,000	1+	60	Area affected due to avulsion at Elk Run Boulevard	N/A	N/A	Area not affected Contained in channel

Note: The information presented for a 100 to 300-year return period is based on the assumption that Elk Run Boulevard is blocked by debris and an avulsion occurs at the culvert (Scenario 3b in BGC Drawing 11). Widespread inundation on the eastern part of the fan is a result with water concentrating due south of the culvert toward Boulder Crescent and Glacier Drive junction. A similar assumption is made for the 300 to 1,000-year return period (Scenario 4 in BGC Drawing 11).

b. Refer to the response to part a) above.

References:

BGC Engineering Inc. (BGC). 2014. *Town of Canmore, Cougar Creek Debris Flood Hazard Assessment - Final*. Report prepared for the Town of Canmore. Vancouver, British Columbia. March 7, 2014.

Proposed Debris Flood Retention Structure

Landslide Dam Outbreak Flood Scenario

Baseline (Unmitigated) **Mitigated**

Figure 74-1 Unmitigated and Mitigated Case for a Landslide Dam Outbreak Flood Scenario

75	**Volume 1, Section 6.6.32, Page 6-52** The Town of Canmore states *slope erosion in the inundation area is anticipated during high flow events.... Following erosion in the inundation area, coarse sediment that passes the Structure will deposit upstream of the Cougar Creek and Bow River confluence.* The inundation area covers 58,742 m^2 surface area at the maximum impoundment height. a. Discuss the anticipated volume of eroded sediment and debris volume from the inundation area slope due to large floods and quick draw down process.

Response:

a. The volume of soil present within the maximum inundation area is 2,550 m^3, which was estimated using the soil survey conducted during the baseline assessment. It is likely that a small percentage of the total soil volume will be eroded from the inundation area during and following a peak flood event because:

- the soils in the inundation area are generally protected from erosion by vegetation cover; and
- most of the soils present in the inundation area are at higher elevations and therefore flow velocity may be relatively low because of the total depth of the flowing water (i.e., as the water level in the inundation area increases, the velocity decreases).

The response to SIR 67 summarizes that there are no anticipated impacts to bedrock slope stability as a result of the inundation area or quick drawdown process.

Based on the above, the potential volume of eroded sediment and debris originating from the inundation area during and following a flood event is expected to be a small percentage of 2,550 m^3. This volume is considered insignificant relative to both the sediment and debris volume generated upstream during a major flood event (up to 260,000 m^3, as estimated in BGC 2014) and the total potential storage volume of the inundation area.

References:

BGC Engineering Inc. (BGC). 2014. *Town of Canmore, Cougar Creek Debris Flood Hazard Assessment - Final*. Report prepared for the Town of Canmore. Vancouver, British Columbia. March 7, 2014.

76	**Volume 1, Section 10.2, Page 10-3** a. Provide information on the design discharge of the emergency bypass pipe.

Response:

a. The design discharge of the emergency bypass pipe depends on the impoundment height. It ranges from 0 m^3/s to 11.8 m^3/s at full impoundment of the Structure.

77	**Volume 1, Section 6.5.1.1, Page 6-14** The Town of Canmore states *upon leaving the Upper Cougar Creek Reach, Cougar Creek flows southwest through No Man's Land.* a. Confirm that the term "No Man's Land", is an acceptable term, recognized by the Town. If this is not an official term, justify why this term is being used in the EIA.

Response:

a. The term *No Man's Land* has been used by the Town of Canmore, its consultants and its contractors since 2014 to define the area between the debris net and the start of the articulated concrete mats. The term can be found in several reports since January 2015 and is an term accepted by the Town.

5.3 Surface Water Quality

78	**Volume 1, Section 6.3.1.1, Page 6-5** The Town of Canmore states *the downstream portion of the surface water RSA includes any areas that may have been affected by Cougar Creek flows in the past or could potentially be affected if a flood event were to cause Cougar Creek to change its flow path.* a. What is the base to delineate the NW boundary of the downstream portion of RSA (Figure 6.3-1)? Is it based on the watershed boundary, street elevation, inundation area, or others? This boundary cuts into the middle of the Town.

Response:

a. As described in the environmental impact assessment, the downstream portion of the regional study area(RSA) was delineated generally with respect to the Cougar Creek alluvial fan (i.e., the extents of previous flow paths of Cougar Creek before reaching Policeman Creek or the Bow River). The alluvial fan extents were defined by BGC Engineering Ltd. in previous reports (BGC 2014).

   The northwest boundary of the downstream portion of the RSA considered that the alluvial fan ends at approximately the Benchlands Trail crossing of Highway 1. The northwest boundary of the RSA was therefore extended an additional 500 m northwest (i.e., upstream) along the Bow River Valley to ensure the RSA captured the complete extents of any past or future flow paths of Cougar Creek. The RSA boundary then continued perpendicular to the Bow River flow, across Policeman Creek until it reached the Bow River. The RSA delineation did not consider any anthropogenic development such as street elevations.

References:

BGC Engineering Inc. (BGC). 2014. *Town of Canmore, Cougar Creek Debris Flood Hazard Assessment - Final*. Report prepared for the Town of Canmore. Vancouver, British Columbia. March 7, 2014.

79	**Volume 1, Section 6.5.1.1, Page 6-22** The Town of Canmore states t*hese contributions are limited due to the tendency of debris and sediment to settle in the alluvial fan, and infrequent considering that flood events are required to transport sediment and debris to downstream aquatic habitats.* It seems there is more qualitative analysis than quantitative assessment due to lack of monitoring data and measurements on flow and sediment. The related modelling work also needs the monitoring data for validation and calibration. a. Justify why the level of data currently used for flow and sediment analysis of the EIA was sufficient.

Response:

a. Refer to the response to SIR 84.

80	**Volume 1, Section 6.5.1.2, Page 6-26** The Town of Canmore states *the Bow River Basin Council (BRBC) has assessed the entire Bow River basin and compiled a Bow River Basin State of the Watershed Summary, 2010 report (BRBC 2010).* a. Did BRBC update the result of surface water quality quoted in this paragraph since 2010? If BRBC updated the result, update the assessment of the relevant indicators of water quantity, water quality, landscape, and biological communities.

Response:

a. The 2010 *Bow River Basin State of the Watershed* summary is the most recent Bow River Basin Council (BRBC) assessment and is also reflected in the web-based State of the Watershed (BRBC 2016). The characterization of surface water quality based on BRBC 2010 is consistent with the Alberta water quality index results calculated for the reach located upstream of Cochrane during the available time period of 1996 to 2014 (AEP 2016). The overall index was rated as excellent for all years with exception of 2007/2008 and 2013/2014 when it was rated as “good.” The lower index rating in 2013/2014 was due to floods that resulted in some metals exceedances as well as bacteria exceedances in October 2014.

References:

Alberta Environment and Parks. (AEP). 2016. *Alberta River Water Quality Index Results (2013-2014).* April 2016. http://aep.alberta.ca/water/reports-data/documents/WaterQualityIndexResults-2013-14-Apr2016.pdf

Bow River Basin Council (BRBC). 2016. *Bow River Basin State of the Watershed.* http://watershedreporting.ca/

81	**Volume 1, Section 6.5.1.2, Page 6-27** The Town of Canmore states *while Cougar Creek is prone to debris flows, most debris and sediment transported during flood events is either trapped by the debris net or deposited on the Cougar Creek Fan rather than passing through to the Bow River confluence.* a. Justify the current monitoring data on debris and sediment was sufficient to support this judgment.

Response:

a. For the purposes of this response, sediment is divided into coarse sediment (i.e., gravel to boulder size) and fine sediment (i.e., smaller than gravel). The vast majority of coarse sediment would either be trapped by the debris net or deposited on the alluvial fan. Although some fine sediment would be trapped by the debris net or deposited on the alluvial fan, the fine sediment contribution to Policeman Creek and the Bow River is not expected to be impacted by the Structure or the existing debris net (BGC 2014a).

Aside from the BGC Engineering Ltd. (BGC) conclusion, which is based on their professional judgement as specialists on debris floods and associated sediment transport on mountain streams and alluvial fans, the existing data on debris and sediment was sufficient to support this judgement for the following reasons:

- the debris net is designed to capture debris and coarse sediment and the performance of these debris nets has been verified in other locations; and
- geologic formation of alluvial fans is based on the principle of sediment deposition due to laterally unconstrained flow and the lower channel gradients on alluvial fans relative to upper mountain reaches.

The debris flood hazard assessment conducted by BGC (BGC 2014b) was a comprehensive assessment based in part on deposition information collected in a number of test pits excavated across the Cougar Creek alluvial fan. Fine sediment deposits from historical debris flood events were observed within several of the test pits, which further supports the statement that most sediment reaching the alluvial fan will deposit on the alluvial fan rather than reaching the Bow River. This method of assessment is expected to be more accurate than using measured sediment data, even if it was available, particularly because the test pits can review sediment size and volume deposition over the past several thousands of years.

Collecting additional debris and sediment data for the purposes of the environmental impact assessment was not considered reasonable because of the following:

- flood events that correspond with major debris and sediment transport and deposition occur rarely; and
- sampling of debris or sediment during a flood event would either be unsafe or the instruments would be damaged or lost during sampling.

References:

BGC Engineering Inc. (BGC). 2014a. *Bow River – Cougar Creek Sedimentation Considerations.* BGC Project Memorandum. Report prepared for the Town of Canmore. October 14, 2014.

BGC Engineering Inc. (BGC). 2014b. *Town of Canmore, Cougar Creek Debris Flood Hazard Assessment - Final*. Report prepared for the Town of Canmore. Vancouver, British Columbia. March 7, 2014.

82

Volume 1, Section 6.6.4.2, Page 6-55

The Town of Canmore states *during construction, effective ESC measures will mitigate effects on water quality around the construction site. Effective spill control and equipment refueling measures will also be employed to protect surface water quality. Impacts to water quality during construction are considered negligible.*

a. Can the detailed effective ESC measures be described and emphasized here to conclude *the negligible impacts to water quality during construction* due to those effective measures?

Response:

a. Detailed erosion control measures and contamination prevention and management measures that were considered in the assessment of surface water quality around the construction site are listed in Sections 4.9.2.4 and 4.9.4 of the environmental impact assessment, respectively. A detailed erosion and sediment control (ESC) plan, that is based on a pre-construction site assessment and contains specific erosion controls for the Project, will be developed, implemented and monitored by a certified professional in erosion and sediment control. Impacts to surface water quality during construction are not expected since effectual and well-established ESC measures will mitigate effects to water quality. Effective spill control and equipment refueling measures will also be employed to protect surface water quality. Impacts to water quality during construction are therefore expected to be negligible. Further information regarding ESC measures are provided in the response to SIR 42.

83	**Volume 1, Section 6.6.4.2, Page 6-55** The Town of Canmore states *during operation, the Structure is designed to attenuate flows and store some of the larger rock and woody debris mobilized out of the watershed. The water and smaller sized sediments, including suspended sediments will pass through the Structure.* *The resultant downstream water quality with the Structure in place will be the same as if the Structure was not present.* a. Will the resultant downstream water quality with the Structure in place be the same as if the Structure was not present? Justify how this conclusion was reached.

Response:

a. The conclusion that downstream water quality would be the same with the Structure present or not present was reached based on the assumption that during high precipitation events, the Structure will prevent any large rocks and woody debris from entering Cougar Creek, while allowing dissolved constituents and suspended sediments to enter. The excluded larger components would not influence water quality if present; therefore, the resultant downstream water quality would be the same as if the Structure was not present.

   Cougar Creek has minimal or no surface water flow during most of the year with seasonal flows restricted to significant rainfall and snow melt events. During these periods surface water containing any suspended sediments would flow unimpeded through the Structure and into the creek and would therefore have similar water quality compared to if the Structure was not present.

   Groundwater will continue to flow to the creek during normal and flood conditions. Groundwater will rise to the surface at the cutoff wall and continue to flow through the Structure before exiting and allowing to filter back into the creek gravels.

84	**Volume 1, Section 12, Page 12-1** In "Aquatic Monitoring" section, the Town of Canmore states *these predictions will be verified by water level and water quality monitoring at a well in the Valley/Fan Aquifer downstream of the Structure.* a. Justify why the level of data currently used for flow, debris, and sediment analysis of the EIA was sufficient. Besides TH-3 well observation and sampling, Canmore needs to consider other monitoring program on sediment/debris transport rate and flow measurements for certain rainfall events to validate the related hydrology and sediment analysis. In the report we often read such description and explanation *as lack of site-specific data (Page 5-10), no hydrometric monitoring data available (Page 6-10), no meteorological monitoring data available (Page 6-10),no meteorological monitoring data (Page 6-10), The exact quantities of debris and sediment generated in the Cougar Creek watershed and transported downstream are not known (Page 6-13), Surface water quality of Cougar Creek has rarely been the focus of studies; therefore, historical data and information is limited from a surface water quality and aquatic ecology perspective (Page 6-13).*

Response:

a. The assessment of impacts to flow, debris, and sediment was presented for peak flow conditions only because normal and low flows (and associated debris and sediment transport) would not be impacted by the Structure and therefore were not relevant to the assessment. Therefore, the following response focusses on the sufficiency of the peak flow, debris, and sediment data and analyses.

A description of proposed monitoring is provided in the response to SIR 96.

Peak Flows

The most common way of estimating peak flows is using measured data from a hydrometric station to conduct a flood frequency assessment. However, no hydrometric data specific to Cougar Creek exists. Installation of a hydrometric gauge for determining peak flows for the environmental impact assessment (EIA) was not considered reasonable because of the following:

- peak flows may only occur every few years and so a reasonable study period may not record any data useful for a flood frequency analysis; and
- a traditional flood frequency analysis using measured peak flow data and statistical distributions would not be theoretically appropriate because they cannot account for the hydro-geomorphic processes that are known to occur in Cougar Creek (i.e., debris floods and landslide dam outbreak floods).

In the absence of measured data, peak flows must be estimated using either indirect hydrologic observations or numerical modelling. The two separate peak flow studies presented in the EIA use these unrelated methods to provide a range of peak flow estimates that are expected to represent the peak flow conditions on Cougar Creek.

Debris and Sediment

Directly measuring sediment transport during peak flow events is uncommon but can be completed using grab samples from the water column (suspended load) and bed load samplers (bed load). Debris transport is difficult to measure other than qualitatively. No direct measurements of sediment or debris transport specific to Cougar Creek exists. Conducting sediment and debris transport measurements for the EIA were not considered reasonable for the same reasons listed for peak flows, and because sampling during a Cougar Creek flood would either be unsafe or the instruments would be damaged or lost during sampling.

In the absence of measured data, sediment transport must be estimated using indirect sediment transport observations (refer to the response to SIR 73). The BGC Engineering Ltd. (BGC) assessment (BGC 2014) estimated sediment transport rates based on deposition information collected in a number of test pits excavated across the Cougar Creek alluvial fan. This method of assessment is expected to be more accurate than using measured sediment data, even if it was available, particularly because the test pits can review sediment size and volume deposition over the past several thousands of years.

Summary

Both hydrology studies referenced in the EIA provide a discussion of analysis uncertainty, which is generally understood to be substantial. However, in regards to the BGC assessment, the Town of Canmore requested that three independent reviewers, Dr. Michael Church, Dr. John Pomeroy, and Dr. Norbert Morgenstern, review the technical report and provide comment. This process was repeated until all their concerns, suggestions and comments were appropriately addressed in the reports. The independent reviewers background is included below. Two reviewers also provided a letter of support for the Town's project and are included in Appendix 84-1.

Based on the in-depth technical reports and the independent reviews of the analysis techniques, the level of data used to characterize the baseline flow, debris, and sediment of Cougar Creek was considered not only sufficient, but of the best quality possible considering all information available for such an assessment.

Independent reviewers background:

Dr. Micheal Church

Dr. Church is a professor emeritus in the Department of Geography at the University of British Columbia. He is one of the world's foremost experts in fluvial geomorphology and his research focuses on the morphodynamics (i.e., sediment transport and lateral stability) of rivers at all scales, from steep land streams to large rivers.

Dr. John Pomeroy

Dr. Pomeroy is the Canada Research Chair in Water Resources and Climate Change, Professor of Geography and Director of the Centre for Hydrology at the University of Saskatchewan, an Honorary Professor of the Centre for Glaciology, Aberystwyth University, Wales, and an Institute Professor for the Geoscience Engineering from the University of Saskatchewan. He has authored over 200 research articles and several books and conducted research throughout the world.

Dr. Norbert Morgenstern

Dr. Morgenstern is Professor Emeritus of Civil Engineering at the University of Alberta and an internationally recognized authority in the field of geotechnical engineering. He has received honorary degrees from the University of Toronto and Queen’s University. He has been elected a Fellow of the Engineering Institute of Canada and the Canadian Academy of Engineering. Other major awards include the Centennial Award of the Association of Professional Engineers, Geologists and Geophysicists of Alberta and the Sir Frederick Haultain Prize in Science from the Government of Alberta. Professor Morgenstern has not only made outstanding contributions through his teaching and research but also as a consulting engineer. His work as a consultant on water development projects, landslide studies and other resource development projects carried him to over 20 countries on six continents. Dr. Morgenstern has served his professional community through numerous committees and task forces that have assisted government and professional societies at all levels.

References:

BGC Engineering Inc. (BGC). 2014. *Town of Canmore, Cougar Creek Debris Flood Hazard Assessment - Final*. Report prepared for the Town of Canmore. Vancouver, British Columbia. March 7, 2014.

85	**Volume 1, Section 12, Page 12-1** In Aquatic Monitoring section, the Town of Canmore states *samples will be taken once before construction, annually during construction and annually until the conclusions of the hydrogeology assessment are verified.* a. Provide the reference to support an "annual" frequency of sampling for water quality during the Project construction, rather than bi-annually or quarterly, even monthly.

Response:

a. Water quality monitoring described in Section 12, page 12-1 and Section 6, page 6-48 refers to samples that will be collected during an annual program and analyzed for a full parameter suite. These samples are separate from ones that will be collected at a higher frequency and analyzed for parameters related to erosion during construction as to be determined in the Erosion and Sedimentation Control Plan. There are no expected impacts to fish or fish habitat since Cougar Creek and its tributaries are not fish-bearing and there is limited surface water connectivity between Cougar Creek and Policeman Creek and the Bow River (which are fish-bearing).

   Surface water quality monitoring during construction will occur if water is flowing and will include daily measurements of field parameters (pH, specific conductance, temperature and turbidity) and monthly collection of water quality samples for submission to an accredited laboratory for analysis of conventional and routine parameters and metals. Monitoring will be completed at sites located upstream and downstream of construction.

   Refer to the response to SIR 65 for a discussion on groundwater monitoring and sampling frequency during construction. The Town of Canmore will work with regulators to prepare the construction monitoring proposal, which will include groundwater and surface water monitoring and sampling.

86	**Volume 1, Section 6.5.1.1, Page 6-18** The Town of Canmore states *groundwater chemistry results from the eight monitoring wells are considered representative of surface water, as flowing water within the creek alternates between surface flow and shallow subsurface flow over its course.* a. Clarify that this statement does not refer to all water quality variables such as suspended sediments, turbidity and associated adsorbed substances – which may be higher in surface water compared to groundwater.

Response:

a. Groundwater chemistry results from the eight shallow (less than 1.2 m below ground surface) monitoring wells are considered representative of surface water, as flowing water within the creek alternates between surface flow and shallow subsurface flow over its course. Exceptions are suspended sediments, turbidity and associated adsorbed parameters such as nutrient and some metal parameters, which are expected to be comparatively lower in groundwater.

87	**Volume 1, Section 6.5.1.1, Page 6-18** The Town of Canmore states *Routine analyses included: …… carbon trioxide.* a. Does the Town of Canmore mean Carbon Carbonate rather than *carbon trioxide*? Explain why this variable is included here as it is not normally used in surface water quality monitoring.

Response:

a. The parameter was intended to read carbonate instead of carbon trioxide. Carbonate is included as a standard parameter in the suite of major ions. Although bicarbonate is the dominant anion, carbonate also typically occurs as a minor constituent of Alberta surface waters that are influenced by limestone geology.

88	**Volume 1, Section 6.5.1.1, Page 6-18** The Town of Canmore states *a review of the general and inorganic parameter (routine) data indicates no exceedances above the Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME 2003).* a. Provide the more up-to-date guideline document namely: Environmental Quality Guidelines for Alberta Surface Waters (2014), found on the AEP website. Ensure all current guidelines are met for the routine data and make any changes, if needed, to Table 6.5-6, page 6-20.

Response:

a. Results for general and inorganic routine water quality parameters collected in August 2015 and a comparison with the *Environmental Quality Guidelines for Alberta Surface Waters* (ESRD 2014) and the *Water Quality Guidelines for the Protection of Aquatic Life* (CCME 2015) are provided in Table 88-1. Results for all parameters met corresponding guidelines.

Table 88-1 Groundwater Quality Results - General and Inorganic Parameters

Monitoring	Sample	MSI Sample	Ca-T	Mg-T	Na-T	K-T	Fe-D	Cl	SO_4	NO_2-N	NO_3-N	NO_2+N O_3-N	T-Alkalinity	HCO_3	Hardness	TDS
Well	**Date**	**Number**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Fan and Valley Aquifer																
TH14-07	19-Aug-15	20746150819001	---	---	---	---	---	<0.50	70.5	<0.010	0.303	0.303	134	163	200	226
TH14-09	19-Aug-15	20746150819002	---	---	---	---	---	<0.50	82.6	<0.010	0.341	0.341	144	176	226	251
TH14-3	19-Aug-15	20746150819003	---	---	---	---	---	<0.50	71.3	<0.010	0.428	0.428	130	158	193	221
TH14-5a	19-Aug-15	20746150819004	---	---	---	---	---	<0.50	75.4	<0.010	0.434	0.434	129	157	196	224
TH14-5b	19-Aug-15	20746150819005	54.2	18.5	6.4	1.16	<0.030	5.42	67.1	<0.010	0.109	0.109	140	171	194	231
TH15-10-V	21-Aug-15	20746150821001	70.2	20.1	1.1	0.94	<0.030	---	---	---	---	---	---	---	---	---
TH15-10-V	25-Aug-15	20746150825001	---	---	---	---	---	<0.50	78.4	<0.010	0.349	0.349	145	177	217	244
TH15-21-I	21-Aug-15	20746150821002	67.9	23.9	3.2	1.57	<0.030	2.4	75	<0.010	0.235	0.235	167	204	238	265
TH15-22-V	22-Aug-15	20746150822001	---	---	---	---	---	2.37	178	<0.010	0.328	0.328	20.1	24.6	169	272
CCME Water Quality Guidelines - Freshwater^{+}			**NS**	**NS**	**NS**	**NS**	**0.3**	**120^{LT}**	**NS**	**0.06**	**3^{LT}**	**NS**	**NS**	**NS**	**NS**	**NS**
ESRD Freshwater Aquatic Life*			**NS**	**NS**	**NS**	**NS**	**0.3**	**120^{LT}**	**H^{SO4}**	**Cl^{LT}**	**3^{LT}**	**NS**	**$<20^{Alk}$**	**NS**	**NS**	**NS**
ESRD Agriculture - Irrigation*			**NS**	**NS**	**NS**	**NS**	**NS^{TM}**	**100^{crop}**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**500^{crop}**
ESRD Agriculture - Livestock*			**1,000**	**NS**	**NS**	**NS**	**NS**	**NS**	**1,000**	**10**	**NS**	**100**	**NS**	**NS**	**NS**	**3,000**

---	- Not analyzed
NS	- Not specified
LT	- Long-term exposure guideline; see applicable guidelines for further details
Alk	- Minimum value, unless natural conditions are less
crop	- Guideline level is crop dependent; criterion shown is most stringent value
SO4	- Guideline level is hardness dependent; hardness values greater than 250 mg/L need to be determined based on site water
TM	- Guideline available for total metal
+	- *Water Quality Guidelines for the Protection of Aquatic Life* (CCME 2015)
*	- *Environmental Quality Guidelines for Alberta Surface Waters* (ESRD 2014)

References:

Alberta Environment and Sustainable Resource Development (ESRD). 2014. *Environmental Quality Guidelines for Alberta Surface Waters*. Water Policy Branch, Policy Division. Edmonton, Alberta. July 14, 2014. ISBN: 978 1 4601 1524 4. http://esrd.alberta.ca/water/education guidelines/documents/EnvironmentalQualitySurfaceWaters 2014.pdf

Canadian Council of Ministers of the Environment (CCME). 2015. *Water Quality Guidelines for the Protection of Aquatic Life.* Canadian Environmental Quality Guidelines, Summary Table. Accessed in October 2015. http://st-ts.ccme.ca/en/index.html

89	**Volume 1, Section 6.5.1.1, Page 6-18** The Town of Canmore states *for total metals, several parameters from the August 2015 sampling program were found to exceed the Canadian Council of Ministers of the Environment (CCME) protection of aquatic life guidelines at several of the monitoring wells.* a. Provide the more up-to-date guideline document namely: Environmental Quality Guidelines for Alberta Surface Waters (2014). Review metals data against the 2014 document. Update and make all required changes to Table 6.5-7, page 6-21.

Response:

a. Results for total metals water quality parameters collected in August 2015 and a comparison with the *Environmental Quality Guidelines for Alberta Surface Waters* (ESRD 2014) and the *Water Quality Guidelines for the Protection of Aquatic Life* (CCME 2015) are provided in Table 89-1. Concentrations of aluminum and selenium measured in all three well samples were above the Canadian Council of Ministers of the Environment (CCME) and Alberta Environment and Sustainable Resource Development (ESRD) guidelines. Concentrations of other metals including chromium, copper, iron, molybdenum, silver and zinc were above corresponding CCME and ESRD guidelines in at least one sample.

Table 89-1 Groundwater Quality Results - Total Metals

Monitoring	**Sample**	**MSI Sample**	**Al**	**As**	**Ba**	**Be**	**Bi**	**B**	**Cd**	**Cr**	**Co**	**Cu**	**Fe**	**Pb**	**Mn**	**Mo**	**Ni**	**Se**	**Ag**	**Sr**	**Tl**	**Sn**	**Ti**	**U**	**V**	**Zn**
Well	**Date**	**Number**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Fan and Valley Aquifer																										
TH14-5b	19-Aug-15	20746150819005	***0.0337***	0.00068	0.0598	<0.00010	0.000054	0.012	0.0000529	***0.00289***	<0.00010	0.00203	<0.030	0.000083	<0.0050	0.00187	0.00084	***0.00127***	0.00001	0.341	0.000011	0.00094	<0.00030	0.00148	0.00202	0.0076
TH15-10-V	21-Aug-15	20746150821001	***0.373***	0.00031	0.0337	<0.00010	<0.000050	0.012	0.0000222	0.0009	0.00014	0.00061	***0.38***	0.000239	0.0165	0.00146	0.00107	***0.00122***	<0.000010	0.328	0.000026	<0.00010	0.00589	0.00175	0.00138	0.0144
TH15-21-I	21-Aug-15	20746150821002	***0.136***	0.00027	0.0439	0.00089	<0.000050	0.02	0.0000836	***0.00409***	0.001	***0.0503***	***0.78***	0.000838	0.0506	***0.167***	0.0078	***0.00147***	***0.0003***	0.294	0.000013	0.00292	0.00443	0.00167	0.00064	***0.0872***
CCME Water Quality Guidelines - Freshwater^{+}			**0.005/0.1**^{Al}	**0.005**	**NS**	**NS**	**NS**	**1.5**^{LT}	**H**^{LT}	**0.001**^{Cr6}	**NS**	**H**	**0.3**	**H**	**NS**	**0.073**	**H**	**0.001**	**0.00025**^{LT}	**NS**	**0.0008**	**NS**	**NS**	**0.015**^{LT}	**NS**	**0.03**
ESRD Freshwater Aquatic Life*			**NS**^{DM}	**0.005**	**NS**	**NS**	**NS**	**1.5**^{LT}	**H**^{LT}	**0.001**^{Cr6}	**0.0025**	**0.007**^{LT}	**NS**^{DM}	**H**^{LT}	**NS**	**0.073**	**H**^{LT}	**0.001**	**0.0001**	**NS**	**0.0008**	**NS**	**NS**	**0.015**^{LT}	**NS**	**0.03**
ESRD Agriculture - Irrigation*			**5**	**0.16**	**NS**	**0.1**	**NS**	**0.5**^{crop}	**0.0082**	**0.0049**^{Cr3}	**0.05**	**0.2**^{crop}	**5**	**0.2**	**0.2**	**0.01**	**0.2**	**0.02**^{Se}	**NS**	**NS**	**NS**	**NS**	**NS**	**0.01**	**0.1**	**1**^{Zn}
ESRD Agriculture - Livestock*			**5**	**0.025**	**NS**	**0.1**	**NS**	**5**	**0.08**	**0.05**^{Cr3,Cr6}	**1**	**0.5**^{animal}	**NS**	**0.1**	**NS**	**0.5**	**1**	**0.05**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.2**	**0.1**	**50**

NS - Guideline not specified
Al - Guideline level is dependent on pH; 0.005 mg/L if pH < 6.5 and 0.1 mg/L if pH ≥ 6.5
Cr6 - Guideline level for Cr(VI)
crop - Guideline level is crop dependent; criterion shown is most stringent value
DM - Guideline available for dissolved metal
H - Dependent on hardness value
LT - Long-term exposure guideline; see applicable guidelines for further details
Se - Continuous use guideline value
\+ - *Water Quality Guidelines for the Protection of Aquatic Life* (CCME 2015)
* - *Environmental Quality Guidelines for Alberta Surface Waters* (ESRD 2014)
Italics - Values do not meet applicable guidelines

References:

Alberta Environment and Sustainable Resource Development (ESRD). 2014. *Environmental Quality Guidelines for Alberta Surface Waters*. Water Policy Branch, Policy Division. Edmonton, Alberta. July 14, 2014. ISBN: 978 1 4601 1524 4. http://esrd.alberta.ca/water/education guidelines/documents/EnvironmentalQualitySurfaceWaters 2014.pdf

Canadian Council of Ministers of the Environment (CCME). 2015. *Water Quality Guidelines for the Protection of Aquatic Life.* Canadian Environmental Quality Guidelines, Summary Table. Accessed in October 2015. http://st-ts.ccme.ca/en/index.html

5.4 Aquatics

90 **Volume 1, Section 6.2.3, Page 6-3**

The Town of Canmore states *the Structure is an area of Cougar Creek that does not support fish, provide fish habitat, or contribute directly to habitat value to Policeman Creek or Bow River. For the purpose of this EIA, the assessment of the aquatic ecology is focused on Policeman Creek and Bow River, both known to be fish-bearing watercourses*.

a. Notwithstanding the limited surface flow and discontinuous nature of flow in Upper Cougar Creek, we have no information that I am aware of from any fish sampling efforts in this area to be confident that fish are not present. We have examples from many other water bodies (rivers and streams), that show fish can and do exist in and above areas of low and/or discontinuous flow. To fill this data gap, Fisheries Management requests that a field assessment be conducted in upper Cougar Creek in the area of the proposed structure and potential inundation. Based on the opinion of a qualified aquatic/fisheries biologist, if conditions are suitable, we would request fish sampling in this area likely with a backpack electrofisher. If the biologist determines conditions are not suitable for sampling, then we would request a written habitat assessment accompanied by photos of typical habitat. As we have two Threatened fish species in nearby drainages (Westslope Cutthroat Trout and Bull Trout) and we have found both of these species above areas of extensive sub-surface flow, we believe fish sampling in Upper Cougar Creek should be conducted.

Response:

a. An assessment of a 2.25 km reach immediately downstream of the Structure to the confluence with Policeman Creek was completed by ISL Engineering and Land Services Ltd. in April 2016. Cougar Creek was observed to be heavily modified with extensive bank armouring, widened channel (55 m, dry at the time of the survey), and no riparian vegetation. Site photographs show a trapezoidal-shaped channel with no potential instream cover or thalweg to provide passage for fish during flows other than flooding or bankfull conditions.

The assessment results described Cougar Creek as lacking water throughout most of the year, excluding spring runoff or flooding events, providing limited to nil migration potential. Similarly, the lack of water, lack of cover and lack of adequate depth were considered to provide no potential for rearing, feeding or spawning of local fish species.

In the unlikely event that fish could access Cougar Creek via Policeman Creek during a high-water event, there is no evidence to show that habitat exists upstream of the Project area that would provide for life history requirements of local fish species. The extreme ephemeral nature of Cougar Creek is due to runoff events only. Once the event is over, any fish remaining in Cougar Creek in the lower 2.25 to 2.5 km would suffer mortalities as the water flow ceased. If fish were able to reach habitat upstream that did provide habitat, the Structure is not anticipated to interfere with or remove any potential habitat. Sampling for fish upstream of the Structure is not recommended at this time due to the assessment and conditions observed.

91

Volume 1, Section 6.5.1.2, Page 6-22

Between Lake Louise and Calgary, the Bow River features four hydroelectric dams operated by TransAlta: Seebe Dam, Interlakes Dam, Ghost Dam, and Bearspaw Dam. The Interlakes Dam is on the Kananaskis River between Upper and Lower Kananaskis Lakes and not on the Bow River. The two facilities on the Bow River near Seebe are called Kananaskis and Horseshoe.

a. Shouldn't *Seebe Dam, Interlakes Dam* be replaced with *Kananaskis Dam, Horseshoe Dam*? Update the required pages to reflect this change. More information can be found here: http://www.transalta.com/facilities/plants-operation

Response:

a. The sentence should read "Between Lake Louise and Calgary, the Bow River features four hydroelectric dams operated by TransAlta: Kananaskis Dam, Horseshoe Dam, Ghost Dam, and Bearspaw Dam."

92	**Volume 1, Section 6.6.5.1, Table 6.6-7, Page 6-56**
	In Table 6.6-7 one of the indicators is *sediment load and woody debris contribution from Cougar Creek to Policeman Creek.* As Policeman Creek drains into the Bow River approximately 100 m upstream of the Cougar Creek confluence, it is not clear on how sediment and woody debris would normally be distributed from Cougar Creek to Policeman Creek. a. Is this because the floodplains of both Cougar and Policeman overlap at the Bow River confluence? b. In the *Measurable Parameter* column it states *deposition in downstream aquatic habitats from Cougar Creek* so it may just be a matter of changing the Indicator to *Sediment load and woody debris contribution from Cougar Creek to Bow River/Bow River floodplain*? If this is changed, it would also have to be changed in the subsequent section 6.6.5.2.

Response:

a. The portion of Policeman Creek that is referred to is the overlap at the Bow River, a section of braided channel that is within the floodplain of both Cougar and Policeman Creek.

b. Tables 6.6-7 and 6.6-8 of the environmental impact assessment have been updated and are included below as Tables 92-1 and 92-2, respectively.

Table 92-1 Aquatic Ecology Indicators for Assessment

Indicator	Description	Rationale for Inclusion	Measurable Parameter
Sport Fish Habitat in the Bow River Floodplain and Policeman Creek	Bull Trout and Brown Trout spawn in the fall/winter, often in small creeks off of larger rivers; females of both species dig redds and cover fertilized eggs with gravel.	Cutting off contribution of gravel used for spawning could impact this life stage of valuable sport fish and threatened species (Bull Trout); changes in discharge to downstream surface water bodies and wetlands could impact water quantity/chemistry of fish habitat.	Gravel and surface water/groundwater contribution from Cougar Creek to Policeman Creek and the Bow River.
Sediment load and woody debris contribution from Cougar Creek to Bow River/Bow River Floodplain	Changes in the sediment/gravel contributions can have an effect on the instream habitat structure of the Bow River; woody debris is an important habitat component of the Bow River/Bow River floodplain area and can be affected by the Structure.	Operation of the Structure can have an impact on contributions of sediment, gravel, and woody debris that can provide instream habitat components for sport fish species.	Change in frequency or quality of sediment and large woody debris deposition in downstream aquatic habitats from Cougar Creek.

Table 92-2 Aquatic Ecology Assessment Summary

Criteria	Indicator	
	Sport Fish Habitat in the Bow River Floodplain and Policeman Creek	**Sediment Load and Woody Debris Contribution from Cougar Creek to Bow River/Bow River Floodplain**
Direction	Decrease	Decrease
Extent	Subregional	Subregional
Magnitude	Low	Low
Duration	Short-term	Short-term
Frequency	Rare	Rare
Permanence	Irreversible1	Irreversible1
Prediction Confidence	High	High
Environmental Consequences	Negligible	Negligible
Rationale	Impacts to the quantity and frequency of the contribution of spawning gravels from Cougar Creek to the Bow River floodplain area where confirmed spawning redds have been documented can have an effect on this available habitat resource for resident fish species. Cougar Creek's contribution of gravels is minimal; therefore, the overall environmental consequence for this indicator is considered to be negligible.	The sediment load from Cougar Creek to the aquatic habitat of the downstream habitats is considered to be unchanged from baseline conditions. Current large woody debris contribution from Cougar Creek is infrequent and tends not to reach critical spawning habitat. Reclaimed woody debris from behind the Structure could be made available for habitat enhancement; therefore, resulting in negligible consequence.

1. The Structure is intended to remain in place forever and as such assessing the reversibility, as is done with projects that are decommissioned and reclaimed, is not applicable for this Project.

Section 6.6.5.2 should read:

Sediment Load and Woody Debris Contribution from Cougar Creek to Bow River/Bow River Floodplain

Similar to the potential impacts to gravel distribution, changes to the sediment load and large woody debris contributions to downstream aquatic habitat can result from the construction and operation of the Structure. During the site preparation and construction of the Structure, there is the potential that the physical changes of the Project area could result in changes to the sediment load available for transport down Cougar Creek. As described in Section 6.6.4, impacts to water quality from construction are considered negligible. Operation of the Structure will reduce the frequency and quality of large woody debris transport down Cougar Creek to the Bow River/Bow River floodplain. However, under baseline conditions, large woody debris contribution from Cougar Creek is infrequent and tends not to reach critical spawning habitat. As part of operations, the debris retained behind the Structure will be cleaned out after significant events. Trees and wooden debris are expected to be salvageable and of suitable quality to relocate into Policeman Creek and the Bow River/Bow River floodplain if there is a need to use them to augment fish habitat. Decisions to augment any fish habitat will be made by Alberta Environment and Parks and if suitable materials are salvaged, the Town can make these materials available. The Structure is considered to have a negligible effect on this selected indicator.

93	**Volume 1, Section 4.4.1, Page 4-19** With the removal of debris and aggregate, explain the impacts of fine sediment on Cougar Creek and receiving water bodies. a. Will the removal of debris and aggregate increase fine sediment loading and transport downstream on the Bow River to areas outside of the RSA (i.e. Ghost and Bearspaw Reservoirs). Explain why or why not.

Response:

a. There will be no additional changes to debris and coarse sediment transport in Cougar Creek as a result of the Structure compared to the baseline case since the existing debris net will withhold debris and coarse sediment under current conditions.

The following excerpt from BGC Engineering Ltd.'s *Bow River – Cougar Creek Sedimentation Considerations* memorandum (BGC 2014) indicates that the Structure will have very minimal effects on fine sediment transport to the Bow River:

> *"The recommended debris barrier structure on Cougar Creek is designed to allow normal stream bedload to reach the Bow River. In extreme events, namely debris floods and landslide dam outbreak floods, coarse sediment and water would be stored. Water would be released through grillages and a water tunnel, while sediment upstream of the structure would need to be excavated following an extreme event. Coarse sediment (gravel to boulder size) passing the structure would continue to be deposited upstream of the Bow River – Cougar Creek confluence, while finer bedload would still be delivered to the Bow River floodplain on a regular basis during high flows irrespective of the structure in place. As a result, BGC does not expect significant changes in the sediment input to the Bow River."*

Based on the above, fine sediment loading and transport downstream on the Bow River is not expected to be impacted by the Structure because fine sediment will continue to reach the Bow River in volumes similar to baseline conditions.

References:

BGC Engineering Inc. (BGC). 2014. *Bow River – Cougar Creek Sedimentation Considerations.* BGC Project Memorandum. Report prepared for the Town of Canmore. October 14, 2014.

94	**Volume 1, Section, 6.5.1.2, Page 6-27** The Town of Canmore states *it was estimated that bed load transported to the Bow River was likely an order of magnitude less than what was deposited onto the Cougar Creek Fan (BGC 2014f).* This paragraph describes the existing conditions as it relates to the type of material and estimation of volume of material moved to both the Cougar Creek Fan and the Bow River. a. Provide information that would support how much material will be permitted to move to the Bow River post-construction and how impacts to the aquatic environment will be mitigated.

Response:

a. As described in the response to SIR 93, the Structure is not expected to impact debris and sediment transport to the Bow River compared to the baseline case with the debris net in place. Therefore, there will be no impacts to sediment related aquatic environment considerations in the Bow River as a result of the Structure.

95	**Volume 1, Section 6.6.5.3, Table 6.6-8, Page 6-58** *Reclaimed woody debris from behind the Structure could be made available for habitat enhancement; therefore, resulting in negligible consequence.* a. Provide an indication of consequence rating should woody debris not be placed back in Policeman Creek.

Response:

a. Should the woody debris not be placed back in Policeman Creek, the consequence would still be considered negligible and would not cause a change to downstream fish habitat conditions. This rating is based on the extremely rare occurrence of flows present in Cougar Creek that are high enough to transport woody debris. The contribution of woody debris from Cougar Creek downstream to Policeman Creek and the Bow River is therefore considered sporadic and insignificant. Other sources of woody debris in the upper Bow River watershed (and other tributaries) exist.

96	**Volume 1, Section 12, Page 12-1** Town of Canmore states *sediment and debris transport regimes to the Bow River are not anticipated to be impacted as a result of the Structure. Coarse sediment (i.e., gravel to boulder size) that passes through the Structure will likely deposit upstream of the Cougar Creek and Bow River confluence, while the Structure will still allow normal stream bed load to reach the Bow River (BGC 2014f).* (page 6-51). No monitoring program was proposed to verify this prediction. a. Will Town of Canmore consider adding Sediment and Debris transport monitoring program during peak floods at Cougar Creek, at Cougar Creek and Bow River confluence and at Bow River downstream of the confluence? If the monitoring program is not going to be considered then explain the reason for not considering it. Moreover, the Town of Canmore states *there are no hydrometric monitoring stations on Cougar Creek to characterize the existing flow regime….. Records from stations identified cannot be transferred reliably to the Cougar Creek (Page 6-14).* b. Will Town of Canmore consider adding flow monitoring program to verify the flow estimations done for the Cougar Creeks during the EIA process? If the monitoring program is not going to be considered then explain the reason for not considering it.

Response:

a. The Town of Canmore is proposing the following program to monitor sediment and debris transport during peak floods at Cougar Creek, at Cougar Creek and Bow River confluence, and at Bow River downstream of the confluence:

- a baseline analysis to determine if underlying trends in channel morphology were present before construction of the Structure; and
- periodic air photograph analysis and field review to assess changes in channel pattern and reach-scale morphology in Policeman Creek and Bow River.

Figure 96-1 shows the areas recommended for monitoring.

Baseline Monitoring

Monitoring relies on the underlying assumption that observed changes in channel morphology are a direct result of a given intervention. In this case, monitoring is intended to isolate the impacts of the Structure on bed morphology, grain size, and channel pattern downstream of Cougar Creek. However, the Bow River is likely experiencing ongoing adjustments in response to prior human activities; earlier diking has limited lateral migration, while waste rock was directly dumped into the Bow River during the coal mining period, altering the sediment balance in downstream reaches (BGC 2014). In order to assess the impact of the Structure, underlying morphologic trends in the Bow River and Policeman Creek before construction of the Structure must therefore be assessed. The Town of Canmore will undertake a detailed air photograph assessment to examine historic trends, with a specific focus on:

- shifts in channel pattern;
- systematic widening or narrowing;

- evidence of aggradation or degradation; and
- changes in lateral migration (i.e., erosion) rates.

Figure 96-1 shows the approximate 6 km long reach that will be considered in the baseline assessment. Air photos taken at regular intervals will be combined with Light Detection and Ranging to create orthorectified three dimensional models. The channel banks – as well as in-channel islands – will then be mapped for each air photograph, throughout the 6 km long reach. Important geomorphic features such as large woody debris jams and exposed bars will also be mapped, if visible.

The channel network mapped in successive years will then be compared to determine the average migration rate during the air photograph interval, as well as changes in vegetation coverage and channel width. This method of spatial mapping produces an estimated error of approximately +/-5 m, and enables detection of reach-scale patterns of channel change.

Air Photograph Assessments

Future air photograph assessments will be conducted in the study reach to assess potential reach-scale adjustments to decreased sediment supply on Policeman Creek and the Bow River. The same methods described under baseline monitoring would be used. If the sediment supply is reduced by the Structure, channel degradation is likely to occur, and may be accompanied by a shift toward a single-thread channel pattern. Given the relatively infrequent nature of significant sediment transport events on Cougar Creek and the time lag for Policeman Creek and the Bow River to respond to any change in sediment supply, it is recommended that future air photograph assessments be conducted at 10 year intervals and following high flow (>10-year return period) events.

b. The Structure will feature a radar gauge at the bottom outlet structure that will record flow height. The flow rate of Cougar Creek can easily be calculated using the flow height, the cross-sectional area and the grade of the bottom outlet structure. This is standard instrumentation on such a structure and the data will be monitored during flood events. All the data will be stored on a sever, along other critical data related to the Structure.

References:

BGC Engineering Inc. (BGC). 2014. *Bow River - Cougar Creek Sedimentation Considerations.* Memorandum prepared for the Town of Canmore. Edmonton, Alberta. October 14, 2014.

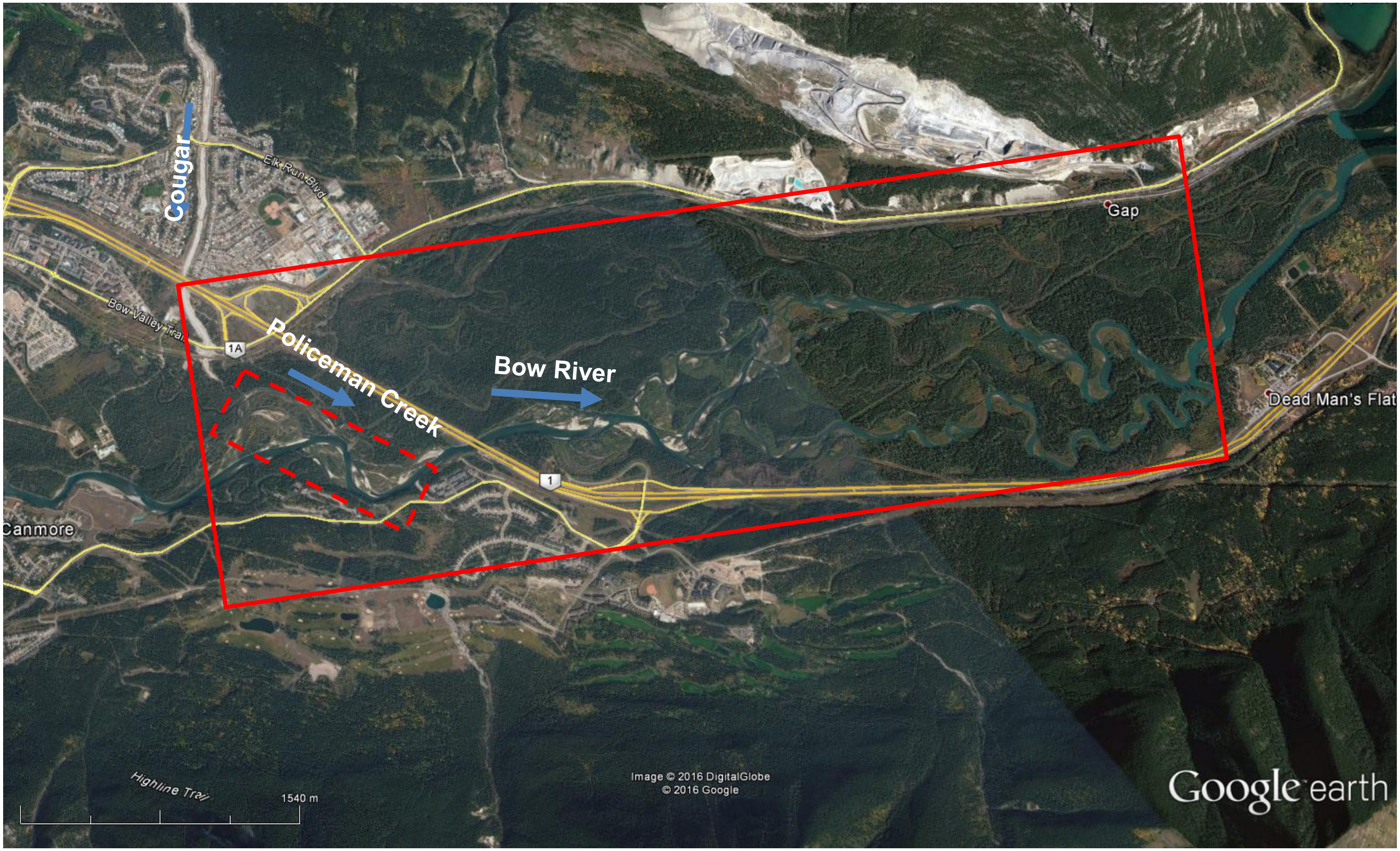


Figure 96-1 Reaches Recommended for Monitoring

(The solid red rectangle shows the area recommended for the baseline assessment and long-term air photo monitoring, and the smaller red dashed rectangle shows the area recommended for regular UAV survey)

97 **Volume 1, Section 6.2.3, Page 6-3**

The Town of Canmore states *the Structure is an area of Cougar Creek that does not support fish, provide fish habitat, or contribute directly to habitat value to Policeman Creek or Bow River.*

a. Clarify the term “directly” as Cougar Creek does provide direct value to habitat in Policeman Creek and the Bow River via supply of LWD, debris, finer sediments, and gravel recruitment.

Response:

a. The Structure is located in an area that does not provide potential fish habitat, areas where fish can complete life history requirements such as spawning, rearing, feeding or overwintering. Cougar Creek would be considered to provide indirect habitat from sporadic water flow and contributions of woody debris and bed substrates such as silt, sand, clay, gravel, cobbles and boulder. The contribution of large woody debris and coarse sediment (i.e., cobble or boulder) from Cougar Creek to the Bow River would be considered limited and very sporadic (i.e., limited to flood events).

Considering that substrate transport is a function of water velocity, the ability of a channel to transport larger bed materials increases with increased water velocity. Lower flows, such as runoff during precipitation events is expected to transport fine sediments (i.e., silt, sand, clay) and would remain uninhibited by the Structure. Gravels, larger in size than sediment, would require slightly higher water velocities (i.e., greater discharge) to be transported. The Structure is not anticipated to inhibit the contribution of bed substrates to Policeman Creek or the Bow River; however, the timing of the contribution may be altered as substrates may deposit in the vicinity of the Structure during lower flow periods. Higher flows would be expected to redistribute fines and gravels downstream.

98	**Volume 1, Section 6.5.1.2, Page 6-22** The Town of Canmore states *these contributions are limited due to the tendency of debris and sediment to settle in the alluvial fan and infrequent considering that flood events are required to transport sediment and debris to downstream aquatic habitats.* On page 6-16 it provides an estimate of 9000 m^3 was deposited in the Bow River from Cougar Creek during the 2013 flood. On page 6-37 it also suggests the bedload transported to the Bow River is mainly deposited in the Cougar Creek fan. a. Explain how 9000 m^3 of debris transported to the Bow River is 'limited', and whether this amount can have a significant impact or not on the Bow R/Policeman's Creek floodplain.

Response:

a. The sediment volume that was transported to the Bow River during the 2013 flood was estimated to be an order of magnitude less than the volume deposited on the alluvial fan (Section 6.5.1.2 of the environmental impact assessment). Therefore, the volume of sediment transported to the Bow River is a "limited" portion of the overall sediment reaching the Lower Cougar Creek Reach.

   As described in the response to SIR 93, the vast majority of the sediment transported to the Bow River is fine sediment. This sediment is expected to reach Policeman Creek and the Bow River regardless of the debris net or the Structure, so there will be no impacts to the Policeman Creek and Bow River floodplain.

99	**Volume 1, Section 6.6.5.1, Page 6-57** The Town of Canmore states *while deposition of gravels into key habitat remains possible, the probability of this occurring is very low and is considered to have a negligible effect on the key aquatic habitat.* a. Clarify this statement relative to the issue of a potential benefit of supplying spawning gravel recruitment.

Response:

a. As described in the response to SIR 93, the Structure is not expected to impact debris and sediment transport to the Bow River compared to the baseline case with the debris net in place. Therefore, there will be no impacts to sediment related aquatic environment considerations in the Bow River as a result of the Structure.

100	**Volume 1, Section 6.8, Page 6-63** The Town of Canmore states *it is not expected that the construction and operation will have any residual effects on surface water quality or aquatic ecology of the aquatic resources in the RSA.* a. The above statement refers to the RSA. Explain and justify if the same statement holds true for the LSA or not.

Response:

a. The local study area (LSA) shares the same boundary as the regional study area (Figure 7.5-1 of the environmental impact assessment) downstream of the Structure; therefore, the statement holds true for the LSA.

101	**Volume 1, Section 11, Page 11-4** The Town of Canmore states *cleaning equipment before arrival onsite to prevent the spread of terrestrial and aquatic weeds seeds and other biota of concern.* a. Is the Town of Canmore going to ensure that equipment to be used in the Bow River will be decontaminated for Whirling Disease? If so explain what measures will be used for decontamination. If not, justify why not.

Response:

a. There will be no work associated with this Project in the Bow River. Within Cougar Creek, no work is proposed to occur in flowing water; however, Whirling Disease decontamination protocols will be used for any equipment before and after construction. Protocols will align with recommended measures in the interim guidelines released by the Government of Alberta (2016).

References:

Government of Alberta (GoA). 2016. *Interim Guidelines for the Disinfection of Fisheries Equipment to Reduce the Spread of Whirling Disease in Southern Alberta*. AEP Fish and Wildlife 2016 No. 5. Alberta Environment and Parks Support and Emergency Response Team (ASERT). October 15, 2016.

6 TERRESTRIAL

6.1 Land Use and Land Management

102	**Volume 1, Section 4.4.5.1, Figure 4.4-8, Table 4.4-1, Page 4-27** The Town of Canmore states *they will channel reinforcement to improve areas over the articulated concrete mats at the boundary of Bow Valley Wildland Park in preparation for the project construction.* a. Define stone pitching and how this will be completed, since there are different interpretations…i.e. grouting or cement between boulders. b. Explain improvements to be made on the concrete mats.

Response:

a. Stone pitching to be applied to reinforce the channel would be placed on a concrete bed with grouting between the rocks. The stone pitching is done with large angular rocks; typically riprap class IV. The concrete and rocks are placed in layers, starting at the bottom of the slope. The rocks are placed in the concrete bed by an excavator. The grouting of the gaps between the rocks is done by hand. The finished products should produce a wall with a fairly even surface that is highly durable and offers a high level of protection from floods and debris floods.

b. Proposed improvements consist of concrete stone pitching over sections of the articulated concrete mats. The sections to be improved are where the creek transitions from the wide area in *No Man's Land* to the confined area of the artificial channel where it enters the residential area. High forces are expected through this funnel area during a large event and the articulated mats would also be subject to erosional forces due to the debris and sediment concentration. Both sides of the creek at the funnel would be better protected with the addition of stone pitching on top of the concrete mats.

103	**Volume 1, Section 4.9.1.2, Page 4-52** a. Confirm the definition of LSA is the same prior to this section. The formal definition appears in Section 6.3 (Page 6-4).

Response:

a. These definitions are not the same. As described in Section 5.2.5 of the environmental impact assessment (EIA), appropriate spatial boundaries are defined for each discipline. Section 4.9.1.2 of the EIA refers to the terrain and soils local study area (LSA). Section 6.3 of the EIA refers to the aquatic environment LSA. Detailed descriptions and associated figures of discipline LSAs and regional study areas are included in their relevant sections:

- Aquatic Environment (Section 6.3);
- Terrestrial Environment (Section 7.2.5); and
- Human Environment:
  - Air Quality and Climate (Section 8.2.2);
  - Land Use and Management (Section 8.4.2);
  - Socio-Economics (Section 8.5.2); and
  - Historical Resources (Section 8.6.2).

104	**Volume 1, Section 4.4, Figure 4.4-8** Clarify the construction step timing, including month and year, for: a. Rock blasting activities. b. Vegetation clearing required for the access road. c. Any other vegetation clearing required.

Response:

a. Construction activities will occur in the sequence described in Section 4.4, Table 4.4-1 and Figure 4.4-8 of the environmental impact assessment. Dependencies and seasonal restrictions for each step are also provided in Table 4.4-1. The proposed schedule was prepared for a March start with rock blasting and clearing activities scheduled outside of restriction periods for bird migration and nesting (Table 4.4-1). All blasting and clearing activities are associated with the following two construction steps and no other vegetation clearing will be required:

- Access Road and Site Clearing (Construction Step 4): Clearing of the site and Access Road to the top of the right abutment (downstream side) and rock blasting for road construction to that location was originally scheduled for September of the first year of construction.
- Access Road Completion (Construction Step 10): Completion of the Access Road on the crest and upstream side of the Structure including any remaining blasting or clearing was originally scheduled for October of the second year of construction.

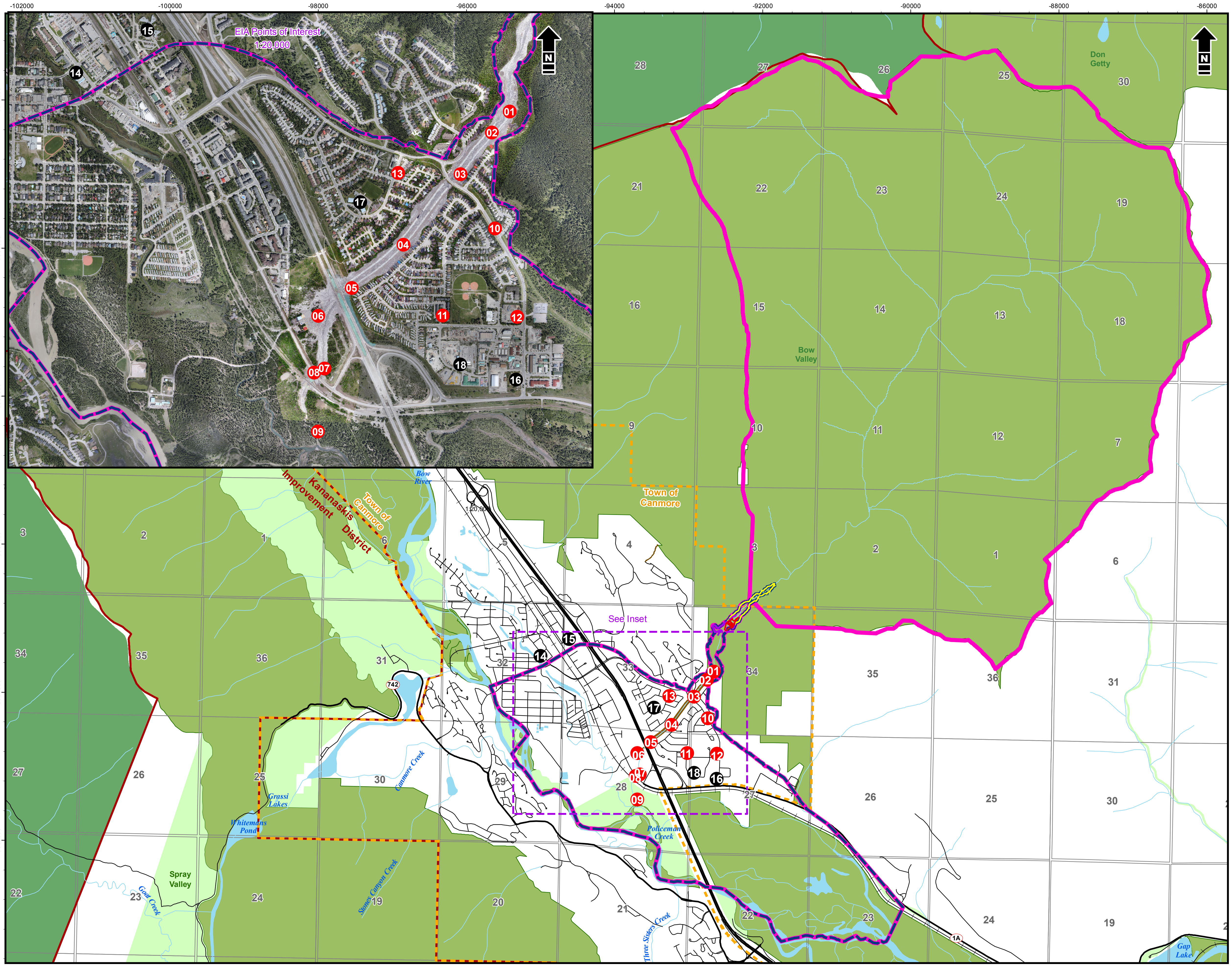
The actual start date and construction sequencing will be updated once regulatory approval to proceed with the Project is received. First Nations will be invited to harvest traditionally used plants at a time of their choosing once regulatory approval has been received.

Also refer to the response to SIR 130 regarding clearing during sensitive wildlife periods.

105	**Volume 1, Section 6.3.2, Figure 6.3-1, Page 6-7** Local Study Area (LSA) shown on Figure 6.3-1 does not show much detail of the LSA. a. Provide a Figure of LSA showing the points of interest as shown in Appendix 4F Figure 17.

Response:

a. Figure 6.3-1 of the environmental impact assessment has been updated to include the information presented in Appendix 4F, Figure 17. The updated figure is included here as Figure 105-1.



Surface Water Local Study Area
Surface Water Regional Study Area
Town of Canmore Municipal Boundary
Community
Municipal District
Provincial Park
Wildland Provincial Park
National Park
Water Body
Watercourse
Highway
Road
Railway

Articulated Concrete Mats
Above Ground
Below Ground

Proposed Footprint
Debris Flood Retention Structure
Access Road
Inundation Area

Floodwave Hydrograph Readouts
- 01 No Man's Land 01
- 02 No Man's Land 02
- 03 Elk Run Boulevard Culvert
- 04 Pedestrian Channel Crossing
- 05 Highway 1 Culvert
- 06 Heliport
- 07 Highway 1A
- 08 CPR
- 09 Cougar Creek Mouth
- 10 Junction Elk Run Boulevard - Ridge Road
- 11 Junction Boulder Crescent - Glacier Drive
- 12 Junction Elk Run Boulevard - Glacier Drive
- 13 Junction Cougar Creek Drive - Kodiak Road

Points of Interest
- 14 Canmore Fire Rescue Station
- 15 Canmore General Hospital
- 16 Royal Canadian Mounted Police
- 17 Elizabeth Rummel School
- 18 Premises of BECL & Fortis Alberta Inc.

Reference: Watercourse data for Cougar Creek and associated tributary subcatchments obtained from the client. Data obtained from AltaLIS © Government of Alberta, GeoBase® and GeoGratis © Department of Natural Resources Canada (all rights reserved) used under license. GDM transportation infrastructure data provided by IHS © 2015 used under license. Imagery (2013 and 2014) obtained from client used under license.

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Town of CANMORE

Cougar Creek Debris Flood Retention Structure

Surface Water Local and Regional Study Areas (Revised)

Date: 07 Jun 2017	Project: 20746-514	
Technical: I. Trimble	Reviewer: R. Sturgess	Drawn: M. Urtheil

Disclaimer: Prepared solely for the use of the Town of Canmore as specified in the accompanying report. No representation of any kind is made to other parties with which the Town of Canmore has not entered into contract.

Figure
105-1

I:\TownOfCanmore\20746\FiguresAndTables\EIA_SIR1\2017\Report\AEP_Response\Figure-105-1-Surface_Water_Local_and_Regional_Study_Areas_Revised.mxd

106	**Volume 1, Section 3.3.3., Page 3-8** The EIA refers to surface land dispositions in the area being for conservation and flood mitigation. a. Provide a list of dispositions that are for conservation purposes.

Response:

a. The five surface land dispositions that overlap the local study area are described in Section 8.4.4.2. The disposition that is in place for conservation purposes is a protective notation (PNT 970018) in place for ungulate migration corridor. No surface dispositions are allowed within this corridor.

107	**Volume 1, Section 4.9.7.1, Page 4-60** Recreational access will be maintained during construction and operation of the Project. a. Elaborate on how this will be accomplished during construction; will a new trail be constructed? b. What will be the impacts of additional fragmentation on the LSA/RSA and how will the impacts associated with the new trail be managed or reduced?

Response:

Refer to Section 8.4.5.3 (Mitigation Measures) and Section 9.2.4.2 (Recreational Access During Construction).

a. A large number of recreational users access Cougar Creek for hiking, mountain biking and rock climbing, and the Town of Canmore wants to ensure that public access to existing trails and recreational areas will be safely maintained at all times. The Town of Canmore and Alberta Environment and Parks (AEP) are in discussions to extend an existing trail on the east bank to provide access into Cougar Creek upstream of the construction site. AEP will approve the route of the trail extension. AEP will also modify adjacent trails in the area as part of planned adjustments for that network of trails. This trail extension may also serve as emergency egress from Cougar Creek during a flood event. The Town of Canmore will inform the public via signage, their website, and social media about the extended route, parking areas, and any access restrictions related to construction.

   During periods with limited truck traffic (e.g., grout work), the construction site will be fenced but access into Cougar Creek from the public parking lot will be maintained. Access will also be maintained to the trails that connect to both the east and west banks of Cougar Creek, and connect to surrounding trails (including Horseshoe Loop, Montane Traverse, and Mount Lady Macdonald).

   Access to trails that begin downstream of the Structure will be maintained at all times; however, during periods of heavy traffic users might have to access those trails using existing alternate routes rather than directly from the Cougar Creek parking lot and trail head. The Town of Canmore will inform the public via signage, their website and social media about access restrictions and alternate routes. During construction planning, the Town of Canmore will work to minimize disruption to recreational users and will only restrict access to the Cougar Creek parking lot and trail head for short periods of time when it is necessary to protect public safety.

b. Additional fragmentation of the local study area/regional study area is expected due to the trail extension considered for this Project; however, the extension is not expected to increase human use relative to baseline conditions. The extension is expected to be approximately 500 m in length and AEP will incorporate the extension into the existing network of trails that they manage. AEP is planning to clean up and re-route some of the trail nodes in the area to minimize impacts of existing and new trails.

6.2 Conservation and Reclamation

108 **Volume 1, Section 4.9.2.3, Page 4-54**
Volume 1, Section 4.9.5, Page 4-56

The Town of Canmore states they will develop Re-Vegetation Plans with AEP. In addition, the Town of Canmore states *soil disturbance will occur during construction. Proper soil handling techniques are important to minimizing Project effects to soils as described in Section 7.*

a. Provide Re-vegetation Plans with wildlife (bear smart, habitat, cover, forage etc.) and Fire Smart strategies included. Explain the re-vegetation strategies using maps and sketches since each area identified for reclamation has its own specific characteristics.

b. Identify and provide rational for soil placement and storage. Soil mapping and sketches can be used to identify specific details of reclamation. Explain erosional mitigation strategies that will be used to ensure the conservation of soils. Explain what is meant by *proper soil handling techniques.*

c. What soil handling procedures will be employed by the Town of Canmore to maintain soil integrity?

d. Provide reclamation area planning detail derived from control (pre-disturbance site data) sampling. Area specific intensive local sampling assessments should support reclamation plans.

Response:

a. The main objective of reclamation of the Project and No Man's Land is the creation of an aesthetically pleasing environment consistent with the surrounding areas, while adding low maintenance cover for erosion control and wildlife use. Refer to the response to SIR 26 for a discussion of the Town of Canmore's FireSmart strategy and its application to the Project.

Structure

Except for the intake, the piers and baffles of the spillway, and the road surfaces on the Structure (Figure 4.4-3 of the environmental impact assessment [EIA]), the revegetation strategy is to establish a low maintenance cover of grasses on the upstream face and the downstream spillway and stilling basin. The native species provided in the response to SIR 120b are consistent with BearSmart since plant species that are bear attractants are excluded. Seeding of the Structure with grasses is discussed in the response to SIR 121a.

Once established on the Structure, the grass cover will provide protection from erosion, will facilitate wildlife movement over the Structure and may provide habitat for small species. Trees and shrubs will not be planted to avoid effects of their roots on integrity of the Structure. The Town of Canmore will cut back any large brushes or trees establishing on the Structure as part of the maintenance plan.

No Man's Land

The proposed conceptual reclamation in No Man's Land will involve minor grading, de-compaction of scattered small islands, adding imported soil, and planting native herbaceous and shrubby vegetation. Before construction commences, Aboriginal stakeholders will be provided an opportunity to collect/harvest plants and bryophytes on the Project footprint. Following that harvest, Parks Division of Alberta Environment and Parks (AEP), the Town of Canmore and volunteers will collect native species, such as mountain avens (*Dryas* spp.) and other useful species, including roots and some soil material from the Project site and relocate the plants to moist areas where conditions will allow their survival until later use during reclamation.

The islands will be teardrop-shaped, 5 m wide by 7 m long on average but variable in size, scattered across No Man's Land, and placed to not interfere with creek hydrology or flow paths. Final placement of the islands will be decided by the Town of Canmore and the Parks Division of AEP after results from the wildlife monitoring are reviewed and understood. A conceptual cross-section of a reclaimed, vegetated patch/island is shown on Figure 108-1.

After topsoil is added and spread in the islands, available stones and coarse woody material will be added to create microsites, retain soil moisture and aid in the establishment of vegetation (Vinge and Pyper 2012). The islands will then be seeded with native grasses. The native species proposed for planting and seeding are provided in the response to SIR 122, which include species with roots that provide some protection from soil erosion and exclude plant species that are bear attractants.

After native grasses are initially established in No Man's Land, native plants collected before the start of reclamation (e.g., mountain avens) will be transplanted on the islands and additional shrubs will be planted. The purpose of planting shrubs is to increase the diversity of vegetation and supplement erosion protection. The chosen timing of planting will take into consideration the best chance of success for the planted species. The Town of Canmore will consider transplanting (spading in) shrubs collected from adjacent areas in lieu of ordering and planting individual species. Willow cuttings will be collected in the fall from areas as close to the Project site as possible. The Parks Division of AEP will provide permits to harvest willows and other shrubs for reclamation of the Project and the patches in No Man's Land, and may assist in this effort.

In total the vegetated islands may comprise approximately 5% to 8% of the surface area of No Man's Land. The vegetated islands in No Man's Land are expected to add habitat and provide cover for wildlife, which was partially removed by the 2013 flood waters.

Access Road

Where salvaged topsoil is replaced along the ditches of the Access Road, the Town of Canmore will broadcast seed or hydroseed the ditches using the seed blend presented in the response to SIR 120b. Native plants collected before reclamation started (e.g., mountain avens and short shrub species) will be transplanted. A conceptual cross-section of the Access Road with vegetated ditches is presented on Figure 108-2. Options for additional planting of shrubs and erosion control along the Access Road are addressed in the response to SIR 120.

b. *Structure*

Salvaged topsoil from the footprint of the Structure will be stockpiled short-term during construction before being spread. Salvaged topsoil and imported topsoil will be spread to a thickness of 10 cm over a 5 cm thickness of clay/silty clay on the upstream face of the Structure and downstream spillway and stilling basin. The soil materials will be applied to provide a medium for revegetating to a cover of grasses. The source of imported topsoil is the Three Sister's development and an assessment of soil quality is addressed in the responses to SIR 109, SIR 113a, and SIR 117a. The Town of Canmore has experience with soil placement and revegetation in the creek corridor through the residential area that was re-engineered and revegetated.

No Man's Land

After native plant collections, surface de-compaction of the islands in No Man's Land using a hoe and a suitable attachment will be completed to leave a rough and loose surface (Polster 2011) to enhance the rooting zone. Boulders/large stones will be added and incorporated within the islands, particularly on the upstream side, to improve stability of the islands during higher creek flows. Topsoil imported from the Three Sisters development will be applied to a depth of 20 cm to 30 cm within the islands. Imported topsoil spread within the islands will improve the medium for establishing native plants compared to the gravels and sand prevalent at ground surface. After topsoil is added and spread in the islands, available stones and coarse woody material will be added to create microsites (Vinge and Pyper 2012), add erosion control, provide cover for several species, and aid in snow accumulation. The islands will then be seeded with native grasses (refer to the response to SIR 122). Snow fence will be installed around the islands to assist in vegetation establishment by discouraging human use and augmenting snow accumulation on the islands. The snow fences will be kept in place until vegetation is well established, after which they will be removed.

Access Road

Topsoil salvaged from the Access Road will be windrowed along the edge of the right-of-way (RoW) at the start of construction and will be spread in the ditches and the edge of the RoW after the Access Road grade is constructed.

Proper soil handling techniques described in the EIA include the following measures:

- restricting soil disturbance to the Project footprint;
- maintaining vegetative buffer strips wherever possible, particularly along perimeters of construction areas;
- stripping surface organics (LFH/O) with A horizon soil; topsoil will be salvaged from areas that will be disturbed for construction of the Project;
- suspending soil handling when sustained strong winds or intense precipitation events (rainfall or snowmelt) result in visible movement of sediment or soil, unless otherwise authorized by regulators;
- reducing the wheel traffic load on the soil to the extent practicable;
- optimizing construction scheduling to limit activities to dry soil conditions (summer to autumn), or to winter when soils are frozen;

- stockpiling soils on like materials (e.g., topsoil on topsoil) either onsite if space allows, or offsite within the Town of Canmore boundary;
- placing erosion matting to hold soil in place on temporary stockpiles; and
- revegetating reclaimed areas where topsoil is replaced.

c. The Town of Canmore will maintain soil integrity, or quality, by employing the soil handling mitigation measures listed in the responses to SIR 108b and SIR 109c.

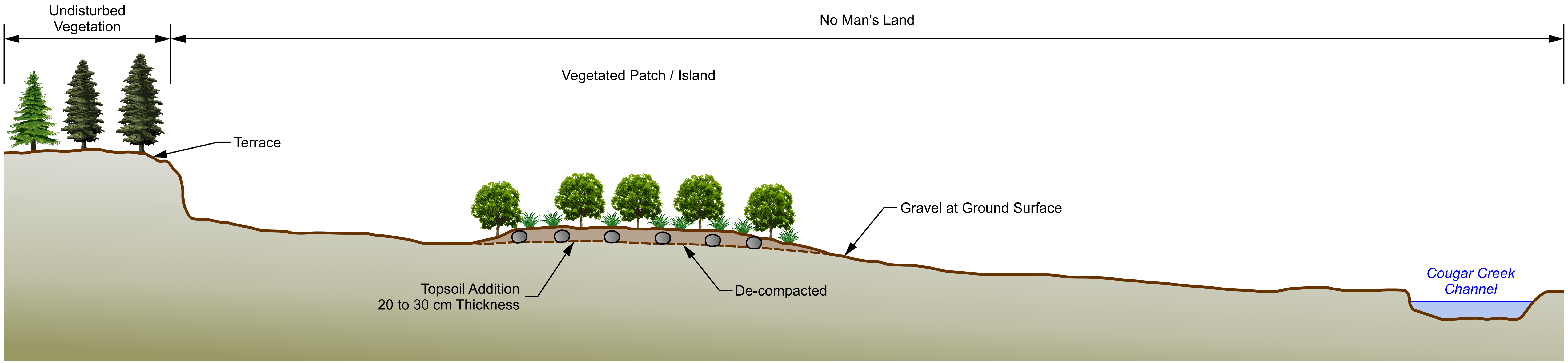
d. In 2015 (pre-disturbance), little vegetation was present in No Man's Land due to the 2013 flood, and limited areas of vegetation were in the proposed footprint of the Structure. The Town of Canmore referred to the pre-disturbance soil and vegetation data collected for the Access Road in developing the reclamation plan. The pre-disturbance soils data was used to determine the soil map units, land capability classification, reclamation suitability, and the erosion risk classes of soil types (Appendix 7A of the EIA). The pre-disturbance soils data was also used to calculate the reclamation material volumes (Section 4.9 of the EIA) based on topsoil thicknesses. The pre-disturbance vegetation ecological land classification map units and ecosite phase species lists (Appendix 7B of the EIA) were used to inform the preparation of candidate species for planting presented in the responses to SIR 120 and SIR 122. However, trees and tall shrubs will not be planted within the Access Road RoW because, once grown, these will impede ditch maintenance and visibility of wildlife to drivers when animals approach to cross the road. Additional reclamation planning details presented in the responses to SIR 108a, SIR 108b, SIR 109, SIR 117, SIR 120, SIR 121, and SIR 122 are not repeated here.

The overall objective of reclamation for the Project remains the creation of an aesthetically pleasing environment consistent with surrounding areas, while adding cover for wildlife. For reclamation purposes, the Town of Canmore has selected native species for compatibility with the adjacent surroundings, but also selected them based on the strategies presented in the response to SIR 108a, including the collection of cuttings and native plants for transplanting during reclamation.

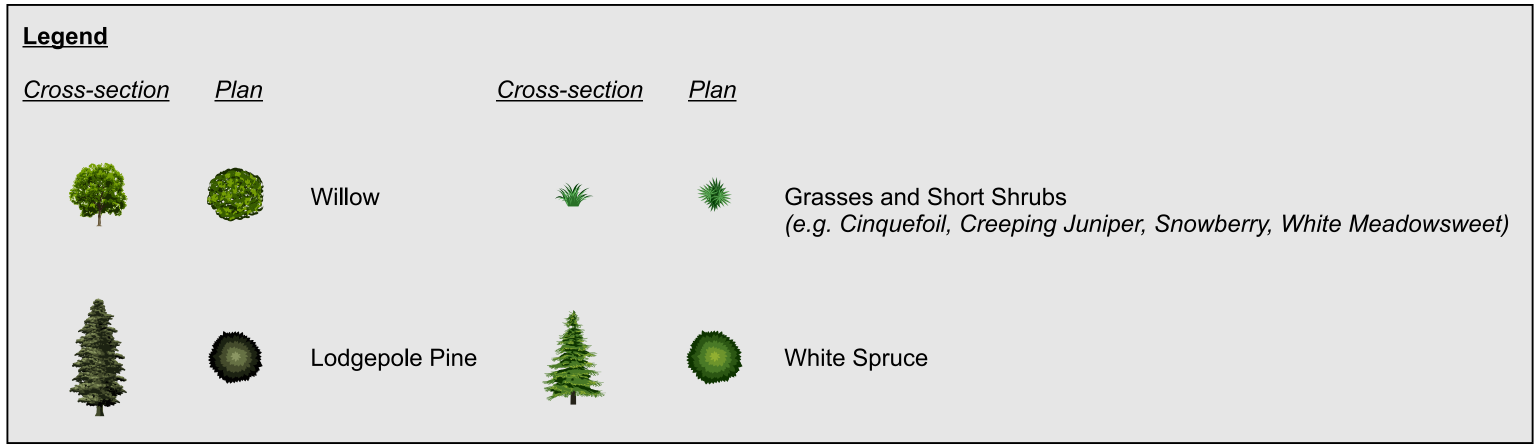
References:

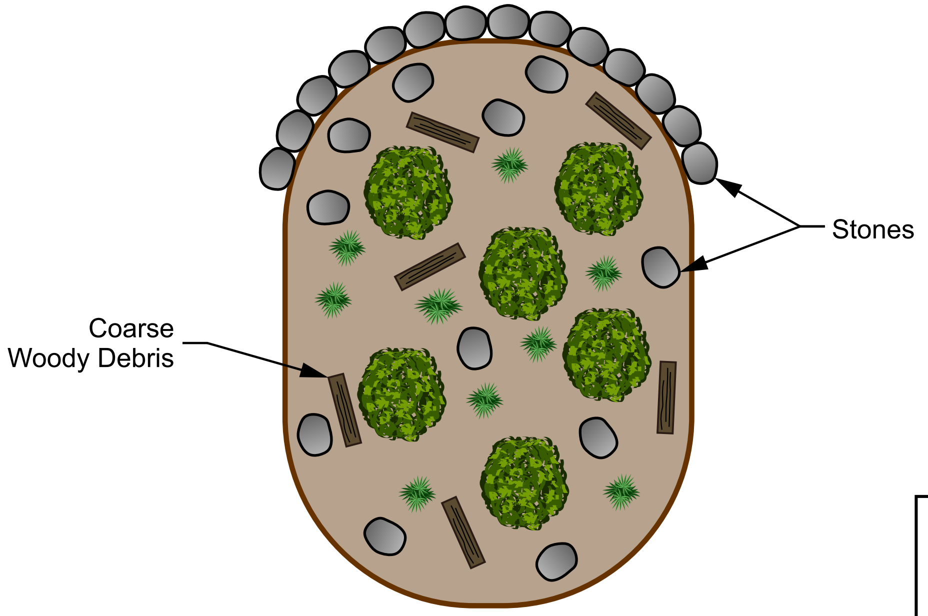
Polster D.F. 2011. *Effective reclamation: Understanding the ecology of recovery*. Paper presented at the 2011 Mine Closure Conference and B.C. Technical and Research Committee on Reclamation, BC Mine Reclamation Symposium. Lake Louise, AB. September 18-21, 2011.

Vinge T. and M. Pyper. 2012. *Managing Woody Materials on Industrial Sites: Meeting Economic, Ecological and Forest Health Goals through a Collaborative Approach*. Department of Renewable Resources. University of Alberta. Edmonton, Alberta. 32 pp.



Cross-section View (Viewing Upstream)





Vegetated Island Plan View

Not to scale.

Town of CANMORE

Cougar Creek Debris Flood Retention Structure

Conceptual Reclaimed Island of Vegetation in No Man's Land

Date: 3 Feb 2016	Project: 20746-SCH-16	
Technical: R. Labbe	Reviewer: C. Gomez	Drawn: G. Evenson

Figure
108-1

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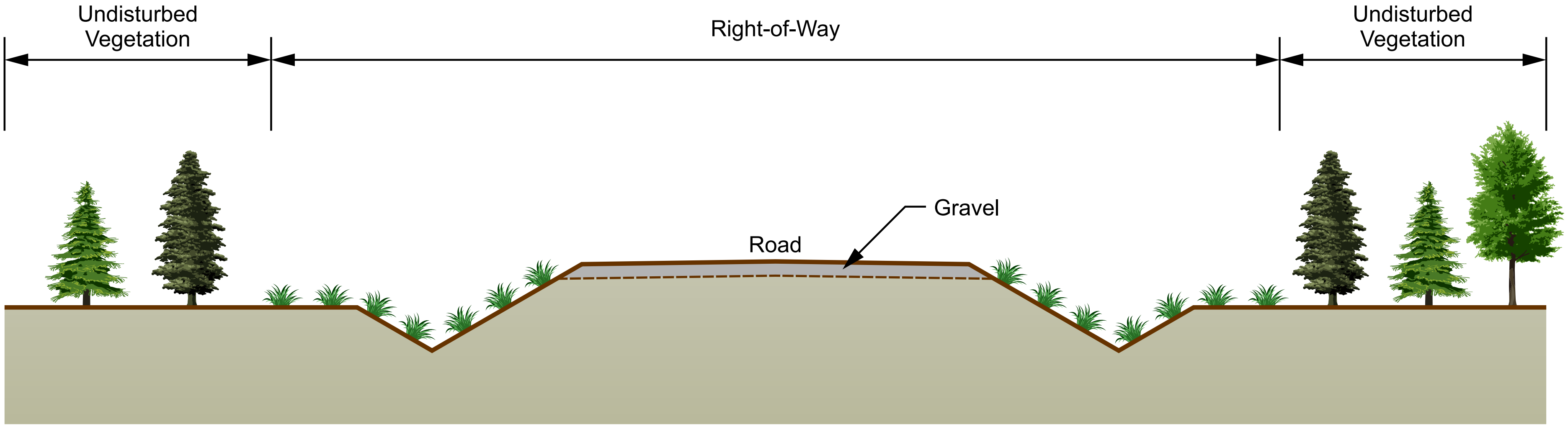

Not to scale and not an engineered design.

Legend

Aspen

Grasses, Forbs and Short Shrubs
(e.g. Cinquefoil, Creeping Juniper, Snowberry, White Meadowsweet and Mountain Avens)

Lodgepole Pine

White Spruce

Town of CANMORE

Cougar Creek Debris Flood Retention Structure

Conceptual Cross-section of Access Road and Vegetated Ditch

Date: 3 Feb 2016	Project: 20746-SCH2-16

Technical: R. Labbe	Reviewer: C. Gomez	Drawn: G. Evenson

Disclaimer: Prepared solely for the use of Town of Canmore as specified in the accompanying report. No representation of any kind is made to the other parties with which Town of Canmore has not entered into contract.

Figure

108-2

109	**Volume 1, Section 4.9.5.1, Pages 4-56** **Volume 1, Section 4.9.5.1, Table 4.9-1, Page 4-57** The Town of Canmore makes general reference to reclamation materials, imported soils and procedures on areas to be reclaimed. Provide more reclamation details on the following concerns for top soil distribution: a. Potential seed banks (tree/shrub/forbs/grass) in imported soils can be problematic with the introduction of unwanted vegetation species. The introduction of weeds is in addition to this concern. b. Potential for increased negative soil characteristics (i.e. chemical composition) is greater for imported soils especially if proper screening is not undertaken. c. Admixing of soils (top & sub-soils). d. Erosion matting and tackifiers.

Response:

a. As indicated in Section 4.1.6, the Town of Canmore is planning to source reclamation materials from a residential development in the Three Sisters area. Within the Three Sisters area a topsoil source has been identified. An analysis for weed seeds from two samples of the source topsoil was completed March 1, 2017, and weed seeds were absent in both samples (Appendix 113-2). A visual inspection of vegetation growth at the topsoil source location will be done to confirm no prohibited noxious or noxious weeds at the topsoil source location. Prohibited noxious and noxious weeds are listed in the Alberta *Weed Control Regulation - Alberta Regulation 19/2010*, and legislated under the *Weed Control Act*. The Town of Canmore will conduct weed surveys and weed control, including spraying of appropriate non-residual herbicides if necessary, at the Three Sisters topsoil source area ahead of importing the soil.

b. The Town of Canmore recognizes a potential for negative soil characteristics in soil imported from another area; however, the Three Sisters area has landscape features and vegetation relatively comparable to the local area of Cougar Creek. The strategy for screening imported soil is addressed in the responses to SIR 109a and SIR 117.

c. The Town of Canmore will have a qualified environmental monitor to guide topsoil stripping and minimize admixing of subsoil with topsoil. Also by handling and spreading subsoil separately from topsoil on the Structure, the Town of Canmore will minimize the occurrence of admixing.

d. Erosion control mats, tackifiers and hydromulches will be used to control erosion and protect areas recently seeded. A discussion of where these and other materials will be used is presented in the responses to SIR 120 to SIR 122.

110	**Volume 1, Section 4.9.5.5, Page 4-58** The Town of Canmore references that they will use an "Adaptive Management Approach" and will evaluate success and adjust accordingly. The Town of Canmore also does not tie in how their reclamation of No Man's Land will achieve their stated wildlife objectives. a. What does "adaptive management approach" mean in this context? Provide more details on the evaluation program such as how will this be measured? Does the Town of Canmore have any standards? What is success? Are there any timelines? Elaborate b. Explain how the reclamation of No Man's Land will be used to achieve wildlife objectives.

Response:

a. An adaptive management approach in this context means implementation of the Town of Canmore Operation, Maintenance and Surveillance (OMS) manual for the Project (Section 4.4.7.2 of the environmental impact assessment [EIA]) and assessing if further reclamation is warranted, based on inspection results. The OMS will be in effect once construction of the Structure is complete. Surveillance and maintenance of the Structure will be implemented every three months and after any period of unusual operations. During a site inspection, the upstream and downstream embankments, the Structure, adjacent slopes, the toe of the embankments, the Access Road, the channel section downstream of the Structure and the inundation area will be inspected. The OMS manual includes monitoring for:

- small slides or erosion scars on embankments and the Structure;
- erosional scars and gullies along the Access Road;
- damaging or obstructive vegetation (trees and large shrubs) along the Access Road and on the Structure;
- percent cover of grass on the Structure; percent cover of grass and shrubs in ditches along the Access Road; and
- undesirable vegetation including weeds that will invoke the use of control actions.

The Town of Canmore will use monitoring observations and data to inform maintenance and management decisions and activities.

Also, as indicated in Section 4.1.10 of the EIA, "The Town of Canmore will conduct a vegetation and soil survey of reclaimed areas to evaluate the success of reclamation practices. The need for additional reclamation monitoring and adaptive management practices will be evaluated based on the results of the survey." The monitoring of revegetation by a qualified environmental specialist will be conducted 2 years after reclamation and the need for additional environmental monitoring will be evaluated based on the results. This environmental monitoring will be in addition to the requirements outlined in the OMS manual.

Percent ground cover by grasses will be monitored the year following seeding and the Town of Canmore will develop a plan for reseeding bare areas, if any. Monitoring results will be used to inform development of reseeding plans for the reclaimed areas.

As part of adaptive management, the Town of Canmore has incorporated the learnings from experience with soil placement and revegetation on concrete articulated mats where the creek corridor was re-engineered into the reclamation strategy for the Structure.

b. Reclaimed islands will be interspersed in No Man's Land and will be placed to avoid creek flow channels and paths. Final placement of the islands will be determined in collaboration with Alberta Environment and Parks and will be based on a review of wildlife monitoring results and wildlife use in the area. The location of the Structure and the Access Road will be taken into consideration in placing the islands.

Once reclaimed and vegetated, the islands in No Man's Land will provide cover for wildlife and are expected to add habitat in areas that were disturbed by the 2013 flood. Once established, the vegetation on the reclaimed islands will provide cover from predators and habitat for potential foraging, nesting and resting by wildlife. It is also expected that the island patches will serve as seed sources for natural egress and revegetation around the islands, which will contribute more wildlife cover and support along-channel and across-channel wildlife routes. Please also refer to responses 108 and 122 for more information on the reclamation of No Man's Land.

111	**Volume 1, Section 4.9.2.2, Page 4-53** **Volume 1, Section 7, Page 7-27** a. Provide the timber harvest volumes for merchantable vs non-merchantable volumes. b. Provide details what is proposed with the timber salvage. c. Provide details what is proposed with the woody debris (chipped, firewood, mulch etc….) d. How will the Town of Canmore work with Agriculture and Forestry?

Response:

a. The Access Road and Structure footprint is 1.9 ha, of which 0.8 ha may contain merchantable timber. The remaining 1.1 ha is meadow and previously disturbed areas with no timber present. Merchantable timber harvest volume is estimated to be 138 m^3 (approximately four truckloads, assuming 40 m^3/truck). Merchantable timber will consist of coniferous trees including 47% white spruce, 37% Douglas-fir and 16% Lodgepole Pine. Non-merchantable timber is estimated to be 6 m^3 of deciduous trembling aspen.

b. If the Project is approved, Alberta Parks will issue a disposition to the Town of Canmore and will maintain jurisdiction over all activities within the Bow Valley Wildland Provincial Park (refer to the response to SIR 24). The Town of Canmore will harvest merchantable timber as directed by Alberta Parks. Town of Canmore will be conservative in tree removal for the Project and only remove trees as necessary for the construction and operation of the Project. No additional roads will be constructed for the purposes of tree removal and, if required, alternative methods for timber removal will be reviewed and approved by Alberta Parks (e.g., heli-logging). The Town of Canmore will develop a Timber Removal Plan and have it reviewed by Alberta Parks before construction. It is expected that timber management may include a combination of sale where appropriate, bucking timber into smaller pieces for alternate use and chipping small pieces for use onsite or disposal.

   Non-merchantable timber will be managed in accordance with Alberta Environment and Parks (AEP) direction (burning, disposal offsite, shredding and dispersing onsite, etc.), Alberta regulations (*Forest and Prairie Protection Act*, Parts 1 and 2, and Timber Management Regulation [A.R. 60/1973]) and current guidelines (*Management of Wood Chips on Public Land*; ASRD 2009).

c. Woody debris will be managed as directed by Alberta Parks and in accordance with existing regulations and guidelines (refer to the response to SIR 111b).

d. Alberta Agriculture and Forestry (AAF) has jurisdiction over the transport of timber products on public highways and roadways. While AEP will maintain ownership of any timber that is removed from the site, the Town of Canmore will be responsible for transport and will complete the necessary Forest Products Hauling Records (TM9 – within Province or TM9A for export outside of the Province). The Town of Canmore will contact AAF to confirm if there are any additional requirements.

References:

Alberta Sustainable Resource Development (ASRD). 2009. *Management of Wood Chips on Public Land.* External Directive. Industry Directive Number: ID 2009-01. Lands Division, Land Management Branch, Petroleum Land Use & Reclamation Section. Edmonton, Alberta. July 20, 2009. http://aep.alberta.ca/forms-maps-services/directives/documents/ID2009-01-ManageWoodChipsPublicLand-Directive-Jul09.pdf

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Volume 1, Section 4.9.2.2, Page 4-53
Volume 1, Section 7, Page 7-27

Within the EIA there is no linkage between the Town of Canmore working with Agriculture and Forestry (specifically or generally) for timber operations or required hauling forms and timber volumes.

a. How will the Town of Canmore manage timber resource within the road and project area in accordance with legislation?

b. Indicate where short-term storage of log decks and woody debris will occur.

c. Estimate timber volumes/weights for transport hauling forms.

d. Timber harvest operations and design (e.g. wind firmness in tree retention areas).

e. Where will the wood be transported? Is the Town of Canmore aware of export permits if transport is to occur “out of province”.

f. How will woody debris be managed and disposed? Based on the method of disposal are there any applicable permits/licenses required?

Response:

a. Refer to the responses to SIR 111b and SIR 111d.

b. Final locations of the log deck and woody debris stockpile will be chosen during construction planning and will be located on level or gently sloping and stable terrain paralleling the footprint of the Access Road if possible. Timber will be yarded to one log deck location, likely in No Man’s Land and closer to the Structure than to the Town of Canmore to minimize the visual impact. Large woody debris including stumps will be piled in one location in No Man’s Land until it is used in reclamation along the Access Road or as additions of woody debris on the reclaimed areas in No Man’s Land. Final locations will be chosen to minimize Project footprint, disturbance and visual impact. Restoration of the log decks and woody debris stockpile will be considered in discussions with Alberta Parks regarding reclamation activates.

c. Refer to the response to SIR 111a.

d. The Town of Canmore will review the *Alberta Timber Harvest Planning and Operating Ground Rules Framework for Renewal* (GoA 2016) for any applicable harvesting practices that can be incorporated into the Timber Removal Plan that will be reviewed and approved by Alberta Parks (Refer to the response to SIR 111). Considerations for wind firmness will include the regional wind regime, local topography and soil conditions. The Access Road is a small area and it is expected that wind firmness along the edges will be sufficient due to its winding configuration through the forested area. However, the Town of Canmore recognizes the potential for windthrow along the edges of the cleared Access Road and the new clearing for the Structure during very strong winds. If windthrow occurs at the Project, the Town of Canmore will clear deadfall as part of maintenance and surveillance activities (Application Section 4.4.7).

e. Refer to the response to SIR 111d.

f. Refer to the response to SIR 111c.

References:

Government of Alberta (GoA). 2016. *Alberta Timber Harvest Planning and Operating Ground Rules.* December 2016. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/formain15749/$FILE/TimberHarvestPlanning_OperatingGroundRulesFramework_Dec2016.pdf

113	**Volume 1, Section 4.1.6, Page 4-3** The Town of Canmore states *Reclamation materials will be sourced from a residential development in the Three Sisters area.* a. Provide physical and chemical data on the Three Sisters soil to ensure it is similar to soil near the proposed structure.

Response:

a. The physical data can be found in the letter from Thurber Engineering on the laboratory test results from Stewart Creek (Three Sisters) material (Appendix 113-1).

The chemical data can be found in the Exova soil analysis on the Stewart Creek (Three Sisters) material (Appendix 113-2).

114	**Volume 1, Section 4.9.5.1, Pages 4-56** **Volume 1, Section 4.9.5.1, Table 4.9-1, Page 4-57** a. Clarify material balances between salvaged soil at the site and the amount of soil that will come from Three Sisters (indicated in Section 4.1.6).

Response:

a. As indicated in the response to SIR 108b, 10 cm of topsoil will be applied over 5 cm of clay/silty clay soil over the upstream face of the Structure and the downstream spillway and stilling basin. Based on a topsoil salvage volume of 730 m^3 from the Structure footprint (Section 4.9.5.1 of the environmental impact assessment), this volume will supply a thickness of close to 6 cm of topsoil spread onto 11,830 m^2 of the Structure, excluding the intake and the Access Road on the Structure. Approximately 592 m^3 of clay/silty clay soil (11,830 m^2 × 0.05 m) and 474 m^3 (11,830 m^2 × 0.04 m) of topsoil will be sourced from the Three Sisters area for spreading on the Structure. The topsoil salvaged from the Access Road will be replaced along the Access Road (refer to the responses to SIR 108b and SIR 120a).

The total area of the conceptual reclamation in No Man's Land has yet to be determined since the number of islands, their placement, and their total surface area remains to be developed (refer to the responses to SIR 108, SIR 110b, and SIR 122). The Town of Canmore is therefore unable to provide the reclamation material balance for No Man's Land. Further planning of No Man's Land will be conducted with Alberta Environment and Parks and will be informed by additional an assessment of the wildlife monitoring results.

115	**Volume 1, Section 4.9.7.2, Page 4-60** a. Describe how the Town of Canmore would deal with soil erosion/reclamation of the inundation area should a maximum flood event occur.

Response:

a. The inundation area is within the Bow Valley Wildland Provincial Park and the Alberta Parks division of Alberta Environment and Parks will maintain jurisdiction over all activities within the park. Alberta Parks has indicated a preference to not make formal reclamation plans with the Town of Canmore for the inundation area before construction. Alberta Parks has indicated that any potential reclamation measures for the inundation area will be determined at the time of each flood event and in discussion with Alberta Parks staff. After a flood event, reclamation actions within the inundation area may be considered for public safety reasons only.

116	**Volume 1, Section 5.2.3, Page 5-4** The Town of Canmore states *the Project can be initially divided into three stages: construction, operation, and reclamation.* a. Will the Project go through the reclamation stage after operation stage? If so, it sounds like the project decommission or closure. Clarify. b. Based on the description in Table 4.4.1, this reclamation is only “Grading, shaping and vegetation planting in selected areas between the Structure and the articulated concrete mats”. Should the proper sequence be construction, reclamation, and operation? Explain why or why not.

Response:

a. Reclamation of areas disturbed during construction, the Access Road, and the upstream and downstream faces of the Structure will occur after the construction phase. The Project will be permanent and decommissioning is not proposed; therefore, post-operations reclamation is not planned.

b. The proper sequence for the Project is construction, reclamation, and operation since the Structure will be permanent and remain in operation indefinitely. The reclamation described in Section 5 will mainly occur before operation and might extend into the early part of the operation stage.

6.3 Terrain and Soils

117	**Volume 1, Section 4.1.6, Figure 4.1-2, Page 4-3** The Town of Canmore states aggregate for fill will be imported from operators and residential developments. a. Provide a Soil Importation Strategy for insuring weed/contaminant free fill or aggregate. b. Provide a strategy and sketch plan for the placement and storage of soil.

Response:

a. The Town of Canmore will obtain and review the results of weed seed analysis and analyses of soil reaction (pH), salinity (electrical conductivity, soluble main cations and sodium adsorption ratio), texture and petroleum hydrocarbons before importing topsoil to the Project. For fill that will be imported, the Town of Canmore will obtain and review the results of salinity (electrical conductivity, soluble main cations and sodium adsorption ratio), texture and petroleum hydrocarbons before importing the fill. Soil or fill with analytical results that do not comply with *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* (AEP 2016) will not be imported. Assessment of weed seed content is presented in the response to SIR 109a.

   Aggregate will be visually inspected for potential contaminants before it is imported for use on the Project.

b. Topsoil salvaged from areas other than the Access Road will be stored during construction in two soil stockpile areas as indicated in Sections 4.1.6, 4.4.5, 4.9.2.3, and 4.9.5 of the environmental impact assessment (EIA). The stockpile areas presented on Figure 4.1-2 of the EIA are still the areas planned for stockpiling salvaged soil; however, soil may be stored offsite within the Town of Canmore if additional storage area is required. As indicated in the response to SIR 108b, topsoil from the Access Road will be windrowed to the edge of the RoW during construction and will be spread in the ditches and the edge of the RoW where topsoil was stripped after the road is constructed. Where topsoil is stripped and replaced along the Access Road, the Town of Canmore will plant native grasses and transplant the forbs and shrubs collected before construction commenced (refer to the responses to SIR 120a and SIR 120b).

   For additional protection from erosion, erosion matting will be placed on topsoil stockpiles, but not on the topsoil windrow along the Access Road where it is more sheltered from potential strong winds.

References:

Alberta Environment and Parks (AEP). 2016. *Alberta Tier 1 Soil and Groundwater Remediation Guidelines*. Land Policy Branch, Policy and Planning Division. Edmonton, Alberta. Effective February 2, 2016. http://aep.alberta.ca/lands-forests/land-industrial/inspections-and-compliance/documents/AlbertaTier1Guidelines-Feb02-2016A.pdf

118	**Volume 1, Section 4.4.7.4, Page 4-33** The Town of Canmore states aggregate and debris will be removed from behind the dam structure as post flood maintenance. a. The extraction of aggregate from a water course is normally covered under a Surface Materials Lease (SML). This resource within a water body is considered non-transferable in terms of ownership. How will this be managed within the Park? b. Explain how the aggregate will be handled and utilized.

Response:

a. As described in the response to SIR 24, Alberta Environment and Parks (AEP) has confirmed that if the Project is approved, Alberta Parks will issue a disposition to the Town of Canmore and will maintain jurisdiction over all activities within the Bow Valley Wildland Provincial Park. AEP considers material that may build up in the inundation area or downstream of the Structure to be debris that will have no value as an aggregate material. This alluvial material (debris) is unsorted, containing small and large rocks as well as woody debris. As a requirement of the AEP disposition the Town of Canmore will be required to maintain the Structure, which will include the removal of debris accumulated after flood events.

b. After a flood event, the Town of Canmore will remove debris from within the inundation area and downstream of the Structure as part of their operations and maintenance program. The Town of Canmore will hire a contractor through a tender process to remove and dispose of the debris.

119	**Volume 1, Section 7.4.2.4, Page 7-22** Filling of the inundation area to test the dam has not been accounted for in this EIA. a. What impacts to vegetation, terrain and soil quantity within the inundation area will be expected as a result of testing of the dam post-construction? b. Have the potential effects of testing (filling inundation area) on vegetation, terrain, and soil quantity been evaluated? If so, provide to the section of the EIA report that provides this information. Provide the rationale if the potential effects of testing have not been evaluated.

Response:

a. Two supplementary information packages were sent to Alberta Environment and Parks, before receipt of the first round of supplemental information requests, that discuss changes to the test storage plan. The current test storage proposal is:

- a test storage of 10 m above the inlet structure is still required;
- the test will be performed in the summer to minimize impact during growing season;
- the test should last one full day at 10 m height, instead of ten days as originally proposed;
- the total duration of the test storage is estimated to take 54 hours including filling and draw down; and
- at 10 m above the inlet structure, water in the inundation area will affect no more than 0.27 ha of vegetation (see figures in Appendix 169-1).

Impacts to Terrain

As was indicted in the environmental impact assessment (EIA), no direct or indirect effects to the montane or creek bed terrain in the inundation area are expected from a flood event resulting in the maximum extent of inundation (Section 7.4.2.4). Compared to the maximum inundation water depth of 29.9 m, testing water depth is targeted to be one third of the maximum, or 10 m. No direct or indirect effects to the montane or creek bed terrain are predicted during the storage testing. The environmental consequence rating of the testing on terrain in the inundation area is rated as no impact, with a medium prediction confidence.

Impacts to Soil

The extent of the Ishbel soil series that will be inundated and waterlogged during post-construction testing is no greater than 0.27 ha. Nearly all of the area of the Ishbel soil series that will be inundated is under a cover of native vegetation. Any soil erosion that may occur during the release of water at the end of the inundation test, at an average outflow of 2.5 m^3/s, has not been modelled. However, the majority of the Ishbel soil under vegetation cover is expected to remain in situ during testing. The roots of trees, shrubs and herbaceous vegetation will protect topsoil from erosion given the controlled, low outflow rate. Consequently, no measurable quantity of soil is expected to erode and be carried downstream. The side slopes of the canyon will dry up quickly once the water has receded and waterlogging will not persist because the slopes will allow rapid soil drainage. A larger area of non-soil fluvial deposits will also be under water during testing, but no soil loss will occur from this area since no soil has developed. The effect on soil from the controlled storage test will be neutral, local, short-term, isolated in occurrence, negligible in magnitude and reversible. The effect is reversible because the soil will drain and dry soon after the water is removed, soil loss will not be quantifiable, and soil forming processes will resume. The prediction confidence is medium and the environmental consequence is considered to be negligible.

Impacts to Vegetation

The maximum extent of the baseline native vegetation that will be inundated during testing is 0.27 ha. The storage test should last one full day at 10 m height above the inlet. Although the inundation interval will be a stress, the vegetation will remain in place during the controlled and monitored test.

Based on a review of literature, the impact to vegetation can be minimized by:

- ensuring that the testing is not done at the beginning of the growing season;
- keeping the test duration to a minimum; and
- draining the water in a controlled manner as quickly as possible once the test is completed.

The dominant tree species in Cougar Creek is white spruce, with some lodgepole pine, aspen and balsam poplar. Moderate, short-term flood tolerance of lodgepole pine is likely attributed to the production of large, gas-filled cavities in inundated roots and the ability to actively transport oxygen to submerged root tips in these cavities (Bassman 1985). Lodgepole pine is considered to be more tolerant of flooding and shallow water tables than white spruce, although the latter is not intolerant of short-tern flooding. Productive white spruce stands occur on floodplains where periodic flooding enriches the soil with nutrients (Dyrness 1980). Aspen and balsam poplar trees have tolerance to short-term inundation.

Flooding during the active growing season is typically more harmful to trees compared to flooding during dormant periods, and the longer the trees are impounded, the greater the potential for negative effects (Iles and Gleason 2008). Accordingly, the test will done later in the summer season or in the fall, and its duration has been reduced significantly.

Lower branches that are submerged could die back after a few days of impoundment; however, the test will only occur over one day and no or little damage is expected to occur. Notwithstanding, if any branches were to die back after inundation, the trees and shrub species are expected to resume growth and physiological function after the water is released. In the understory, the effect of inundation will vary by species based on growth habit and tolerance to flooding. Moderately flood tolerant shrubs, such as alders and willows, will recover after test storage inundation. For herbaceous species with flood tolerance of a few days, plant function and tissue growth will resume. For shrubs and herbaceous species with no or limited tolerance to flooding, new growth will be from the soil seed bank or roots that survived.

Based on the review of literature, minimal long-term effects to vegetation are predicted from inundation during the short-term storage test. The effect on vegetation from the controlled storage test will be a negative, local, short-term, isolated occurrence, low in magnitude and reversible in the short-term. The prediction confidence is medium and the environmental consequence is considered to be negligible.

b. The potential effects of inundation from post-construction storage testing on vegetation, terrain, and soils were not evaluated in the EIA because a maximum inundation event was assessed as the most conservative effects assessment scenario. The storage test does not change the conclusions of the assessment of effects on vegetation, terrain and soils.

   The potential impacts of a maximum inundation on vegetation, terrain, and soil after construction of the Structure were assessed. The effects of a maximum inundation event were assessed because this event represented conditions of maximum impact and invoked the most conservative terrain, soils and vegetation effects assessment. An assessment of the indirect effects of a maximum inundation on terrain and soils is presented in EIA Section 7.4.2.4, and an assessment of indirect effects on native vegetation and weeds is presented in EIA Section 7.4.3.4, and are not repeated here.

References:

Bassman J.H. 1985. “Selected Physiological Characteristics of Lodgepole Pine.” In: *Lodgepole Pine: The Species and Its Management.* Baumgartner D.M. et al. (Eds.). Symposium proceedings. May 8-10, 1984, Spokane, WA and May 14-16, 1984, Vancouver, British Columbia.

Dyrness C.T. 1980. “White Spruce.” In: *Forest Cover Types of the United States and Canada.* Eyre F.H. (Ed.) Washington, DC: Society of American Foresters: 81 [50012].

Iles J. and M. Gleason. 2008. *Understanding the Effects of Flooding on Trees.* Iowa State University. Revised June 2008.

6.4 Vegetation

120	**Volume 1, Section 4.9.5.2, Page 4-57**
	Provide more details on soil handling procedures and vegetation management regarding re-vegetation of the access road which address the following:
	a. Vegetation strategies.
	b. Seed mixes and seed certs.
	c. Best soil and vegetation management practices.
	d. Erosion control methods (specific details not conceptual ideas).

Response:

a. The desired vegetation for the Access Road ditches and edges will include native herbaceous and short stature shrub species, to provide erosion protection to soil and cover for small wildlife (refer to the response to SIR 108a). Before construction commences, Aboriginal stakeholders will be provided an opportunity to collect/harvest plants and bryophytes on the Project footprint. Following that harvest, Parks Division of Alberta Environment and Parks (AEP) and the Town of Canmore will collect native species (e.g., mountain avens [*Dryas* spp.]) for use in reclamation. Plant collection will include roots and some soil material from the Project site and plants will be relocated to moist areas where conditions will support their survival until they are used for reclamation.

Where topsoil is stripped and replaced in ditches, the Town of Canmore will plant native grasses (refer to the response to SIR 120b). The Town of Canmore will transplant the forbs and shrubs collected before construction commenced. The Parks Division of AEP will provide permits to harvest native plants for reclamation. If additional shrubs are required, short stature shrubs (Table 120-1) will be planted on the Access Road ditches in areas where shrubs are common in adjacent undisturbed areas. Trees and tall shrubs will not be planted to avoid impeding visibility of large wildlife and to reduce maintenance efforts that would be required to clear downed trees or large shrubs growing on the Access Road shoulder during the Project operation phase.

Table 120-1 Candidate Shrub Species for Planting

Botanical Name	Common Name	Condition/ Container Size	Height (Ht.)/ Spread (Sp.)/ Caliper (Cal.)	General Spacing (m)	Planting Recommendation (grouping size)
Evergreen Shrubs					
Juniperus communis	Common Juniper	#3 Container	450 mm Sp.	1	3 to 10
Juniperus horizontalis	Creeping Juniper	#1 Container	300 mm Sp.	1	3 to 10
Deciduous Shrubs					
Potentilia fruiticosa	Shrubby Cinquefoil	#2 Container	300 mm Sp.	0.5	10 to 20
Rosa acicularis	Prickly Rose	#1 Container	450 mm Sp.	1	3 to 5

Botanical Name	Common Name	Condition/ Container Size	Height (Ht.)/ Spread (Sp.)/ Caliper (Cal.)	General Spacing (m)	Planting Recommendation (grouping size)
Spiraea betulifolia	White Meadowsweet	#2 Container	450 mm Sp.	0.5	10 to 20
Symphoricarpos albus	Common Snowberry	#2 Container	450 mm Sp.	1.5	10 to 20

b. The native grasses proposed for planting (Table 120-2) include species with roots that provide protection to soil from erosion and exclude plant species that are bear attractants.

Table 120-2 Proposed Grass Seed Mixture for the Access Road

Botanical Name	Common Name	Proportion by PLS*
Bromus ciliatus or Bromus anomalus	Fringed or Nodding brome	12%
Calamovilfa longifolia	Sand reed grass	13%
Elymus trachycaulus ssp. subsecundus	Awned wheatgrass	14%
Elymus lanceolatus ssp. lanceolatus	Northern wheatgrass	6%
Elymus glaucus	Smooth wild rye	10%
Festuca saximontana	Rocky Mountain fescue	10%
Koeleria macrantha	June grass	10%
Leymus innovatus	Hairy wild rye	10%
Poa alpina or Poa secunda ssp. sandbergii	Alpine or Sandberg's bluegrass	10%
Poa glauca	Glaucous bluegrass	5%
	Total	**100%**

*PLS – Pure live seed

The seed mix will be finalized a few months before reclamation activities begin at Cougar Creek. The mix will be informed by the monitoring of land reclamation underway on the lower reach of Cougar Creek, and the latest information available from consultants, suppliers and AEP. Inclusion of species will be subject to availability of seed of acceptable quality and purity. The Town of Canmore will review seed certificates of different seed lots to understand quality and avoid seed lots that contain prohibited noxious and/or primary noxious weed seeds, as defined by in the *Weed Seeds Order, 2016* (SOR/2016-93), under the *Canada Seeds Act*.

c. Best management practices (BMPs) for soil are presented in the responses to SIR 108b and SIR 109a to SIR 109c. Vegetation BMPs include seeding, planting and transplanting native plant species that are compatible with the pre-disturbance conditions and the surroundings, while managing the vegetation consistent with the revegetation strategies presented in the response to SIR 108a. Another vegetation BMP is regular monitoring for weeds and the timely implementation of weed control measures. Weed control was presented in Section 4.9.5.6 of the environmental impact assessment.

d. Erosion control methods for the ditches along the Access Road will vary according to slope gradients (Table 120-3).

Table 120-3 Erosion Control Methods for the Access Road Ditches

Slope Percent	Options for Erosion Control
0 to 5	• grass mix applied with tackifier; spread woody debris (slash) along ditches; a thin application of hydromulch may be applied • plant short stature shrubs
5 to 10	• grass mix hydroseeded with a hydromulch; spread coarse woody debris along ditches • install straw wattle logs on slope lengths > 25 m; plant short stature shrubs
10 to 20	• where topsoil will be replaced in ditches, hydroseed the grass mix with a hydromulch; spread coarse woody debris along ditches • install erosion matting and straw wattle logs • place small riprap check dams to reduce flow velocity
Greater than 20	• where topsoil will be replaced in ditches, hydroseed the grass mix with a hydromulch • install erosion matting and add riprap check dams to reduce flow velocity • install rock bolts and high performance mesh in exposed rock faces, where required for slope stabilization

121	**Volume 1, Section 4.9.5.3, Page 4-57** Provide more details on soil handling procedures and vegetation management regarding revegetation of the structure which address the following: a. Vegetation strategies. b. Seed mixes and seed certs. c. Best soil and vegetation management practices. d. Erosion control methods (specific details not conceptual ideas).

Response:

a. As indicated in the response to SIR 108a, the vegetation desired for the Structure, excluding the intake, the piers and baffles of the spillway, and the road surfaces, will be a low maintenance cover of grasses. Grasses will be hydroseeded, with a tacking agent and a hydromulch product developed to reduce evaporation and retain soil moisture, help control erosion, suppress weeds and add nutrients to the soil.

   Tree and shrub species will not be planted to avoid effects of their roots on integrity of the Structure. The Town of Canmore will cut back any large brushes or trees establishing on the Structure as part of the maintenance plan.

b. The proposed seed blend of grasses presented in the response to SIR 120b will also be used to establish the vegetation on the Structure. Finalization of the seed blend and the review of seed certificates will be the same as is presented in the response to SIR 120b.

c. Best management practices (BMPs) for soil are presented in the responses to SIR 108b and SIR 109. Vegetation BMPs include seeding native plant species that are compatible with the surroundings, while managing the vegetation consistent with the revegetation strategy presented in 108a. Another BMP for vegetation is regular monitoring for weeds and the timely implementation of weed control measures. Weed control practices were presented in Application Section 4.9.5.6.

d. Apart from the materials integral to the engineered design of the Structure (Application Section 4.4), the low maintenance vegetative cover, after it is established, will provide erosion control. As indicated in the response to part a) above, grass seed will be hydroseeded using a tackifier and a hydromulch to control erosion until the grasses are established. Following seeding, erosion control matting (coconut fibre preferred) will also be installed on the downstream and upstream embankments. There will be no erosion matting in the stilling basin. Monitoring for signs of erosion and maintenance of the Structure is described in the response to SIR 110.

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Volume 1, Section 4.9.5.4, Page 4-56
Volume 1, Section 4.9.5.4, Page 4-57

The Town of Canmore states No Man's Land is not part of the structure project, however, including the lands within the project scope and future planning qualifies the lands as a part of the structure project. TOC proposes many conceptual measures to be in place for No Man's Land.

Provide more details on soil handling procedures and vegetation management regarding revegetation of No Man's Land which addresses the following:

a. Vegetation strategies.

b. Seed mixes and seed certs.

c. Imported soils to create islands. (not sure what objective this represents)

d. Erosion control methods (specific not conceptual).

Vegetation strategy - Provide more details referring to the wildlife corridor which addresses:

a. Explain through maps/sketches where trees, shrubs, forbs, grasses for cover, habitat, forage etc. will be located. Explain how these objectives will be achieved.

b. Explain erosion concepts and application.

c. Explain vegetation maintenance and monitoring program.

d. Explain weed program (contract/timing etc….)

Response:

Soil Handling Procedures and Vegetation Management Regarding Revegetation

a1. As described in the response to SIR 108, the conceptual reclamation proposed for No Man's Land will involve planting native herbaceous and shrubby vegetation after de-compaction of patches or islands and the addition of topsoil. Parks Division of Alberta Environment and Parks (AEP) and the Town of Canmore will collect native species (e.g., mountain avens [*Dryas* spp.]) for use in reclamation. Plant collection will include roots and some soil material from the Project site and plants will be relocated to moist areas where conditions will support their survival until they are used for reclamation.

After topsoil is added and spread in the islands, available stones and coarse woody material will be added to create microsites, retain soil moisture and aid in the establishment of vegetation (Vinge and Pyper 2012). The islands will then be seeded with native grasses. The native species proposed for planting and seeding include ones with roots that provide some protection to soil from erosion and exclude species that are bear attractants.

After the native grasses are initially established in No Man's Land, the native plants collected before the start of reclamation (e.g., mountain avens) will be transplanted on the islands and additional shrubs will be planted. The purpose of planting shrubs is to increase the diversity of vegetation and supplement erosion protection. The chosen timing of planting will take into consideration the best chance of success for the planted species.

The Town of Canmore will consider transplanting (spading in) shrubs collected from adjacent areas in lieu of ordering and planting individual species. Willow cuttings will be collected in the fall from areas as close to the Project site as possible. The Parks Division of AEP will provide permits to harvest willows and other plants for reclamation of the Project and the patches in No Man's Land, and may assist in plant collection. In total the vegetated islands may comprise approximately 5% to 8% of the surface area of No Man's Land.

If planting of seedlings from seed stock is chosen to add a diversity of shrubs, seedlings for the Alberta Montane seed zone M-4.3 will be ordered for planting the following spring. Candidate species of shrubs that will be considered for planting are presented in Table 122-1. Shrubs that produce fruit (berries) preferred by bears will not be planted.

Table 122-1 Shrub Candidate Species for Planting in No Man's Land

Botanical Name	Common Name	Condition/ Container Size	Height (Ht.)/ Spread (Sp.)/ Caliper (Cal.)	General Spacing (m)	Planting Recommendation (grouping size)
Evergreen Shrubs					
Juniperus communis	Common Juniper	#3 Container	450 mm Sp.	1	3 to 10
Juniperus horizontalis	Creeping Juniper	#1 Container	300 mm Sp.	1	3 to 10
Deciduous Shrubs					
Elaeagnus commutata	Wolf Willow	#2 Container	450 mm Sp.	2	1 to 3
Salix Bebbiana	Bebb's Willow	#2 Container	450 mm Sp.	1.5	1 to 3
Potentilia fruiticosa	Shrubby Cinquefoil	#2 Container	300 mm Sp.	0.5	10 to 20
Rosa acicularis	Prickly Rose	#1 Container	450 mm Sp.	1	3 to 5
Spiraea betulifolia	White Meadowsweet	#2 Container	450 mm Sp.	0.5	10 to 20
Symphoricarpos albus	Common Snowberry	#2 Container	450 mm Sp.	1.5	10 to 20

b1. The native species proposed for planting (Table 122-2) include species with roots that provide some protection to soil from erosion and exclude species that are bear attractants.

Table 122-2 Proposed Grass Seed Mixture for No Man's Land

Botanical Name	Common Name	Proportion by PLS*
Bromus ciliatus or Bromus anomalus	Fringed or Nodding brome	12%
Calamovilfa longifolia	Sand reed grass	13%
Elymus trachycaulus ssp. subsecundus	Awned wheatgrass	14%
Elymus lanceolatus ssp. lanceolatus	Northern wheatgrass;	6%
Elymus glaucus	Smooth wild rye	10%
Festuca saximontana	Rocky Mountain fescue	10%
Koeleria macrantha	June grass	10%
Leymus innovatus	Hairy wild rye	10%
Poa alpina or Poa secunda ssp. sandbergii	Alpine or Sandberg's bluegrass	10%
Poa glauca	Glaucous bluegrass	5%
	Total	100%

*PLS – Pure live seed

The seed mix will be finalized a few months before reclamation begins at Cougar Creek. The mix will be informed by the monitoring of reclamation underway on the lower reach of Cougar Creek, and the latest information available from consultants, suppliers and AEP. Inclusion of species will be subject to the availability of seed of acceptable quality and purity. The Town of Canmore will review the seed certificates to understand quality and avoid seed that contain prohibited noxious or primary noxious weed seeds, as defined by in the *Weed Seeds Order, 2016* (SOR/2016-93), under the *Canada Seeds Act*.

c1. As indicated in the responses to SIR 108 and SIR 110, the objective of reclamation in No Man's Land is the creation of an aesthetically pleasing environment while adding low maintenance cover for wildlife use. The islands will be teardrop-shaped, 5 m wide by 7 m long on average but variable in size and conceptually presented on Figure 108-1. The Town of Canmore is currently unable to quantify the management of imported soil because the number and actual dimensions of all of the islands remain to be determined. Final placement of the islands will be decided by the Town of Canmore and the Parks Division of AEP after the results from the wildlife monitoring are reviewed and understood. The islands will be placed to not interfere with creek hydrology or flow paths.

Topsoil imported from the Three Sisters development will be applied to a depth of 20 cm to 30 cm within the islands. Imported topsoil in the islands will improve the medium for establishing native plants compared to the gravel and sand prevalent at ground surface. Gravel is a poor rooting medium with very few plant nutrients. The topsoil to be imported will be screened for quality parameters (refer to the response to SIR 117) and weed seed content (refer to the response to SIR 109a).

Once established, the vegetation will provide cover from predators and habitat for potential foraging, nesting and resting by wildlife. It is also expected that the islands will serve as seed sources for natural egress and revegetation around the islands, which will contribute more wildlife cover and support along-channel and across-channel wildlife routes.

d1. As indicated in the response to SIR 108, boulders/large stones obtained from within No Man's Land will be added and incorporated into the islands, particularly on the upstream side, to improve stability of the islands. After topsoil is added and spread in the islands, available large stones and coarse woody material will be added to create microsites, retain soil moisture and add erosion control.

The islands will then be seeded with native grasses, which include species with roots that provide some protection to soil from erosion. The grass seed will be applied onto the islands either by broadcasting or hydroseeding with a tackifier. The grass seed will be applied at the rate of 30 kg/ha to 35 kg/ha to enhance their establishment and subsequently provide erosion control. A hydromulch product may also be applied to reduce evaporation and retain soil moisture, suppress weeds, provide erosion control and add nutrients to the soil to enhance vegetation establishment.

After the native grasses are initially established, the native plants collected before the start of construction will be transplanted on the islands and additional shrubs will be planted. The purpose of planting shrubs, including willows, is to increase the diversity of vegetation and supplement erosion protection.

Vegetation Strategy - Referring to the Wildlife Corridor

a2. The wildlife corridor (Figure 7.2-1 of the environmental impact assessment [EIA]) overlaps approximately four fifths of the Project footprint and the vegetation strategies presented in previous supplemental information request (SIR) responses also apply to the corridor. Grasses will be seeded in reclamation areas, where topsoil will be spread, along the Access Road (refer to the responses to SIR 108a and SIR 120), on the Structure (refer to the responses to SIR 108a and SIR 121) and the reclaimed islands in No Man's Land (refer to the responses to SIR 108a and SIR 110b). As indicated in the responses to SIR 120a and SIR 122a, shrubs will be planted along The Access Road ditches and on the reclaimed patches in No Man's Land. The cover on the Structure, and the grasses with shrubs along the Access Road ditches and on the reclaimed patches in No Man's Land, will provide cover and habitat for wildlife (refer to the response to SIR 110b).

b2. The erosion mitigations described in Section 4.9.2 of the EIA for the Project are all applicable to the wildlife corridor. The more specific erosion control measures described in the responses to SIR 42, SIR 120d, SIR 121d, and SIR 122d1 are also applicable to the wildlife corridor. No additional erosion control measure will be implemented in the wildlife corridor.

c2. As indicated in the response to SIR 110a, the Town of Canmore has developed an Operation, Maintenance and Surveillance manual for the Project (Section 4.4.7.2 of the EIA). The Town of Canmore will use monitoring observations to inform maintenance/ management decisions and activities. Vegetation monitoring and maintenance will mainly consist of:

- inspecting reclaimed areas for percent vegetation cover;
- reseeding/replanting sparsely vegetated or bare areas and raking the seed into topsoil;
- monitoring for weeds, especially prohibited noxious and noxious weeds; and
- controlling weeds using manual, mechanical and chemical means, as appropriate for the weed type and degree of infestation.

d2. Weed control measures will be informed by monitoring (refer to the responses to SIR 110a and SIR 122c2) and undertaken on an as needed basis. If a prohibited noxious weed (or weeds) is encountered, the Town of Canmore will consult with weed control specialists and AEP on eradication of the weed(s).

In addition to the weed control measures in Section 4.9.5.6 of the EIA, the Town of Canmore will consider the use of the following control measures:

- pulling and disposal of noxious weeds such as scentless chamomile and white cockle;
- extracting scattered individual shoots and roots of Canada thistle and perennial sow thistle with a narrow spade; and
- where other means of weed control are not feasible, contracting a licensed pesticide applicator to apply approved herbicides in accordance with manufacturer label instructions after review and approval by Alberta Parks.

References:

Vinge T. and M. Pyper. 2012. *Managing Woody Materials on Industrial Sites: Meeting Economic, Ecological and Forest Health Goals through a Collaborative Approach*. Department of Renewable Resources. University of Alberta. Edmonton, Alberta. 32 pp.

123	**Volume 1, Section 4.9.5.6, Page 4-59** a. Will qualified inspectors/ environmental monitors be used to ensure mitigation measures such as equipment cleaning and reclamation procedures are followed? b. How will the Town of Canmore ensure the use of organic matter (i.e. straw) will be weed free?

Response:

a. The Town of Canmore will have a qualified environmental monitor to ensure that mitigation measures are followed, including confirmation that equipment is clean and that reclamation procedures are followed.

b. Weed free coconut fibre will be the preferred erosion mat fibre material used for the Project. If the Town of Canmore uses an agronomic source of straw for some erosion control, only straw certified weed free (i.e., free of noxious and prohibited noxious weeds; AAF 2012) will be used.

References:

Alberta Agriculture and Forestry (AAF). 2012. *Alberta Certified Weed Free Hay Program*. Revised on May 23, 2012. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/prm1325/$file/weed_free_hay.pdf?OpenElement

124 **Volume 1, Section 7, Page 7-47**
Volume 1, Section 7, Page 7-48

The Town of Canmore states, *of the eight rare plants observed during the field surveys, two were identified within the project footprint.*

a. Provide mitigation plans for re-location or replacement for:
  - Ramalina sinensis (Lichen within the access area) and
  - Braya humilis (Forb within the inundation area) OR

b. If it is the intention of the TOC to not re-locate or replace the rare plants, provide rational why no effort would be considered.

Response:

a. *Ramalina sinensis* is an S3/G4G5 Tracked/Sensitive lichen, which was observed within the access area. Due to the relatively high nature of the species ranking (S3/G4G5) and the historic under sampling of lichens in Alberta, re-location is not recommended or practical. Given the abundance of similar habitat in adjacent areas, it is expected that this species is well distributed in the area.

Braya humilis is an S3/G5/May be at Risk; observed within the inundation area. Successful translocation of rare species can be difficult with unpredictable results, and with the isolated frequency of disturbance in the inundation area, mitigation is not recommended. *Braya humilis* is found in flood plains (disturbed sites) suggesting flood disturbance may assist with dispersal of seeds (Aiken et al. 2007).

An electronic Alberta Conservation Information Management System form will be submitted for rare plant observations to add to the provincial tracking database.

b. Refer to the response to part a) above.

References:

Aiken S.G. et al. 2007. *Flora of the Canadian Arctic Archipelago: Descriptions, Illustrations, Identification, and Information Retrieval.* NRC Research Press, National Research Council of Canada. http://nature.ca/aaflora/data.

125 **Volume 1, Section 3.3.2, Page 3-6**

The Project will have no impact on wetlands, riparian communities, or old growth forests. Project impacts on all other vegetation indicators are predicted to have final environmental consequence ratings of negligible or low.

a. Advise of any impacts outside of the Project i.e. downstream on the Bow River.

b. If the deposition of debris and aggregate contribute to healthy riparian zones in river systems, what is the extent of the impact on the Bow River when removing contributing material from Cougar Creek.

Response:

a. No additional impacts on wetlands, riparian communities or old growth forests are expected outside of the Project area (i.e., downstream on the Bow River).

b. No riparian communities were identified during field surveys along Cougar Creek. The lack of riparian communities adjacent to the creek is likely due to surface hydrology, rapid drainage, and the absence of soil; with the creek bed and adjacent natural vegetation disturbance consisting of unconsolidated non-soil (fluvial) material. Increasing elevation adjacent to the creek bed also limits vegetation access to subsurface water flow, constraining the development of riparian communities.

The same amount of water will continue to flow through the system. The deposition of debris and sediment will continue to occur as per the current situation. As described in the response to SIR 93, the Structure is not expected to impact debris and sediment transport to the Bow River compared to the baseline case (debris net in place). Therefore, there will be no impacts to sediment related aquatic environment considerations in the Bow River as a result of the Structure.

126	**Volume 1, Section 4.9.2.2, Page 4-53** With reference to the following statement, *preferentially conducting vegetation clearing outside of sensitive wildlife periods including:…* Tree clearing is not permitted within the migratory bird window under the *Migratory Bird Act.* a. Is the Town of Canmore aligning with the *Migratory Bird Act* and Alberta Environment and Parks policy by planning tree clearing activities outside the migratory bird window? If not explain why.

Response:

a. The Town of Canmore is committed to conducting clearing outside of the sensitive wildlife periods mentioned and will only conduct clearing within the sensitive wildlife periods if it is deemed necessary for completion of the Project (also refer to the response to SIR 130). Government bodies will be contacted if there is potential to violate the *Migratory Bird Convention Act*. Extending the period of construction, to avoid sensitive wildlife periods may have more impact on wildlife than completing small amounts of clearing within sensitive wildlife periods. A nest sweep survey will be conducted before any clearing that is deemed necessary. If evidence of breeding or nesting is found during nest surveys, construction will stop and the Town of Canmore will abide with setback distances as recommended through consultation with Environment and Climate Change Canada and AEP. Construction and clearing activity will resume when the nest is deemed inactive by subsequent nest surveys.

6.5 Wildlife

127	**Volume 1, Section 7.4.1.4, Page 7-18** The Town of Canmore states *conducting a den site investigation on the proposed footprint areas before initiating winter season clearing between November and mid-April* will occur to mitigate for the bear den found within the local study area (LSA) (as noted on page 7-57) and other dens/burrows that may be within the footprint. a. Describe what actions will occur if any den or burrow is found to be active during the site investigation.

Response:

a. The Town of Canmore will follow legislation and guidelines set out to protect wildlife including the *Wildlife Act* and the *Integrated Standards and Guidelines, Enhanced Approval Process (EAP)* (ESRD 2013). While the *Integrated Standards and Guidelines* are specifically directed toward conventional oil and gas development, the guidelines represent best practices in the province and the Town of Canmore will follow them where they apply. As there is no provincial grizzly bear zone within the local study area, Project activity will not be restricted by Alberta grizzly bear zone standards and best management practices. Active bear dens found during den site investigations will be reported to Alberta Environment and Parks (AEP) and the Town of Canmore will work with AEP to decide on the most appropriate course of action. Appropriate mitigation could include setbacks from active dens from October 1 through April 30 by 200 m, 500 m, or 750 m depending on the level of disturbance (i.e., low medium or high as defined in ESRD 2013) as well as local site conditions. If an active den is found, construction will not go forward without written permission from the Minister as per the conditions in the Alberta *Wildlife Act*.

References:

Alberta Environment and Sustainable Resource Development (ESRD). 2013. *Integrated Standards and Guidelines, Enhanced Approval Process (EAP)*. Revised December 1, 2013. http://aep.alberta.ca/forms-maps-services/enhanced-approval-process/eap-manuals-guides/documents/EAP-IntegratedStandardsGuide-Dec01-2013.pdf

128	**Volume 1, Section 7.4.4.3, Page 7-55** The Town of Canmore states they *will adhere to Bear Smart behaviours to reduce human-bear interactions.* Bear Smart behaviours include a wide range of actions, some of which are not relevant to the project. a. Describe the Bear Smart actions that will be employed throughout the project duration, include a discussion regarding the on-site lunch shelter for the workers.

Response:

a. The Town of Canmore will follow BearSmart behaviours outlined for industrial use (GoA 2011) with consideration for the proximity to Canmore, presence of nearby Fish and Wildlife officers and a lack of need for a permanent camp. This level of behaviours should allow the Town of Canmore to be compliant with Alberta Occupation Health and Safety as well as the Alberta *Wildlife Act*. The Town of Canmore's objectives are to reduce conflicts with bears and other wildlife, thereby reducing the risk of injury or death to human and bear, reducing damage caused by bears, and the need for bear relocations. The Town of Canmore and any contractors onsite will employ the following BearSmart behaviours:

- Ensure bear response plans are in place.

- Report all bear encounters promptly to the site supervisor, Kananaskis Country Emergency Services and the local Fish and Wildlife office by calling 310-0000. In an emergency situation, workers should call the Report a Poacher line at 1-800-642-3800.

- Trained personnel will use appropriate deterrents to keep bears away including air horns, bear bangers and screamers, and bear spray. If additional deterrents are necessary, that action will be discussed with local Fish and Wildlife and likely left to the local Fish and Wildlife officer to deal with properly.

- Manage attractants:
    - using Bear-proof containers and promptly removing garbage from the work site;
    - minimizing odours (e.g., plastic garbage bags, tight-fitting lids, reducing odours on garbage cans and washing often);
    - not leaving food unattended in an unenclosed area; and
    - chemical storage containers will be stored in enclosed and secure areas. Containers will be checked for leaks and spills weekly.

Given the proximity to the Town of Canmore and the existing level of wildlife habituation to human use in the area it is not expected that electric fences or motion detectors will be needed at the worksite. If wildlife human conflict becomes an issue, further mitigations to control worksites will be considered in discussions with Alberta Environment and Parks. All control techniques, outside of the listed mitigations, will be handled by a Fish and Wildlife officer.

The onsite lunch shelter will adhere to the BearSmart actions above. A bear-proof container will be provided at the shelter to manage waste and a waste disposal plan will be put in place to remove attractants from the work site on a daily basis.

In addition to the BearSmart behaviours listed above, the Town of Canmore included the following site-specific mitigations in the environmental impact assessment (Section 7.4.1.4) that apply to bears as well as other wildlife:

- Allowing wildlife to travel passively through the work area. Work will stop when large carnivores, bears or aggressive elk are present in the work area and will only resume when they have passed out of the work area.
- Following BearSmart behaviours. Managing attractants (e.g., using bear-proof containers and garbage removed) and educating staff and contractors regarding proper waste management practices to reduce wildlife exposure to attractants and limit interactions between people and wildlife.
- Clearing blast sites of large mammals by conducting a walk-through before blasting to avoid wildlife mortality during blasts.
- Keeping blast sites clean of any attractants such as food scraps or containers to prevent attracting wildlife and birds to the blast site.
- Conducting a den site investigation on the proposed footprint areas before initiating winter season clearing between November and mid-April.
- Storing toxic materials that attract wildlife (e.g., sodium nitrite used in blasting) in secure areas inaccessible to wildlife (e.g., buildings, storage areas surrounded by wildlife-proof fencing).
- Reporting all carnivores and aggressive wildlife to the site supervisor and to Kananaskis Country Emergency Services.
- Training all contractors on wildlife awareness and issues with working next to a wildlife corridor and wildlife habitat patch.

References:

Government of Alberta (GoA). 2011. *Alberta BearSmart Program Manual.* Pub. No. I/307. ISBN: 978-0-7785-7043-1. May 2011.

129	**Volume 1, Section 7.4.4.4, Page 7-60** The Town of Canmore outlines the potential for direct wildlife mortality due to removal of nuisance wildlife, particularly the relocation or euthanasia of bears. a. *The proponent states the magnitude of potential effects on bears are considered negligible in the LSA since removal of any nuisance bears are unlikely to cause a detectable change in their populations.* Provide evidence to support this assumption, particularly as it relates to the statement from the grizzly bear recovery plan that the known human caused mortality rate excluding relocations in this BMA is slightly over the 4% threshold estimate to allow for population growth…and…when relocated bears are factored into the mortality estimates for the bear management area (BMA), the mortality rate is substantially over the thresholds (taken from the Alberta Grizzly Bear Recovery Plan, 2016, Alberta Environment and Parks, page 22). b. Provide rationale for why the Removal of Nuisance Wildlife sub-section (page7-60) does not follow Alberta Environment and Parks policy for responding to human-bear conflicts as described in the Grizzly Bear Response Guide (Government of Alberta 2016) and the Black Bear Response Guide (Government of Alberta 2016), particularly in relation to the escalation of preventative actions to response actions.

Response:

The Town of Canmore intends to reduce the potential for human – bear conflict by employing the BearSmart behaviours discussed in the response to SIR 128 and mitigations listed in Section 7.4.1.4 of the environmental impact assessment (EIA).

a. The text in question a) seems to be referring to text on page 22 of the Alberta Environment and Parks (AEP) “Alberta Grizzly Bear Recovery Plan” (AEP 2016) that is related to bear management area (BMA) 5. Figure B.4 of the “Alberta Grizzly Bear Recovery Plan” (AEP 2016) suggests that the local study area (LSA) is in BMA 4. Rates for mortality, which incorporate relocations are also over the 4% threshold for BMA 4 but not to the same degree as BMA 5. The mortality rate was not considered in the “Threats and Related Recovery Activities Section” for BMA 4 as it was for BMA 5 where the text for this question is drawn from.

   Given the low levels of known grizzly bear use in the LSA and that the construction is located outside of a Grizzly Core or Secondary Zones (Figure 7.2-2 of the EIA) the probability of needing to relocate a bear in the LSA to an area outside of the BMA is considered very low. Additionally, if a relocation is believed to be a threat to the population it is likely that Fish and Wildlife officers would use alternate control methods before relocation and could try to relocate within the BMA, if needed.

   When relocations are factored into mortality estimates for a BMA, that is done with the assumption that the bear is translocated out of the BMA. The relocation area that a problem bear would be transported to if there was a human–bear conflict is unknown at this time. As the LSA is in the southern portion of the Clearwater BMA, there may be potential for the bear to remain within the Clearwater BMA (BMA 4). If this occurs, a relocation will not count within the mortality estimates. However, it is noted in AEP (2016) that 87% of translocations between 2009 and 2013 were out of the resident BMA. There were 11 translocations from BMA 4 from 2009-2013 and two in an area adjacent to the BMA.

It is noted in AEP (2016) that if the mortality rate is calculated with 2014 grizzly population numbers from Stenhouse et al. (2015) that the mortality/translocation rate drops from 3.1% to 1.2% in BMA 3 because of the population has almost doubled in 10 years. The last population estimate within BMA 4 was for 2005.

b. The Removal of Nuisance Wildlife section (page 7-60) states that increased bear encounters "may result in the trapping and relocation or, at worst, destruction of bears as a control measure at the discretion of AEP." These possible outcomes follow the possible outcomes from the grizzly bear and black bear response guides (GoA 2016a, 2016b). The guides are intended for use by trained government staff (i.e., an experienced Fish and Wildlife Officer in consultation with a Regional Biologist) and not construction contractors. The Town of Canmore will follow the AEP policy for responding to human-bear conflicts as described in the guides where it pertains to notification and consultation with Fish and Wildlife but the decisions related to preventative actions will be carried out by Fish and Wildlife and the Regional Biologist.

References:

Alberta Environment and Parks. 2016. "Alberta Grizzly Bear Recovery Plan." Draft. Alberta Environement and Parks, Alberta Species at Risk Recovery Plan No 38. Edmonton, Alberta. June 1, 2016. http://aep.alberta.ca/files/GrizzlyBearRecoveryPlanDraft-Jun01-2016.pdf

Government of Alberta (GoA). 2016a. *Grizzly Bear Response Guide*. AEP, Fish and Wildlife, 2016, No. 1. Fish and Wildlife Policy. April 1, 2016. http://aep.alberta.ca/fish-wildlife/wildlife-management/grizzly-bear-recovery-plan/documents/GrizzlyBearResponseGuide-2016.pdf

Government of Alberta (GoA). 2016b. *Black Bear Response Guide.* Fish and Wildlife Policy. April 1, 2016. http://aep.alberta.ca/fish-wildlife/wildlife-management/documents/BlackBearResponseGuide-2016B.pdf

Stenhouse G. B. et al. 2015. *Estimates of Grizzly Bear Population Size and Density for the 2014 Alberta Yellowhead Population Unit (BMA 3) and South Jasper National Park Inventory Project.* fRI Research Grizzly Bear Program Report. Report prepared for Weyerhaeuser Ltd., West Fraser Mills Ltd., Alberta Environment and Parks, and Jasper National Park. Hinton, Alberta. October 2015. https://friresearch.ca/sites/default/files/GBP_2015_10_Report_PopulationSize.pdf

130	**Volume 1, Section 7.4.1.4, Page 7-17** The Town of Canmore states that vegetation clearing will preferentially be conducted outside of sensitive wildlife periods including, the early nesting period and migratory nesting period. a. Clarify what situations are anticipated to trigger a referral or further communication with a government body. b. What action will the proponent take if evidence of breeding or nesting is found during any nest surveys?

Response:

a. The Town of Canmore is committed to conducting clearing outside of the sensitive wildlife periods mentioned and will only conduct clearing within those periods if it is deemed necessary for completion of the Project. Government bodies will be contacted if there is potential to violate the Alberta *Wildlife Act*, *Migratory Bird Convention Act*, or the *Species at Risk Act* such as conducting any clearing within sensitive wildlife periods, finding an active bear den or other sensitive wildlife habitat feature (e.g., raptor nest) in the vicinity of the Project (refer to the response to SIR 127), the occurrence of problem wildlife (e.g., habituated or aggressive bears, wolves or cougars).

   Extending the period of construction, to avoid sensitive wildlife periods may have more impact on wildlife than completing small amounts of clearing within sensitive wildlife periods. A nest sweep survey will be conducted before any clearing that is deemed necessary.

b. If evidence of breeding or nesting is found during nest surveys, construction will stop and the Town of Canmore will abide with setback distances recommended through consultation with Environment and Climate Change Canada and AEP. Construction and clearing activity will resume when the nest is deemed inactive by subsequent nest surveys.

131	**Volume 1, Section 7.3.3.3, Page 7-13** **Volume 1, Appendix 7C, Page 7C-10** The proponent states that *bighorn sheep are confirmed to be using the wildlife LSA* (page 7-13) as supported by observation of bighorn sheep pellets during the wildlife habitat use transect survey (Table 7C-3) and tracks during the winter tracking survey (Table 7C-5) and cites that *larger activities that accumulate over time have a larger impact on populations (page 7C-10).* a. Provide rationale for lack of mitigation measures for project disturbance and creation of new access road within a Provincial Mountain Goat and Sheep Range, when this is in contrast with the recommended land use guidelines for mountain goat and bighorn sheep ranges in Alberta (as found in Appendix 3 of Management Plan for Bighorn Sheep in Alberta, 2015).

Response:

a. While no mitigation measures were specifically added for bighorn sheep, general wildlife mitigations in Section 7.4.1.4 will reduce the impacts of the Project on bighorn sheep. Additional access for Project vehicles is being built for the Project at the edge of the Provincial Mountain Goat and Sheep Range; however, the Project itself is surrounded by heavily forested habitat that is not likely to be frequently used by mountain goats or bighorn sheep. Sheep and goats that may use higher slopes on Mount Lady Macdonald will be separated from the Access Road by unsuitable forested habitat as well as altitude allowing them to have the escape terrain at higher elevations that is essential for maintaining habitat use.

The guidelines from Appendix 3 of the draft “Management Plan for Bighorn Sheep in Alberta” (GoA 2015) limit industrial activity from July 1 to August 22. The focus of the appendix is primarily on long-term programs that contain geophysical exploration. Given the low quality sheep and goat habitat within and adjacent to the Project footprint, and the mitigation measures currently planned, effects on sheep and goats in the area is expected to be low.

Additional mitigations:

- The Town of Canmore does not anticipate the need for extensive helicopter use. When a helicopter is needed, the Town of Canmore will avoid the spring and early summer lambing and kidding period. If a helicopter is needed, a sheep/goat biologist will be onsite to monitor the location and activity of sheep and/or goats around the construction site. The biologist and Project team will use monitoring information to redirect or stop activities if needed.

- Blasting will preferentially occur outside of the early summer lambing and kidding period. If blasting needs to occur during this period, the area will be surveyed for bighorn sheep or mountain goat activity. If any bighorn sheep or mountain goat are detected, blasting will stop.

- There will be no vehicular traffic along the Access Road aside from maintenance work for the Structure. No fencing will be added to the Access Road as that would inhibit wildlife movement; however, a locked, removable bollard or a gate that is passable by hikers and wildlife will be installed to restrict vehicle access (refer to the response to SIR 134).

References:

Government of Alberta (GoA). 2015. "Management Plan for Bighorn Sheep in Alberta." Draft. Wildlife Management Series Number, Wildlife Management Branch. June 25, 2015. http://aep.alberta.ca/fish-wildlife/wildlife-management/documents/BighornSheepMgmtPlan-Draft-Jun25-2015A.pdf

132	**Volume 1, Section 7.4.1.4, Page 7-17** Provide rationale for how the mitigation of *limiting clearing and construction activities from 7 am to 7 pm* will minimize disturbance to animals. In particular, discuss the probability of disturbing birds that are breeding or nesting and the increase of large mammals use of the wildlife corridor at dawn and dusk, which at certain times of the year fall within the daily construction timing.

Response:

In order to complete the Project, work is scheduled from 7 am to 7 pm. Limiting clearing and construction activities to those times mitigates disturbance to nearby residents and wildlife during half of each 24-hour period. As indicated in the environmental impact assessment and in the response to SIR 130, clearing activity is planned to be conducted outside the breeding season for most species of wildlife. Construction activity will be ongoing when birds return from migration and therefore will be occurring before birds begin nesting. Since there is ongoing activity, effects on birds nesting adjacent to the construction site is anticipated to be less than birds nesting in pristine undisturbed areas. However, some disturbance is likely to occur. Extending the period of construction, to avoid sensitive wildlife periods, may have more impact on wildlife than completing small amounts of clearing within sensitive wildlife periods.

The schedule does not mitigate all impacts on wildlife but does reduce the potential impacts by constraining work hours. There may be disturbance of mammals using the wildlife corridor at dawn and dusk for the parts of the year that sunrise is after 7 am (beginning of September to mid-April) and sunset is before 7 pm (mid-October to mid-April).

133	**Volume 1, Section 4.4.6, Page 4-30** **Volume 1, Section 4.4.7, Table 4.4-2, Page 4-31** Section 4.4.6 explains that a storage level of 10 m for 10 days will be used for testing. a. Provide mitigation measures to reduce potential effects (connectivity and safety) to human and wildlife movement into the canyon for the duration of testing.

Response:

a. Two supplementary information packages were sent to Alberta Environment and Parks, before receipt of the first round of supplemental information requests (SIRs), that discuss changes to the test storage plan (refer to the response to SIR 119). The test will only be conducted for 24 hours at a storage height of 10 m. The total duration of the test will be 54 hours, which includes the filling and emptying of the inundation area and is based on conservative assumptions. The test is expected to be conducted in the summer or fall, depending on the eventual construction schedule. The emptying of the inundation area will begin during the day to allow easy monitoring of downstream effects and to minimize impacts to wildlife movement across Cougar Creek.

   The test will be announced via all the media outlets available to the Town of Canmore, including sharing the information with hiking, climbing and cycling clubs and groups. Signs will be posted at the Cougar Creek parking lot and trailhead and at different locations on the trail network to inform users. Town of Canmore representatives and/or security personnel will be posted 24 hours a day, for the duration of the test, on the downstream and upstream sides of the Structure to ensure that no one enters the “exclusion.” The Structure will be lit during the test to ensure good visibility.

   Wildlife movement along the creek might be impeded for that short duration. The only proposed mitigation consists of using personnel onsite to ensure that animals do not attempt to travel in the “exclusion” zone during the test storage and controlling the outflow at a level no more than typical spring runoff (2.5 m^2/s).

134 **Volume 1, Section 7.4.1.4, Page 7-17**
Volume 1, Section 7.4.4.4, Page 7-60

Mitigation measures have not been identified on Page 7-17 and 7-60 to reduce the potential effects of the Structure and Access Road on habitat connectivity. Mitigation tends to focus on reduced speeds and daytime construction hours.

Facilitating wildlife movement through the potential Project barrier is critical.

a. Provide information on how wildlife will move through the canyon and bypass and/or go over the Structure? Will wildlife use the hikers trail on the east side of the creek or the access road?

b. Will non-project human activity be restricted on the access road to facilitate wildlife use of the road?

c. Has the Town researched other similar projects to compare wildlife connectivity with such structures? If so, what learnings have been incorporated into the Project design/operation.

Response:

a. Movement of wildlife through the Cougar Creek canyon will be difficult during the peak of construction as the area will contain workers, heavy equipment and other obstacles. However, wildlife will be able to use the hiking and game trails on either side of the canyon at all times. During operations, once construction is complete, movement of animals along the canyon is expected to return to baseline movement rates as the Structure is sloped at 30°, or 57%, and fully grassed to allow movement of animals over the Structure. Wildlife is also anticipated to use the Access Road, game and hiking trails.

b. There will be no vehicular traffic along the Access Road aside from infrequent maintenance work for the Structure. No fencing will be added to the Access Road as that would inhibit wildlife movement; however, a locked, removable bollard or a gate that is passable by hikers and wildlife will be installed to restrict vehicle access.

c. Similar structures exist in Europe; however, no similar projects exist in Canada or in environments with similar wildlife movement considerations. Therefore, no wildlife connectivity learnings from similar projects have been incorporated into the Project design/operation. The Town of Canmore has been working with wildlife biologists from Alberta Environment and Parks throughout the Project development to mitigate potential effects on wildlife movement and to ensure that habitat connectivity is maintained or enhanced.

135	**Volume 1, Section 7.4.4.4, Page 7-59** The Town of Canmore states *potential barriers to movement due to the Project include the Structure and Access Road as well as any additional human activity resulting from construction and operation of the Project.* This statement acknowledges wildlife movement along the creek. The Town of Canmore also states *the magnitude is low as connectivity is expected to be affected only during periods of high volume traffic.* In addition, the confidence rating is medium (based on a good understanding of cause-effect using data from elsewhere). a. Does this relate to the potential effect of the Structure on habitat connectivity? Provide references to wildlife studies in regards to these structures elsewhere that provide the rationale for the confidence rating.

Response:

a. The confidence rating takes into account movement across and along Cougar Creek and is based on a good understanding of wildlife movement in the area and along slopes. The Structure is not a vertical cement barrier but will instead be a rock and earth filled embankment structure. The exterior of the Structure will be reclaimed to a fully grassed slope on both sides in a way that allows wildlife movement in as natural a way as possible, without compromising the integrity of the Structure. Grassy slopes are available and used by wildlife within the Bow Valley. The slope of the Structure will be consistent with surrounding areas and is not expected to have an impact on wildlife movements. The Structure may actually facilitate movements across the canyon since the canyon in many areas consists of cliffs and extremely steep terrain.

Similar structures exist in Europe; however, no similar projects exist in Canada or in environments with similar wildlife movement considerations. No wildlife studies from similar structures were used to provide rationale for the confidence rating. The confidence rating was instead based on the final design of the Structure including covering the Structure with a grassy slope and an understanding of how species typical to the Bow Valley use the terrain.

136	**Volume 1, Section 7.4.1.4, Page 7-17** a. How will the construction zone and laydown areas take into account sensitivity of the regional (cross-channel) corridor to minimize impacts during the construction period ?

Response:

a. The construction zone and laydown areas are largely determined by logistics and engineering constraints. The extent of the construction zone will be minimized in order to reduce the potential effect of the Project on wildlife movement. The laydown areas are shown on Figure 4.1-2 of the environmental impact assessment (EIA). The three laydown areas are placed in areas that minimize the amount of driving needed to access construction areas. A reduction in traffic reduces potential impacts to wildlife disturbance and mortality. Mitigations are put in place to minimize the impacts of the Project on movement (Section 7.4.1.4 of the EIA) through the corridor including;

- Limiting clearing and construction activities from 7 am to 7 pm to minimize disturbance to animals (also for reduced disturbance to residents).
- Designating a construction zone with limited activity outside of that boundary.
- Allowing wildlife to travel passively through the work area. Work will stop when large carnivores, bears or aggressive elk are present in the work area and will only resume when they have passed out of the work area.
- Establishing signs in consultation with Alberta Environment and Parks to clearly mark intended trail use and prevent use of unmarked trails within the wildlife corridor and habitat patches. Refer to the response to SIR 144f for information on proposed signage.

137	**Volume 1, Section 7.2, Page 7-1** a. Will there be lighting associated with the project site during the construction phase? If so, what measures will be taken to avoid impacts to nocturnal wildlife habitat use and movements in the vicinity of the construction zone?

Response:

a. There will be lighting associated with the Project during the construction phase; however, as stated in the response to SIR 132, activity will occur from 7 am to 7 pm. During some months, lighting will be required during these hours; however, lighting outside of this daily construction period will not be required. Considering the extensive lighting that exists throughout the Bow Valley and within the Town of Canmore, lighting at the construction site during work hours is not anticipated to negatively affect wildlife habitat use and movement. There may be some residual effects but they are anticipated to be low in magnitude and medium-term in duration.

The Town of Canmore will use the following mitigations to reduce impacts to nocturnal wildlife.

- leave vegetation intact where possible to reduce sensory disturbance effects to wildlife from light and allow passage of wildlife around Project activities;
- use fully shielded directional luminaires aimed at specific target areas, preferably with flat bottom lenses and no upward directed lights; and
- all lighting will be turned off when not in use, including outside of regular working hours.

138	**Volume 1, Section 4.9.2.2, Page 4-53** In regards to timber clearing and salvage, the EIA suggests that dens site investigation will be conducted before initiating any winter season clearing between November and mid-April. a. What will be the procedure if active dens are located?

Response:

a. Refer to the response to SIR 127.

139	**Volume 1, Section 7.4.1.4, Page 7-17** a. Given the special importance of this area for wildlife, what start-up training or orientation will be provided to all construction and oversight workers with regard to wildlife-friendly/low impact procedures?

Response:

a. The Town will require contractors to prepare environmental construction operations (ECO) plan in accordance with the Alberta Transportation ECO Plan Framework (AT, City of Calgary, City of Edmonton 2014). The ECO plan will address site-specific environmental sensitivities and features that require additional protection and education including wildlife and wildlife habitat.

All workers at the construction site will be required to take a wildlife awareness program that the Town of Canmore and Alberta Environment and Parks, Parks Division have reviewed and approved before construction.

References:

Alberta Transportation, City of Calgary, City of Edmonton. 2014. *Environmental Construction Operations (ECO) Plan Framework: Instructions for preparing ECO Plans for Alberta Transportation, City of Calgary and City of Edmonton Construction Projects.* January 1, 2014. http://www.transportation.alberta.ca/Content/docType245/Production/EcoPlan.pdf

140	**Volume 1, Section 7.4.4.3, Page 7-55** a. Describe the specific actions that will be taken during construction activities to avoid the food conditioning of bears, wolves and coyotes on the project site?

Response:

a. The avoidance of food conditioning of wildlife will be achieved through the BearSmart actions discussed in the response to SIR 128.

141	**Volume 1, Section 7.4.4.3, Page 7-56** a. Has indirect mortality as a result of wildlife displacement from the regional corridor been assessed? For example, wildlife may avoid the project construction zone and cross the channel closer to the residences, or use less favourable areas that involve additional road crossings.

Response:

a. Wildlife displacement from the regional corridor relative to baseline conditions is not expected to result in increases in indirect wildlife mortality or change the assessment ratings for the following reasons;

- Mitigations have been put in place to reduce impacts to wildlife movement (Section 7.4.1.4 of the environmental impact assessment [EIA]) including restricting construction activity to 12 hours of the day.
- Baseline information has shown that human use is very high in the area. Wildlife are habituated to human use and are unlikely to show high levels of displacement.
- Elk and deer use is already high within the residential community relative to other areas in the wildlife corridor (Appendix 7C, Figure 7C-3 of the EIA).
- Construction is temporary and conditions for wildlife movement across Cougar Creek are expected to return to baseline conditions or improve once the revegetation program in No Man's Land is complete (Section 4.9.5.4 of the EIA).

142	**Volume 1, Section 7.7, Page 7-77** The impacts to along-channel movement are suggested as being associated with construction activities and traffic. Data collected at the debris net site in the winter of 2013/14 shows substantial up and down channel movement at this pinch point (cougar, coyote, elk, fox, deer) which will be impacted by the structure itself. The ability to retain this important movement route is entirely dependent on the structure design and mitigation success in facilitating wildlife movement. a. What mitigations will be implemented to facilitate wildlife movement along Cougar Creek at the Structure site?

Response:

a. During operations, once construction is complete, wildlife movement is expected to continue along Cougar Creek using the Structure, the Access Road and existing trails. Both sides of the Structure are sloped at 30°, or 57%, and fully grassed to allow for wildlife movement over the Structure. The Access Road is at a shallower angle than the Structure, with a maximum grade of 10%, and also allows for wildlife movement along Cougar Creek. Wildlife movement will be evaluated as part of a long-term monitoring project using cameras to record wildlife use in Cougar Creek.

6.6 Biodiversity and Fragmentation

143	**Volume 1, Section 5.2.7, Page 5-8** **Volume 1, Section 6.6.3.3, Page 6-53** **Volume 1, Section 6.6.5.3, Page 5-58** **Volume 1, Section 6.6.6.3, Page 6-61** **Volume 1, Section 7.4.3.5, Page 7-51** **Volume 1, Section 7.4.4.4, Page 7-63** With reference to the following statement*: Permanence describes the potential for the recovery or reversibility of an effect. Permanence is classified as effects that are reversible in the short-term (within 1 year), reversible in the medium-term (1 to 10 years), reversible in the long-term (greater than 10 years), or irreversible (permanent)* (Page 5-8). As noted in Section 5.2.7, effects criteria for some disciplines were refined. For hydrology, groundwater and aquatics, permanence is considered not applicable because the Structure will be *in place forever.* However for the vegetation assessment permanence is considered 'permanent' and the wildlife assessment described permanence as irreversible. Irreversible, permanent and 'forever' are the same when related to the Project. a. Explain why the approach is non consistent between the disciplines.

Response:

a. Refer to the response to SIR 68.

6.7 Mitigation and Monitoring

144 **Volume 1, Section 11, Page 11-1**
Volume 1, Section 11, Page 11-2
Volume 1, Section 11, Page 11-3
Volume 1, Section 11, Page 11-4

a. Clarify how TOC will work with Agriculture and Forestry for the management of timber harvest operations.

b. Provide woody debris management plans and rational as per Department Directive.

c. Provide further details regarding the TOC's Fire Smart strategies.

d. Provide further details on how grading will be utilized to prevent increased run-off on slopes.

e. Provide planning/ mapping detailing how natural drainage will be achieved using properly sized culverts. Use mapping and sketches to illustrate the number and where these culverts will be located.

f. Provide signage plan outlining:
  - Sign prototype (dimensions, messaging/wording, sign location etc.)
  - Signs - Explain how education and enforcement will be achieved.

g. Provide linkage of wildlife corridor and habitat patch strategies to the re-vegetation planning.

h. Provide rational and more details behind mitigative measures, such as wind barriers, vegetative buffers, sediment control etc.

Response:

a. Refer to the response to SIR 111d.

b. Refer to the responses to SIR 111b and SIR 111c.

c. Refer to the response to SIR 26. The Town of Canmore *FireSmart Mitigation Strategy* (Town of Canmore 2010) is also available on the Town website.

d. Grading will be used to reduce the gradient of steeper slopes and help manage runoff velocity, while not specifically preventing increased runoff. Grading will be used mainly along some portions of the Access Road to reduce the gradient of the road and the ditches to help control runoff velocity. Grading of the laydown areas to very gentle slopes will also provide erosion control through reduced runoff velocity.

e. Figure 144-1 illustrates how natural drainage will be achieved using culverts. On Figure 144-1:

- red arrows are the natural flows;
- blue arrows are modified flows;
- green lines are culverts with a diameter of 800 mm and a length of 7 m; and
- pink/purple lines are culverts with a diameter of 600 mm and a length of 4 to 7 m.

Culverts will be designed with grades of 1% and capacity for a 1 in 10-year precipitation event. Using the 10 year event is standard for road crossings and the design ensures that no damage occurs for the 10 year peak flow. For a total drainage area of 3 hectares, which covers the whole area above the Access Road that could contribute water, the discharge was calculated to be 0.733 m^3/s using the following design parameters: high runoff coefficient of 0.8; rainfall intensity of 110 mm/hour, and Manning coefficient of 0.024 for corrugated steel culvert pipe. Each 800 mm culvert has a capacity of 0.72 m^3/s (at 1.43 m/s) and each 600 mm culvert has a capacity of 0.33 m^3/s (at 1.18 m/s). Beyond a 10-year precipitation event some water could start to flow over the Access Road; however, the culverts design is conservative and considerably more water can be accommodated than the 10-year event.

f. The Town of Canmore will develop a full signage plan that includes design and placement with their selected contractors before construction. Signage will be placed for safety purposes (e.g., changes in traffic patterns, speed limits, pedestrian and cyclist crossing points, work site boundaries, dangerous goods, etc.) and for educational purposes (e.g., project information, construction information, detours, etc.). Signs will conform to regulatory (e.g., dangerous goods, occupational health and safety) or available industry standards (e.g., traffic control) where applicable. Contractors will be directed to the City of Calgary *Temporary Traffic Control Manual* (The City of Calgary 2016) as a reference for the development of a traffic signage plan for review by the Town of Canmore. Examples of non-standard signs previously used by the Town of Canmore are provided in Appendix 144-1. The dimensions of educational and informational signs will be based on use and location but signage used in the past for this purpose has ranged from 24-inch by 36-inch to 36-inch by 48-inch. Construction and traffic control signs will be standard dimensions. At a minimum, signs will be placed in the following locations:

- safety signage will be placed immediately upstream and downstream of the construction site;
- safety, trail use and interpretive information will be placed in the Cougar Creek trailhead parking lot;
- trail use information will be placed both upstream and downstream of the construction site;
- trail use information will be placed at existing junctions (Montane Traverse, Horseshoe, G8 and the proposed trail extension);
- construction and safety signs will be placed in areas along the creek as required (e.g., pull outs, changes to speed limits, traffic crossings, pedestrian and cyclist crossings); and
- construction signs will be placed along the roads leading to the Cougar Creek construction area (i.e., Benchlands Trail, Highway 1A, Elk Run Boulevard).

The Town will continue to inform and educate local stakeholder groups and the general public regarding Project progress and construction activities. Information will be provided by email, in local publications (e.g., Rocky Mountain Outlook, Crag and Canyon) and posted on the Town of Canmore website, Facebook page and twitter feed. For items that are under the jurisdiction of Alberta Environment and Parks (AEP), information will also be posted on the AEP website.

Enforcement will be a joint effort between the Town and the construction contractor. Confirmation of enforcement roles will occur as part of construction planning. It is expected that AEP staff will enforce trail use within the Bow Valley Wildland Provincial Park and the contractor will be responsible for site security and construction safety including the provision of flaggers at crossings as necessary. The Town of Canmore will support both AEP and the contactor as needed and will work to mitigate any gaps in signage, enforcement or safety that arise (e.g., speeding, need for additional trail signage, etc.). A safety supervisor will be onsite at all times and the construction site will be fenced if necessary to control site access and ensure public safety.

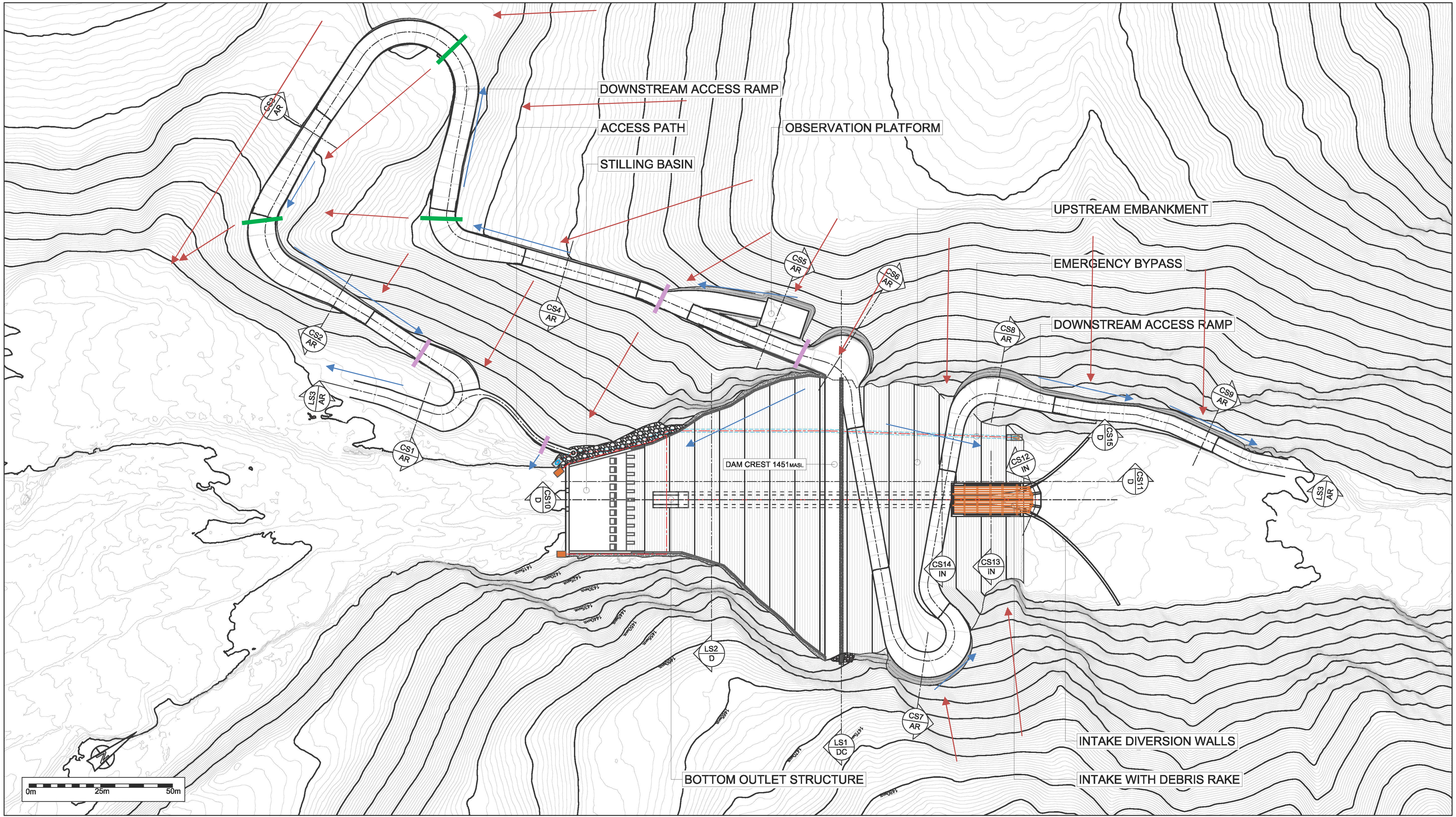
g. As indicated in the responses to SIR 108 and SIR 110, the objective of reclamation in No Man's Land is the creation of an aesthetically pleasing environment while adding low maintenance cover for wildlife use. The reclamation strategy is expected to facilitate wildlife movement between the wildlife corridor and habitat patch. The proposed conceptual reclamation in No Man's Land will involve minor grading, de-compaction of scattered small islands, adding imported soil, and planting native herbaceous and shrubby vegetation. The islands will be teardrop-shaped, 5 m wide by 7 m long on average but variable in size, scattered across No Man's Land, and placed to not interfere with creek hydrology or flow paths. Final placement of the islands will be decided by the Town of Canmore and the Parks Division of AEP after the results from the wildlife monitoring are reviewed and understood. Once established, the islands will provide cover from predators and habitat for potential foraging, nesting and resting by wildlife. It is also expected that the islands will serve as seed sources for natural egress and revegetation around the islands, which will contribute more wildlife cover and support along-channel and across-channel wildlife routes.

h. Refer to the responses to SIR 42, SIR 82, SIR 120, SIR 121, and SIR 122 for details regarding erosion and sediment control measures and vegetation strategies.

References:

Town of Canmore. 2010. *FireSmart Mitigation Strategy*. December 2010. https://canmore.ca/documents/municipal-development-plan

The City of Calgary. 2016. *Temporary Traffic Control Manual.* 2016 Edition. https://www.calgary.ca/Transportation/Roads/Documents/Contractors-and-Consultants/temporary-traffic-control-manual.pdf?noredirect=1



REV.	DATE	REVISION NOTES	DRAWN	REVIEW	APPROVED

SCALE: 1:1,250
DATE: June 15, 2016
DRAWING: ALe
DESIGN: ALe, MSc
REVIEW: MSc
APPROVED: EIs

PROFESSIONAL SEAL:
EMAD ISKANDER
08/10/2016
Emad Iskand

APEGA PERMIT NUMBER: 13440

CLIENT:
Town of CANMORE

ENGINEERING:
CANADIAN HYDROTECH CORPORATION

PROJECT:
COUGAR CREEK
DEBRIS FLOOD RETENTION STRUCTURE

Figure 144-1 Site Drainage

PROJECT No.: 16494
DRAWING No.: LTMM CC-DAM-501 R00
REV: 00

145	**Volume 1, Section 12, Page 12-1** The soil and monitoring program lacks sufficient detail. a. What are the standards, criteria, goals, and objectives of both the vegetation and soil monitoring program?

Response:

a. As stated in Section 12 of the environmental impact assessment, the objective of soil and vegetation monitoring of reclaimed areas is to evaluate the success of reclamation. The need for additional monitoring and adaptive reclamation management will be evaluated based on the monitoring results.

The Town of Canmore will monitor surface soil in the reclamation areas for the following indicators:

- stability, based on signs of slumping or soil creep where topsoil was placed;
- signs of erosion and effectiveness of control measures; and
- surface soil compaction and vehicle ruts impeding vegetation growth.

The forested lands reclamation criteria (ESRD 2013) will be referenced for additional guidance on assessing the soil parameters listed above.

Town of Canmore will monitor vegetation for the following:

- prohibited noxious and noxious weeds as listed in the Alberta *Weed Control Regulation - Alberta Regulation 19/2010*; and
- establishment and growth of the desired native plants in reclamation areas, including monitoring sparsely vegetated and/or bare areas and evaluating the initial growth of problem weeds that compete and impede the growth of the desired vegetation.

Additional information on monitoring during operation of the Project and adaptive management practices is presented in the response to SIR 110a.

References:

Alberta Environment and Sustainable Resource Development (ESRD). 2013. *2010 Reclamation Criteria for Wellsites and Associated Facilities for Forested Lands*. Edmonton, Alberta. Updated July 2013. http://aep.alberta.ca/lands-forests/land-industrial/programs-and-services/reclamation-and-remediation/upstream-oil-and-gas-reclamation-and-remediation-program/documents/2010-ReclamationCriteria-ForestedLands.pdf

7 HEALTH

146	**Volume 1, Section 9.1.1.1, Page 9-1**
	The Town of Canmore states *the first part of the human health risk assessment process is the problem formulation stage whereby a conceptual model is developed that describes the project and its interactions with the surrounding human population and the environment.* The conceptual model also assists in determining which of the chemicals, pathways and receptors are significant and have the greatest potential to contribute to health risk (Alberta Health and Wellness, 2011). However, no conceptual model is presented or described in the human health risk assessment. Reference: *Alberta Health and Wellness, 2011. Guidance on Human Health Risk Assessment for Environmental Impact Assessment in Alberta* a. Provide a comprehensive conceptual model for the project and its surrounding area, or provide rationale as to why a conceptual model is not required or relevant to this application.

Response:

a. Based on discussions with Alberta Environment and Parks and Alberta Health, a screening level human health risk assessment (SLHHRA) and associated conceptual model were prepared and are included in Appendix 146-1.

The conclusion of the SLHHRA (Appendix 146-1) is as follows:

> *"The potential health risks associated with the construction emissions of the Project were assessed using a SLHHRA approach. Both short-term and long-term inhalation health risks were determined by comparing maximum predicted ground-level air concentrations to health-based exposure limits. Health risks associated with secondary pathways of exposure were determined by comparing maximum predicted soil concentrations to provincial health-based soil quality guidelines. In all cases, predicted air concentrations were less than their exposure limits. Similarly, in all cases, predicted soil concentrations for chemicals of potential concern (COPC) were less than their soil quality guidelines. In light of the conservative nature of the assessment and the predicted risk estimates, the Project's construction emissions are not expected to have an adverse effect on the health of the area residents."*

147	**Volume 1, Section 9.1.1.1, Page 9-1** **Volume 1, Section 9.1.1.1, Page 9-2** The Town of Canmore states that the human health risk assessment is focused on the potential effects of air emissions on human health, and references the Air Quality Assessment (Section 8.2). Chemicals of concern related to air emissions are said to include SO_2 compounds, CO, VOCs, NO_x and $PM_{2.5}$, although the air quality assessment appears to address only NO_2 and $PM_{2.5}$. Little discussion or rationale is provided with respect to the identification of potential chemicals of concern and the selection of those included in the air quality assessment or the human health risk assessment. a. Provide a complete inventory of chemicals potentially emitted from vehicles, equipment and other sources associated with the project. b. Provide a detailed description of the screening process undertaken to identify chemicals of concern from a health standpoint. c. Provide a list of those chemicals specifically addressed in the air quality assessment and the human health risk assessment, and provide justification for any chemicals of concern, identified as a result of the above screening, that were subsequently excluded from the modelling and health assessment.

Response:

A screening level human health risk assessment for the Project is included in Appendix 146-1. It includes:

a. An inventory of chemicals potentially emitted from Project sources (Section 3.1).

b. A description of the screening process undertaken to identify chemicals of potential concern (Section 3.1 and Section 4.0).

c. A list of chemicals and justification for their inclusion or exclusion from the modelling (Section 4.0).

148 **Volume 1, Section 9.1.1.1, Page 9-2**

The Town of Canmore states *the Structure is located within the Town of Canmore boundaries; therefore, the Town's residents were considered to be receptors for the purposes of the human health risk assessment.* The Town also states (Section 9.1.1.2) that: *the screening model was completed for the closest residences to the Structure, which are approximately 450 m away.*

a. Given that several other communities have been identified in the air quality RSA, provide rationale as to why only the Town residents were considered in the human health risk assessment.

b. Explain why the screening air quality modelling was only completed for the closest residences to the Structure, and provide evidence to demonstrate that receptors at other locations could not be exposed to higher predicted concentrations of chemicals of concern, given local topography and meteorological conditions.

c. Provide a figure showing the location of the nearest or critical receptor(s), as well as other relevant receptors in the vicinity of the project.

Response:

a. The focus of the screening level human health risk assessment (SLHHRA) was on the location where the maximum influence of the Project (with respect to air quality) is expected to occur. By doing so, the assessment was able to characterize the health risks associated with a reasonable worst-case scenario. The closest residence is approximately 450 m away from the Project. When compared to the closest residence, the predicted ground level air concentrations at the other community locations would be lower than those that formed the basis of the SLHHRA. Because the SLHHRA indicates that the health risks at the nearest residence are low, the addition of other locations would not change the overall conclusions of the assessment.

b. Air quality was assessed using the conservative AERSCREEN model. The construction equipment were modelled as emission sources, low to the ground. As such, the maximum impact is expected to occur nearest to the Project (i.e., at the closest residence). Air concentrations of contaminants will decrease as distance increases from the Project.

c. Refer to the response to SIR 12, Figure 12-1.

149	**Volume 1, Section 9.1.1.2, Page 9-2** The human health risk assessment references the air quality assessment, in which baseline and predicted project emissions are compared to Alberta Ambient Air Quality Objectives (AAAQO). The human health risk assessment does not contain a toxicity assessment for the identified chemicals of concern. a. Complete a toxicity assessment for the identified contaminants of concern, and provide justification for the use of AAAQO as appropriate toxicity reference values (TRVs) or exposure limits for human health. Given the duration of the construction phase of the project, ensure that the potential effects of both acute and chronic exposures are considered.

Response:

a. A toxicity assessment was completed as part of the appended screening level human health risk assessment (SLHHRA; Appendix 146A). Section 5.0 (Toxicity Assessment) of Appendix 146A includes a discussion on exposure limits, as well as acute and chronic exposures.

As shown in Table 5-1 of Appendix 146A, Alberta Ambient Air Quality Objectives (AAAQOs) were used for nitrogen dioxide (NO_2) and sulphur dioxide (SO_2). Although the exposure limits for the other chemicals of potential concern (COPC) were adopted from other regulatory agencies, all of the exposure limits used in the SLHHRA were adequately protective of human health. For an exposure limit to be used in the SLHHRA, it was required to be:

- protective of the health of the general public based on current scientific knowledge of the health effects associated with exposure to the COPCs;
- protective of sensitive individuals (i.e., children and the elderly) through the incorporation of uncertainty or safety factors; and
- established or recommended by reputable scientific or regulatory authorities.

All of the exposure limits used in the SLHHRA met these criteria, including the AAAQOs for NO_2 and SO_2. Alberta Environment and Parks (AEP) periodically reviews its ambient air quality objectives. AEP's AAAQOs were last updated in June 2016. The AAAQOs are developed under the Alberta *Environmental Protection and Enhancement Act* and are intended to protect Alberta's air quality. According to AEP, the AAAQOs for NO_2 and SO_2 are health-based (i.e., intended to protect against respiratory effects; AEP 2016).

References:

Alberta Environment and Parks (AEP). 2016. *Alberta Ambient Air Quality Objectives and Guidelines Summary.* Air Policy Branch. Government of Alberta. June 2016. ISBN: 978-1-4601-2861-9. 6 pp. http://aep.alberta.ca/air/legislation/ambient-air-quality-objectives/documents/AAQO-Summary-Jun2016.pdf

150 **Volume 1, Section 9.1.1.2, Page 9-2**

The human health risk assessment references the air quality assessment, but does not itself provide any information on potential human health impacts under baseline conditions.

a. Provide a table of results of the Baseline Case assessment, expressing potential human health impacts in the form of estimated hazard quotients or exposure ratios for all identified chemicals of concern for relevant receptors.

b. Provide a discussion of the significance of predicted human health impacts, if any, associated with baseline conditions.

Response:

a. As described in Section 8.2.4 of the environmental impact assessment (EIA) and according to the requirements outlined in Section 3.1.1 of the Project EIA terms of reference, baseline conditions were described in terms of meteorology and existing ambient air quality conditions and no baseline air quality modelling was completed. Therefore, air quality predictions were not provided for a Baseline Case screening level human health risk assessment (SLHHRA). In addition, there are no suitable ambient data available for the Town of Canmore that can be used in the SLHHRA. Similarly, there are no measured site-specific soil concentrations available for the chemicals of potential concern.

b. For the reasons stated in the response to part a) above, the SLHHRA does not include an assessment of the potential health risks associated with baseline conditions. Although the responses to SIR 8 and SIR 56 describe the use of ambient measurements from monitoring stations that are near the Project site (Lafarge) or in similar mountain valley terrain (Hinton) to represent potential baseline conditions (available for fine particulate matter less than 2.5 µm in diameter and nitrogen dioxide only), there is significant uncertainty associated with the use of these data in the SLHHRA. Considering that the predicted air concentrations and soil concentrations for the Project are generally orders of magnitude below their respective exposure limits and soil quality guidelines, the addition of baseline data is not expected to change the overall findings of the SLHHRA.

151 **Volume 1, Section 9.1.1.2, Page 9-2**

The human health risk assessment again references the air quality assessment, but does not itself provide any information on potential human health impacts associated with construction activities. The referenced air quality assessment does not include a formal presentation of the results of the air modelling; the results of the modelling, which appear to form the basis for the conclusions of the health risk assessment, are instead summarized in the text at the end of Section 8.2.6.5.

a. Provide a table of results for the Construction Case assessment, expressing potential human health impacts in the form of estimated hazard quotients or exposure ratios for all identified chemicals of concern for relevant receptors.

b. Provide a discussion of the significance of predicted human health impacts, if any, associated with construction activities.

Response:

a. Tables including risk quotients for the construction case were prepared as part of the screening level human health risk assessment (SLHHRA; Appendix 146-1) for the following:

- acute inhalation (Table 7-1 of the SLHHRA);
- chronic inhalation non-carcinogenic risks (Table 7-2of the SLHHRA); and
- chronic inhalation carcinogenic risks (Table 7-3 of the SLHHRA).

b. The conclusion of the SLHHRA (Appendix 146-1) is as follows:

> *"The potential health risks associated with the construction emissions of the Project were assessed using a screening level human health risk assessment approach. Both short-term and long-term inhalation health risks were determined by comparing maximum predicted ground-level air concentrations to health-based exposure limits. Health risks associated with secondary pathways of exposure were determined by comparing maximum predicted soil concentrations to provincial health-based soil quality guidelines. In all cases, predicted air concentrations were less than their exposure limits. Similarly, in all cases, predicted soil concentrations for COPC were less than their soil quality guidelines. In light of the conservative nature of the assessment and the predicted risk estimates, the Project's construction emissions are not expected to have an adverse effect on the health of the area residents."*

Additional information is presented in Appendix 146-1.

152	**Volume 1, Section 9.1.1.2, Page 9-2** There does not appear to have been an evaluation, either in the human health risk assessment or in the air quality assessment, of the effect of construction emissions combined with baseline concentrations on air quality at the identified receptor location(s). For example, it appears, based on the limited information provided, that baseline concentrations of $PM_{2.5}$ exceed, or are close to, the referenced guidelines (depending on the percentile of the data set used), and that incremental concentrations of $PM_{2.5}$ due to construction alone are themselves approximately 58% of the referenced guideline value. This suggests that the combined effect of baseline and construction conditions could be well above the referenced guidelines. a. Provide a table of results for an assessment of the Construction Case combined with the Baseline Case, expressing potential human health impacts in the form of estimated hazard quotients or exposure ratios for all identified chemicals of concern for relevant receptors, or provide justification as to why such an assessment is not required. b. Provide a discussion of the significance of predicted human health impacts, if any, associated with construction activities in combination with baseline conditions.

Response:

a. As described in Section 8.2.4 of the environmental impact assessment (EIA) and according to the requirements outlined in Section 3.1.1 of the Project EIA terms of reference, baseline conditions were described in terms of meteorology and existing ambient air quality conditions and no baseline air quality modelling was completed. Therefore, air quality predictions were not provided for a Baseline Case human health risk assessment and a table of results for an assessment of the construction case combined with the baseline case cannot be provided. A screening level human health risk assessment (SLHHRA) was completed for the Project. Section 8 of the SLHHRA (Appendix 146A) discusses uncertainty surrounding the risk estimates related to various items including the lack of baseline air quality information. The SLHHRA also notes that there are no ambient data available for the Town of Canmore that can be used in the SLHHRA. Similarly, there are no measured site-specific soil concentrations available for the chemicals of potential concern (COPC). Considering that the predicted air concentrations and soil concentrations for the Project are generally orders of magnitude below their respective exposure limits and soil quality guidelines, the addition of baseline data is not expected to change the overall findings of the SLHHRA.

b. The SLHHRA concluded that: “The potential health risks associated with the construction emissions of the Project were assessed using a SLHHRA approach. Both short-term and long-term inhalation health risks were determined by comparing maximum predicted ground-level air concentrations to health-based exposure limits. Health risks associated with secondary pathways of exposure were determined by comparing maximum predicted soil concentrations to provincial health-based soil quality guidelines. In all cases, predicted air concentrations were less than their exposure limits. Similarly, in all cases, predicted soil concentrations for COPC were less than their soil quality guidelines. In light of the conservative nature of the assessment and the predicted risk estimates, the Project’s construction emissions are not expected to have an adverse effect on the health of the area residents."

153	**Volume 1, Section 9.1.1, Pages 9-1** **Volume 1, Section 9.1.1, Page 9-2** **Volume 1, Section 9.1.1, Page 9-3** The human health risk assessment does not include an evaluation of uncertainties. a. Provide an evaluation of the uncertainties associated with the human health risk assessment. In particular, discuss the potential for human health impacts to be greater than those predicted in the assessment.

Response:

a. A discussion of uncertainties is included in Section 8 of the screening level human health risk assessment (SLHHRA) found in Appendix 146A.

The intent of the SLHHRA was to evaluate the potential health risks associated with the Project based on the available data and the existing state of knowledge, without underestimating the potential risks to human health. Due to the predictive nature of human health risk assessments, uncertainty is inherent in these types of assessments.

Some examples of the uncertainties that may have contributed to the potential for health impacts to be greater than those predicted in the SLHHRA relate to:

- air quality predictions for the construction emissions; and
- lack of baseline air quality information.

The ground-level air concentrations of the chemicals of potential concern were estimated using the AERSCREEN model. This model generates site-specific worst-case (conservative) data and is considered suitable for the purposes of a SLHHRA. The equipment emissions estimates are conservative as it was assumed that all heavy construction equipment would be operating for 12 hours per day, 6 days per week for the duration of the construction period. Due to the conservative nature of the AERSCREEN model, the predicted ground-level air concentrations most likely overstate what the actual air concentrations will be from the construction of the Project. Therefore, the health impacts are not expected to be greater than those described in the SLHHRA.

There are no ambient air data available for the Town of Canmore that adequately represent baseline conditions for the SLHHRA. The absence of baseline air concentrations may have resulted in the underestimation of the “cumulative” air concentrations. However, with few exceptions the predicted air concentrations for the Project are orders of magnitude below their respective exposure limits. As such, the addition of baseline data is not expected to change the overall findings of the SLHHRA.

In light of the conservative nature of the assessment and the low overall magnitude of the predicted risk estimates, the Project’s construction emissions are not expected to have an adverse effect on the health of the area residents.

As described in Section 8.2.5 of the environmental impact assessment, potential effects on air quality will be mitigated by minimizing vehicle idling and ensuring all equipment is well-maintained. In addition, road dust suppression is planned to occur up to four times per day during construction.

154	**Volume 1, Section 9.1.1, Pages 9-1** **Volume 1, Section 9.1.1, Page 9-2** **Volume 1, Section 9.1.1, Page 9-3** The conclusions of the human health risk assessment are dependent on the air dispersion modelling results. Through the SIR process, additional air modelling may be required for the air quality portion of the application, thus generating new predicted air concentration data. a. In the event that new or additional air concentration data are generated for any chemical of concern, compare the results to health based TRVs and discuss the potential health impacts, or provide justification for not completing these steps.

Response:

a. Additional air concentration data for the chemicals of potential concern and a discussion of the potential health impacts are included in the appended screening level human health risk assessment (Appendix 146-1, Section 7.0).

8 INCIDENTS, MALFUNCTIONS AND RETENTION STRUCTURE SAFETY

155	**Volume 1, Section 4.1.1, Page 4-1** *Until the Project, or other flood mitigation offering similar risk reduction, is complete, no new development will occur on the Cougar Creek alluvial fan (Section 4.2.5).* a. Clarify how this potential new development would affect the proposed Structure (e.g. consequence classification, design and operation).

Response:

a. There are only five parcels that are available for development in the Cougar Creek area. All of these parcels are zoned single-family residential. This increase in residential units in the area would increase the population and the housing density by less than 0.5%. The development of those parcels is therefore of minimal consequence in relationship to the Structure design and operation. The Canadian Dam Association consequence classification will also not be affected by these new developments as the estimated number of fatalities and the economic risk would not significantly change.

156	**Volume 1, Section 4.1.11, Page 4-5** a. For completeness, provide bonding (e.g. materials) requirements that will be included in the construction documents.

Response:

a. Bid Bond

Bidders will be required to submit with their tender a Bid Bond equal to 10% of the total tender sum as a guarantee that, if awarded the bid, the Bidder will enter into a contract with the Town of Canmore.

Performance Bond, and Labour and Materials Bond

The successful Bidder shall provide at its own expense a Performance Bond, as well as a Labour and Materials Bond, to guarantee the successful Bidder's faithful performance of the contract, and protect the Town against any losses or damage arising by reason of failure of the successful Bidder to faithfully perform the contract.

The Performance Bond and the Labour and Materials Bond are to be issued by a surety company licensed in the Province of Alberta and satisfactory to the Town in the amount of 50% of the contract sum.

The Performance Bond shall remain in force as a maintenance bond for the period specified in the contract general conditions after the date a Construction Completion Certificate has been issued by the Town.

157	**Volume 1, Section 4.1.2, Page 4-2** a. Provide the evacuation procedures that will be initiated for a major flood event that is beyond the design parameters of the structure.

Response:

a. The emergency preparedness plan (EPP) and emergency response plan (ERP), submitted with the Dam Safety submission through the *Water Act* application process, contain specific information regarding the evacuation procedures that will be initiated for a major flood event that is beyond the design parameters of the Structure. The ERP and EPP plans are designed to be used in conjunction with the Town of Canmore existing Municipal Emergency Management Plan (MEMP).

The MEMP was revised in 2014 following the 2013 flood event and will be revised again with specific information pertinent to the Structure if the Project is approved. The specific Cougar Creek Flood Response Plan will also be revised to take into account the Structure and its appurtenant structures.

The ERP and EPP are currently in their first version and are being revised as the Project evolves, and to better integrate them with the MEMP. Revised versions of both plans will be submitted to Dam Safety when they are available later in 2017.

158	**Volume 1 Section 4.2.1, Page 4-9** **Volume 1, Section 4.2.1, Page 4-10** **Volume 1, Section 4.2.1, Page 4-11** With respect to alternatives considered, Option D (no further mitigation) was rejected. a. How does the historical and predicted natural flood scenario compare with the dam failure scenario? I.e., how would a natural landslide dam flooding event compare to the failure of the proposed dam holding back 760, 000 m^3 of water and debris? Provide a figure comparing the 2 scenarios (E.g. Drawing 11 in BGC [2014] vs. Figure 10.3-2 and 10.3-3 in the EIA).

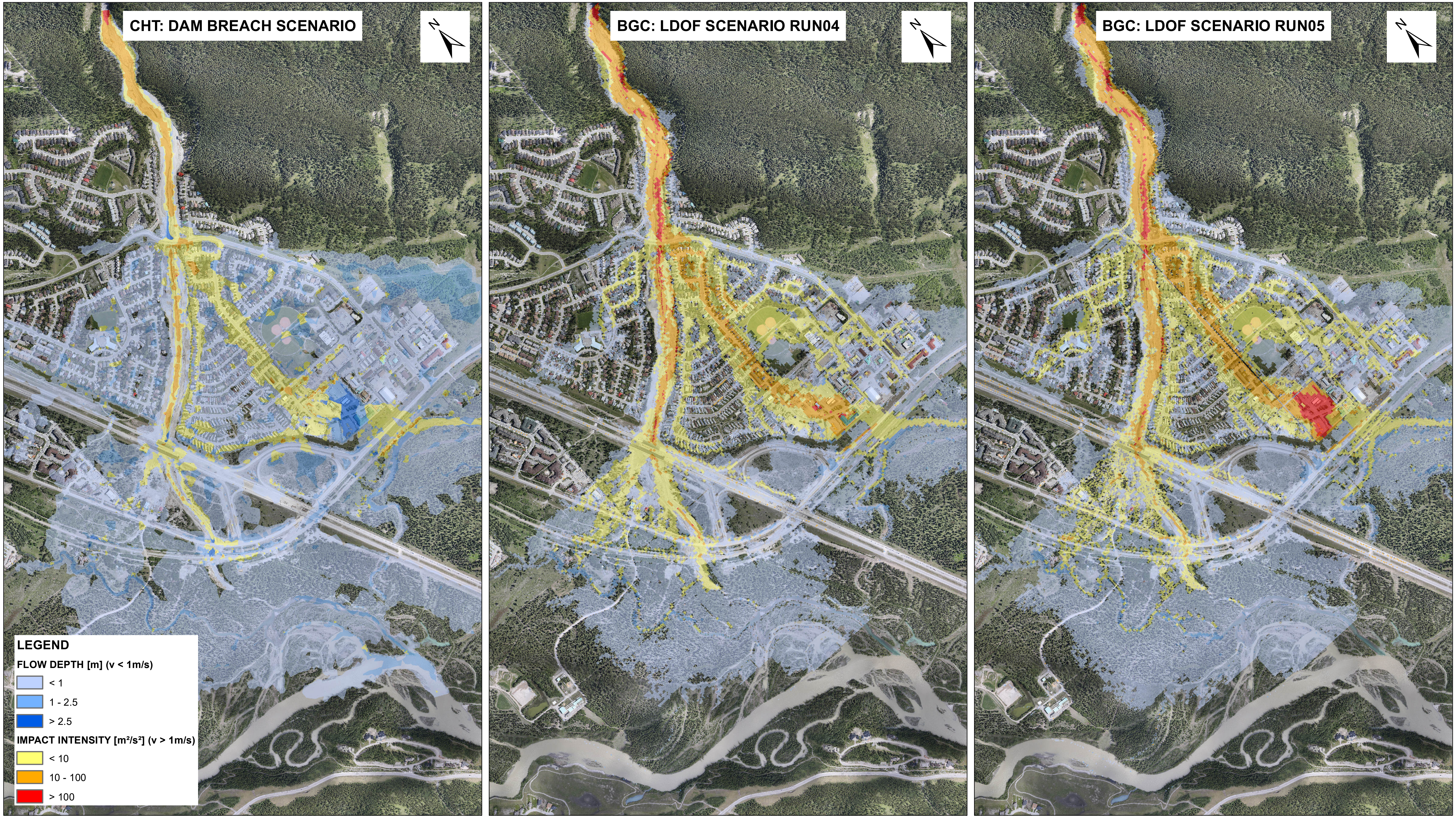
Response:

a. The comparison is shown on Figure 158-1. This figure shows that a Structure breach scenario leads to a wider inundation area with substantially lower impact intensities compared to a landslide dam outbreak flood (LDOF) scenario as assumed in the hazard assessment by BGC Engineering Ltd. (BGC 2014). Figure 158-1 includes two LDOF scenarios for 300 to 1,000-year (Scenario 4) and 1,000 to 3,000-year (Scenario 5) return periods.

However, consideration must be given to the fact that the breach scenario for the Structure is based on a fully impounded structure, which results from a 300-year return period storm event, super-imposed with a 1,000-year return period LDOF event, combined with the elimination of the Structure concrete core wall in the scenario. The estimated return period of such superimposed events for the Structure dam breaching inflow scenario is 300,000-year. This is compared to the estimated return periods of the BGC LDOF scenarios, which are 300 to 1,000-year for Scenario 4, and 1,000 to 3,000-year for Scenario 5. The above return periods are related to the storm events and not to flood return periods.

References:

BGC Engineering Inc. (BGC). 2014. *Town of Canmore, Cougar Creek Debris Flood Hazard Assessment - Final*. Report prepared for the Town of Canmore. Vancouver, British Columbia. March 7, 2014.



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REV.	DATE	REVISION NOTES	DRAWN	REVIEW	APPROVED

SCALE: 1:5,000
DATE: 2017/03/16
DRAWING: DPo
DESIGN: DPo
REVIEW: MSc
APPROVED:

PROFESSIONAL SEAL:

APEGA PERMIT NUMBER: 13440

CLIENT:
Town of CANMORE

ENGINEERING:
CANADIAN HYDROTECH CORPORATION

PROJECT:
COUGAR CREEK
DEBRIS FLOOD RETENTION STRUCTURE

Figure 158-1 Comparison of Flood Wave Impact

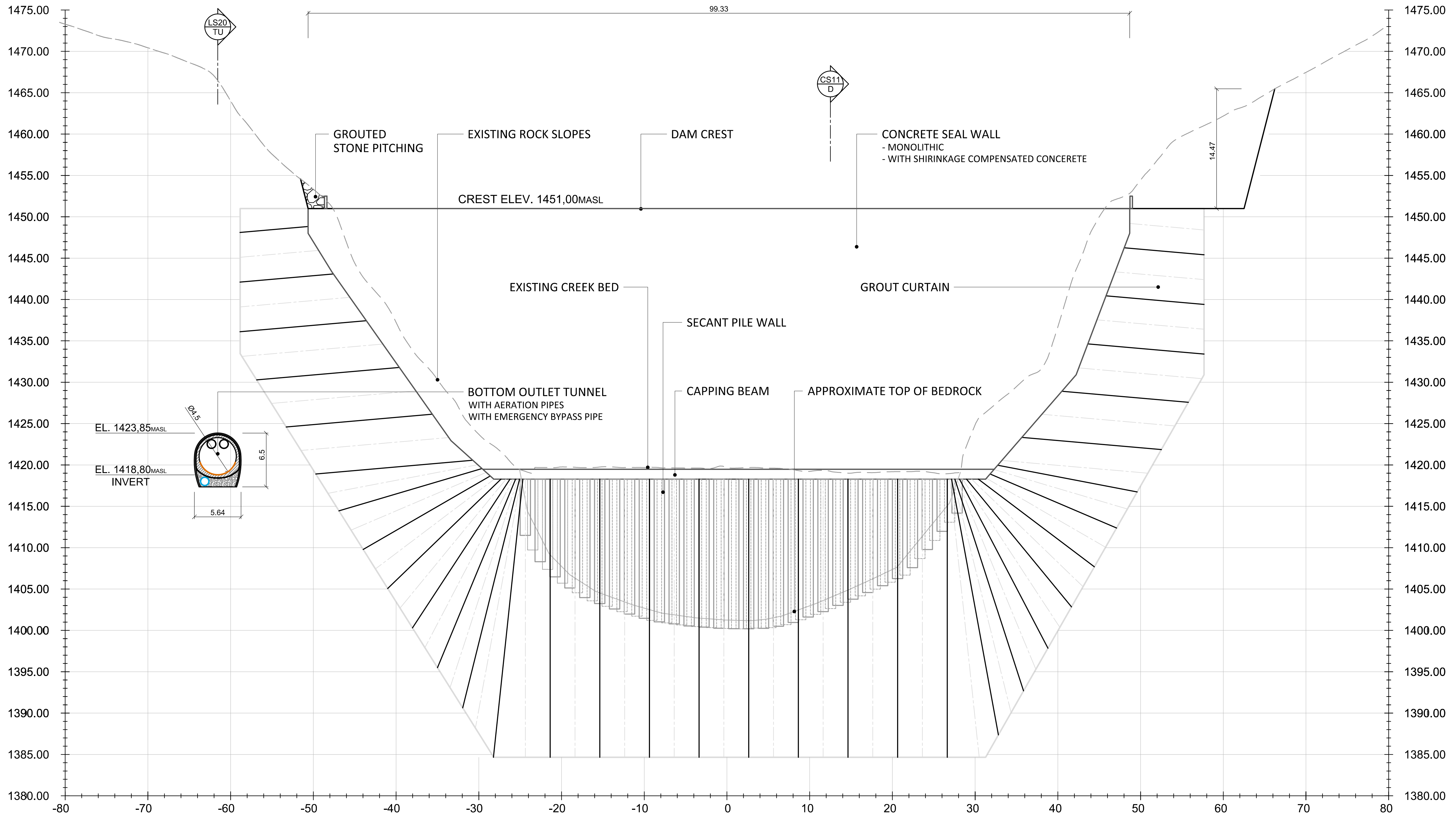
PROJECT No.: 16568
DRAWING No.: LTMM CC-EIA-RES-001 R00
REV: 00

159	**Volume 1, Section 4.4, Page 4-10** **Volume 1, Appendix 4B,Section 05.01.03, Page 55** **Volume 1, Appendix 4B, Section 09.03/09.04, Page 88** **Volume 1, Appendix 4B, Section 09.04/09.05, Page 89** **Volume 1, Appendix 4B, Section 09.05/09.06, Page 90** a. Provide the same level of detail for the Tunnel Option as for the Bottom Outlet Structure Option if the Tunnel Option will be included in the procurement process. This includes any specific environmental impacts.

Response:

a. The two bottom outlet structure options are described in Section 4.4.4.3 (pages 4-24 and 4-25 of the environmental impact assessment [EIA]). Designs for both options were considered by each discipline to determine if there were any differences in potential Project effects. As the two options would result in a slightly different footprint, the EIA was conducted using a maximum potential footprint that considered all areas disturbed by either of these options. This more conservative approach ensures that environmental effects associated with either option were adequately addressed.

   The detailed design of the tunnel option has not been completed; however, available technical details are provided on Figures 159-1 to 159-4. Full design details will be provided with the *Water Act* application and Dam Safety submission update that is being prepared in parallel to the EIA process.



LS1
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REV.	DATE	REVISION NOTES	DRAWN	REVIEW	APPROVED

SCALE: 1:500
DATE: March 15, 2016
DRAWING: MSc
DESIGN: MSc
REVIEW: FFa
APPROVED:

PROFESSIONAL SEAL:

APEGA PERMIT NUMBER: 13440

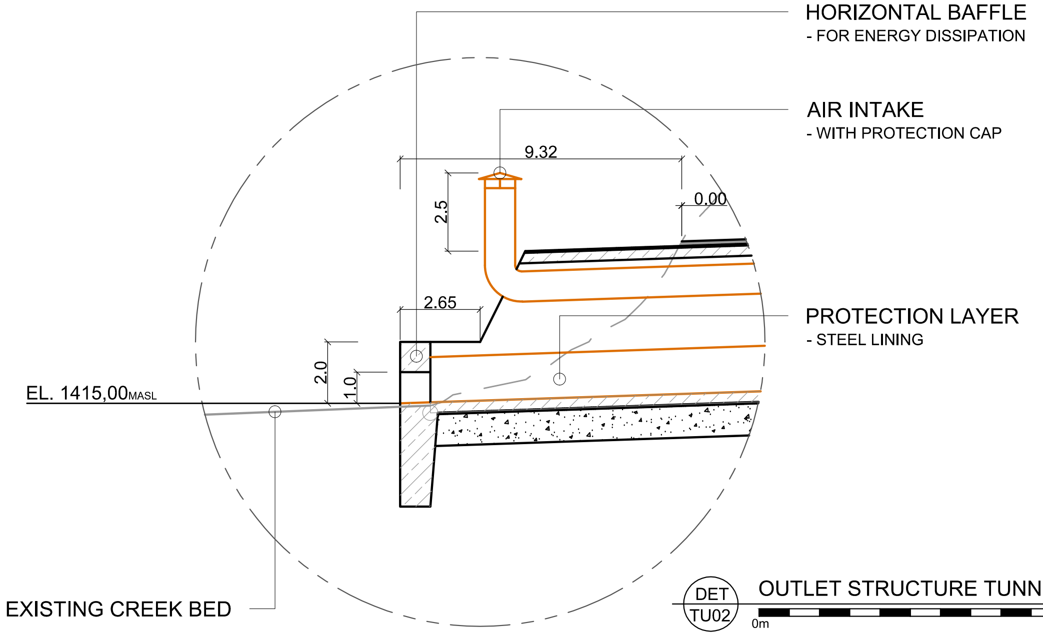
CLIENT:
Town of CANMORE

ENGINEERING:
CANADIAN HYDROTECH CORPORATION

PROJECT:
COUGAR CREEK
DEBRIS FLOOD RETENTION STRUCTURE
ISSUED FOR PERMITTING

Figure 159-1 Structure Cross-section Bottom Outlet Tunnel Option

PROJECT No.: 16494
DRAWING No.: LTMM CC-DAM-530 R00
REV: 00



DET TU02 OUTLET STRUCTURE TUNNEL OPTION

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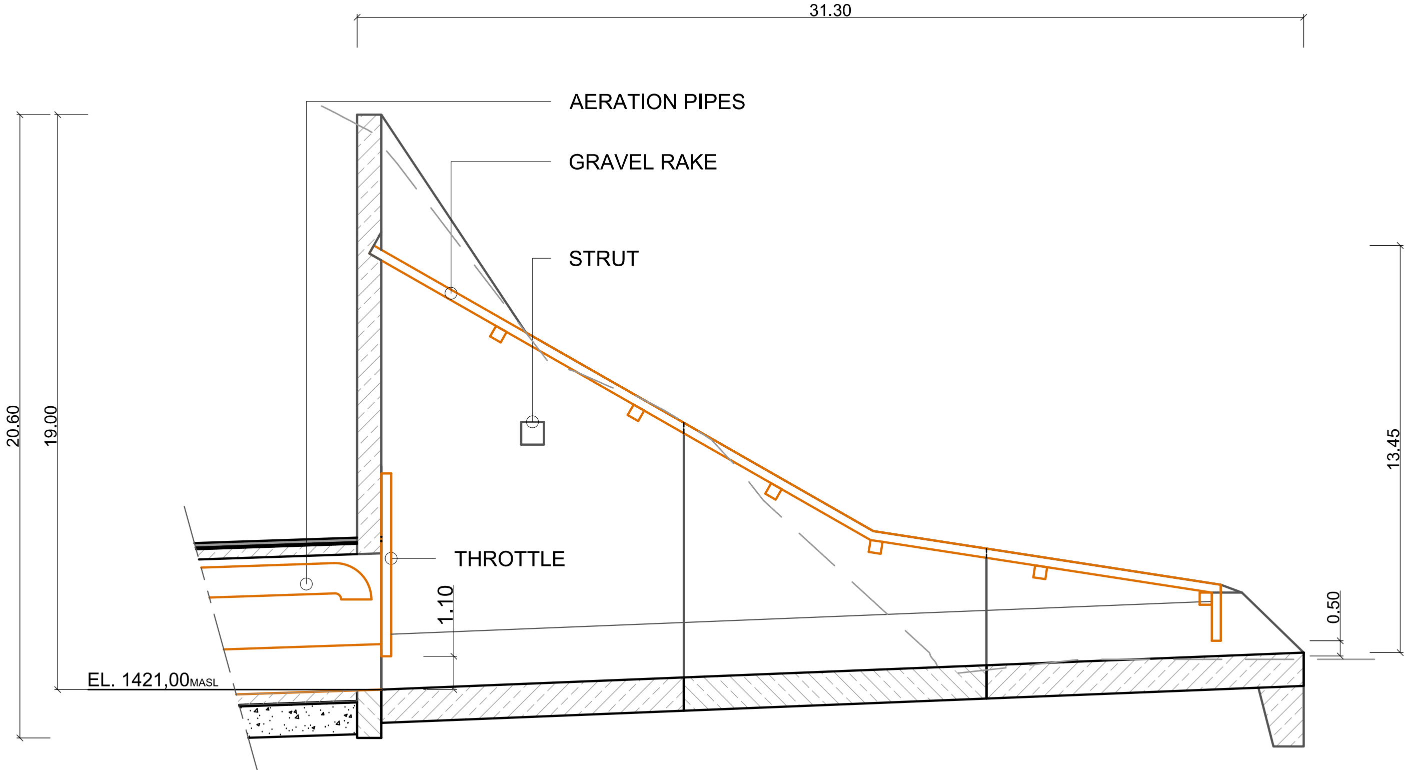

DET TU01 INTAKE STRUCTURE TUNNEL OPTION

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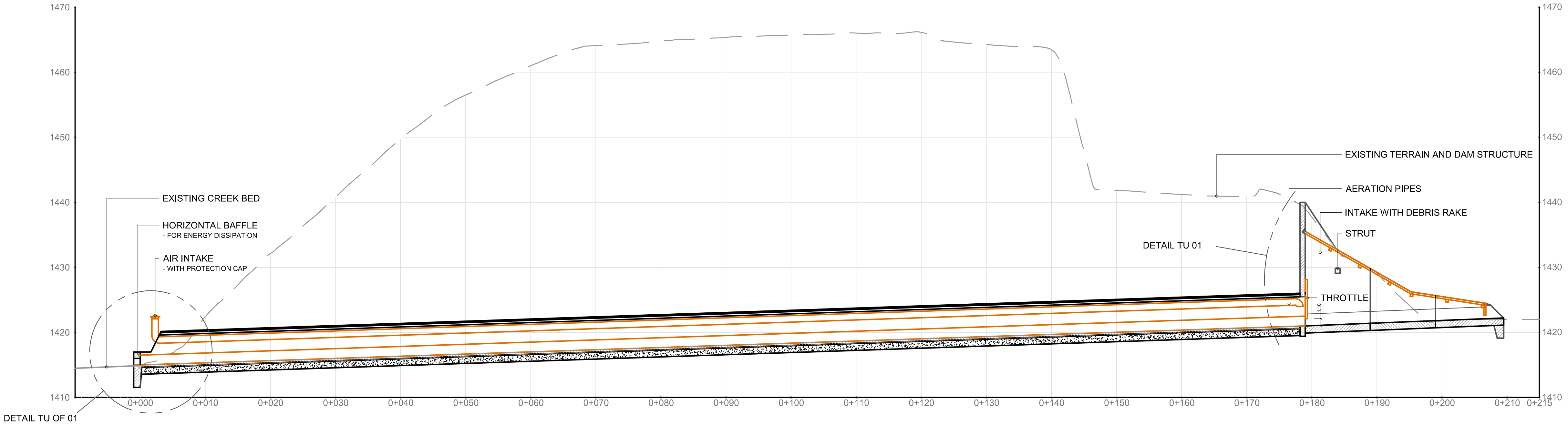

LS20 TU LONGITUDINAL SECTION TUNNEL

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REV.	DATE	REVISION NOTES	DRAWN	REVIEW	APPROVED

SCALE: 1:750
DATE: March 15, 2016
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DESIGN: MSc
REVIEW: FFa
APPROVED:

PROFESSIONAL SEAL:

APEGA PERMIT NUMBER: 13440

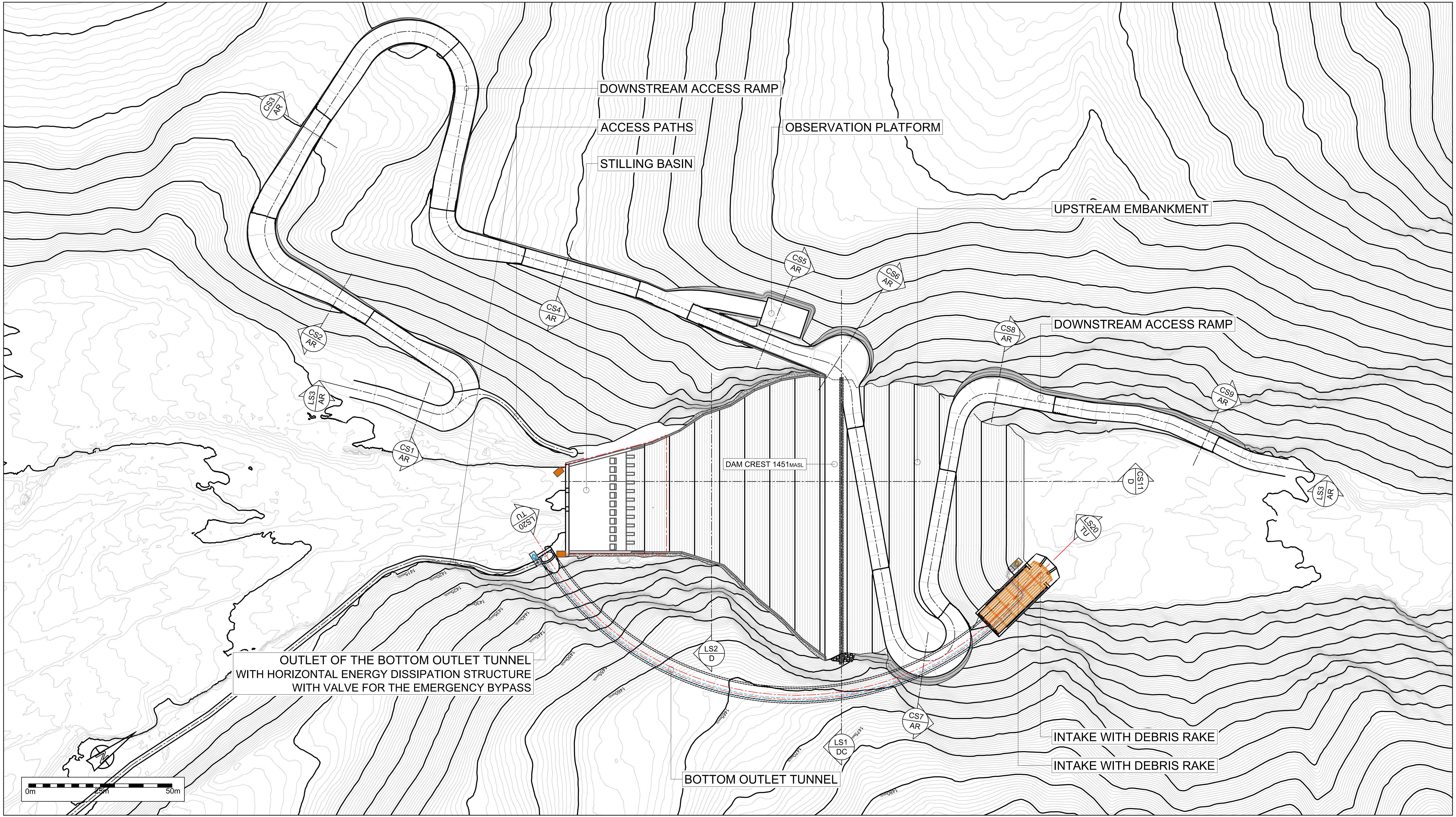
CLIENT:
Town of CANMORE

ENGINEERING:
CANADIAN HYDROTECH CORPORATION

PROJECT:
COUGAR CREEK
DEBRIS FLOOD RETENTION STRUCTURE
ISSUED FOR PERMITTING

Figure 159-2 Tunnel Longitudinal Section

PROJECT No.: 16494
DRAWING No.: LTMM CC-DAM-531 R00
REV: 00



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REV.	DATE	REVISION NOTES	DRAWN	REVIEW	APPROVED

SCALE: 1:1,250
DATE: June 15, 2016
DRAWING: MSc
DESIGN: MSc
REVIEW: MSc
APPROVED:

PROFESSIONAL SEAL:

APEGA PERMIT NUMBER: 13440

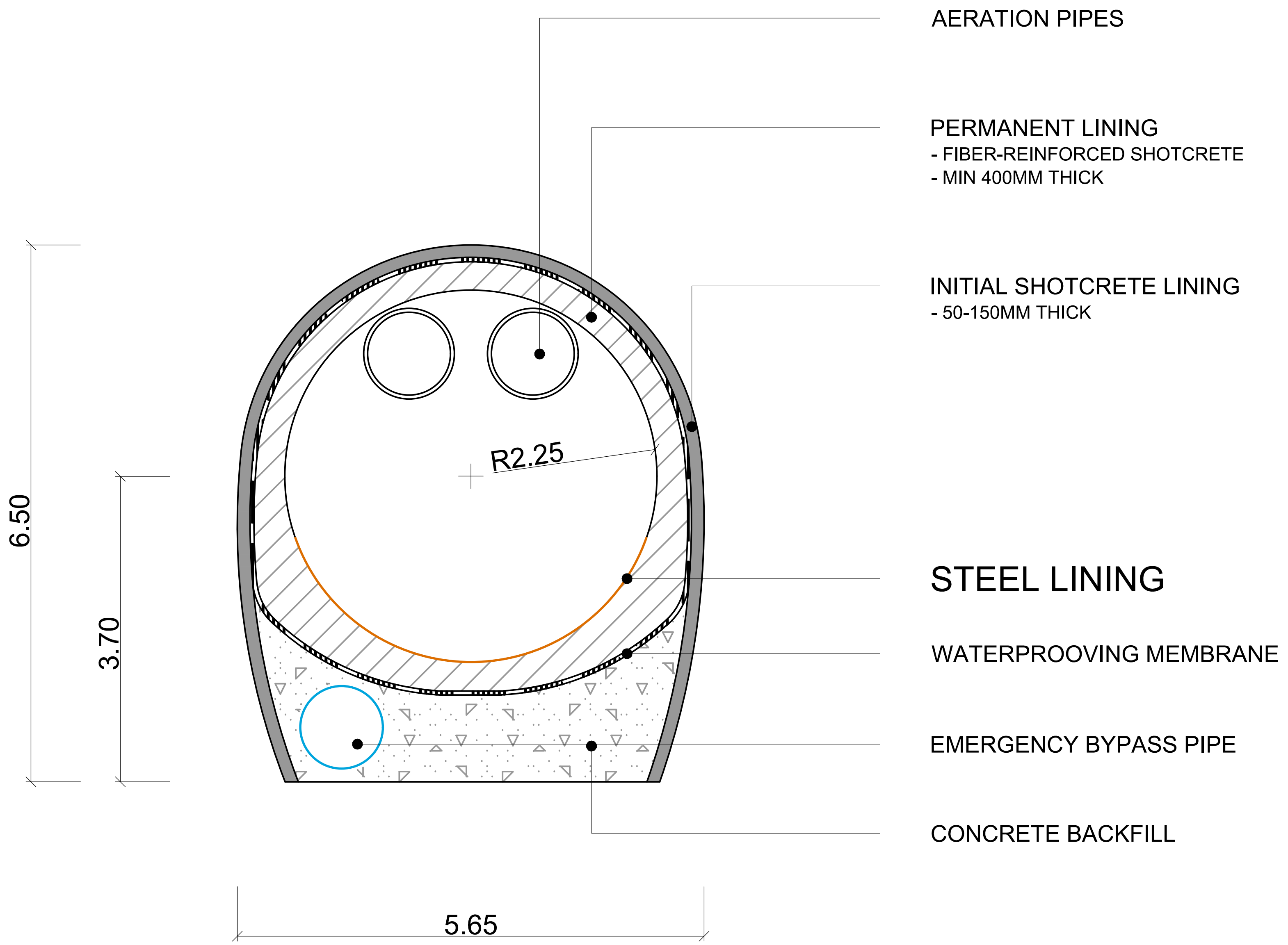
CLIENT:
Town of CANMORE

ENGINEERING:
CANADIAN HYDROTECH
CORPORATION

PROJECT:
COUGAR CREEK
DEBRIS FLOOD RETENTION STRUCTURE
ISSUED FOR PERMITTING

Figure 159-3 Access Road and Retention Structure, Bottom Outlet Tunnel Option

PROJECT No.: 16494
DRAWING No.: LTMM CC-DAM-532 R00
REV: 00



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REV.	DATE	REVISION NOTES	DRAWN	REVIEW	APPROVED

SCALE: 1:75
DATE: March 23, 2017
DRAWING: MSc
DESIGN: Els
REVIEW: MSc
APPROVED:

PROFESSIONAL SEAL:

APEGA PERMIT NUMBER: 13440

CLIENT: Town of CANMORE

ENGINEERING: **CANADIAN HYDROTECH CORPORATION**

PROJECT:
COUGAR CREEK
DEBRIS FLOOD RETENTION STRUCTURE
ISSUED FOR PERMITTING

Figure 159-4 Tunnel Cross-section, Bottom Outlet Tunnel Option

PROJECT No.: 16494
DRAWING No.: LTMM CC-DAM-533 R00
REV: 00

160	**Volume 1, Section 4.4, Page 4-19** a. Explain how the project is designed to work in conjunction with the articulated concrete mats portion of Cougar Creek within Canmore.

Response:

a. The articulated concrete mats have a design flow of 64 m^3/s. They were installed to reduce erosion of the banks and to prevent the creek from migrating laterally, as occurred in the 2013 flood event. Flood events of return periods of 200-year and above, can produce flows that are significantly higher than the design flow of the mats. The resistance of the mats against erosion has been identified as a limiting factor. Debris floods contain a large amount of entrained debris of different size and shape. This debris could damage the mats during a debris flood. To maintain the integrity and function of the mats, it is imperative that flow is limited to below 64 m^3/s and that large debris does not flow through the channel. The Structure will restrict the flow in the channel to a maximum of 45 m^3/s and prevent large debris from being transported downstream through the channel.

161	**Volume 1, Section 4.4.1, Page 4-19** a. Clarify that the expected condition is a *debris flood* (i.e., not a debris flow) and this condition is the basis for the proposed Structure.

Response:

a. The expected hydrogeomorphic process, or design event, at the Structure location is classified as a debris flood/landslide dam outbreak flood (LDOF). This process informs the loading assumptions and therefore the design basis for the Structure. There are several steep tributaries of Cougar Creek that are prone to debris flows. Once debris flows impact the Cougar Creek channel, they will dilute and assume debris-flood characteristics. LDOFs may, over some distance downstream, assume characteristics of debris flows but then likely dilute to a debris flood before reaching the Structure.

162	**Volume 1, Section 4.4.1, Page 4-20** a. Provide information on the expected erosion that will occur downstream of the stilling basin during operation of the Bottom Outlet Structure and Spillway.

Response:

a. Erosion directly downstream of the stilling basin will be mainly controlled by its design, which is based on the standard USBR Type III stilling basin, as shown on Figure 162-1. The primary function of the stilling basin it to protect the toe of the Structure from erosion and scouring when the spillway is engaged. The physical scale modelling undertaken at the Institute of Mountain Risk Engineering at the University of Natural Resources and Life Sciences in Vienna, Austria (described below), and other studies undertaken in the last several years, such as the one by Frizell and Svoboda (2012), show that USBR Type III stilling basins are very effective at protecting the toe of the Structure and dams from scouring and erosion.

Physical modelling of the stilling basin of the Structure by the Institute of Mountain Risk Engineering showed that the ramp on the end-sill significantly reduces any potential scouring of the downstream side of the basin and avoids exposure of the foundation, as shown on Figures 162-2, 162-3, and 162-4. Figure 162-3 shows the spillway flood with a defined hydraulic jump at the baffles and a secondary hydraulic jump downstream of the ramp shaped end-sill. Most of the gravel within the stilling basin was washed out at the early stage of the spillway-flood. Figure 162-4 shows the situation after testing the buried stilling with a spillway-flood. The basin was mostly free of gravel. However, directly downstream of the end-sill, gravel accumulation can be observed The ramp and the deep end-sill footing are therefore essential design elements of the spillway for scour protection. The total depth of the Structure end-sill footing is 7.25 m. This designed depth is sufficient for all modelled scenarios. Limitations of this modelling should be noted: the base of the model is not deep enough for a precise determination of scour depth; and the model frame somewhat forms a second end-sill, which also influences the results.

Flows from the bottom outlet structure are discharged through a low water channel running along the stilling basin (Figure 162-6). This low water channel consists of large riprap in concrete that sits on the gravel/alluvium bed filling the stilling basin. This channel is strong enough to convey the maximum flow of the bottom outlet structure. However, during a spillway flood the low water channel will most likely be damaged and will require rehabilitation or reconstruction post event. Downstream of the spillway, some erosion of the alluvium is expected to take place with higher flows. However, no critical scouring or erosion should occur at the end-sill due to its depth.

In regards to the tunnel option, the flows are discharged directly into the No Man’s Land alluvium, downstream of the stilling basin. There is therefore no scouring issue at the stilling basin with this option. Some erosion of the alluvium is expected to take place with higher flows. However, the tunnel outlet is on bedrock and no critical or scouring erosion should occur at the outlet.

Complementary design drawings are provided as Figures 162-5 to 162-8. The updated drawings showing the low water channel are Figures 162-5 and 162-6. The revised stilling basin with the ramp at the end-sill is shown on the updated drawings (Figures 162-7 and Figure 162-8). Figure 162-8 is also showing the low water channel in longitudinal section, as well as the tunnel discharging downstream of the stilling basin.

References:

Frizell K.W. and C.D. Svoboda 2012. *Performance of Type III Stilling Basins – Stepped Spillway Studies: Do Stepped Spillways Affect Traditional Design Parameters?* Hydraulic Laboratory Report HL-2012-02. U.S. Department of Interior, Bureau of Reclamation, Hydraulic Investigations and Laboratory Services. Denver, Colorado. May 2012.

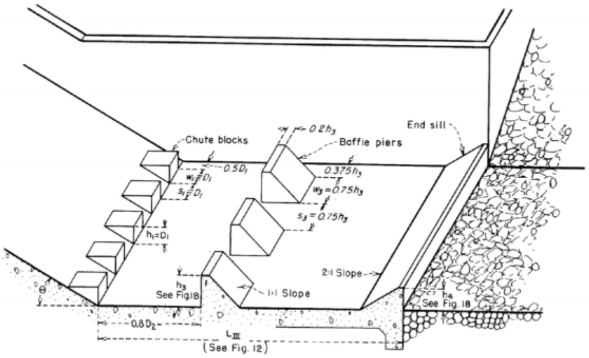


Figure 162-1 USBR Standard Type III Stilling Basin

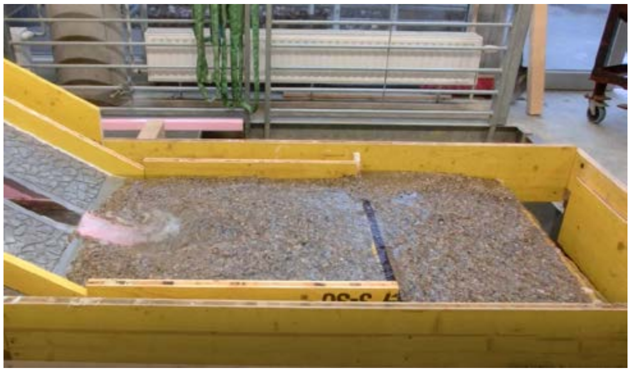


Figure 162-2 Initial Situation before the Model Run with a Buried USBR Standard Type III Stilling Basin

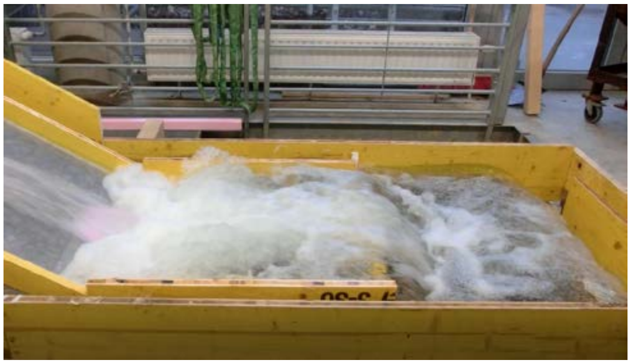


Figure 162-3 Spillway Flood Testing

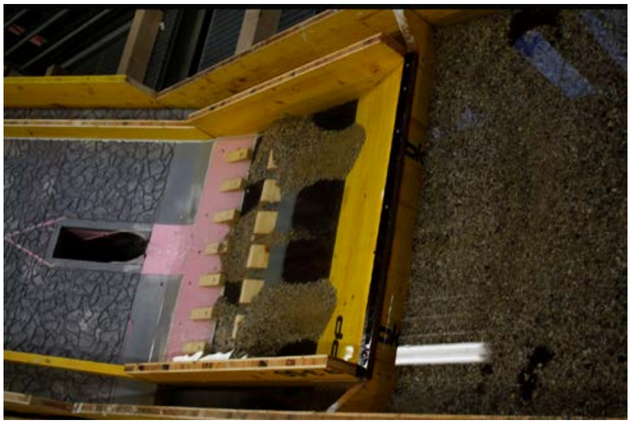
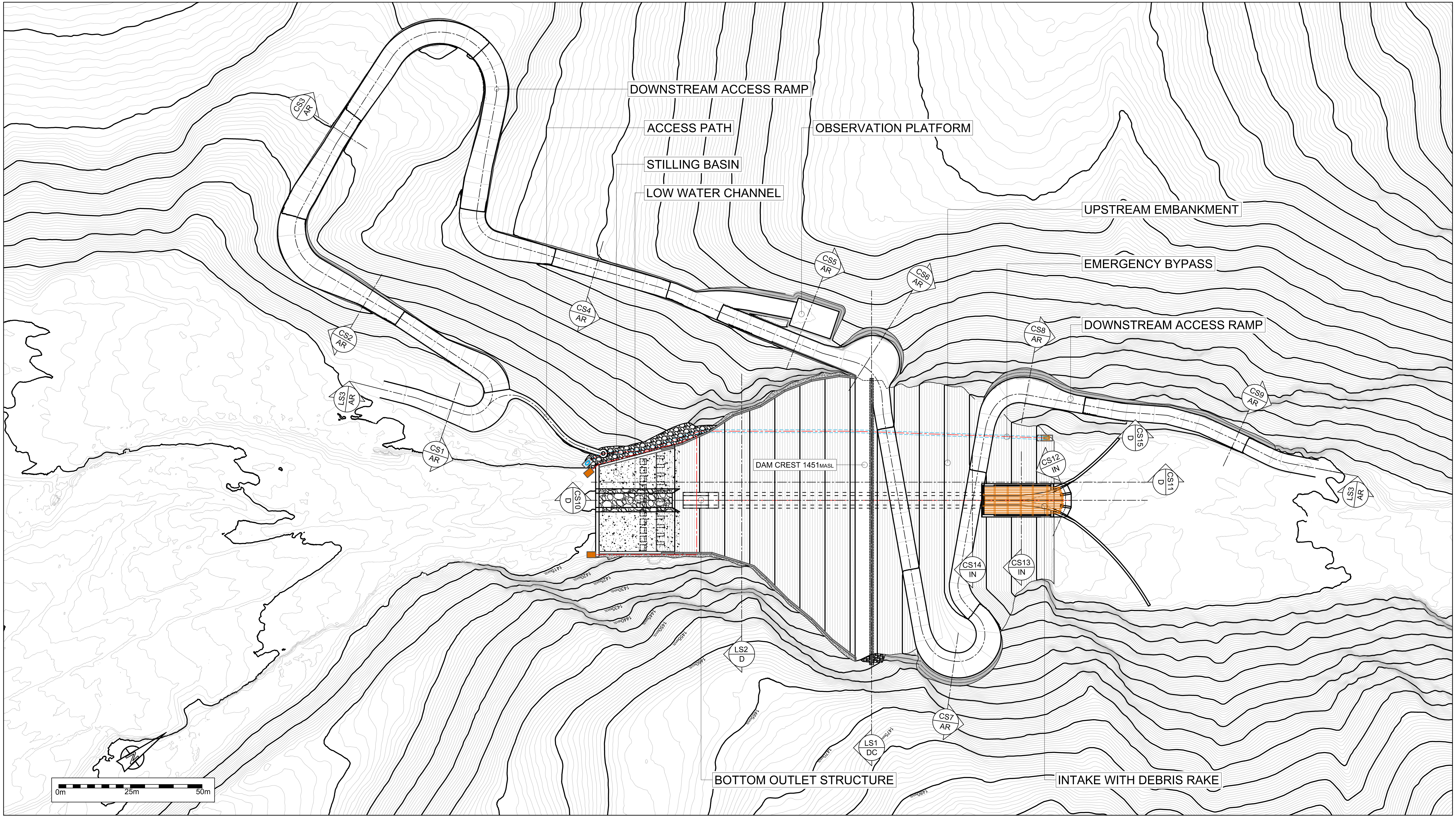


Figure 162-4 Situation After Testing is Complete



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REV.	DATE	REVISION NOTES	DRAWN	REVIEW	APPROVED
	March 30, 2017	Update of the design at the stilling basin with a low water channel	MSc		

SCALE: 1:1,250
DATE: June 15, 2016
DRAWING: ALe
DESIGN: ALe, MSc
REVIEW: MSc
APPROVED: EIs

PROFESSIONAL SEAL:

APEGA PERMIT NUMBER: 13440

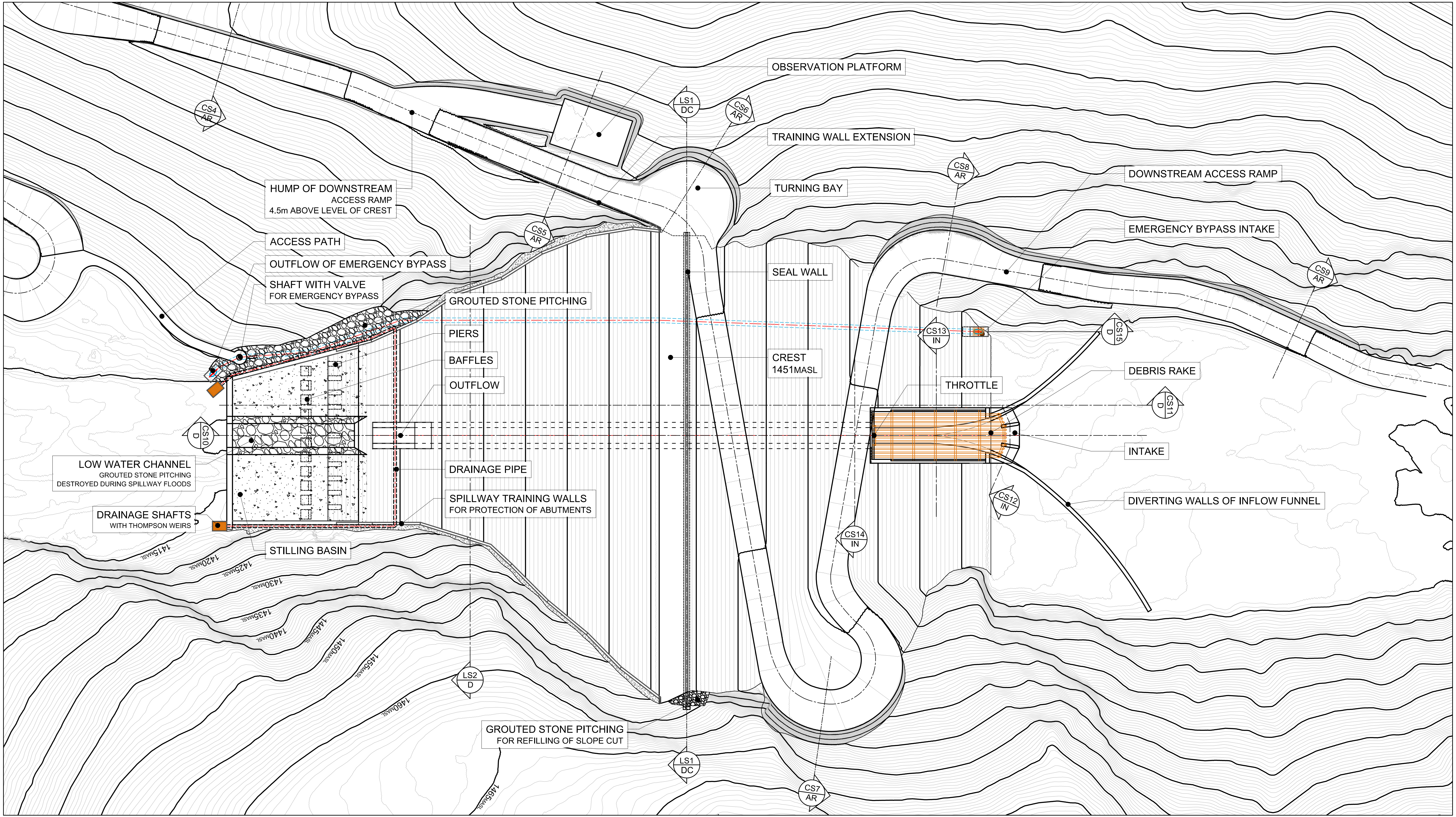
CLIENT:
Town of CANMORE

ENGINEERING:
CANADIAN HYDROTECH CORPORATION

PROJECT:
COUGAR CREEK
DEBRIS FLOOD RETENTION STRUCTURE
ISSUED FOR PERMITTING

Figure 162-5 Access Road and Retention Structure, Site Overview

PROJECT No.: 16494
DRAWING No.: LTMM CC-DAM-501 R01
REV: 00



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REV.	DATE	REVISION NOTES	DRAWN	REVIEW	APPROVED
	March 30, 2017	Update of the design at the stilling basin with a low water channel	MSc		

SCALE: 1:750
DATE: June 15, 2016
DRAWING: ALe
DESIGN: ALe, MSc
REVIEW: MSc/FWi
APPROVED:

PROFESSIONAL SEAL:
APEGA PERMIT NUMBER: 13440

CLIENT: Town of CANMORE

ENGINEERING: **CANADIAN HYDROTECH CORPORATION**

PROJECT:
COUGAR CREEK
DEBRIS FLOOD RETENTION STRUCTURE
ISSUED FOR PERMITTING

Figure 162-6 Retention Structure, Site Overview

PROJECT No.: 16494
DRAWING No.: LTMM CC-DAM-502 R01
REV: 00

① **HIGH PERFORMANCE SHELL**
- minimum shear angle 41°
- angular shaped well graded fill material 0-300mm
- grading according to specifications
- compacted in layers of 60cm maximum thickness
- required loading capacity according to specifications
- minimum permeability $2*10^{-5}$ [m/s]

② **INNER SUPPORT BODIES**
- minimum shear angle 36°
- angular shaped to subangular well graded fill material 0-300mm
- grading according to specifications
- compacted in layers of 60cm maximum thickness
- required loading capacity according to specifications
- minimum permeability $1*10^{-5}$ [m/s]

③ **DECELERATION ZONE**
- minimum shear angle 33°
- fine-grained material with maximum grain size of 32mm
- grading according to specifications
- compacted in layers of 30cm maximum thickness
- required loading capacity according to specifications
- maximum permeability $5*10^{-7}$ [m/s]

④ **CUT-OFF WALL**
- secant pile wall
- 3m tied into the bedrock
- grouted at the contact with the bedrock

⑤ **GROUT CURTAIN**
- single central row grouted to a maximum remaining transmissivity of 10 Lugeon
- upstream and downstream connection rows grouted to a maximum remaining transmissivity of 10 Lugeon
- structural grouting of the contact to the seal wall

⑥ **PROTECTION AND FILTER LAYER**
- minimum shear angle 36°
- subangular to rounded filter material 8-32mm
- grading according to specifications
- compacted in layers of 30cm maximum thickness
- required loading capacity according to specifications
- minimum permeability $5*10^{-3}$ [m/s]

⑦ **DRAINAGE PRISM AND DRAINAGE LAYER**
- minimum shear angle 36°
- subangular to rounded filter material 16-150mm
- grading according to specifications
- compacted in layers of 30cm maximum thickness
- required loading capacity according to specifications
- minimum permeability $5*10^{-3}$ [m/s]

⑧ **ASPHALT CONCRETE CAPPING**
- for sealing expansion joint between shell and seal wall
- AC mix design to be defined in detail prior to construction

⑨ **TRANSITION LAYER**
- for separation of AC from dam fill

⑩ **CONCRETE SEAL WALL**
- tied into the abutments by means of a rock trench
- structural grouting at the contact with the grouted bedrock

⑪ **SPILLWAY SHELL**
- grouted stone pitching - riprap class 4
- set in steel reinforced concrete bed

⑫ **SPILLWAY TRAINING WALLS**
- structurally connected to base slab of shell
- 2m offset between rock abutments and wall

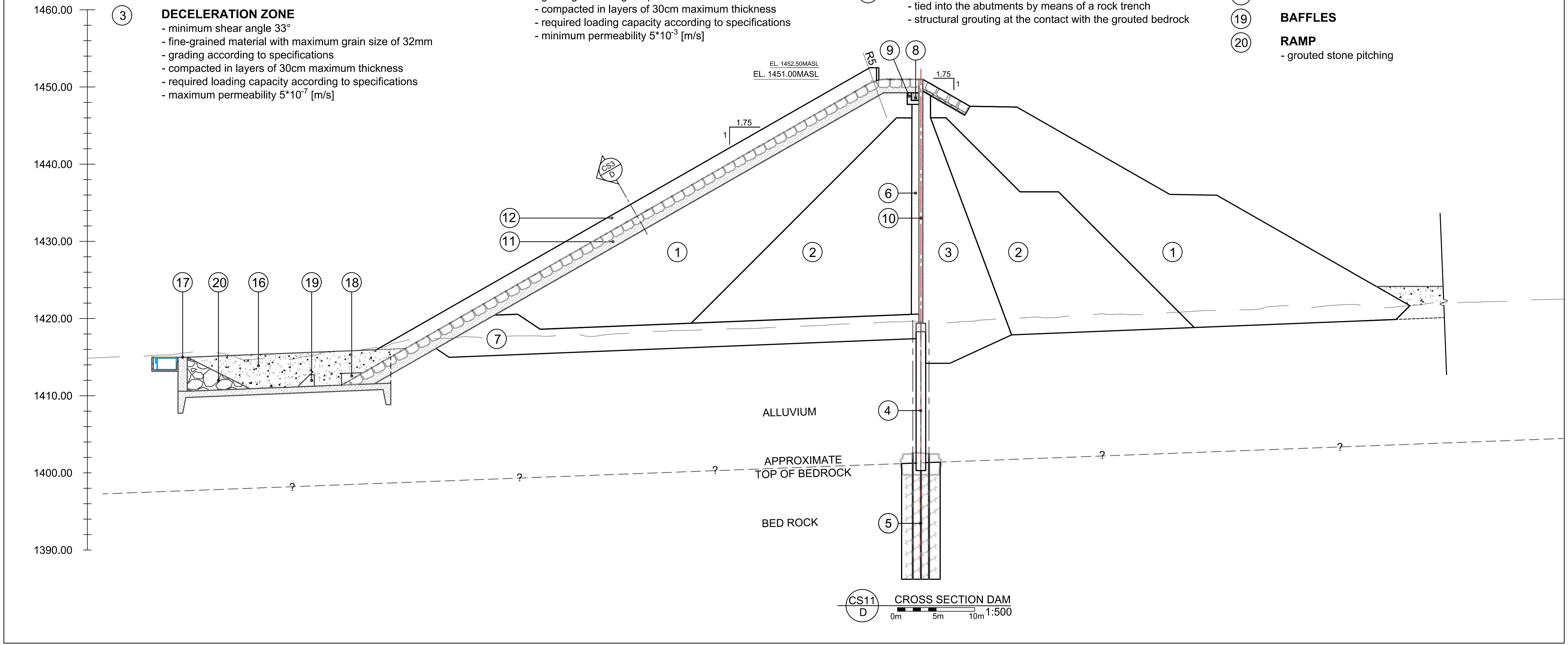
⑯ **STILLING BASIN**
- covered with loose soil
- landscaped according to specifications

⑰ **COUNTER SILL**
- spans the full width of the creek bed
- 3m tied into bedrock abutments

⑱ **PIERS**

⑲ **BAFFLES**

⑳ **RAMP**
- grouted stone pitching



CS11 D CROSS SECTION DAM
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REV.	DATE	REVISION NOTES	DRAWN	REVIEW	APPROVED
	March 30, 2017	Update of the design at the stilling basin with a ramp at the end-sill and showing the fill	MSc		

SCALE: 1:500
DATE: June 13, 2016
DRAWING: ALe
DESIGN: ALe, MSc
REVIEW: MSc
APPROVED: Els

PROFESSIONAL SEAL:

APEGA PERMIT NUMBER: 13440

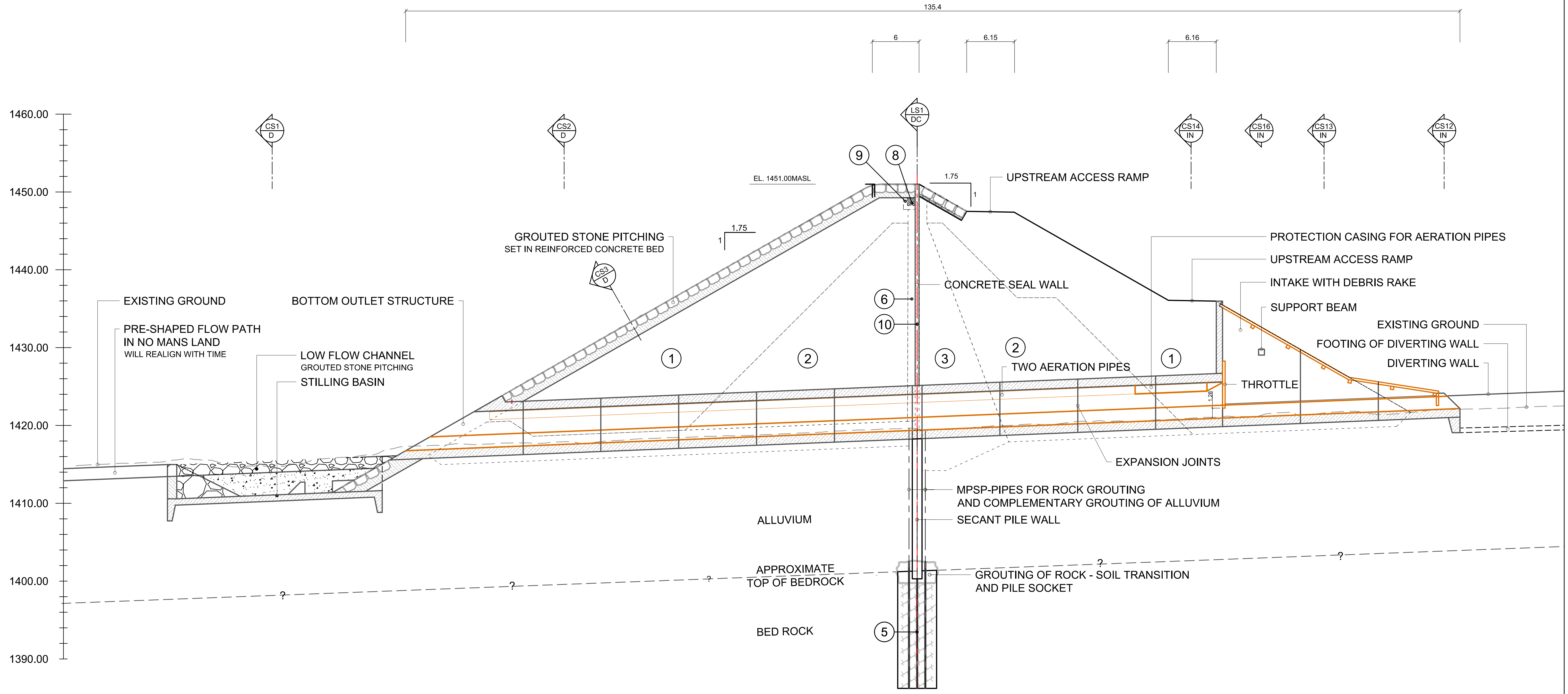
CLIENT: Town of CANMORE

ENGINEERING: CANADIAN HYDROTECH CORPORATION

PROJECT: COUGAR CREEK
DEBRIS FLOOD RETENTION STRUCTURE
ISSUED FOR PERMITTING

Figure 162-7 Structure Construction Concept, Cross-section 11D

PROJECT No.: 16494
DRAWING No.: LTMM CC-DAM-503 R00
REV.: 00



CS10
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CROSS SECTION DAM
1:500

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REV.	DATE	REVISION NOTES	DRAWN	REVIEW	APPROVED
	March 30, 2017	Update of the design at the stilling basin with a ramp at the end-sill, the low water channel and showing the fill	MSc		

SCALE: 1:500
DATE: June 6, 2016
DRAWING: ALe
DESIGN: ALe, MSc
REVIEW: MSc
APPROVED: Els

PROFESSIONAL SEAL:

APEGA PERMIT NUMBER: 13440

CLIENT:
Town of CANMORE

ENGINEERING:
CANADIAN HYDROTECH CORPORATION

PROJECT:
COUGAR CREEK
DEBRIS FLOOD RETENTION STRUCTURE
ISSUED FOR PERMITTING

Figure 162-8 Intake, Bottom Outlet And Stilling Basin, Cross-section 10D

PROJECT No.: 16494
DRAWING No.: LTMM CC-DAM-504 R01
REV: 00

163	**Volume 1, Section 4.4.1, Page 4-20** Section 4.4.1 indicates that the bottom outlet structure and spillway include measures to protect them from abrasion however no such measures are discussed for the stilling basin. a. Provide information on abrasion protection requirements for the stilling basin including against impact damage to the piers and baffles.

Response:

a. The stilling basin will experience impact only during spillway floods, which are very rare. A spillway flood will not entrain a large amount of debris as most of the debris and gravel will have been deposited at the apex of the inundation area. Some woody debris could make it down the spillway and spillway floods will flush out the soil and vegetation placed on the spillway. This, in combination with cavitation caused by clear water impact during a spillway flood, is expected to lead to some abrasion at the piers and baffles, as well as at the end-sill and side walls.

Extensive investigations on the performance of stilling basins, and in particular of the piers and baffles of the USBR Type III stilling basins were conducted in 2009 by Frizell and Svoboda (2012). The piers and baffles could sustain some damage during a spillway flood as described above; however, catastrophic damage is not expected. Concrete repair may be required on damaged areas after a spillway flood. Any necessary repairs will be conducted using the *Guide to Concrete Repair* (von Fay 2015).

Due to the very low frequency of spillway floods, the higher costs of protection measures, and the very small amount of debris and gravel going over the spillway (leading to minimal damage and abrasion), extra protection measures for the stilling basin are not deemed necessary. However, extra protection measures for the stilling basin could be added if recommended through the Dam Safety review. Additional measures could include hard stone lining in the form of stone pitching, a high performance concrete shell, or additional steel lining on the baffles and piers. The steel lining is the less appealing option since it would be covered by gravel and constantly exposed to ground water, which would cause corrosion issues.

The elements that are constantly exposed to gravel discharge, such as the invert of the bottom outlet structure, are protected with a steel lining. Value engineering is currently being used to further analyze the spillway design. It is possible that the updated design of the spillway will show a thickness decrease in its protective layers, or a change in material. An updated design will be submitted to the Dam Safety branch of Alberta Environment and Parks later in 2017.

References:

Frizell K.W. and C.D. Svoboda 2012. *Performance of Type III Stilling Basins – Stepped Spillway Studies: Do Stepped Spillways Affect Traditional Design Parameters?* Hydraulic Laboratory Report HL-2012-02. U.S. Department of Interior, Bureau of Reclamation, Hydraulic Investigations and Laboratory Services. Denver, Colorado. May 2012.

von Fay K.F. 2015*. Guide to Concrete Repairs.* Second Edition. Concrete, Geotechnical, and Structural Laboratory. U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center. August 2015.

164	**Volume 1, Section 4.4.2, Page 4-20** a. Provide information (population at risk, loss of life, environmental, cultural values, infrastructure, and economics as per Table 2.1 in the CDA guidelines) to support the selection of the very high consequence classification for the structure.

Response:

a. ***Population at Risk***:

Permanent population at risk estimated at 3,780.

High to Extreme Consequence.

Loss of Life:

The loss of life calculations are based on the *RCEM - Reclamation Consequence Estimating Methodology* guidelines (USBR 2015). Two different scenarios have been analyzed: failure with little or no warning and a failure with adequate warning.

- Little or no warning: The estimated number of fatalities is 76 people in the case of little or no warning. The calculations are based on the "middle of suggested limit" values for the little to no warning case.

Very High Consequence

- Adequate warning: The estimated number of fatalities is 3.9 people in the case of adequate warning. The calculations are based on the "upper suggested limit" values in a case with adequate warning. The DV (average depth multiplied by velocity) has been calculated for several areas in the adjacent neighborhood, using the standard three people per dwelling units, with the number of units being conservative. Adequate warning is credible in the case of this structure since a breach could only happen in a "flood-induced failure" and not a "sunny-day failure" as the Structure does not permanently retain water. During a flood event, the emergency response plan would be initiated and the area would be evacuated before the Structure is full. This would provide enough time for the evacuation.

High Consequence

Environmental and Cultural Values:

Wildlife habitat: The only area of concern is No Man's Land. It is an important wildlife corridor that would be damaged during a failure. However, it is an area that was already badly affected by the 2013 floods. Another significant flood or a Structure failure would not significantly worsen the area. No Man's Land will be restored following the construction of the Structure and it would be fairly easy to restore following a failure, based on the reclamation plans for the Project. Restoration or compensation in kind highly possible.

Fish habitat: Cougar Creek is not fish bearing and has no riparian areas. The only area of concern is the confluence of Cougar Creek, Policeman Creek and the Bow River. The grades are flat for the last 500 m between Highway 1A and the confluence. At that location, the peak flow and associated debris entrainment during a failure is fairly low, and minimal effects are expected. Most of the debris larger than very coarse gravel, like cobble and boulder, are expected to aggrade before entering the Bow River. This effect is similar to a flood event; therefore, no significant loss or deterioration of fish habitat is expected. Restoration or compensation in kind highly possible.

Significant Consequence

Infrastructure and Economics:

Some of the information used for the following assessment is from the Dam Safety Program (B.C. MFLNRO 2016).

Very high economic losses are likely. More than $100 million dollars estimated in direct building damage cost. This cost does not include damage to contents or inventory or the cost of clean-up and recovery. If these were considered, actual damage costs could increase by a factor of two or more. The cost also does not capture the economic losses to the business in the area (annual business revenues in impacted area are over $100 million dollars).

The following important infrastructure could be impacted by a breach: Elizabeth Rummel School, Mountain Munchkin Daycare, RCMP detachment, Alpine Helicopters, and the industrial storage yard. The following municipal, provincial and private infrastructure could also be severely damaged: Elk Run Boulevard, Trans-Canada Highway, Highway 1A, Canadian Pacific Railway (CPR) tracks, AltaLink power transmission line, ACTO gas pipeline and the SuperNET fibre optic. The cost associated with the damaged infrastructure has not been calculated. It is also likely in hundreds of millions of dollars.

The loss of Highway 1 is highly possible due to high velocities and depth of water at the crossing. It is likely that the culverts of Highway 1 would, at a minimum, become blocked due to the increased amount of debris travelling to the crossing during a dam failure. Since Highway 1 is a primary highway, its loss is considered to be of "very high consequence." The loss of the CPR tracks are possible due to its exposure to flood waters on a long length of tracks. Similarly, if this main railway is washed out the consequence classification is very high.

Very High Consequence

Final dam classification based on all factors: *Very high consequence*.

References:

British Columbia Ministry of Forests, Lands and Natural Resource Operations (B.C. MFLNRO). 2016. *Downstream Consequence of Failure Classification Interpretation Guideline for Dam Safety Offices.* Dam Safety Program. September 2015, revised January 2016.

U.S. Department of the Interior, Bureau of Reclamation (USBR). 2015. *RCEM – Reclamation Consequence Estimating Methodology: Guidelines for Estimating Life Loss for Dam Safety Risk Analysis*. Interim. July 2015.

165	**Volume 1, Section 4.4.2, Page 4-20** **Volume 1, Appendix 4B, Section 01, Page 28** **Volume 1, Appendix 4B, Section 06.01.05, Page 66** Section 4.4.2 indicates that *the Structure is not intended to permanently hold water, but at full impoundment it has been classified by the Town of Canmore as a "very high consequence dam" and has been designed to meet the CDA guidelines for this classification.* Based on the CDA guidelines, the Structure meets the definition for a Dam as is acknowledged by the above. a. Clarify the relevance of the statement in Appendix 4B (e.g. Executive Summary) which states *considering a dry dam and an empty retention basin, the structure is not to be seen as a water retaining structure or water storing structure, but still as a water diversion structure.*

Response:

a. This statement does not refer to the technical nature of the Structure or to its applicable guidelines. It is an attempt to describe what kind of structure is being proposed and how often water will be impounded behind it. It is very important to the Town of Canmore that people understand that the Structure is a debris flood retention structure, not a dam with a reservoir that permanently impounds water.

   This kind of structure is a fairly new concept to North America since the large majority of dams are holding mine tailings or holding back water on a permanent basis to generate power and/or to provide water for activities such as irrigation, human consumption, industrial use, aquaculture, and navigability. However, debris flood retention structures and debris retention structures are common in Europe, Japan and New Zealand. These structures are also different from retention basins, sediment retention structures, and detention basins that are more commonly seen in North America.

166	**Volume 1, Section 4.4.3, Page 4-21** The physical model study appears to have considered a spillway and stilling basin with a constant width of about 90 m (1/30 scale, 3 m wide model) however the proposed Structure transitions from a width of 100 m at the top of the dam to 30 m as it enters the stilling basin. a. Explain how this difference has been accounted for in the Structure design.

Response:

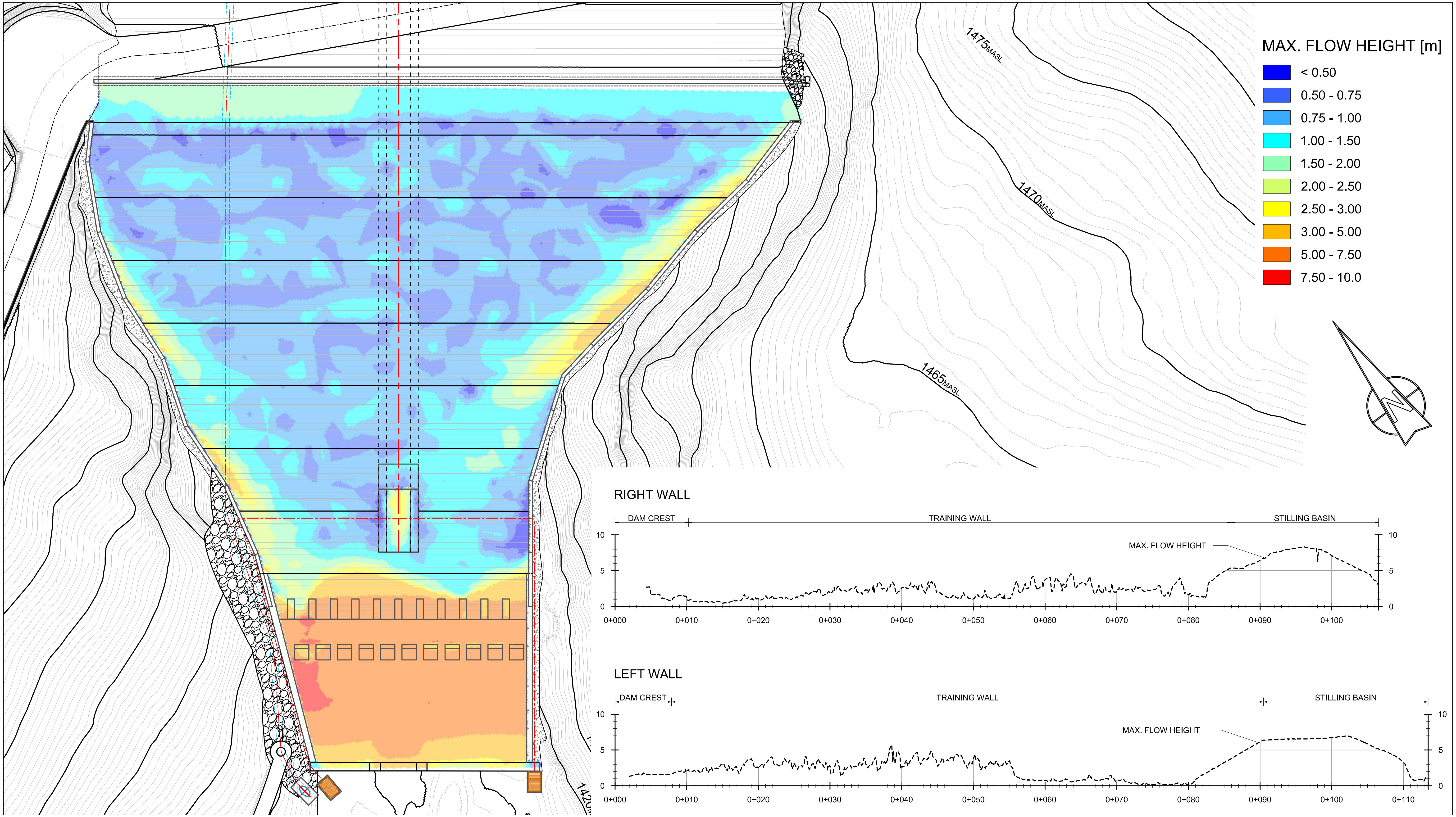
a. Flow heights at the spillway have been analyzed considering a tapering 30 m wide spillway. Full tests of the tapered spillway were not in the scope of investigation by the Institute of Mountain Risk Engineering. However, the effect of deflection was informally investigated in the hydraulic laboratory by means of different deflection elements. An example is show on Figures 166-1 and 166-2.

Figure 166-1 Informal investigation of deflection elements

Figure 166-2 Informal measurement of run-up wave

Two dimensional (2D) hydraulic calculations were performed on the proposed spillway shape (Figure 166-3). The results show flow heights of up to 5 m for a probable maximum flood (PMF) spillway flood. Based on these results, the training walls have been modified. They are now higher and wider to ensure robustness. A layer of riprap in concrete will also fill the void between the training walls and the rock abutments. This layer will be higher than the maximum height of water for the PMF spillway flood. The highest impact forces will be at the lower section of the training wall. The upper section of the wall, as well as the riprap layer, should not be exposed to the main flow, but rather only to the run-up wave after the main flow impacts the lower wall. The updated drawing showing the new cross-section is provided as Figure 166-4.

A final detailed investigation will be conducted during construction, after preparation of the abutments which comprises of rock removal and scaling. This work could result in a change of conditions and geometry at the abutments. 2D hydraulic calculations will be performed again if the final configuration of the abutments have changed. Updated construction drawings will be produced based on the updated calculations.



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REV.	DATE	REVISION NOTES	DRAWN	REVIEW	APPROVED

SCALE: 1:500
DATE: April 06, 2017
DRAWING: DPo
DESIGN: MSc/DPo
REVIEW: MSc
APPROVED:

PROFESSIONAL SEAL:

APEGA PERMIT NUMBER: 13440

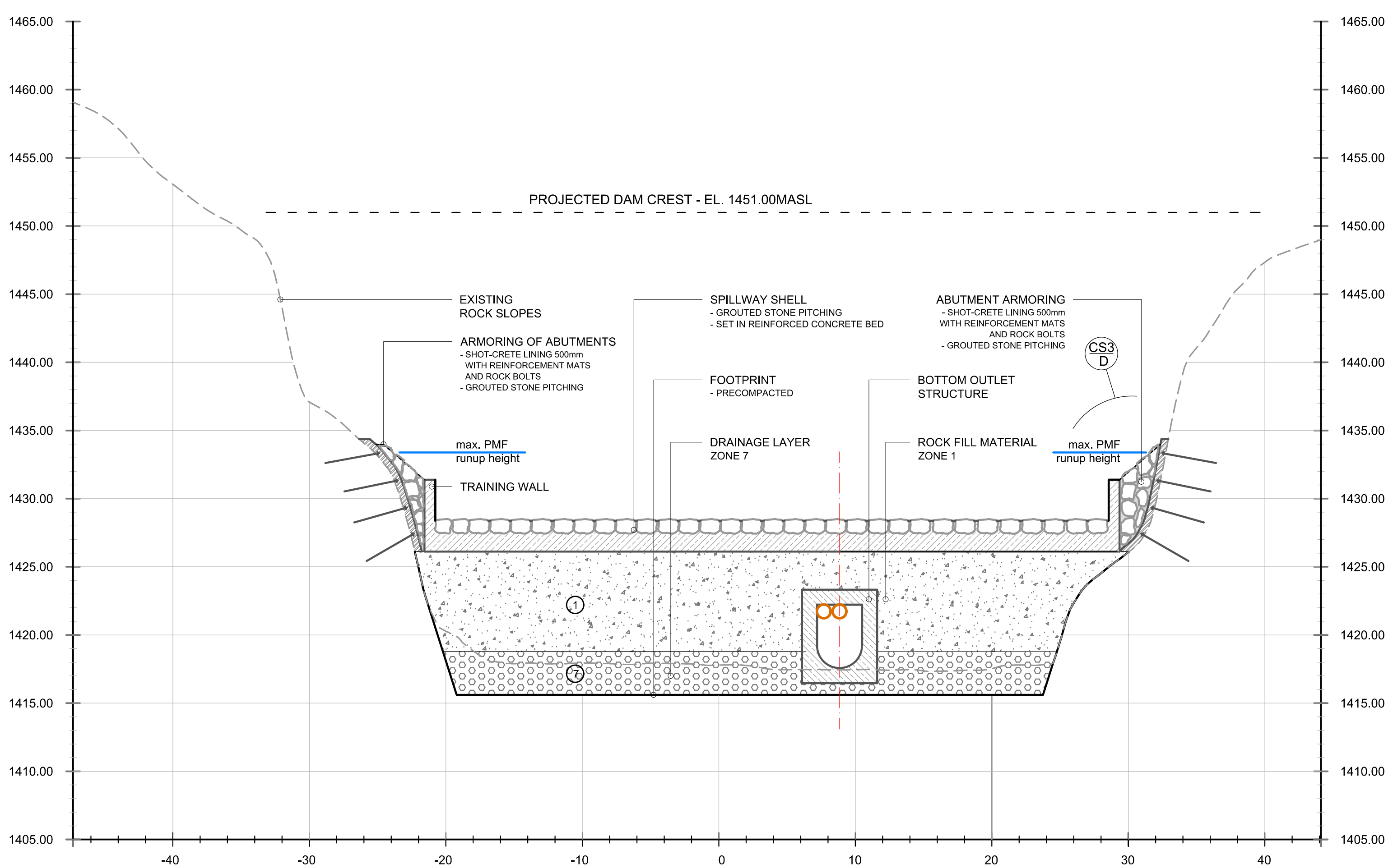
CLIENT:
Town of CANMORE

ENGINEERING:
CANADIAN HYDROTECH CORPORATION

PROJECT:
COUGAR CREEK
DEBRIS FLOOD RETENTION STRUCTURE
ISSUED FOR PERMITTING

Figure 166-3 **Max. Flow Height From PMF Spillway Flood, Plan View and Longitudinal Section Along Training Walls**

PROJECT No.: 16568
DRAWING No.: LTMM CC-EIA-RES-010 R00
REV.: 00



CS2
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DOWNSTREAM CROSS SECTION

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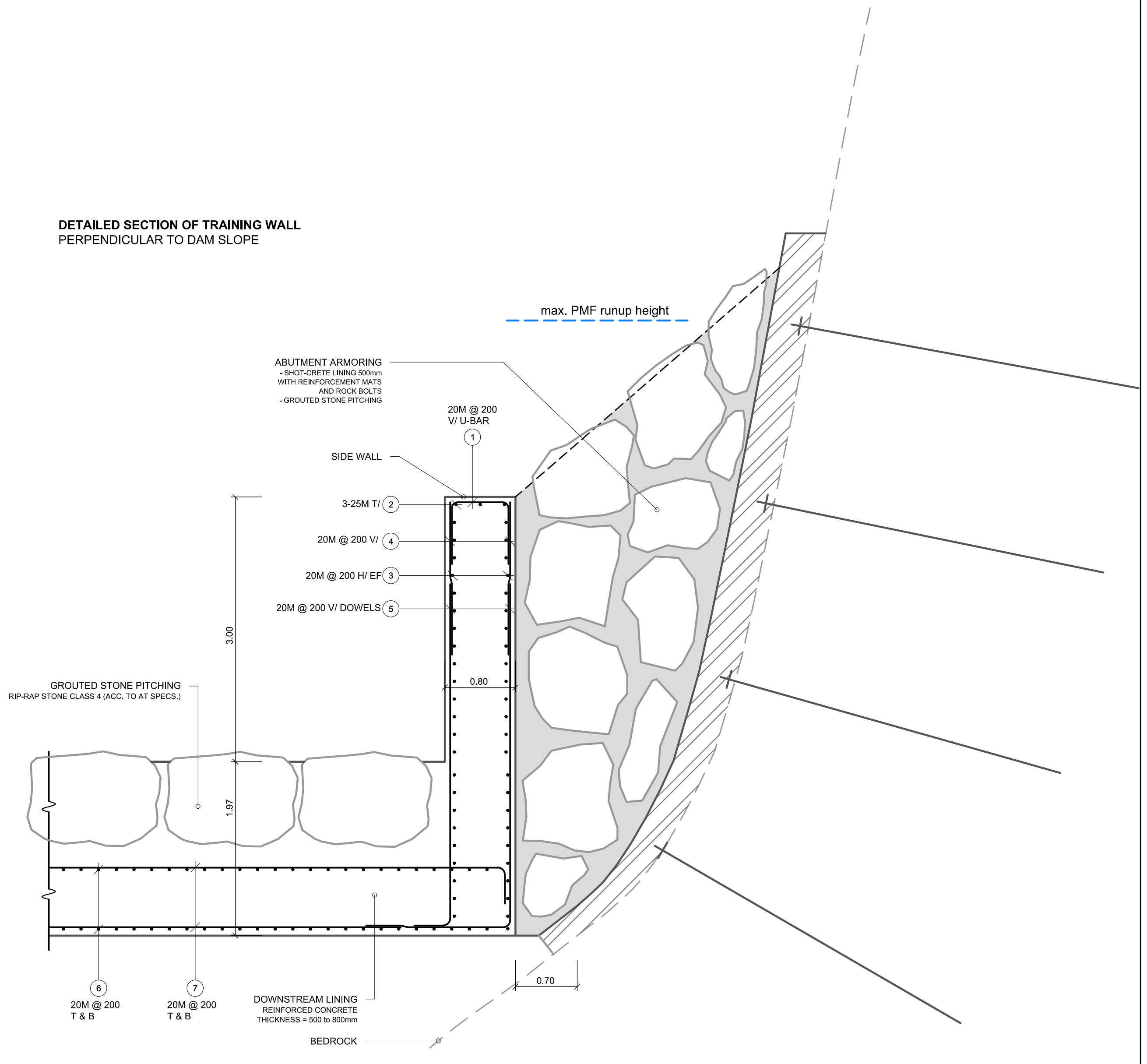

CS3
D

DETAIL AT ABUTMENTS

0m 2.5m 1:75

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REV.	DATE	REVISION NOTES	DRAWN	REVIEW	APPROVED
	April 25, 2017	Update of the design at the abutments based on runup height calculations	MSc		

SCALE: 1:500/1:50
DATE: June 14, 2016
DRAWING: MSc
DESIGN: ALe, MSc
REVIEW: MSc
APPROVED: Els

PROFESSIONAL SEAL:

APEGA PERMIT NUMBER: 13440

CLIENT:
Town of CANMORE

ENGINEERING:
CANADIAN HYDROTECH CORPORATION

PROJECT:
COUGAR CREEK
DEBRIS FLOOD RETENTION STRUCTURE
ISSUED FOR PERMITTING

Figure 166-4 Spillway Cross-section and Abutment Details

PROJECT No.: 16494
DRAWING No.: LTMM CC-DAM-506 R01
REV: 00

167	**Volume 1, Section 4.4.3.1, Page 4-22** a. For the Tunnel Option, explain if there are data limitations and knowledge gaps that will need to be addressed. Specifically explain what these data limitations and knowledge gaps are and how they will be addressed.

Response:

a. The existing geotechnical design basis is sufficient for permitting and tender purposes. Geotechnical investigation results and the information acquired from the exposed creek walls provide adequate information to define the required support classes, based on different rock type and quality expected, that will inform the detailed drawings. These drawings will be submitted as part of an updated Dam Safety submission that is forthcoming.

The Town of Canmore main consultant, Canadian Hydrotech Corporation, is a partnership between Dr. Sauer & Partners and Alpinfra Engineering + Consulting. Dr. Sauer & Partners specializes in underground works, including tunneling. Based on the feedback from engineers at Dr. Sauer & Partners, the Town of Canmore is therefore confident that its existing data and information are sufficient for the tunnel design.

168	**Volume 1, Section 4.4.4.3, Page 4-25** a. For the Tunnel Option, explain if abrasion is a concern. If so, how will abrasion be addressed?

Response:

a. Abrasion at the invert of the tunnel will be an issue and protection measures will be addressed in the detailed design of the tunnel option. The same requirements and design criteria as for the bottom outlet structure will be considered. The two main options to be considered are a high performance concrete lining and a steel lining.

Refer to response to SIR 159 and SIR 167 for more information regarding the tunnel option.

169	**Volume 1, Section 4.4.6, Page 4-30** a. Clarify when the Testing and Commissioning (section 4.4.6) will be conducted. b. Provide details on how long it would take to impound the required volume of water and any associated risks (e.g. flood) and mitigation measures.

Response:

a. Testing and commissioning will be conducted during the first summer or fall following construction completion.

b. **Time to impound water:** Two supplementary information packages regarding test storage were sent to Alberta Environment and Parks before the first round of supplemental information requests (SIRs) were received. The test will only be conducted for 24 hours at a storage height of 10 m. The total duration of the test will be 54 hours, which includes the filling and emptying of the inundation area and is based on conservative assumptions of inflow of 2.5 m^3/s and outflow of 2.5 m^3/s during drawdown. Please refer to the Test Storage Maps (Appendix 169-1) for the inundation area for different heights of water during impoundment and water releases. Refer to the response to SIR 119 for a discussion of potential effects on terrain, soil and vegetation.

   Risks associated with the test: The safety risk to humans and wildlife has been addressed in the response to SIR 133. The risk of a high precipitation / flood event during testing can be mitigated with careful planning of the timing of the test with regards to the weather forecast. The risk of the Structure failing can be mitigated with continuous monitoring during the testing – the impounded water could be quickly released with a full opening of the winding gate to allow full outflow capacity through the bottom outlet structure. Only a few hours would then be needed to empty the Structure.

170	**Volume 1, Section 4.4.5.1, Page 4-26** **Volume 1, Section 4.4.5.1, Page 4-27** a. Provide details on the criteria (e.g. flood event) that will be used to design the temporary diversion works required. b. Provide details of the proposed diversion works including cofferdams through the course of construction. c. Explain if temporary care of water and dewatering provisions will be required to facilitate construction.

Response

a. The definition of a design and capacity criteria for temporary diversion works depend on the risk distribution between the owner and the contractor and will be decided before the procurement process. However, a reasonable risk level would be for the contractor to provide temporary water diversion for a flood discharge related to a 30-year storm event return period. Details on the temporary water diversion, as well as the associated emergency response plan, will be part of the pre-construction submittals by the contractor. These will be reviewed by the Town, its consultant(s) and Alberta Environment and Parks if deemed necessary.

b. The selection and the design of water diversion measures will be part of the pre-construction submittals by the contractor and will depend on the construction staging plan chosen by the contractor. The tunnel or the bottom outlet structure can be used as the main water diversion structure throughout the construction work as soon as it is completed.

c. Temporary water management, as well as dewatering, will most likely be required for foundation works. However, these will depend on the selected construction technique and details of the secant pile wall, concrete mixes, and grout mixes. Provisions will be in the tender package to address this.

171	**Volume 1, Section 4.4.5.3, Page 4-30** a. Provide plans to address future decommissioning and restoration, if any, in accordance with applicable regulations at that time.

Response:

a. As discussed in the response to SIR 177, the Structure design life is established at 100 years.

As the Structure is in support of public safety, there are no plans for decommissioning. Future decommissioning would only be necessary if the Structure does not perform its intended purpose due to excessive change in climate, irreparable damage due to an unforeseen event or if new technology is available that would further reduce the flood risk. If that were to occur, the best available technology, best available practices and applicable regulations in place at that time will be used to design any replacement mitigation. If the Structure is removed and the site is reclaimed at any time in the future, reclamation regulations in place at that time will be followed and a reclamation plan will be developed with Alberta Environment and Parks.

For its safe operation, regular maintenance and medium to long-term restoration of the Structure will be necessary. The Operations, Maintenance and Surveillance manual, included in the Dam Safety submission, contains specific information regarding the quarterly maintenance requirements and the maintenance and repairs to be performed every 2 years. Any of the more extensive repairs required on the Structure will use the best available technology and best available practices at the time. Any applicable regulations will also be followed.

Any concrete repairs required will be done based on the *Guide to Concrete Repair* (von Fay 2015).

References:

von Fay K.F. 2015. *Guide to Concrete Repairs.* Second Edition. Concrete, Geotechnical, and Structural Laboratory. U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center. August 2015.

172	**Volume 1, Section 4.4.6, Page 4-30** a. For the water storage test, explain the selection of a target test level of 10 m and duration of 10 days. b. Explain the risks associated with using explosives to remove the winging gate (due to unforeseen complications), and clarify if there are other options. If there are other options explain why using explosives was considered as the best option.

Response:

a. Two supplementary information packages regarding the test storage were sent to Alberta Environment and Parks before receipt of the first round of supplemental information requests (refer to the response to SIR 133). The test will only be conducted for 24 hours at a storage height of 10 m. The total duration of the test will be 54 hours, which includes the filling and emptying of the inundation area and is based on conservative assumptions. The test is expected to be conducted in the summer or fall, depending on the eventual construction schedule.

The selection of a target test level of 10 m is based on standard practice in Austria, and recommended by Project technical experts, to test debris flood retention structures to 1/3 of their height. This will provide the minimum required loading on the main components of the Structure, including the interface between the deep foundation elements and the seal wall, the emergency bypass, all of the sensors, etc. This test permits measurement of deflection and settlement under loading and it ensures that all components of the Structure are functional.

b. Explosives are only foreseen for contingency and will be located outside of the Structure footprint. The explosives are placed on the valves that control the outflow. They are small charges, just large enough to remove the valve and not do any significant damage to the surroundings, including the Structure itself. The charges can be triggered remotely and will respect all applicable Alberta guidelines and codes, including the Occupational Health and Safety Code.

In case of an emergency during the test storage, the first response will be to open the temporary valves of the winding gates to release the impounded water. If any issue is encountered with the opening of the valves, the emergency bypass would then be opened to release the water. The third option will be the use of portable industrial irrigation or dewatering pumps. The explosives would only be detonated If these three options do not perform as expected.

A system for temporary shut-off was successfully used at a similar retention structure in Lankowitzbach, Austria. Several photos are shown below of the set-up and test storage (Figure 172-1 to 172-4).

Figure 172-1 **Temporary Shut-off Plate, Placed at the Intake Throttle, with Inflow Strainer Feeding the Downstream Pipes going through the Bottom Outlet Structure**

Figure 172-2 **Inflow Area before the Test Storage Start**

Figure 172-3 Test Storage to ~1/3 (10 m) of the Structure Height at Lankowitzbach

Figure 172-4 Controllable Outlet Pipes with Remotely Controlled Charges at the Valves

(The proposed system for Cougar Creek will feature longer pipes to ensure that the charges are outside of the Structure footprint)

173	**Volume 1, Section 4.4.7.1, Table 4.4-3, Page 4-32** a. Clarify whether the values in the table account for solids contributing to fill the impoundment or if they assume water only.

Response:

a. The values in the table do account for solids contributing to volume of impoundment. It is the overall volume of water, sediment and debris.

174	**Volume 1, Section 4.4.7.4, Page 4-34** The post-flood maintenance plans indicate that *after a flood event, rock and woody debris will be removed from behind the Structure.* a. Clarify the loss of storage threshold that would require the removal of rocks and woody debris.

Response:

a. The removal of debris will be undertaken at an approximate threshold volume of 15,000 m^3, which corresponds to a 10-year flood event. This is a reduction of 2% of the storage capacity and this volume of debris does not significantly reduce the level of protection provided by the Structure. Woody debris will also be removed whenever it accumulates at the debris rake when observed during regular inspections.

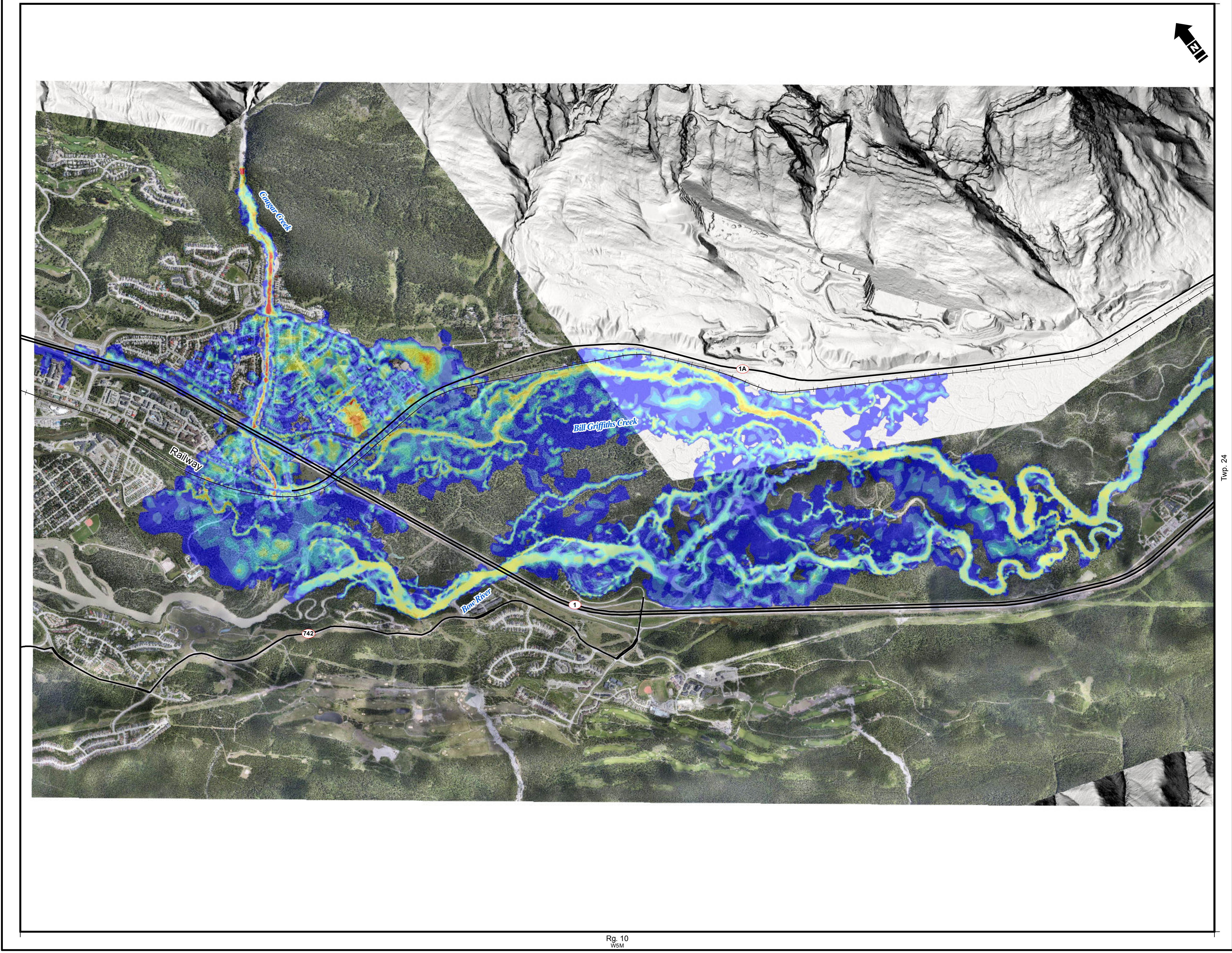
175	**Volume 1, Section 10, Figure 10.3-2, Page 10-8** **Volume 1, Section 10, Figure 10.3-3, Page 10-9** The scale of the map is not sufficient to provide the full extent of the inundation area. Based on the modeled flows and depths, the water would be expected to reach the Bow River. a. Provide figures that show the extent, routes and the locations of confluence with the Bow River.

Response:

a. The inundation analysis was extended to provide the extent of the inundation area. Three new maps are provided:.

- Figure 175-1 shows the clear water discharge for the breach of the Structure only.
- Figure 175-2 shows the Bow River flooding during a 100-year flood event. The inflow hydrograph data used for the Bow River flood is based on Government of Alberta information that is publicly available.
- Figure 175-3 shows overall flow depth of the combined Bow River flood and the breach of the Structure. The full extent of the downstream inundation area is clearly shown on this figure. It is important to note that Figure 175-3 shows a worst-case scenario because the Structure expected failure mode would be a flood-induced failure and not a sunny-day failure. Therefore, a 100-year return period flood discharge at the Bow River was considered while the flood wave from the theoretical structure breach was released.

The flood wave mostly discharges to the Bow River in two areas. The first location is the current outlet of Cougar Creek to Policeman Creek and the Bow River where the flood wave flows into the Bow River over a wider area than in a regular flow event. The second location is approximately 3.5 km downstream at the confluence of Bill Griffith's Creek and the Bow River. This entire area is in the flood plain of the Bow River and there is minimal difference in grade between the floodway and the flood fringes. There is an existing intricate and meandering network of channels that get regularly inundated during flood events on the Bow River (clearly shown on Figure 175-2).



Highway

Railway

Maximum Water Depth (m)

- <0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- >3.00

Topographical basis: Post flood lidar data (2013), not correct for subsurface river channel topography.

Reference: GDM transportation infrastructure data provided by IHS © 2017 used under license. Data obtained from AltaLIS © Government of Alberta used under license. Adapted from figure created by Canadian Hydrotech Corporation (© 2017 - CANADIAN HYDROTECH CORPORATION).

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Town of CANMORE

Cougar Creek Debris Flood Retention Structure

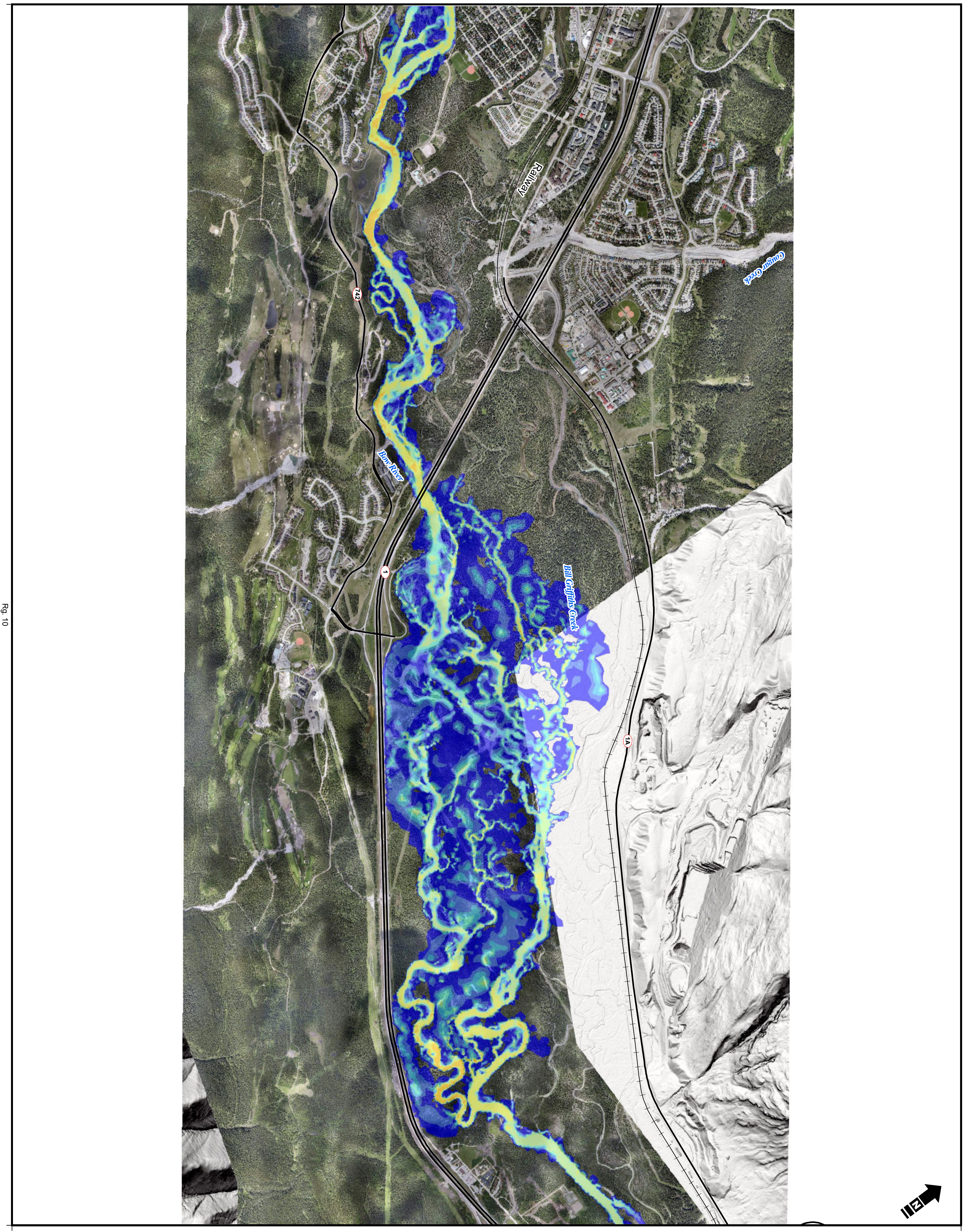
Dam Breach Inundation Map - Clear Water Discharge Calculation from Dam Breach Scenario

Date: 06 Jun 2017
Project: 20746-514
Technical: I. Trimble
Reviewer: R. Sturgess
Drawn: M. Darroch

Disclaimer: Prepared solely for the use of the Town of Canmore as specified in the accompanying report. No representation of any kind is made to other parties with which the Town of Canmore has not entered into contract.

Figure
175-1

I:\TownOfCanmore\20746\FiguresAndTables\EIA_SIR1\2017\Report\AEP_Response\Figure-175-1-Dam_Breach_Inundation_Map_Clear_Water_Discharge_Calculation_from_Dam_Breach_Scenario.mxd



— Highway
┼ Railway

Maximum Water Depth (m)

- <0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- \>3.00

Bow River flood calculation based on a steady state flood discharge of 378m3/S, corresponding to 100 year return period event (according to Banff flood hazard study; NHC, 2013).

Topographical basis: Post flood lidar data (2013), not correct for subsurface river channel topography.

The Bow River flood discharge calculation is used to estimate the effect of the confluence of a dam breach discharge and a Bow River flood.
Results of a detailed Bow River flood inundation analysis may vary.

Reference: GDM transportation infrastructure data provided by IHS © 2017 used under license. Data obtained from AltaLIS © Government of Alberta used under license. Adapted from figure created by Canadian Hydrotech Corporation (© 2017 - CANADIAN HYDROTECH CORPORATION).

1:26,500

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Metres

NAD 1983 3TM 114

Town of CANMORE

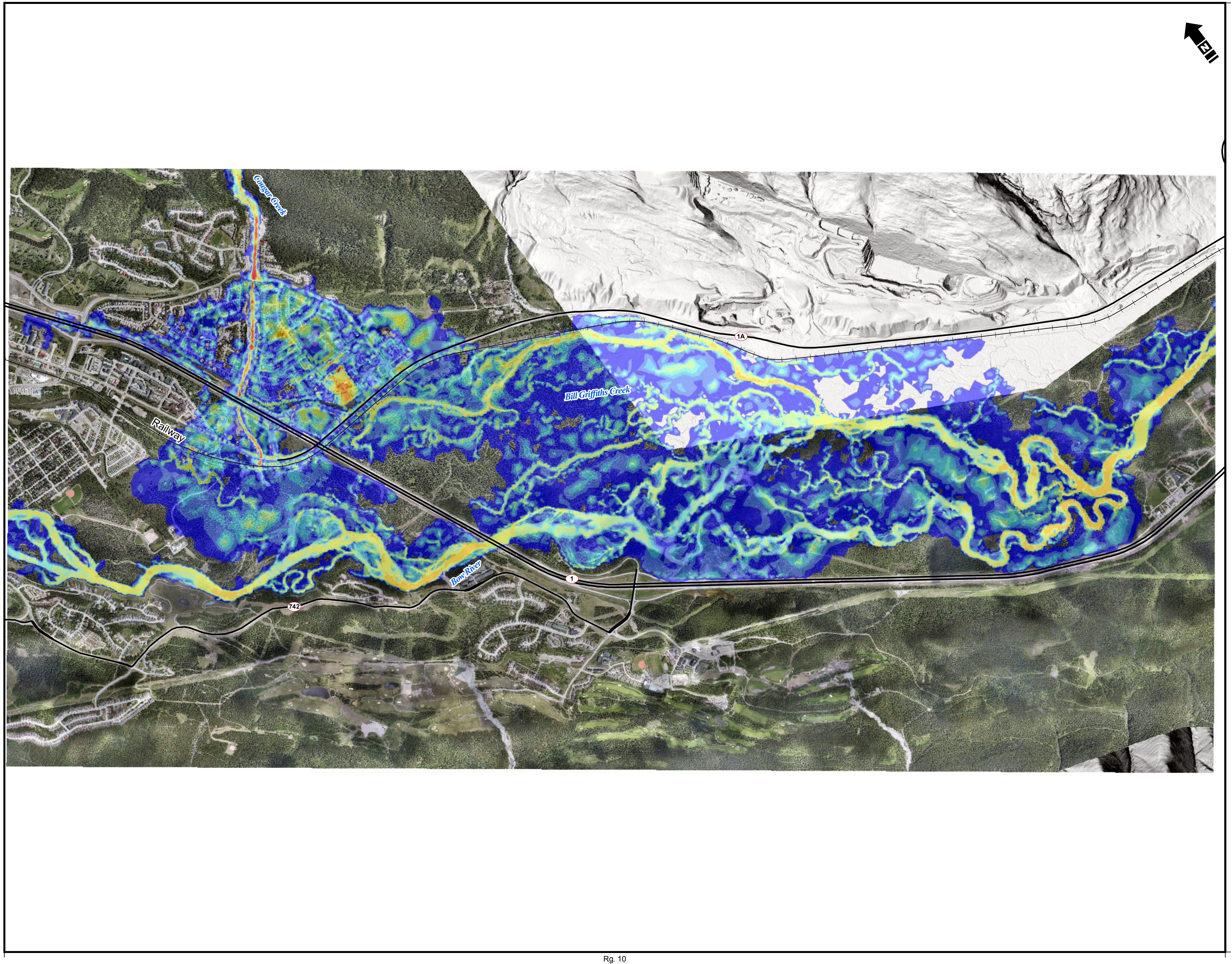
Cougar Creek Debris Flood Retention Structure

Bow River Flood Inundation Map - Approximate Inundation of 100 Year Flood Discharge

Date: 06 Jun 2017
Project: 20746-514
Technical: I. Trimble
Reviewer: R. Sturgess
Drawn: M. Darroch

Disclaimer: Prepared solely for the use of the Town of Canmore as specified in the accompanying report. No representation of any kind is made to other parties with which the Town of Canmore has not entered into contract.

Figure
175-2



- Highway
- Railway

Maximum Water Depth (m)

- <0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- >3.00

Bow River flood calculation based on a steady state flood discharge of 378m3/S, corresponding to 100 year return period event (according to Banff flood hazard study; NHC, 2013).

Topographical basis: Post flood lidar data (2013), not correct for subsurface river channel topography.

The Bow River flood discharge calculation is used to estimate the effect of the confluence of a dam breach discharge and a Bow River flood.
Results of a detailed Bow River flood inundation analysis may vary.

Reference: GDM transportation infrastructure data provided by IHS © 2017 used under license. Data obtained from AltaLIS © Government of Alberta used under license. Adapted from figure created by Canadian Hydrotech Corporation (© 2017 - CANADIAN HYDROTECH CORPORATION).

1:26,500

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Metres

NAD 1983 3TM 114

Town of
CANMORE

Cougar Creek Debris Flood Retention Structure

Dam Breach and Bow River Inundation Map - Clear Water Discharge Calculation from Dam Breach and Bow River 100 Year Flood Discharge

Date: 06 Jun 2017
Project: 20746-514
Technical: I. Trimble
Reviewer: R. Sturgess
Drawn: M. Darroch

Disclaimer: Prepared solely for the use of the Town of Canmore as specified in the accompanying report. No representation of any kind is made to other parties with which the Town of Canmore has not entered into contract.

Figure
175-3

I:\TownOfCanmore\20746\FiguresAndTables\EIA_SIR1\2017\Report\AEP_Response\Figure-175-3-Dam_Breach_and_Bow_River_Inundation_Map_Clear_Water_Discharge_Calculation_from_Dam_Breach_and_Bow_River_100_Year_Flood_Discharge.mxd

176	**Volume 1, Appendix 4B, Section 04.06.01, Page 49** a. Clarify if increasing the discharge capacity of the existing culverts at Elk Run Blvd, Highway 1, and Highway 1A would reduce the flood risk and provide an opportunity to enhance the proposed Structure design.

Response:

a. Increasing the capacity of the existing culvert at Elk Run Boulevard would not significantly reduce the flood risk. Its current capacity of 160 m^3/s is much higher than the 64 m^3/s capacity of the articulated concrete mats and culverts of Highways 1 and 1A. This culvert provides enough capacity as long as it is kept free of debris. The Structure will prevent debris from accumulating at the culvert.

Increasing the capacity of the culverts at Highways 1 and 1A would be very costly and would only marginally reduce the economic risk to infrastructure. It would not significantly reduce the risk of loss of life since the culverts are downstream of most of the developed areas. The Town of Canmore has recommended to Alberta Transportation (AT) that the Highway 1 culverts be replaced with a clear-span bridge at the end of their lifespan. The Town will be looking at a similar upgrade for the Highway 1A culverts. Even if the culverts were replaced with clear-span bridges in the near future, a significant upgrade to the channel would most likely be required to ensure its stability for higher than 45 m^3/s flows. The total cost of all upgrades would likely surpass the cost of the Structure.

The Town of Canmore was managing a construction project on behalf of AT for Highway 1 culvert improvements in the Spring of 2017. The goal of the project was to improve the hydraulics of the culvert; therefore, reducing the flood risk and minimizing maintenance requirement. The improvements will reduce backwater effects and improve the sediment and debris carrying capacity of the culverts. The project was completed in mid-May of 2017.

177	**Volume 1, Appendix 4B, Section 06.01.04, Page 66** a. Provide precedent for the design life of the structure being at least 500 years. b. Explain the comment *regardless of the level of protection of at least 2000 years.*

Response:

a. The design life of the Structure is established at 100 years. This is an accepted design life for similar structures. The 500 years was referring to the maximum life that the Structure can attain with a proper maintenance program. The maintenance program will evolve over the years to take into account specific site issues, new studies available and new technologies.

b. Appendix 4B of the environmental impact assessment (EIA) was the “90% Design Stage – Draft for Final Coordination” of the design report. Since the EIA submission, the design report has been updated and a newer version, “Issued for Permitting” was submitted with the Dam Safety submission. This specific sentence was edited in the newer version and the reference to “2,000 years” has been removed.

The sentence was referring to the idea that the level of protection is the capability of the Structure to retain flood events without overtopping. The Structure can retain floods with return periods of up to 2,000 years; however, this is not the design life of the Structure.

The sentence referred to in this supplemental information request should read: ”The design life of the Structure is established at 100 years.”

178	**Volume 1, Appendix 4C, Section 06.02.01, Page 28** **Volume 1, Appendix 4C, Section 08.02.03, Page 52** **Volume 1, Appendix 4C, Section 07.01, Page 39** **Volume 1, Appendix 4C, Section 04.02, Page 21** a. Provide a rationale for using rainfall-runoff modelling as the only approach for estimating the 1:1000 year flood. b. Provide a discussion of the persistence of snow in the basin and how that might affect flood discharges. c. Provide a rationale for excluding snowmelt from the rainfall-runoff modelling for return period events, while considering it for the PMF. d. Provide a rationale for transposing Kananaskis precipitation IDF values to the basin without adjustment for the difference in elevation between the station and the catchment.

Response:

a. The Town of Canmore is expecting an updated probable maximum precipitation and probable maximum flood study in June of 2017 for the Cougar Creek Structure location within the Cougar Creek watershed. It is likely that the updated study will change the necessity or validity of these questions. Therefore, the answer to these questions are postponed until the updated study is available. A response to this supplemental information request (SIR), along with other SIR responses affected by the new study, will be submitted separately from the response package for this first round of SIRs. The study will also be sent directly to the Dam Safety branch of Alberta Environment and Parks. After review, supplemental questions could be directed through the Dam Safety review process.

b. Refer to the response to part a) above.

c. Refer to the response to part a) above.

d. Refer to the response to part a) above.

179	**Volume 1, Appendix 4C, Section 04.01.01, Page 17** The Town of Canmore states *the design storm event to be selected and determined for hydrologic calculations at Cougar Creek shall be characterized as rather long-duration and widespread precipitation event than as local and short duration heavy rainfall.* a. Explain how the analysis focusing on events of 24 hours and less meets this objective.

Response:

a. The Town of Canmore is expecting an updated probable maximum precipitation and probable maximum flood study in June of 2017 for the Cougar Creek Structure location within the Cougar Creek watershed. It is likely that the updated study will change the necessity or validity of this question. Therefore, the answer to this question is postponed until the updated study is available. A response to this supplemental information request (SIR), along with other SIR responses affected by the new study, will be submitted separately from the response package for this first round of SIRs. The study will also be sent directly to the Dam Safety branch of Alberta Environment and Parks. After review, supplemental questions could be directed through the Dam Safety review process.

180	**Volume 1, Appendix 4C, Section 06.04.01, Page 33** The Town of Canmore states *in order to get a better understanding of the behavior of the Cougar Creek watershed, the June 2013 storm was back calculated based on observations at the Elk Run Boulevard and records from rain gauges in the Marmot Basin.* a. Provide the observations at Elk Run Boulevard. b. Discuss how well the simulation reproduced those observations.

Response:

a. The observations are based on photos provided in Appendix A of the 2013 BGC Engineering Ltd. forensic report (BGC 2013) and videos recorded at the time of the flow peak that are available online on YouTube (YouTube 2013).

b. Modelling parameters were adjusted in the simulation until the same flow height at the intake of the Elk Run Boulevard culvert was reproduced. This led to a better understanding of the behaviour of the culvert. Gravel transport potential, back water effects and realistic discharge capacity under full loading conditions were then re-assessed.

References:

BGC Engineering Inc. (BGC). 2013. *Cougar Creek, 2013 Forensic Analysis and Short-Term Debris Flood Mitigation, Final*. Report prepared for the Town of Canmore. December 2013.

YouTube. 2013. *Canmore, Alberta, Cougar Creek Flood, June 20, 2013*. Published on June 20, 2013. https://www.youtube.com/watch?v=RcMfAsh-jK0

181	**Volume 1, Appendix 4C, Section 07.02, Page 42** The Town of Canmore simulated both a steady rainfall and one unsteady rainfall scenario, and concludes that *the synthetic and steady rainfall scenario represents a more conservative load case. Because the characteristic of future storm events is not known, standard practice is to idealize design events as done herein.* a. Provide Canadian support for the assertion that standard practice is to use steady rainfall for design events.

Response:

a. The Town of Canmore is expecting an updated probable maximum precipitation and probable maximum flood study in June of 2017 for the Cougar Creek Structure location within the Cougar Creek watershed. It is likely that the updated study will change the necessity or validity of this question. Therefore, the answer to this question is postponed until the updated study is available. A response to this supplemental information request (SIR), along with other SIR responses affected by the new study, will be submitted separately from the response package for this first round of SIRs. The study will also be sent directly to the Dam Safety branch of Alberta Environment and Parks. After review, supplemental questions could be directed through the Dam Safety review process.

182	**Volume 1, Appendix 4C, Section 08.02.01, Page 50** The Town of Canmore states that *because extreme storm events, for example with a return period of 500 years, may have occurred within the last 30 years, these kind of events have to be excluded* and excludes the 2013 storm from the statistical analysis. a. Provide additional discussion on why extreme events should be excluded from a statistical analysis aimed at estimating the PMP.

Response:

a. The Town of Canmore is expecting an updated probable maximum precipitation and probable maximum flood study in June of 2017 for the Cougar Creek Structure location within the Cougar Creek watershed. It is likely that the updated study will change the necessity or validity of this question. Therefore, the answer to this question is postponed until the updated study is available. A response to this supplemental information request (SIR), along with other SIR responses affected by the new study, will be submitted separately from the response package for this first round of SIRs. The study will also be sent directly to the Dam Safety branch of Alberta Environment and Parks. After review, supplemental questions could be directed through the Dam Safety review process.

183	**Volume 1, Appendix 4F, Section 07.01, Page 30** The Town of Canmore states that *flood-wave and inundation calculations were reduced to pure water.* a. Provide a discussion of the potential inaccuracy in the model due to this assumption and the consequences of that inaccuracy for dam classification.

Response:

a. The pure water flood wave inundation analysis does not reliably take into account and convey debris transport. The Town has made an attempt at modelling a breach with the effects of debris. The latest version of BASEMENT, a software for simulating river morphology and sediment transport processes, was used to model a Structure breach including debris transport. However, the modelling run was not successful, even after many hours of computation by powerful computers. After several attempts, this modelling was abandoned. A simpler debris aggradation analysis was performed and is described below.

Effects of Debris

Thousands of cubic metres of debris would be transported during a Structure breach. This transport would have three main effects: higher impact forces compared to clear-flood analysis, debris deposition where the water slows down or where backwater effects exist, and increased potential blockage of culverts at Elk Run Boulevard, Highway 1, and Highway 1A.

The impact force is related to the density of the debris flood; higher densities produce higher impact forces. The higher impact forces affect houses and infrastructure in the water path during a Structure breach. Greater damage is therefore expected from debris flood versus clear water floods.

Debris will deposit on the Cougar Creek fan anytime the grades are shallower, especially when they are less than 1%. Deposition is therefore expected in areas of shallow grades, such as at the downstream edge of the alluvial fan, as well as in any large depression, such as in the Elk Run industrial area.

Similar effects are anticipated wherever backwater effects happen. This is expected where there is a constriction of the available cross-sectional area of a flow path. Deposition is therefore forecasted at the culverts of Elk Run Boulevard, Highway 1, and Highway 1A. The backwater effect will most likely lead to very quick aggradation and the blockage of culverts. This results in the filling of the existing channel with debris and avulsions upstream of those culverts.

Debris Aggradation Analysis

A potential debris aggradation analysis was completed and its results are presented on Figure 183-1. The following is a description of the flow paths shown in this analysis.

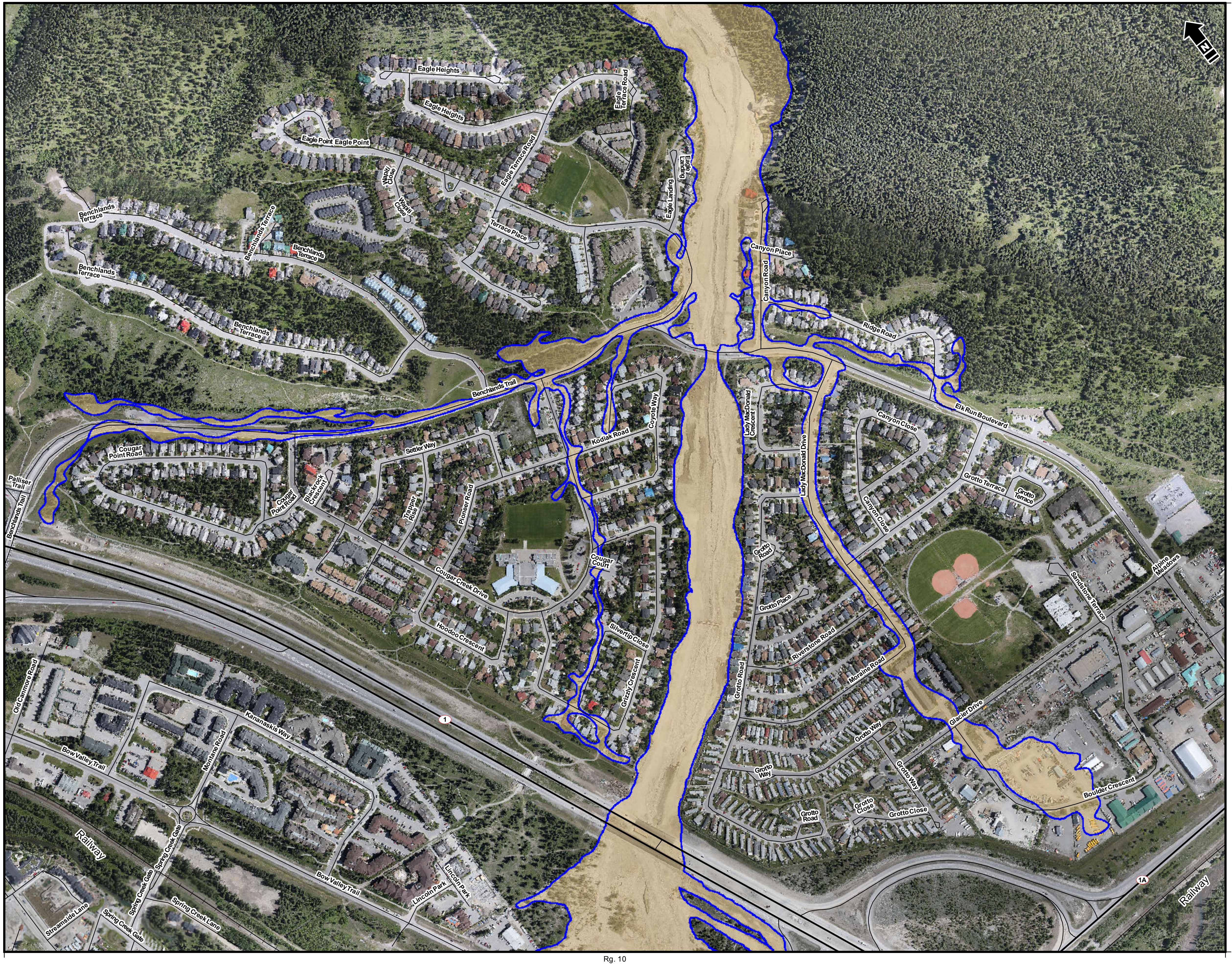
Houses along Canyon Road will be exposed to an impact similar to a debris flood. This debris laden discharge will then spread toward Ridge Road and along the trough between Elk Run

Boulevard and the houses northeast of Elk Run Boulevard. Further downstream, Lady MacDonald Drive might act as a discharge path leading the flow toward the industrial area. Very large sediment aggradation could take place in that area as mentioned above. Canyon Road, Ridge Road, Lady MacDonald Drive, and Boulder Crescent might potentially be blocked by debris deposition post-event.

On the northwest side a potential flow path along Benchlands Trail could carry debris. The flow could then enter the residential development between Benchlands Trail and Coyote Way, as well as along Cougar Creek Drive, and further into the Grizzly Crescent area. Aggradation at subsidence would also occur with several roads being blocked by debris.

Further downstream, blockage of the Highway 1 culvert, as discussed above, is very likely and would result in an avulsion. A debris laden flow would then impact both lanes of the highway and would subsequently impact downstream infrastructure such as the Ford dealership and the Canmore heli port. The Highway 1A would also be impacted, as well as the Canadian Pacific Railway tracks. The grade of this downstream area is very shallow and a high quantity of debris would aggrade at the tail-end of the discharge.

Regarding the Structure classification, it is classified as “very high consequence.” The economic risks is the driving factor for this classification. The dam classification was re-calculated based on all available information, including taking into account sediment transport for risk of loss of life and infrastructure damage. Therefore, the potential inaccuracy of the model does not affect the classification. Refer to the response to SIR 164 for the dam safety classification.



Sediment Aggradation
Highway
Road
Railway

Reference: GDM transportation infrastructure data provided by IHS © 2017 used under license. Data obtained from AltaLIS © Government of Alberta used under license. Adapted from figure created by Canadian Hydrotech Corporation (© 2017 - CANADIAN HYDROTECH CORPORATION).

1:6,500

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Metres

NAD 1983 3TM 114

Town of CANMORE

Cougar Creek Debris Flood Retention Structure

Potential Debris Aggradation Areas Related to a Dam Breach Scenario

Date: 02 Jun 2017
Project: 20746-514
Technical: I. Trimble
Reviewer: R. Sturgess
Drawn: J. Koning

Disclaimer: Prepared solely for the use of the Town of Canmore as specified in the accompanying report. No representation of any kind is made to other parties with which the Town of Canmore has not entered into contract.

Figure
183-1

I:\TownOfCanmore\20746\FiguresAndTables\EIA_SIR1\2017\Report\AEP_Response\Figure-183-1-Potential_Debris_Aggradation_Areas_Related_to_a_Dam_Breach_Scenario.mxd

9 APPROVALS

9.1 *Water Act*

184	**Volume, Section, 4.7.2 Page 4-50** *Water diversion will consider vehicle traffic inside the creek during construction so that no water is flowing over areas used by vehicles for construction access.* a. Provide further detail regarding vehicle traffic and access points and routes especially as it relates to Cougar Creek. Is the *Water Act* Code of Practice for Watercourse Crossings applicable? Explain why or why not.

Response:

a. Figure 4.1-2 of the environmental impact assessment (EIA) shows the access routes. The routes are described in Section 4.1.4, on page 4-3, of the EIA report. Only one water crossing is currently proposed just inside the southern limit of the Bow Valley Wildland Provincial Park. At this location the traffic going upstream will need to cross the creek from the east side to the west side (river's left to river's right). It is possible that more water crossings may be necessary to better manage traffic or water flows; however, they would all be in the area between the Structure and the southern limit of the Bow Valley Wildland Provincial Park. The *Water Act* code of practice for watercourse crossing is applicable for these crossings):

- The crossing(s) would be in place for longer than 6 months (does not meet the temporary definition).
- At the location of the crossing(s) Cougar Creek is a Class D watercourse that is non-fish bearing.
- The type of crossing(s) to be used is currently unknown and will be specified in the Code of Practice notification(s). However, the guide to the code of practice for watercourse crossings states that "Installation of any crossing type may be installed and may be done at any time without isolation of the site" (AENV 2001).

References:

Alberta Environment (AENV). 2001. *Guide to the* Code of Practice for Watercourse Crossings*, Including Guidelines for Complying with the Code of Practice.* Pub No. I/8422. May 2000. Revised in April 2001. http://aep.alberta.ca/water/legislation-guidelines/documents/WatercourseCrossingsGuide-Apr2001.pdf

185	**Volume 1, Section, 6.6.2, Page 6-47** 5th bullet: *to maintain drainage as much as practical.* a. The alteration of drainage may be considered an activity under the *Water Act* and may or may not require prior authorization under the *Water Act*. If it is not practical to maintain drainage, explain or identify those measures to be taken to prevent or mitigate impacts to the aquatic environment.

Response:

a. Any works that will affect surface water drainage will be properly permitted under the *Water Act* through one of the following processes:

- by submitting a notification and completing the works under the *Water Act* code of practice for watercourse crossings; and
- by submitting an application and completing the works under a specific *Water Act* approval.

By designing and constructing the works under these processes, site and project-specific mitigations will be put in place to prevent or mitigate impacts to the aquatic environment. Some of the specific mitigation techniques that may be implemented include but are not limited to:

- erosion and sediment control plans to prevent sedimentation into watercourses;
- qualified aquatic environmental specialist site-specific assessments and recommendations;
- turbidity monitoring; and
- instream isolation works such as berms.

186	**Volume 1, Section 6.6.4.2, Page 6-54** **Volume 1, Section 6.6.4.2, Page 6-56** a. Provide the definition and a description of *Temporary Water Management Measures.* b. Provide information that identifies the mitigative measures that will be implemented to reduce impacts to the aquatic environment while carrying out temporary water management measures and as a result of the alteration of surface and subsurface drainage pathways. Activities associated with this may require authorization under the *Water Act.*

Response:

a. Temporary water management measures may include but are not limited to the following works:

- in-stream berm construction for flow isolation; and
- pumping water from one location to another location within the creek.

b. The Town of Canmore is aware that construction works that affect surface water flows are required to be authorized under the *Water Act*. Appropriate regulatory requirements will be satisfied for implementing any temporary water management measures and mitigations as described in the response to SIR 185.

10 ERRATA

187	**Volume 1, Appendix 7A, Section 3.2.3 – Soil Suitability for Reclamation in the Local Study Area, Page 7A-10** Change the word oil to soil in the second paragraph, first sentence.

Response:

Appendix 7A, Section 7A.3.2.3 second paragraph first sentence should read: "In the local study area, soils are rated unsuitable for reclamation (IBXzr,aa; Table 7A-9) while non-soil units are rated as not applicable (ZNS and ZXL); however, the soil is considered representative of regional soils."

188	**Volume 1, Appendix 7A, Attachment 7A – Soil Inspection Locations** Provide a legend to define the abbreviations used to describe the various soil parameters.

Response:

The requested abbreviation definitions are provided in Table 188-1.

Table 188-1 Soil Parameter Description

Abbreviation	Definition
	Soil Subgroup
O.GL	Orthic Gray Luvisol
O.HR	Orthic Humic Regosol
O.R	Orthic Regosol
T.M	Terric Mesisol
Topsoil Check	Topsoil Check (≤30 cm inspection depth)
	Soil Series
DIS	Disturbed
IBX	Ishbel
MTF	Mitford
NKN	Nickerson
SPR	Spruce Ridge
ZNS	Non soil, fluvial deposits
ZXL	Non soil, colluvium
	Phase Modifier
aa	Not modal to soil correlation area
xl	Lithic at 30 to 99 cm (profile has R horizon), hard rock
zr	Rego/Regosolic
	Parent Material
ANTH	Anthropogenic
COLL	Colluvium
FL	Fluvial
O	Organic
	Texture
L	Loam
S	Sand
Si	Silt
SiCL	Silty clay loam
SiL	Silt loam
SL	Sandy Loam
	Structure
GR	Granular
SG	Single grain
MFGR	Moderate fine granular
MFPL	Moderate fine platy
MMGR	Moderate medium granular
MMPL	Moderate medium platy
MMSB	Moderate medium subangular blocky
WFGR	Weak fine granular

Abbreviation	Definition
Soil Moisture	
D	Dry
M	Moist
W	Wet
Consistence	
FI	Firm
FR	Friable
H	Hard
L	Loose
N	Non-Sticky
S	Sticky
SS	Slightly Sticky
VFR	Very Friable
Root Class	
C	Coarse
F	Fine
M	Medium
MC	Moderately Coarse
VF	Very Fine
Root Abundance	
A	Abundant
F	Few
P	Plentiful
VF	Very Few
Root Orientation	
H	Horizontal
R	Random
Root Distribution	
I	Inped
E	Exped
Aspect	
E	East
N	North
NE	Northeast
S	South
SE	Southeast
SSW	South-southwest
SW	Southwest
W	West

189	**Volume 1, Appendix 7A, Page 7A-10** **Volume 1, Appendix 7A, Page 7A-11** Attachment 7C and 7D are mixed up in the text of this section and will need to be corrected.

Response:

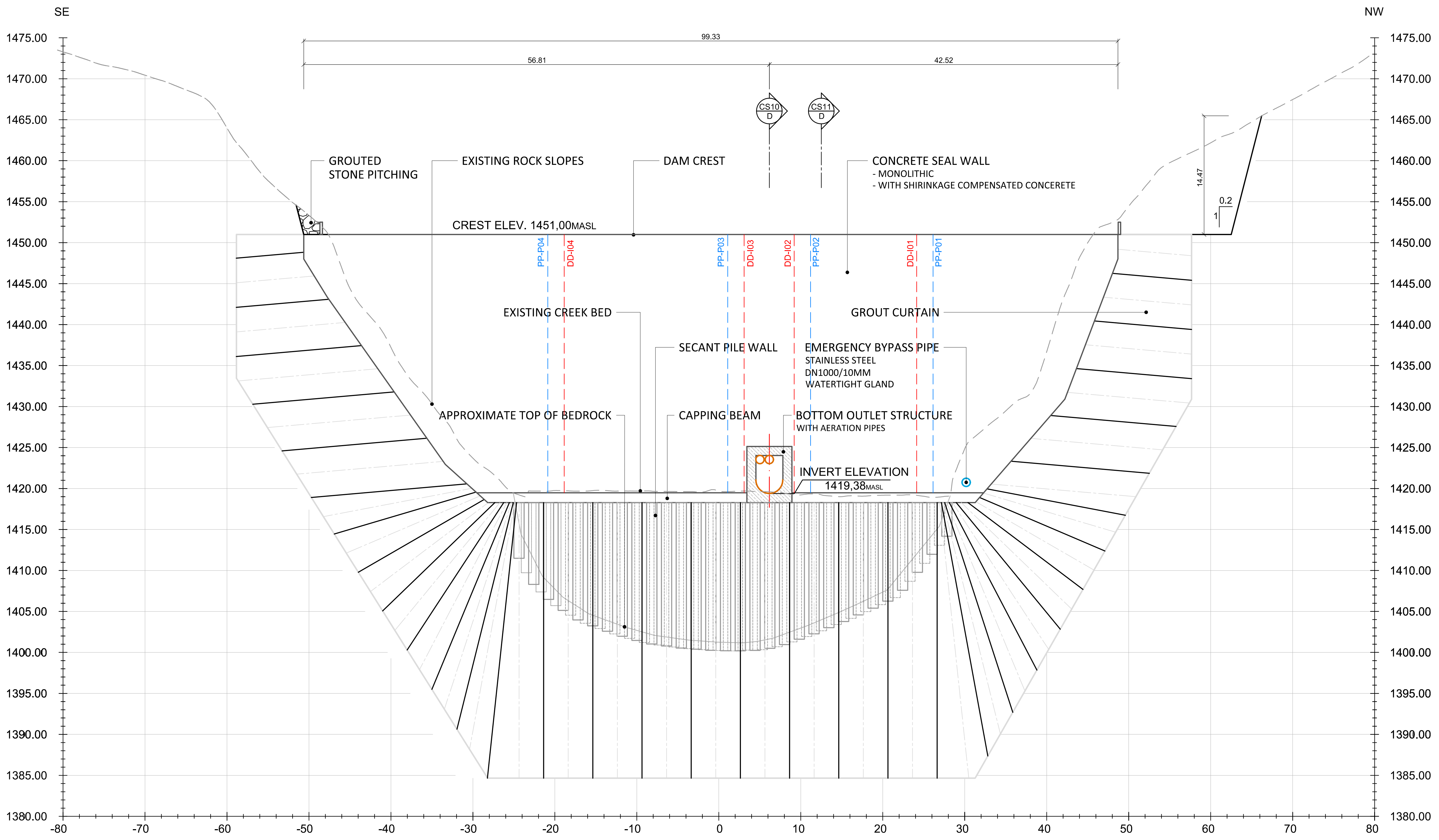
Appendix 7A, Section 7A.3.2.3 of the environmental impact assessment, first paragraph first sentence should read: "Reclamation suitability ratings for surface (upper lift) and subsurface (lower lift) soil materials were determined for the Ishbel series (Attachment 7D)."

Appendix 7A, Section 7A.3.2.4, first paragraph first sentence should read: "Baseline land capability classes were determined for each soil series and the classes were applied to the soil map units in the local study area (Attachment 7C)."

190	**Volume 1, Section 4.4, Figure 4.4-4** The figure titled *Seepage Control Seal Wall, Cut Off and Grout Curtain* is dated June 6, 2013, which seems to be an incorrect date. Provide the correct date and update the required sections.

Response:

The correct date is June 13, 2016. The updated figure is included here as Figure 190-1.



LS1
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LONGITUDINAL SECTION DAM CREST

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REV.	DATE	REVISION NOTES	DRAWN	REVIEW	APPROVED

SCALE: 1:500
DATE: June 13, 2016
DRAWING: ALe
DESIGN: ALe, MSc
REVIEW: MSc
APPROVED: Els

PROFESSIONAL SEAL:

APEGA PERMIT NUMBER: 13440

CLIENT:
Town of
CANMORE

ENGINEERING:
CANADIAN HYDROTECH
CORPORATION

PROJECT:
COUGAR CREEK
DEBRIS FLOOD RETENTION STRUCTURE

Figure 190-1 Seepage Control Seal Wall, Cut Off and Grout Curtain

PROJECT No.: 16494
DRAWING No.: LTMM CC-DAM-505 R00
REV.: 00

191	**Volume 1, Section 6.6.3.2, Page 6-52** Provide the definition of *steady-state conditions.*

Response:

In this instance, steady-state conditions refer to normal or low flow periods. The term steady-state is referenced in other groundwater sections of the environmental impact assessment. In these other locations, steady-state conditions refers to baseline conditions.

192	**Volume 1, Section 3.2.1, Page 3-1** The Town of Canmore states *A Consultation Plan prepared by the Town of Canmore to fulfill requirements for Level 3 extensive consultation was approved by the ACO on October 1, 2105.* Date should be “October 1, 2015”, not “October 1, 2105”

Response:

In Section 3.2.1 of the environmental impact assessment, the first sentence of the third paragraph should read: “A Consultation Plan prepared by the Town of Canmore to fulfill requirements for Level 3 extensive consultation was approved by the Aboriginal Consultation Office on October 1, 2015.”

193	**Volume 1, Section 6.5.1.1, Table 6.5-4, Page 6-15** In the 4th column, the unit of Peak Discharge is *m^3*. Should this unit be m^3/s? If so, update Table 6.5-4 to reflect this.

Response:

Table 6.5-4 of the environmental impact assessment has been updated and provided below as Table 193-1.

Table 193-1 Peak Discharge Estimates for Cougar Creek at the Structure – Frequency Magnitude Analysis[1]

Return Period (year)	**Annual Probability (1/year)**	**Sediment Volume Estimate (m^3)**	**Peak Discharge (m^3/s)**	**Dominant Hydro-Geomorphological Process[2]**
1-10	1-0.1	<6,000	-	Flooding
10-30	01-0.03	30,000	30	Flooding/debris floods
30-100	0.03-0.01	40,000	50	Flooding/debris floods
100-300	0.01-0.003	60,000	60	Debris floods
300-1,000	0.003-0.001	160,000	700	LDOFs[3]
1,000-3,000	0.001-0.0003	260,000	1,000	LDOFs

1. BGC 2014
2. Further information on dominant hydro-geomorphological processes is found in the *Town of Canmore, Cougar Creek Debris Flood Hazard Assessment - Final* (BGC 2014).
3. LDOF - landslide dam outbreak flood

References:

BGC Engineering Inc. (BGC). 2014. *Town of Canmore, Cougar Creek Debris Flood Hazard Assessment - Final*. Report prepared for the Town of Canmore. Vancouver, British Columbia. March 7, 2014.

194	**Volume 1, Section 6.8, Page 6-62** In Section 6.8 the Town of Canmore states *due to the lack of cumulative effects anticipated for all aquatic disciplines, no additional mitigation measures are proposed.* Do the mitigation measures during the Project construction such as ESC belong to the contents of this section? Should be re-arranged into Section 6.7 as Section 6.7.2? Explain the rationale.

Response:

Potential project effects are assessed after known mitigation measures are applied. If a project is found to have residual effects, additional mitigation, monitoring or follow-up programs may be required. Section 6.8 of the environmental impact assessment is confirming that since no cumulative effects are anticipated, no **additional** mitigation is required. At this stage in the assessment, all planned mitigation measures (e.g., erosion and sediment control) have already been applied.

195	**Volume 1, Section 3.2.1, Page 3-1** The Town of Canmore indicates that the First Nation consultation plan was approved on October 1, 2105. Confirm this date should be October 1, 2015. In addition, update this section so it reflects the correct date.

Response:

The correct date is October 1, 2015. As indicated in the response to SIR 192, the first sentence of the third paragraph in Section 3.2.1 of the environmental impact assessment should read: “A Consultation Plan prepared by the Town of Canmore to fulfill requirements for Level 3 extensive consultation was approved by the Aboriginal Consultation Office on October 1, 2015.”

196	**Volume 1, Section 1.4.3, Page 1-10** With reference to the following statement: *Because the Project will permanently remove aggregate, the residual effect on aggregate resources is negative in direction and the final environmental consequence rating is predicted as low.* In reference to the use of 'aggregate' in statements regarding the removal of flood debris for maintenance purposes, can we use the term 'flood debris' or 'debris'. Aggregate may be misleading to mean 'construction aggregate' opposed to unsorted flood debris that contains woody material as well as large and small rocks. Alberta Parks has received concerns from First Nation groups that aggregate or gravel will be removed from behind the Structure and be sold for profit by the Town of Canmore. This is not the case. Going forward, can we refer to the material removed from the Structure as 'flood debris' or 'debris'.

Response:

Going forward, the Town of Canmore will not refer to debris as aggregate. As indicated in the response to SIR 48, Alberta Environment and Parks considers material that may build up in the inundation area or downstream of the Structure to be debris that will have no value as an aggregate material.

197	**Volume 1, Section 4.1.4 Page 4.3** With reference to the following statement: *a single gravel road within the park to the site (right bank).* The 'single gravel road' within the Bow Valley Wildland Park should be referred to as a route, pathway or trail (as an extension of the pedestrian pathway outside the park or a transition to Alberta Parks trails). This will reduce the potential perception that there is a portion of access road (gravel road) to the Structure within the wildland park that has not been included in the Deregulation and Land Sale Proposal. Going forward can we refer to the route that maintenance vehicles will take to the Project as a 'trail'?

Response:

Alberta Environment and Parks notified the Town of Canmore on March 29, 2017, that the South Saskatchewan Regional Plan (SSRP) was amended in January 2017 to allow the Minister to approve the construction and maintenance of an access road within a wildland provincial park if it is in the interest of public safety. Alberta Parks concluded that the SSRP amendment pursuant to the *Alberta Land Stewardship Act* supersedes the *Provincial Parks Act Dispositions Regulation* and that the land sale was no longer required. If the Project is approved, Alberta Parks will issue a disposition to the Town of Canmore and will maintain jurisdiction over all activities within the Bow Valley Wildland Provincial Park. The Town of Canmore will continue to refer to the access route as a gravel road for consistency with the environmental impact assessment.

198	**Volume 1, Section 4.1.3, Page 4-4** With reference to the following statement: During operations, rock and gravel removed from behind the Structure will be transported to gravel and concrete producers in Exshaw **for reuse**. Avoid confirming that flood debris will be 'reused' by concrete producers in Exshaw. This relates to the issues noted by First Nations in Question #2. Table 4.8-1 does not mention *for reuse* in a similar statement.

Response:

Going forward, the Town of Canmore will not refer to debris as a product that will be reused. As indicated in the response to SIR 48, Alberta Environment and Parks considers material that may build up in the inundation area or downstream of the Structure to be debris that will have no value as an aggregate material.

199	**Volume 1, Section 6.5.1, Table 6.5-4, Page 6-15** Correct the unit of peak discharge in Table 6.5-4

Response:

The table has been corrected and included as part of the response to SIR 193 (Table 193-1).

200	**Volume 1, Section 6.5.1.1, Tables 6.5-6, Page 6-20** **Volume 1, Section 6.5.1.1, Table 6.5.7, Page 6-21** The Town of Canmore in these two tables has superscripts that are not explained, in the first table ‘*LT’* and in the second table, a superscript ‘1’. a. Clarify the two superscripts with text under both tables.

Response:

a. The superscript “LT” indicates the long-term exposure guideline for Tables 6.5-6 and 6.5-7 of the environmental impact assessment. The superscript “1” indicates that he wells were sampled during clear, low-flow conditions for Tables 6.5-6 and 6.5-7. Revised tables are provided in the responses to SIR 88 and SIR 89 as Tables 88-1 and 89-1, respectively.

Appendix 24-1

Alberta Environment and Parks Notification Letter

Alberta Environment and Parks

Parks/Kananaskis Region
Canmore Provincial Building, Suite 201,
800 Railway Avenue
Canmore, AB
T1W 1P1
Telephone 403-678-5500
www.alberta.ca

March 29, 2017

Felix Camire
Project Engineer
Town of Canmore
902 7th Avenue
Canmore Alberta
T1W 3K1

Re: Cougar Creek Flood Retention Structure Project

Dear Mr. Camire:

Please accept this as an update to the letter dated April 16, 2015 that outlined Alberta Environment and Parks (AEP) position on the construction of the access road in Bow Valley Wildland Provincial Park as part of the Cougar Creek Flood Retention Structure (Project). At the time, Alberta Parks determined that as part of the designation of wildland provincial parks, the access road was prohibited under the *Provincial Parks Act Dispositions Regulation*.

In January 2017, an amendment to the South Saskatchewan Regional Plan (SSRP) under the *Alberta Land Stewardship Act* allows the Minister of AEP to approve construction and maintenance of an access road within a wildland provincial park in the South Saskatchewan Region, if it is in the interest of public safety.

The detailed wording in the SSRP amendment includes:

> *Section 18.2: The Minister responsible for the Provincial Parks Act may grant or renew authority to construct and maintain an access road, if such access road is necessary to ensure the safety of the public, in (d) Bow Valley Wildland Provincial Park.*

Alberta Parks concludes that the SSRP amendment under the *Alberta Land Stewardship Act* supersedes the *Provincial Parks Act Dispositions Regulation*. The entire Project including the access road supports public safety and is allowed in Bow Valley Wildland Provincial Park under the SSRP amendment. Alberta Parks will issue a disposition to the Town of Canmore to support the construction and operation of the Project.

Please let me know if you have any questions or require addition information.

Sincerely,

Mark Storie
Regional Director,
Kananaskis Region,
Alberta Parks,
403-678-5500 ext.272

Appendix 55-1

AERSCREEN Run Output

```
AERSCREEN 15181 / AERMOD 13350                                      02/25/17
                                                                    14:32:56

TITLE: NO2_O3@0.042


------------------------------------------------------------------------------
*****************************  STACK PARAMETERS  ****************************
------------------------------------------------------------------------------

SOURCE EMISSION RATE:           13.4000 g/s              106.349 lb/hr
STACK HEIGHT:                      5.00 meters             16.40 feet
STACK INNER DIAMETER:             0.500 meters             19.69 inches
PLUME EXIT TEMPERATURE:          Ambient
PLUME EXIT VELOCITY:             20.000 m/s                65.62 ft/s
STACK AIR FLOW RATE:               8321 ACFM
RURAL OR URBAN:                  RURAL

INITIAL PROBE DISTANCE =          5000. meters            16404. feet


NOx TO NO2 CHEMISTRY                                       OLM
NO2/NOx IN-STACK RATIO:                                   0.10000
OZONE BACKGROUND CONCENTRATION:                0.42000E-01 PPM



------------------------------------------------------------------------------
***********************  BUILDING DOWNWASH PARAMETERS  **********************
------------------------------------------------------------------------------

         NO BUILDING DOWNWASH HAS BEEN REQUESTED FOR THIS ANALYSIS


**************************  PROBE ANALYSIS  ***************************
                25 meter receptor spacing: 1. meters - 5000. meters


     Zo       ROUGHNESS       1-HR CONC   DIST      TEMPORAL
     SECTOR     LENGTH         (ug/m3)     (m)       PERIOD
     ----------------------------------------------------------------------
      1*         1.300        2993.        25.0      ANN
* = worst case flow sector



------------------------------------------------------------------------------
**********************  MAKEMET METEOROLOGY PARAMETERS  *********************
------------------------------------------------------------------------------

MIN/MAX TEMPERATURE:    250.0 / 310.0 (K)

MINIMUM WIND SPEED:       0.5 m/s

ANEMOMETER HEIGHT:     10.000 meters

SURFACE CHARACTERISTICS INPUT: USER ENTERED

ALBEDO:                  0.35
BOWEN RATIO:             1.50
ROUGHNESS LENGTH:       1.300 (meters)
```

```
       METEOROLOGY CONDITIONS USED TO PREDICT OVERALL MAXIMUM IMPACT
       -------------------------------------------------------------

 YR MO DY JDY HR
 -- -- -- --- --
 10 02 19  19 01

    H0      U*      W*  DT/DZ ZICNV ZIMCH  M-O LEN    Z0  BOWEN ALBEDO  REF WS
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 -0.99  0.187 -9.000  0.020 -999.  186.    508.2 1.300   1.50   0.35    1.00

    HT  REF TA     HT
- - - - - - - - - - -
  10.0   250.0    2.0

WIND SPEED AT STACK HEIGHT (non-downwash):        0.5 m/s
STACK-TIP DOWNWASH ADJUSTED STACK HEIGHT:         5.0 meters
ESTIMATED FINAL PLUME RISE (non-downwash):        0.0 meters
ESTIMATED FINAL PLUME HEIGHT (non-downwash):      5.0 meters


       METEOROLOGY CONDITIONS USED TO PREDICT AMBIENT BOUNDARY IMPACT
       --------------------------------------------------------------

 YR MO DY JDY HR
 -- -- -- --- --
 10 02 13  19 12

    H0      U*      W*  DT/DZ ZICNV ZIMCH  M-O LEN    Z0  BOWEN ALBEDO  REF WS
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
259.35  0.211  1.800  0.020  691.  222.     -2.8 1.300   1.50   0.35    0.50

    HT  REF TA     HT
- - - - - - - - - - -
  10.0   250.0    2.0

WIND SPEED AT STACK HEIGHT (non-downwash):        0.3 m/s
STACK-TIP DOWNWASH ADJUSTED STACK HEIGHT:         5.0 meters
ESTIMATED FINAL PLUME RISE (non-downwash):      112.6 meters
ESTIMATED FINAL PLUME HEIGHT (non-downwash):    117.6 meters


-----------------------------------------------------------------------------
************************ AERSCREEN AUTOMATED DISTANCES **********************
                  OVERALL MAXIMUM CONCENTRATIONS BY DISTANCE
-----------------------------------------------------------------------------


                      MAXIMUM                             MAXIMUM
            DIST     1-HR CONC                  DIST     1-HR CONC
             (m)      (ug/m3)                    (m)      (ug/m3)
         ---------------------              ---------------------
            1.00     30.69                  2525.00     90.26
           25.00     2993.                  2550.00     90.18
           50.00     1531.                  2575.00     90.10
           75.00     1047.                  2600.00     90.02
          100.00     798.5                  2625.00     89.94
          125.00     630.6                  2650.00     89.86
          150.00     513.9                  2675.00     89.78
          175.00     430.8                  2700.00     89.70
          200.00     369.8                  2725.00     89.63
```

```
  225.00      323.9                  2750.00      89.55
  250.00      288.3                  2775.00      89.48
  275.00      260.3                  2800.00      89.41
  300.00      237.8                  2825.00      89.34
  325.00      219.3                  2850.00      89.27
  350.00      204.1                  2875.00      89.20
  375.00      191.3                  2900.00      89.13
  400.00      180.5                  2925.00      89.07
  425.00      171.3                  2950.00      89.00
  450.00      163.3                  2975.00      88.94
  475.00      156.4                  3000.00      88.87
  500.00      150.3                  3025.00      88.81
  525.00      144.9                  3050.00      88.75
  550.00      140.2                  3075.00      88.69
  575.00      136.0                  3100.00      88.63
  600.00      132.2                  3125.00      88.57
  625.00      128.8                  3150.00      88.51
  650.00      125.8                  3175.00      88.45
  675.00      123.0                  3200.00      88.39
  700.00      120.5                  3225.00      88.34
  725.00      118.2                  3250.00      88.28
  750.00      116.1                  3275.00      88.22
  775.00      114.2                  3300.00      88.17
  800.00      112.4                  3325.00      88.12
  825.00      110.8                  3350.00      88.06
  850.00      109.3                  3375.00      88.01
  875.00      107.9                  3400.00      87.96
  900.00      106.6                  3425.00      87.91
  925.00      105.4                  3450.00      87.86
  950.00      104.3                  3475.00      87.81
  975.00      103.2                  3500.00      87.76
 1000.00      102.2                  3525.00      87.71
 1025.00      101.3                  3550.00      87.66
 1050.00      100.7                  3575.00      87.26
 1075.00      100.3                  3600.00      86.79
 1100.00      99.93                  3625.00      86.33
 1125.00      99.59                  3650.00      85.87
 1150.00      99.26                  3675.00      85.42
 1175.00      98.94                  3700.00      84.97
 1200.00      98.63                  3725.00      84.53
 1225.00      98.34                  3750.00      84.10
 1250.00      98.05                  3775.00      83.66
 1275.00      97.78                  3800.00      83.24
 1300.00      97.51                  3825.00      82.81
 1325.00      97.25                  3850.00      82.40
 1350.00      97.00                  3875.00      81.98
 1375.00      96.76                  3900.00      81.57
 1400.00      96.52                  3925.00      81.17
 1425.00      96.30                  3950.00      80.77
 1450.00      96.07                  3975.00      80.37
 1475.00      95.86                  4000.00      79.98
 1500.00      95.65                  4025.00      79.60
 1525.00      95.45                  4050.00      79.21
 1550.00      95.25                  4075.00      78.83
 1575.00      95.06                  4100.00      78.46
 1600.00      94.87                  4125.00      78.09
 1625.00      94.69                  4150.00      77.72
 1650.00      94.51                  4175.00      77.35
 1675.00      94.34                  4200.00      76.99
 1700.00      94.17                  4225.00      76.64
 1725.00      94.01                  4250.00      76.28
 1750.00      93.85                  4275.00      75.93
 1775.00      93.69                  4300.00      75.59
```

```
         1800.00     93.54                   4325.00     75.24
         1825.00     93.39                   4350.00     74.90
         1850.00     93.24                   4375.00     74.57
         1875.00     93.10                   4400.00     74.24
         1900.00     92.96                   4425.00     73.91
         1925.00     92.83                   4450.00     73.58
         1950.00     92.69                   4475.00     73.25
         1975.00     92.56                   4500.00     72.93
         2000.00     92.43                   4525.00     72.62
         2025.00     92.31                   4550.00     72.30
         2050.00     92.19                   4575.00     71.99
         2075.00     92.07                   4600.00     71.68
         2100.00     91.95                   4625.00     71.37
         2125.00     91.84                   4650.00     71.07
         2150.00     91.72                   4675.00     70.77
         2175.00     91.61                   4700.00     70.47
         2200.00     91.50                   4725.00     70.18
         2225.00     91.40                   4750.00     69.88
         2250.00     91.29                   4775.00     69.59
         2275.00     91.19                   4800.00     69.31
         2300.00     91.09                   4825.00     69.02
         2325.00     90.99                   4850.00     68.74
         2350.00     90.90                   4875.00     68.46
         2375.00     90.80                   4900.00     68.18
         2400.00     90.71                   4925.00     67.91
         2425.00     90.62                   4950.00     67.63
         2450.00     90.53                   4975.00     67.36
         2475.00     90.44                   5000.00     67.09
         2500.00     90.35


-----------------------------------------------------------------------------
**********************  AERSCREEN MAXIMUM IMPACT SUMMARY  *********************
-----------------------------------------------------------------------------

                     MAXIMUM     SCALED      SCALED      SCALED      SCALED
                      1-HOUR     3-HOUR      8-HOUR     24-HOUR      ANNUAL
  CALCULATION          CONC       CONC        CONC        CONC        CONC
   PROCEDURE         (ug/m3)    (ug/m3)     (ug/m3)     (ug/m3)     (ug/m3)
---------------    ----------  ----------  ----------  ----------  ----------
FLAT TERRAIN        8657.       8657.       7791.       5194.       865.7

DISTANCE FROM SOURCE          8.00 meters



IMPACT AT THE
AMBIENT BOUNDARY    30.69       30.69       27.62       18.41       3.069

DISTANCE FROM SOURCE          1.00 meters
```

Appendix 60-1

Groundwater Flow Numerical Model

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

May 15, 2017 Matrix 20746-514

Mr. Félix Camiré
TOWN OF CANMORE
902 - 7 Ave.
Canmore, AB T1W 3K1

Subject: **Groundwater Flow Numerical Model, Cougar Creek Debris Flood Retention Structure, Town of Canmore**

Dear Mr. Camire:

1 BACKGROUND

The Town of Canmore submitted an environmental impact assessment (EIA) report for Cougar Creek debris flood retention structure (the Structure) in July 2016. Round 1 supplemental information requests (SIRs) were received in December 2016.

The Structure is designed to allow groundwater to pass through above grade from the intake through the bottom outlet structure, before being re-introduced to the groundwater system at the outlet (Canadian Hydrotech 2016). In other words, the Structure is designed such that it will not impact groundwater flux or recharge into the Valley/Fan Aquifer. The hydrogeology portion of the EIA is based on this assumption, recognizing that there may be very localized changes in groundwater levels and horizontal gradient.

Despite this, hydrogeology questions were raised by the EIA reviewer, regarding groundwater flux pre- and post-construction.

1.1 Objective

The objective of this letter report is to support the round 1 SIR responses by quantitatively illustrating that:

- if the Structure performs as designed, the overall groundwater flux is not affected as is assumed in the EIA
- impacts to groundwater levels and horizontal gradient are locally restricted to the area of the Structure

2 CONCEPTUAL MODEL

Bedrock units in the Cougar Creek valley are interpreted to have relatively low permeability compared to the overlying drift. On the local scale at the Structure, fracturing and jointing at the bedrock/alluvium interface may locally enhance the hydraulic conductivity of the bedrock near the interface, but the proposed seepage control structure (combination of seal wall, cut-off wall and grout curtain) should significantly reduce the hydraulic conductivity of these local features. Therefore, the bedrock units are considered as aquitards for the purposes of this numerical model, with non-significant contribution to natural groundwater flux under the Structure.

The drift units are comprised of alluvial fan sediments (dominated by coarse-grained material) and they are stratigraphically inter-fingered with fluvial and glaciofluvial deposits in the main Bow River Valley. The drift units are treated as one hydrogeologic unit and are referred to as the Valley/Fan Aquifer. Near the Structure, the aquifer is approximately 17 m deep and 50 m wide. A continuous confining layer has not been observed overlying the Valley/Fan Aquifer locally at the Structure. Therefore, the Valley/Fan Aquifer is considered an unconfined aquifer and interpreted to be in direct hydraulic communication with overlying surface water features (i.e.; Cougar Creek). Finally, based on measured groundwater elevations, the aquifers horizontal hydraulic gradient was estimated to range between 4% and 6%.

3 MODEL CONSTRUCTION

3.1 Software Selection

This work assumes that a representative elementary volume (Bear 1972) of the porous medium exists and can represent the effective hydraulic behaviour of the medium. Groundwater flow within the model domain was interpreted to be normal gravity driven flow that can be represented by the fluid continuity equation:

$$\frac{\partial}{\partial x}\left(K_x\frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(K_y\frac{\partial h}{\partial y}\right)+\frac{\partial}{\partial z}\left(K_z\frac{\partial h}{\partial z}\right)=S_s\frac{\partial h}{\partial t}$$

where:

x, y, z = Cartesian coordinates (L)
h = hydraulic head (L)
S_s = specific storage (L^{-1})
K = hydraulic conductivity (L/t)
t = time

The above equation is derived based on the assumption that the principle directions of the hydraulic conductivity tensor are uniform throughout the model domain and that the Cartesian coordinate system is chosen such that its axes (*x, y, z*) coincide with the principal directions of the hydraulic conductivity tensor. The major assumptions within the continuity equation and in its application are that groundwater flow follows Darcy's Law and the fluid throughout the model domain has a constant density. Furthermore, in solving the fluid continuity equation, it is assumed that the hydraulic properties of saturated units (K and S_s) do not vary over time and are independent of hydraulic head.

Groundwater flow was simulated using the 3D FEFLOW (Version 6.2) simulator developed by DHI-WASY GmbH (2014). FEFLOW (Version 6.2) was used to solve for mass conservative groundwater flow within fully saturated porous media using finite element discretization of the media.

3.2 Model Discretization

The model domain has a width of 50 m, a length of 800 m, and is composed of a single layer with constant thickness of 17 m. To represent the Structure, the finite element mesh was refined around its key features: 1) the intake, 2) the outlet of the stilling basin, and 3) the seepage control structure. The mesh is composed of 3,452 elements with a node spacing varying from 2 to 10 m.

3.3 Model Parameterization

The hydraulic conductivity of the Valley/Fan Aquifer at the Structure has been assessed using a variety of methods, including analytical methods from grain size distributions and in situ hydraulic conductivity testing (single well slug tests and a 72-hour constant rate pumping test) using groundwater wells (Thurber 2015a, 2015b, 2015c; Waterline 2015). Based on these analyses, the hydraulic conductivity of the aquifer is on the order of 10^{-5} to 10^{-3} m/sec. For this effort, the horizontal hydraulic conductivity assigned to the aquifers material was set to a value of 1.0×10^{-4} m/sec.

3.4 Model Boundary Conditions

3.4.1 Natural Groundwater Flux

The upgradient boundary condition represents the inflow of natural groundwater flux from the Valley/Fan Aquifer into the model domain. A fluid flux boundary condition was assigned and set as an adjustable parameter in the calibration process.

The boundary condition downgradient of the Structure was physically based and represented the groundwater elevation from the Valley/Fan Aquifer downstream in the Bow River Valley at a distance of 1,000 m with a reference hydraulic head of 1,360 m above sea level (asl).

Finally, the model bounds perpendicular to the groundwater flow direction were assigned to no-flow. Assigned boundary conditions are illustrated on Figure 1 below.

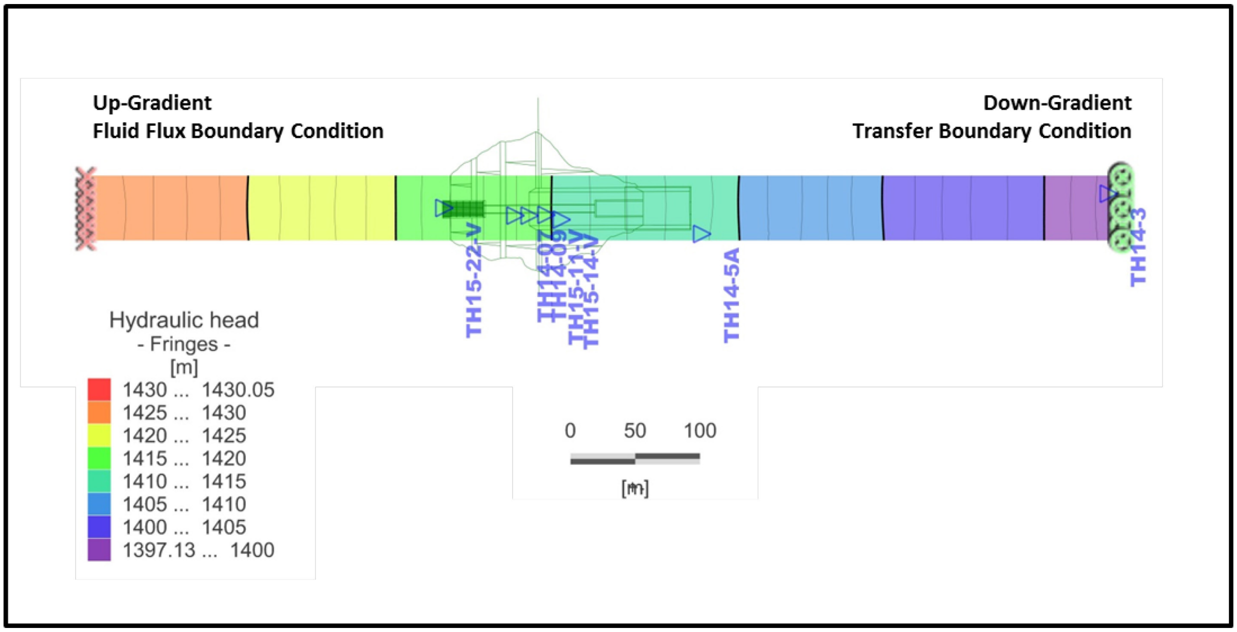


Figure 1 Assigned Boundary Conditions – Natural System

3.4.2 Debris Flood Retention Structure

To represent the seepage control structure in the numerical model, mesh's elements were inactivated preventing any groundwater flow beneath the Structure.

Upgradient, the intake was represented as constant hydraulic heads with designed elevation of 1,421.15 m asl as per the proposed final structure design (Canadian Hydrotech 2016). This boundary condition has an outflow constraint only (i.e., not allowing water inflow).

Downgradient, the outlet of the stilling basin was represented by a set of well boundary conditions on the upper slice only, with a cumulative infiltration rate equivalent to the outflow from the intake. This represents intercepted groundwater from the intake infiltrating through openings at the stilling basin bottom, and therefore being re-introduced into the groundwater system. The boundary conditions associated with the Structure are illustrated on Figure 2.

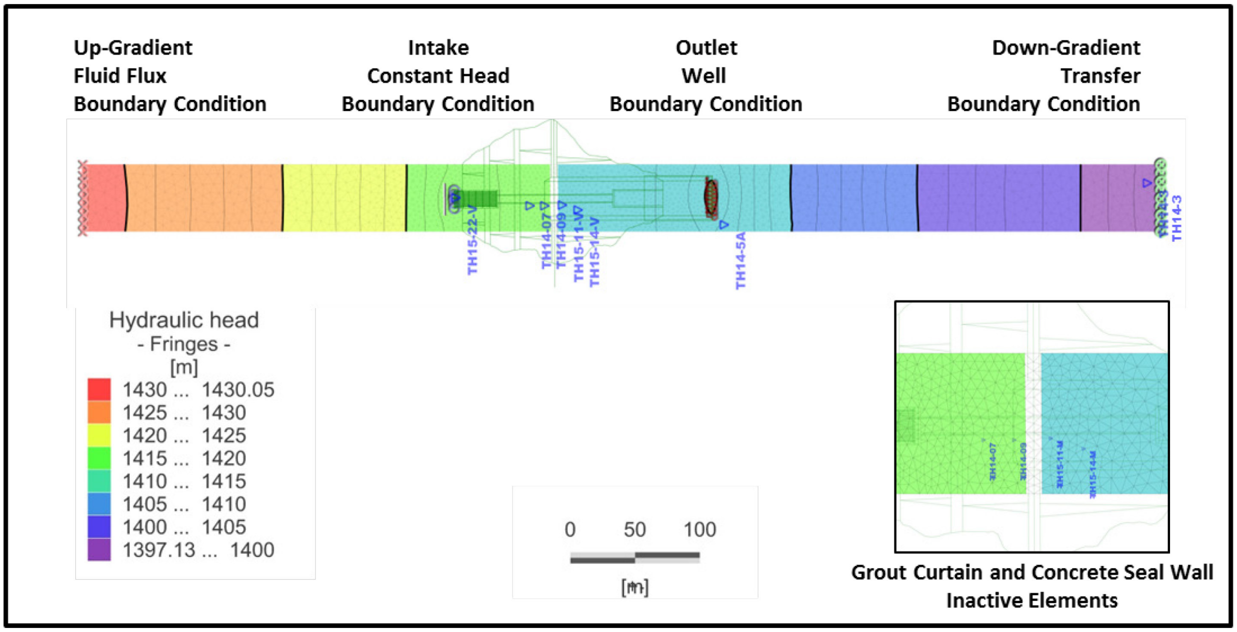


Figure 2 Assigned Boundary Conditions –Structure

4 MODEL CALIBRATION

The calibration strategy was to minimize, through a “trial and error” approach, the misfit between measured and simulated steady-state hydraulic heads by adjusting the fluid flux at the upgradient bound of the numerical model. Table 1 below summarizes the final calibration results.

Table 1 Calibration Results Summary

Monitoring Well	Easting	Northing	Observed Hydraulic Heads – October 17, 2015 (m asl)	Simulated Hydraulic Heads – Natural Conditions (m asl)	Simulated Hydraulic Heads – Post-construction Conditions (m asl)
TH14-07	617,655	5,661,727	1416.71	1416.02	1423.32
TH14-09	617,649	5,661,719	1416.55	1415.60	1423.38
TH15-11-V	617,642	5,661,708	1416.42	1415.12	1412.25
TH15-14-V	617,632	5,661,700	1415.80	1414.72	1412.28
TH15-22-V	617,691	5,661,769	1417.94	1418.17	1421.39
TH14-5A	617,561	5,661,618	1408.97	1411.20	1413.79
TH14-3	617,434	5,661,321	1397.56	1397.53	1397.53

Simulated hydraulic heads from the most upgradient monitoring well (TH15-22-V) is 0.21 m higher than the measured value, while the most downgradient monitoring well (TH14-3) simulated head is 0.03 m lower than the measured value. Based on these results, the horizontal hydraulic gradient is deemed to be a reasonable representation of measured conditions. The simulated hydraulic gradient is approximately 4%.

The calibrated natural groundwater flux upgradient from the Structure (i.e., fluid flux boundary condition) was estimated to be 265 m^3/day or 184 L/min based on a representative horizontal hydraulic conductivity of 1.0 × 10^{-4} m/sec.

5 EFFECTS ON GROUNDWATER FROM THE STRUCTURE

Figure 3 below, illustrates in a cross-section view the groundwater elevations under both groundwater flow regimes. Based on the assumption and design criteria that all of the groundwater captured by the intake will be able to re-infiltrate into the ground at the Structure outlet, the groundwater flux from natural conditions to post-construction of the Structure remains unchanged at 265 m^3/day.

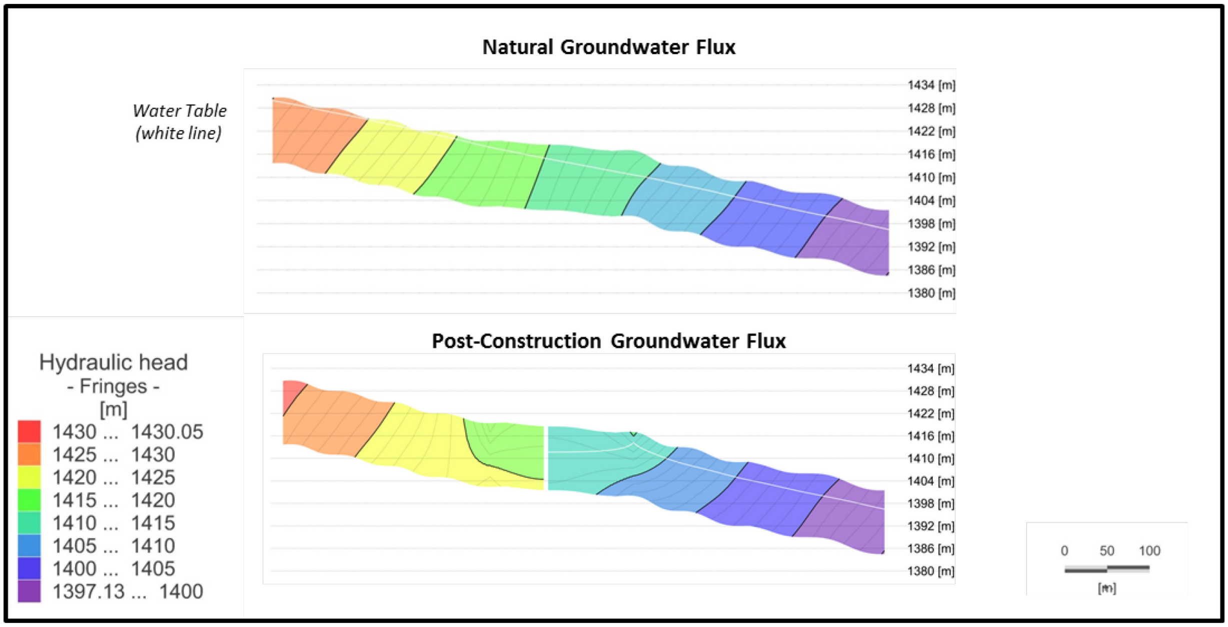


Figure 3 Groundwater Elevations – Post-construction of the Structure

Simulation results indicate that groundwater elevation upgradient from the Structure will take approximate 11 days to saturate the aquifers pore space before an intake elevation of 1,421.15 m asl is reached, assuming specific yield of 20%. As shown on Figure 3, the decrease in groundwater elevation downgradient of the Structure is estimated to be limited to the area between the seepage control structure and the outlet. Further downgradient, the groundwater elevation is simulated to regain natural conditions beyond 200 m from the Structure's outlet.

6 CONCLUSIONS

This modeling exercise supports the following conclusions:

- If the Structure performs as designed, groundwater levels in the Valley/Fan Aquifer may be impacted by the Structure, but these impacts are minor and restricted to a localized area near the Structure.
- Horizontal groundwater gradient in the Valley/Fan Aquifer may be impacted by the Structure but these impacts are minor and restricted to a localized area near the Structure.

7 MODEL SENSITIVITY

One hydrogeologic parameter that is subject to a fair amount of uncertainty is Valley/Fan Aquifer horizontal hydraulic conductivity. Horizontal hydraulic conductivity of the Valley/Fan Aquifer could be an order of magnitude higher or lower than represented in this model. However, changing the horizontal hydraulic conductivity does not change the conclusion that the Structure is not anticipated to impact groundwater flux to the Valley/Fan Aquifer. All things being equal, lower horizontal hydraulic conductivity with an unchanged horizontal hydraulic gradient will result in:

- lower estimates of the aquifers natural groundwater flux
- slower filling of aquifer pore space to intake level after construction until the flow system achieves a new steady state equilibrium

8 CLOSURE

We trust that this letter report suits your present requirements. If you have any questions or comments, please call either of the undersigned at 403.237.0606.

Yours truly,

MATRIX SOLUTIONS INC.

Louis-Charles Boutin, P.Eng.
Senior Groundwater Engineer
May 15, 2017

Reviewed by

William Wilmot, P.Geol.
Senior Hydrogeologist
May 15, 2017

APEGA Permit to Practice
Permit No. P5540

LC/lv
Attachments

copy: Félix Camiré, Town of Canmore, Canmore, Alberta

DISCLAIMER

We certify that this letter report is accurate and complete and accords with the information available during the site investigation. Information obtained during the site investigation or provided by third parties is believed to be accurate but is not guaranteed. We have exercised reasonable skill, care, and diligence in assessing the information obtained during the preparation of this letter report.

This letter report was prepared for Town of Canmore. The letter report may not be relied upon by any other person or entity without our written consent and that of Town of Canmore. Any uses of this letter report by a third party, or any reliance on decisions made based on it, are the responsibility of that party. We are not responsible for damages or injuries incurred by any third party, as a result of decisions made or actions taken based on this letter report.

REFERENCES

Bear 1972. *Dynamics of Fluids in Porous Media*. American Elsevier, New York.

Canadian Hydrotech Corporation (Canadian Hydrotech). 2016. *Long Term Flood Mitigation Measures, Cougar Creek: Design Report (Issued for Permitting)*. Prepared for the Town of Canmore. August 10, 2016 .

DHI-WASY GmbH. 2014. *FEFLOW* (Version 6.2 [3D + 2D]). Interactive Graphics-based Finite Element Simulation System for Subsurface flow and Transport Processes. Copyright © 1979-2014 by DHI-WASY GmbH. Berlin Bohnsdorf, Germany. July 2014.

Thurber Engineering Ltd. (Thurber). 2015a. *Cougar Creek Long Term Mitigation Project Geotechnical Investigation for Phase 1 – Option Analysis.* File 19-598-440.Report prepared for the Town of Canmore. Calgary, Alberta. November 9, 2015.

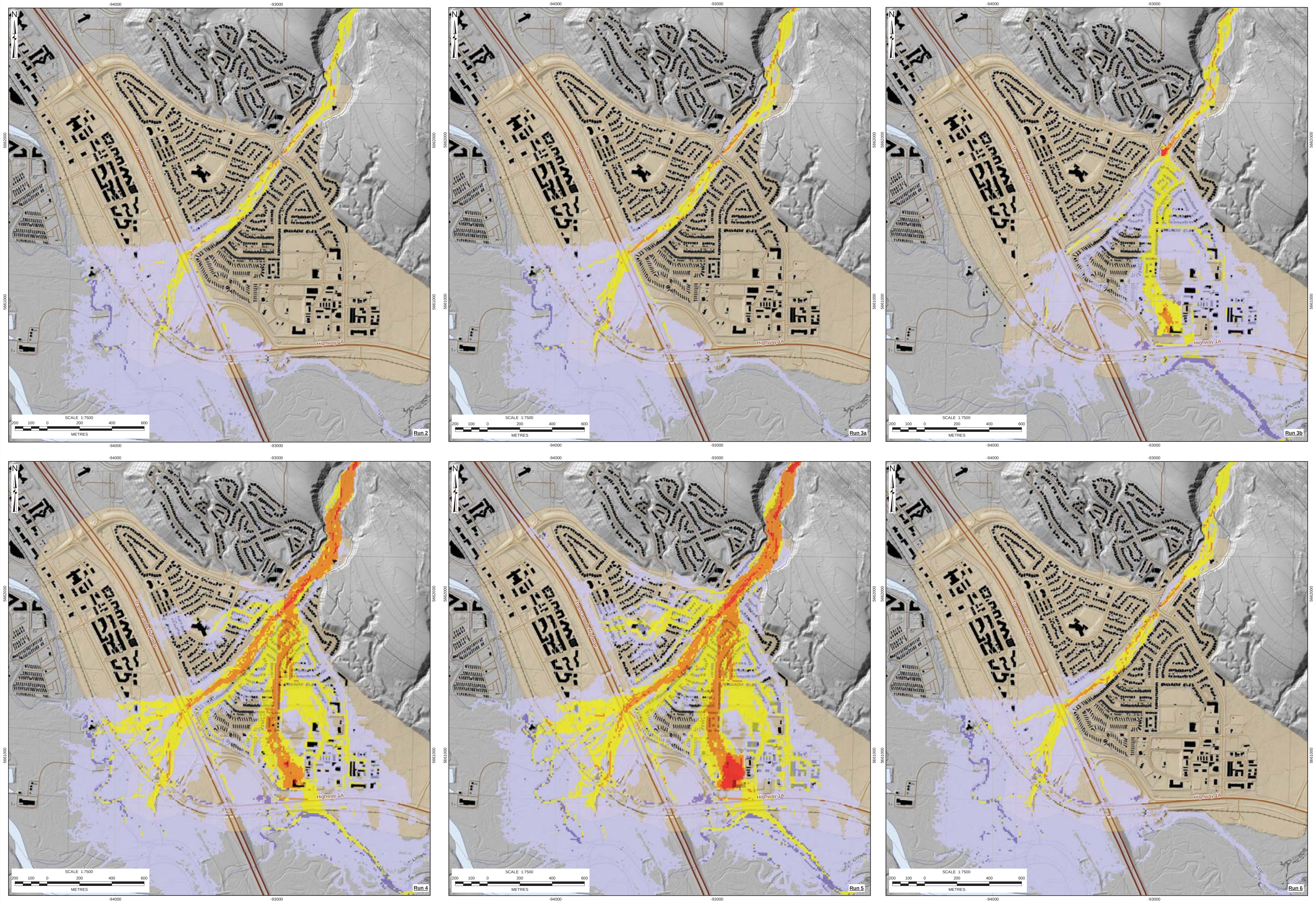
Thurber Engineering Ltd. (Thurber). 2015b. *Cougar Creek Long Term Mitigation Project Phase 2A Geotechnical Investigation*. File 19-598-440B. Report prepared for the Town of Canmore. Calgary, Alberta. November 12, 2015.

Thurber Engineering Ltd. (Thurber). 2015c. *Cougar Creek Long Term Debris Flood Mitigation Project Phase 2B Geotechnical Investigation.* File 14-264-2. Report prepared for the Town of Canmore. Calgary, Alberta. November 9, 2015.

Waterline Resources Inc. (Waterline). 2015. *Cougar Creek Debris Flood Mitigation - Production Well Testing Program Results.* Technical memorandum prepared for Thurber Engineering Ltd. Calgary, Alberta. September 28, 2015.

Appendix 74-1

Debris Flood Intensity Modelling



LEGEND

FLOW DEPTH (m) (v < 1 m/s)

🟪	< 1
🟪	1 to 2.5
🟦	> 2.5

IMPACT INTENSITY (m^2/s^2) (v > 1 m/s)

🟨	< 10
🟧	10 to 100
🟥	> 100

☐	PARCELS
■	BUILDING
▨	FAN BOUNDARY
—	ROAD
—	HIGHWAY
┼	RAILWAY
—	WATERCOURSE
▭	WATERBODY

NOTES:
1. ROADS, STREAMS AND WATERBODIES FROM NRCAN CANVEC.
2. TOPOGRAPHY DERIVED FROM LIDAR RECEIVED FROM TOWNSHIP OF CANMORE, JULY 2013.
3. PARCELS, ROADS, GAS LINES, SANITARY, STORM AND WATER SYSTEMS OBTAINED FROM TOWN OF CANMORE.

LIMITATIONS:
1. MODELLED DEBRIS FLOOD SCENARIOS ARE LABELLED IN THE LOWER RIGHT HAND CORNER OF EACH MAP INSET.
2. SEE THE REPORT FOR DESCRIPTION OF METHODS AND LIMITATIONS OF MODELLING.

3TM

REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE: 1:7,500
DATE: MAR 2014
DRAWN: GLT
DESIGNED: MJ, KH
CHECKED: MJ, HW, KH
APPROVED: MJ, KH

PROFESSIONAL SEAL:

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT:
TOWN OF CANMORE

PROJECT:
COUGAR CREEK DEBRIS FLOOD HAZARD ASSESSMENT

TITLE:
DEBRIS FLOOD INTENSITY:
SURFACE INFRASTRUCTURE (RUNS 2-6)

PROJECT No.: 1261001
DWG No.: 11
REV.:

X:\Projects\1261\001\Workspace\20131101_Report_Cougar_Creek_Debris_Flood_Hazard_Assessment11_Debris_Flood_Intensity_Surface_Infrastructure.mxd Date: Thursday, March 06, 2014 Time: 10:31 AM

DWG TO BE READ WITH BGC REPORT TITLED "COUGAR CREEK DEBRIS FLOOD HAZARD ASSESSMENT" DATED MARCH 2014

Appendix 84-1

Letters of Support

Norbert R. Morgenstern Consulting Ltd.
106 Laurier Drive
Edmonton, Alberta, T5R 5P6

December 2, 2014

Mr. A. Esarte, P.Eng.
Manager of Engineering
Town of Canmore
Canmore, Alberta

Re: Cougar Creek Debris Flood Risk Management

As your advisor with respect to debris flood risk management on Cougar Creek, I am writing to re-affirm my support for the direction that you and the Town of Canmore (Canmore) are taking to mitigate the effects of future flooding on Canmore Creek.

Following the June 19 and 20, 2013 event, Canmore retained Consultants (BGC) to assess flood hazards and options for future flood risk management. Canmore had retained Consultants in the past to evaluate flood risk, but until BGC were brought into the picture, none had either recognized or adequately articulated the central challenge of debris management in future safety concerns associated with development on the mountain creek fans. The Province had not recognized the issue and flood management had relied on traditional prescriptive floods for the design of protective works.

It was an outstanding achievement on the part of BGC to decipher the past and to develop a Magnitude – Return Period relationship for these past events. This recognizes that larger events than the June 2013 debris flood can occur with even greater intensity. This awareness cannot be set aside.

There is experience in Canada to totally deny development on a debris fan if events causing multiple deaths with a Return Period of 5-10,000 years were conceivable. The Village of Garibaldi in British Columbia was such an example. The Village was denied planning permission to grow and ultimately prior land owners were obliged to sell back to the Crown when the wished to give up use of their properties. This is not an option for Canmore, which must find its way to manage its risk in a feasible fair and affordable manner. Not to do so would, in my mind, be unconscionable.

In order to frame options BGC have proposed that Canmore adopt group risk tolerance criteria to help it evaluate its choices. I have been involved in the development of these criteria when acting as a Consultant to the Government of Hong Kong and have supported BGC in promoting the adoption of these criteria by the City of North Vancouver, and elsewhere. They are entirely appropriate for use by Canmore. Modelling debris flow scenarios consistent with the Cougar Creek geomorphological history indicates that the outcomes, the societal risk, are unacceptable. There is both a moral and a practical obligation to reduce risk to the broadly acceptable range.

With this as an objective, I regard it as up to the community to establish its own risk tolerance and preferred option(s) to meet its risk targets. Canmore has done this in an open and transparent manner. Other jurisdictions are looking on with great interest and respect for the leadership provided by Canmore on this issue.

I urge Council to support the proposed way forward. The science is right; the logic of risk assessment and management is right; and the public policy leadership is right. As a home-owner in Canmore I look forward to expressing my appreciation to the professional staff and elected officials who bring this positive outcome, as proposed, to fruition.

Sincerely yours,

N.R. Morgenstern, CM, AOE, FRSC, Ph.D., P.Eng.
Consultant and
Distinguished University Professor Emeritus
University of Alberta

NRM/sp

Department of Geography
The University of British Columbia
Vancouver, British Columbia, V6T 1Z2

22 November, 2014

Mr. Andy Esarte
Manager of Engineering
Town of Canmore, AB T1W 1K8

Dear Mr. Esarte

This letter is in reply to your request that I provide a comment on the work of BGC Engineering, Ltd. to analyze and recommend remedies for hazards presented in your community by the mountain creeks. I begin by indicating that I have acted as an independent reviewer of BGC's reports. I was, however, nominated for this role by BGC (a usual practice in review of engineering work) and I have been for many years a professional colleague of their senior consultant in this work, Dr. Matthias Jakob. Your request asks me to summarize the reviews completed, how my questions and comments have been addressed, and my satisfaction with the final reports and their conclusions.

I have reviewed the following documents:

Cougar Creek Debris Flood Hazard Assessment, Final Report 24 June, 2014

Cougar Creek Forensic Analysis: Hydroclimatic Analysis of the June, 2013, Storm, Final Report 1 Aug., 2014

Echo Canyon Creek Forensic Analysis and Long-term Debris Flow Mitigation Concepts, Draft Report 10 Oct., 2013

Pigeon Creek Forensic Analysis and Short-term Debris Flow mitigation, Final Draft Report 1 Oct., 2013.

Stone Creek Debris Flow Hazard Assessment, Draft Report 20 Aug., 2014.

Stoneworks Creek Forensic Analysis and Short-term Debris Flood Mitigation, Draft Report 8 Oct., 2013.

Three Sisters Creek Forensic Analysis and Short-term Debris Flood Mitigation, Final Draft Report, 1 Oct., 2013,

Three Sisters Creek Debris Flood Hazard Assessment, Final Draft Report 1 Aug., 2014.

Three Sisters Creek Debris Flood Hazard and Risk Assessment. Draft Report 7 March, 2014.

X, Y and Z Creeks Forensic Analyis and Debris Flow Mitigation Concepts, Draft Report 28 Oct., 2013.

In cases annotated 'final report' I have also seen one or more draft versions.

I made many comments on the reports, some of editorial character, some to improve clarity, and some to suggest substantive changes. BGC responded to all my comments. In particular, they changed the organization of some of the earlier reports to respond to my opinion that the draft presentation was not organized to facilitate reading by non-experts (such as Councillors) – that the main issues were not directly and straightforwardly presented. I judge that this has changed the overall accessibility and usefulness of the reports. We have also had detailed discussions over the construction and presentation of the critical magnitude-frequency analyses for debris floods/flows to achieve the most appropriate presentation of the limited historical data and prehistoric reconstructions.

Two aspects of BGC's analyses stand out in my mind. The first is the separation of hazard and risk in appraising the potential problems presented by the mountain creeks. BGC, and particularly Dr. Jakob, have been pioneers in Canada in advocating this approach to the appraisal and management of natural hazards. It is particularly important in a situation such as that faced in Canmore where varying degrees of development on different alluvial fans, and different hazards (debris flood versus debris flow) should lead to different degrees of mitigation as the most cost-effective way to ensure public safety at different sites, and whereby the necessary mitigative costs of proposed future developments can be rationally assessed.

The second aspect is BGC's insistence that, in order to plan appropriate mitigation, geophysical processes in the upstream drainage basin must be properly understood. It is lack of understanding of this requirement that resulted in earlier engineering assessments of the 'flood' potential of the mountain creeks to be grossly underestimated. BGC's explorations of the upstream sources of potential sedimentation hazards represent exemplary problem analysis.

Beyond these important initiatives, I have found BGC's work consistently to be of the high scientific and professional standard. They have, in particular, brought to bear advanced methods of dating and stratigraphical analysis in attempts to appraise the magnitude and frequency of hazardous flows in the subject streams, and they have given due consideration to the likelihood for changes in event frequency under the influence of a changed future climate. These analyses do not yield perfect clarity simply because the complete record of past events is not available to recover. In this respect, I have questioned the strategy of using the compilation of recent events in different places as a substitute for the possible historical record of events on one stream through time (a strategy sometimes used in environmental reconstruction but, in this case, of doubtful validity). BGC personnel engaged this matter in a professional manner, as I expected, and have qualified their analyses accordingly.

Because of his European origin, Dr. Jakob is very aware of the more extensive experience in the European Alps of hazards presented by mountain streams. The engagement of Austrian experts and some of their techniques toward resolving the potential problems at Canmore is a further advantage that BGC has brought to their work for you.

Altogether, then, I believe that BGC Engineering, bringing a combination of geological, hydrological and engineering expertise to the task, has served your needs as well as any consultancy could and that their advice points to viable resolution of the mountain stream hazards present in your community. I trust that my engagement in the work has also been helpful.

Yours sincerely

Michael Church, D.Sc., FRSC, P.Geol.(BC), FGC, FEC(Hon.)

(transmitted by e-mail)

Appendix 113-1

Stewart Creek Phase 3 Test Pit Program, Laboratory Test Results

THURBER ENGINEERING LTD.

May 13, 2015 File: 14-264-0

Engineering Services, Town of Canmore
902 – 7th Avenue
Canmore, AB T1W 3K1

Attention: Felix Camire, E.I.T.

COUGAR CREEK LONG TERM MITIGATION PROJECT
STEWART CREEK PHASE 3 TEST PIT PROGRAM
LABORATORY TEST RESULTS

Dear Felix:

This letter provides the findings and initial laboratory test results on soil samples collected during the test pit program carried out by Thurber Engineering Ltd. (Thurber) on behalf of the Town of Canmore (the Town) at the proposed Stewart Creek Phase 3 Residential Development in Canmore, Alberta.

This letter is subject to the Statement of limitations and Conditions, which are included at the end of this text. The reader's attention is specifically drawn to these conditions as it is considered essential that they be followed for the proper use and interpretation of the data and recommendations provided in this letter.

1. BACKGROUND

The construction of a cut-fill platform at the Stewart Creek Phase 3 Residential Development requires the stripping and removal of approximately 140,000 m^3 of gravel soil from the site. The gravel soil is being considered as a potential source of borrow material for the construction of the proposed flood mitigation structure on Cougar Creek outside Canmore.

A test pitting program comprising 8 test pits was proposed to characterize the nature of the gravel deposit in this area and to collect bulk samples for laboratory testing.

2. SCOPE OF WORK

Thurber's scope of work for the test pitting and laboratory testing program was submitted to the Town in our proposal dated March 12, 2015. The main tasks outlined in that proposal included:

- Excavate 8 test pits at selected locations.
- Visually inspect and describe the soil stratigraphy of each test pit.
- Collect bulk samples for laboratory testing.
- Rehabilitate the test pits once field inspection and sampling is complete.
- Prepare a factual report documenting the results of the test pit program and laboratory test results.

Authorization to proceed with the test pit program was received from The Town in an email dated March 12, 2015.

3. METHODOLOGY

3.1 Test Pit Program

The test pit program was carried out on May 18th and 19th, 2015 under the supervision of Mr. T. Kujawa, P.Geol., and Ms. S. Bryant, E.I.T. of Thurber. The test pits were excavated using a John Deere 225C LC tracked excavator, owned and operated by Bremner Engineering and Construction Ltd. (BECL). The excavation of the first two test pits (TP14-02 and TP14-03) was also observed by Mr. M. Scheikl of alpinfra consulting + engineering gmbh (alpinfra), and Ms. J. Eisl and Mr. F. Camire of The Town.

Eight test pits (TP15-01 to TP15-08) were excavated to depths ranging between 1.4 m and 5.8 m. The final test pit locations were surveyed by ISL Engineering and Land Services Ltd. (ISL) and are shown on Figure 1.

Soils encountered at each test pit location were visually logged in the field, noting material type and thickness. One representative bulk sample was collected from the excavated material from each test pit.

Soil conditions encountered during test pitting were documented in the field and are summarized in the test pit log sheets attached to this letter. An explanation of the symbols and terms used in the test pit logs and details of the Modified Unified Soil Classification system are also provided.

All test pits were backfilled to original grade and the material compacted using either the excavator bucket or tracks.

3.2 Laboratory Testing

The bulk soil samples were returned to Thurber's laboratory in Calgary for further examination and classification.

Based on the initial visual observation of the excavated soil material on site, it was decided by alpinfra to separate the laboratory testing program into two phases i.e. an initial laboratory testing program to characterize the soils encountered, followed by an advanced laboratory program to determine the soil strength and durability characteristics (i.e., direct drained shear and tri-axial tests, and LA Abrasion tests). The need for the advanced laboratory testing program is based on the results of the initial laboratory testing program.

The initial laboratory testing program comprised the following:

- Visual identification and natural moisture content determination on bulk samples collected from test pits TP15-02, TP15-03, TP15-04, TP15-05 and TP15-08.
- Loose (un-compacted) dry bulk density determination on bulk samples collected from test pits TP15-02, TP15-03 and TP15-04. The loose dry bulk density was determined by filling a container of pre-determined volume with sample material and then dividing the sample mass by the volume of the container.
- Particle size distribution analyses (sieve and hydrometer) on bulk samples collected from test pits TP15-02, TP15-03 and TP15-04.
- Atterberg Limits on the finer portion of bulk samples collected from test pits TP15-02, TP15-03 and TP15-04, (these tests were performed on material passing the 5 mm sieve size).
- Sieve analysis on bulk samples collected from test pits TP15-05 and TP15-08.
- Standard Proctor tests on bulk samples collected from test pits TP15-02, TP15-03 and TP15-04.

The results of the initial laboratory tests are presented in the test pit logs attached.

4. SUBSURFACE CONDITIONS

Based on the results of the test pitting, the site is generally underlain by upper surficial soils, varying in thickness between 0.3 m to 0.9 m (TP15-07) at the test pit locations. The surficial soils consist of sand and/or silt containing varying amounts of clay and gravel, and organic material.

The surficial soils are underlain by a well-graded, sandy, silty gravel, with frequent cobbles and boulders (up to 850 mm in size), to the full depth of each test pit. The gravel contains varying amounts of clay. Gravel particles are generally rounded to angular (in angularity) and typically blocky to elongate in shape.

An about 1.0 m thick, very loose, poorly graded, fine grained sand zone was encountered in TP15-03 at a depth of 3.0 m below ground surface.

All test pits were dry during excavation.

5. CLOSURE

The initial phase of the laboratory testing program on bulk samples collected from selected test pits has been completed and the results are reported herein. Thurber will await further instruction from the Town on whether to proceed with the advanced laboratory testing program or not. The advanced laboratory testing, if required, will be carried out on the bulk sample material collected from test pits TP15-02, TP15-03 and TP15-04.

Yours truly,
Thurber Engineering Ltd.
John Sobkowicz, Ph.D., P.Eng.
Review Engineer

THOMAS KUJAWA
May 13, 2015

PERMIT TO PRACTICE
THURBER ENGINEERING LTD.
Signature John Sobkowicz
Date 13 May 2015
PERMIT NUMBER: P 5186
The Association of Professional Engineers, Geologists and Geophysicists of Alberta

Thomas Kujawa, P.Geol.
Project Geologist

Attachment

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.

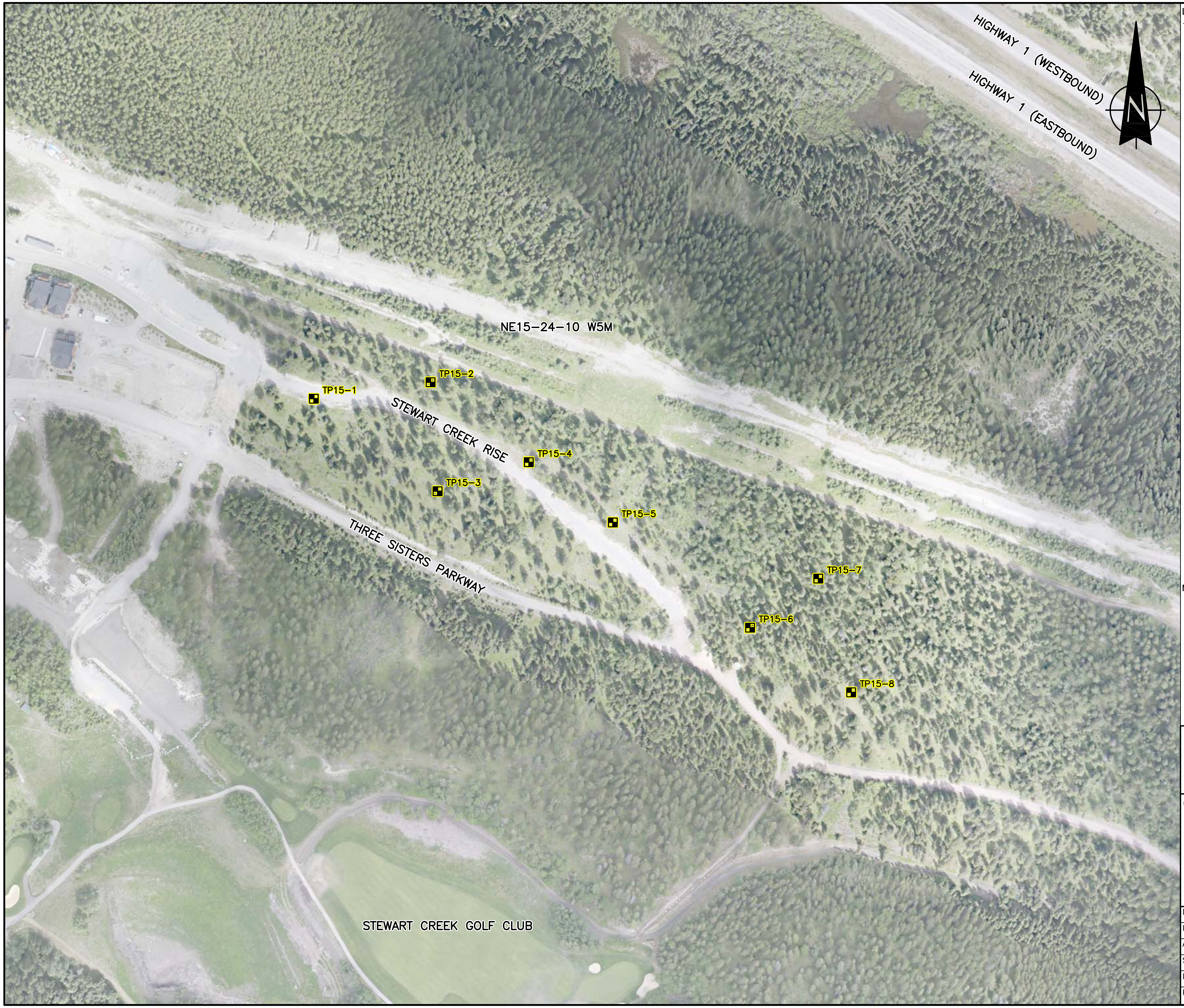
d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.



LEGEND:

TEST PIT LOCATION ▣

NOTES:

1 DRAWING MUST BE USED IN CONJUNCTION WITH THE ATTACHED REPORT REFERENCE 14-264-0 DATED MAY 2015 AND IS SUBJECT TO THE STATEMENT OF LIMITATIONS AND CONDITIONS INCLUDED IN THE REPORT.

2 AIR PHOTO BASE SUPPLIED BY THE CLIENT.

0 50 100 150 200 m

Town of CANMORE

COUGAR CREEK LONG TERM FLOOD MITIGATION PROJECT STEWART CREEK PHASE 3 TEST PITTING PROGRAM

TEST PIT LOCATION PLAN

FIGURE 1

DRAWN BY	ICB
DESIGNED BY	THK
APPROVED BY	JCS
SCALE	1:2500
DATE	MAY 7, 2015
FILE No.	14-264-0-A0B

THURBER ENGINEERING LTD.

SYMBOLS AND TERMS USED ON TEST HOLE LOGS

1. VISUAL TEXTURAL CLASSIFICATION OF MINERAL SOILS

CLASSIFICATION	APPARENT PARTICLE SIZE
Boulders	Greater than 200 mm
Cobbles	75 mm to 200 mm
Gravel	5 mm to 75 mm
Sand	Not Visible to 5 mm
Silt	Non-Plastic particles, not visible to the naked eye
Clay	Plastic particles, not visible to the naked eye

2. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	APPROXIMATE UNDRAINED SHEAR STRENGTH	
Very Soft	Less than 10 kPa	
Soft	10 - 25 kPa	
Firm	25 - 50 kPa	
Stiff	50 - 100 kPa	
Very Stiff	100 - 200 kPa	Modified from National Building Code
Hard	200 - 300 kPa	
Very Hard	Greater than 300 kPa	

3. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	STANDARD PENETRATION TEST (SPT) (Number of Blows per 300 mm)	
Very Loose	0 - 4	
Loose	4 - 10	
Compact	10 - 30	
Dense	30 - 50	Modified from National Building Code
Very Dense	Over 50	

4. LEGEND FOR TEST HOLE LOGS

SYMBOL FOR SAMPLE TYPE

■	Shelby Tube	▤	A- Casing
◩	SPT	▥	Grab
☒	No Recovery	◨	Core

● MC - Moisture Content (% by weight) as determined by sample

▼ Water Level

CPen - Shear Strength determined by pocket penetrometer

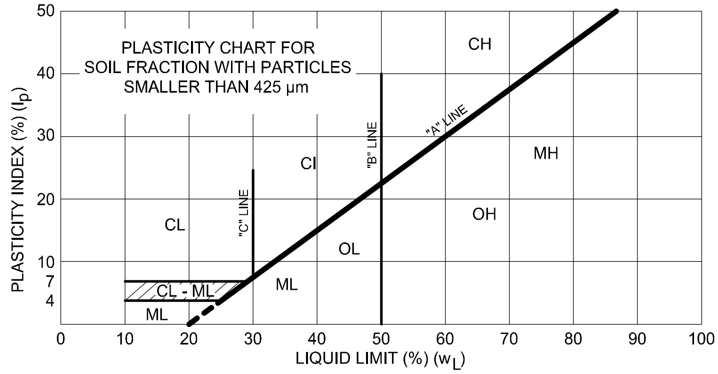
Cvane - Shear Strength determined by pocket vane

Cu - Undrained Shear Strength determined by unconfined compression test

MAJOR DIVISION			SYMBOL	THURBER LOG SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA		
COARSE-GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN 75 μm)	GRAVELS MORE THAN HALF COARSE GRAINS LARGER THAN 4.75 mm	CLEAN GRAVELS (LITTLE OR NO FINES)	GW	▨	WELL GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES	Determine percentages of gravel and sand from grain size curve. Depending on percentages of fines (fraction smaller than 75 μm) coarse grained soils are classified as follows: Less than 5% GW, GP, SW, SP More than 12% GM, GC, SM, SC 5% to 12% Borderline cases requiring use of dual symbols	$C_u = \frac{D_{60}}{D_{10}} > 4$; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3	
			GP	▨	POORLY GRADED GRAVELS, GRAVEL-SAND MISTURES, LITTLE OR NO FINES		NOT MEETING ALL GRADATION REQUIREMENTS FOR GW	
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	GM	▨	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES		ATTERBERG LIMITS BELOW "A" LINE I_p LESS THAN 4	Above "A" line with I_p between 4 and 7 are borderline cases requiring use of dual symbols
			GC	▨	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE I_p MORE THAN 7	
	SANDS MORE THAN HALF COARSE GRAINS SMALLER THAN 4.75 mm	CLEAN SANDS (LITTLE OR NO FINES)	SW	▨	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES		$C_u = \frac{D_{60}}{D_{10}} > 6$; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3	
			SP	▨	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES		NOT MEETING ALL GRADATION REQUIREMENTS FOR SW	
		SAND WITH FINES (APPRECIABLE AMOUNT OF FINES)	SM	▨	SILTY SANDS, SAND-SILT MIXTURES		ATTERBERG LIMITS BELOW "A" LINE I_p LESS THAN 4	Above "A" line with I_p between 4 and 7 are borderline cases requiring use of dual symbols
			SC	▨	CLAYEY SANDS, SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE I_p MORE THAN 7	
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT SMALLER THAN 75 μm)	SILTS BELOW "A" LINE NEGLIGIBLE ORGANIC CONTENT	$w_L < 50\%$	ML	▨	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY	CLASSIFICATION IS BASED UPON PLASTICITY CHART (see below)		
		$w_L > 50\%$	MH	▨	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS			
	CLAYS ABOVE "A" LINE NEGLIGIBLE ORGANIC CONTENT	$w_L < 30\%$	CL	▨	INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY, OR SILTY CLAYS, LEAN CLAYS			
		$30\% < w_L < 50\%$	CI	▨	INORGANIC CLAYS OF MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS			
		$w_L > 50\%$	CH	▨	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS			
	ORGANIC SILTS & CLAYS BELOW "A" LINE	$w_L < 50\%$	OL	▨	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW AND MEDIUM PLASTICITY			
		$w_L > 50\%$	OH	▨	ORGANIC CLAYS OF HIGH PLASTICITY, ORGANIC SILTS			
HIGHLY ORGANIC SOILS			PT	▨	PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOUR OR ODOUR, AND OFTEN FIBROUS TEXTURE		

SPECIAL SYMBOLS

▨	BEDROCK (UNDIFFERENTIATED)	▤	CLAY SHALE
▨	OVERBURDEN / FILL (UNDIFFERENTIATED)	▦	LIMESTONE
▨	CONGLOMERATE	▨	METAMORPHIC ROCK
░	SANDSTONE	■	COAL / OIL SAND
▨	SILTSTONE	▨	TOPSOIL
▤	CLAYSTONE / MUDSTONE		



MODIFIED UNIFIED SOIL CLASSIFICATION SYSTEM

(MODIFIED BY PFRA, 1985)

THURBER ENGINEERING LTD.

CLIENT: Town of Canmore	PROJECT: Cougar Creek Project - Stewart Creek Phase 3 Test Pit Program	TEST PIT NO: **TP15-1**
PROJECT NO: 14-264-0	UTM 11 NAD 83, Northing: 5656588.26 m, Easting: 618555.87 m	ELEVATION: 1368.57 m

SAMPLE TYPE: ▥ Grab Sample

BACKFILL TYPE:

DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	Shear Strength (kPa) ▲ Cpen 50 100 150 200 PL W.C. (%) LL 10 20 30 40	REMARKS	MUSCS / ISRM	SOIL SYMBOL	DESCRIPTION	ELEVATION (m)
0					FILL		FILL	
					SM		SAND, silty, some clay, trace gravel, compact, brown to reddish brown, moist, containing organic matter, containing boulders	
				Difficult to excavate below 0.4 m				1368
1							GRAVEL, sandy, silty, some clay, well graded, dense to very dense, brown, dry, containing frequent cobbles and boulders, well rounded to angular, blocky to elongated	
								1367
2								
					GC-GM		- 0.2 m thick sand layer, some gravel, trace silt, trace clay, dark brown to dark grey, pinches out to the west end of the pit	1366
3	▥	G-1						
								1365
4								
							END OF HOLE at 4.5 m - dry upon completion - backfilled with excavated material	1364
5								
								1363
6								
								1362
7								
								1361
8								
								1360
9								
								1359
10								

THURBER ENGINEERING LTD.	EXCAVATION CO.: Bremner Engineering and Construction Ltd.		
	EXCAVATOR TYPE: John Deere 225C LC	COMPILED BY: SKB	COMPLETION DEPTH: 4.5 m
	EXCAVATION METHOD: Excavation	REVIEWED BY: JCS	COMPLETION DATE: 18/03/2015
	INSPECTOR: THK		Page 1 of 1

CLIENT: Town of Canmore	PROJECT: Cougar Creek Project - Stewart Creek Phase 3 Test Pit Program	TEST PIT NO: **TP15-2**
PROJECT NO: 14-264-0	UTM 11 NAD 83, Northing: 5656598.80 m, Easting: 618630.64 m	ELEVATION: 1371.89 m

SAMPLE TYPE: ▥ Grab Sample

BACKFILL TYPE:

DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	REMARKS	MUSCS / ISRM	DESCRIPTION	ELEVATION (m)
0 – 0.4				TPS	SILT, some clay, trace gravel, trace sand, very loose to loose, brown, containing roots, containing subrounded to rounded cobbles (TOPSOIL)	
0.4 – 4.5				GC-GM	GRAVEL, sandy, silty, some clay, well graded, compact, brown, containing frequeny cobbles and boulders (sandstone, siltstone, quartz, quartzite), angular to well rounded, up to 680 mm, blocky to elongated	1371
2.5			Difficult to excavate below 2.5 m		- becoming dense to very dense	
3.0 – 4.5	▥	G-1	Bulk sample taken from 3.0 m to 4.5 m Loose Dry Density = 1465 kg/m^3 Standard Proctor Max. Dry Density = 2177 kg/m^3 Optimum Moisture = 7.3% Hydrometer Analysis Gravel = 27.8% Sand = 22.5% Silt = 34.2% Clay = 15.5%			
4.5					END OF HOLE at 4.5 m - dry upon completion - backfilled with excavated material	

Depth scale: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Elevation scale: 1371, 1370, 1369, 1368, 1367, 1366, 1365, 1364, 1363, 1362

Shear Strength (kPa)

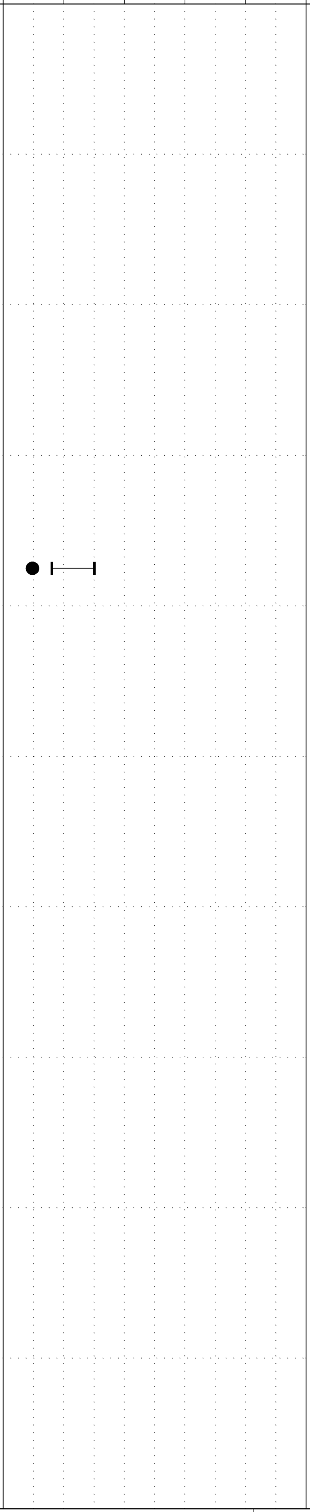
✿ Field Vane Peak ✳ CUP Triaxial

◆ UCS ▲ Cpen

50 100 150 200

PL W.C. (%) LL

10 20 30 40



EXCAVATION CO.: Bremner Engineering and Construction Ltd.		
EXCAVATOR TYPE: John Deere 225C LC	COMPILED BY: SKB	COMPLETION DEPTH: 4.5 m
EXCAVATION METHOD: Excavation	REVIEWED BY: JCS	COMPLETION DATE: 18/03/2015
INSPECTOR: THK		Page 1 of 1

THURBER ENGINEERING LTD.

CLIENT: Town of Canmore	PROJECT: Cougar Creek Project - Stewart Creek Phase 3 Test Pit Program	TEST PIT NO: **TP15-3**
PROJECT NO: 14-264-0	UTM 11 NAD 83, Northing: 5656529.02 m, Easting: 618635.18 m	ELEVATION: 1369.48 m

SAMPLE TYPE: ▥ Grab Sample

BACKFILL TYPE:

DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	Shear Strength (kPa) ✿ Field Vane Peak ✳ CUP Triaxial ◆ UCS ▲ Cpen 50 100 150 200 PL W.C. (%) LL 10 20 30 40	REMARKS	MUSCS / ISRM	SOIL SYMBOL	DESCRIPTION	ELEVATION (m)
0					TPS		SILT, sandy, trace gravel, very loose, brown, containing organic material (TOPSOIL)	
1 2	▥	G-1	● ├─┤	Bulk sample taken from 1.5 m to 3.0 m Loose Dry Density = 1404 kg/m^3 Standard Proctor Max. Dry Density = 2019 kg/m^3 Optimum Moisture = 11.0% Hydrometer Analysis Gravel = 33.2% Sand = 29.2% Silt = 25.8% Clay = 11.7% Excavation sidewall collapsing	GC-GM		GRAVEL, sandy, silty, some clay, non plastic, well graded, compact to very dense, dry, containing frequent cobbles and boulders, rounded to angular, blocky to elongated, up to 800 mm, containing fine grained sand pockets	1369 1368 1367
3					SP		SAND, poorly graded, fine grained, very loose, brown, moist	1366
4 5					GC-GM		GRAVEL, sandy, silty, some clay, non plastic, well graded, compact to very dense, dry, containing frequent cobbles and boulders, rounded to angular, blocky to elongated, up to 800 mm, containing fine grained sand pockets	1365 1364
6 7 8 9 10							END OF HOLE at 5.8 m - dry upon completion - backfilled with excavated material	1363 1362 1361 1360

THURBER ENGINEERING LTD.

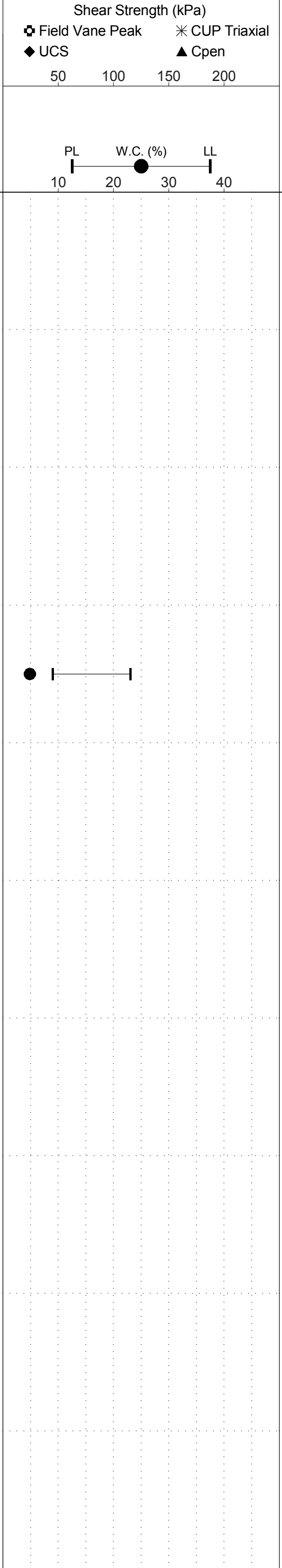
EXCAVATION CO.: Bremner Engineering and Construction Ltd.		
EXCAVATOR TYPE: John Deere 225C LC	COMPILED BY: SKB	COMPLETION DEPTH: 5.8 m
EXCAVATION METHOD: Excavation	REVIEWED BY: JCS	COMPLETION DATE: 18/03/2015
INSPECTOR: THK		Page 1 of 1

CLIENT: Town of Canmore	PROJECT: Cougar Creek Project - Stewart Creek Phase 3 Test Pit Program	TEST PIT NO: **TP15-4**
PROJECT NO: 14-264-0	UTM 11 NAD 83, Northing: 5656547.58 m, Easting: 618693.66 m	ELEVATION: 1371.31 m

SAMPLE TYPE: ▥ Grab Sample

BACKFILL TYPE:

DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	REMARKS	MUSCS / ISRM	DESCRIPTION	ELEVATION (m)
0 – 0.35				SM	SAND, silty, trace gravel, very loose, brown, containing organic matter	1371
0.35 – 4.8			Difficult to excavate below 1.5 m	GC	GRAVEL, sandy, silty, some clay, well graded, compact, brown, containing frequent cobbles and boulders, well rounded to angular, blocky to elongated, up to 850 mm - becoming dense to very dense	1370 1369 1368 1367
3.2 – 3.8	▥	G-1	Bulk sample taken from 3.2 m to 3.8 m Loose Dry Density = 1518 kg/m^3 Standard Proctor Max. Dry Density = 2178 kg/m^3 Optimum Moisture = 6.8% Hydrometer Analysis Gravel = 33.9% Sand = 22.5% Silt = 30.4% Clay = 13.2%			
4.8					END OF HOLE at 4.8 m - dry upon completion - backfilled with excavated material	1366



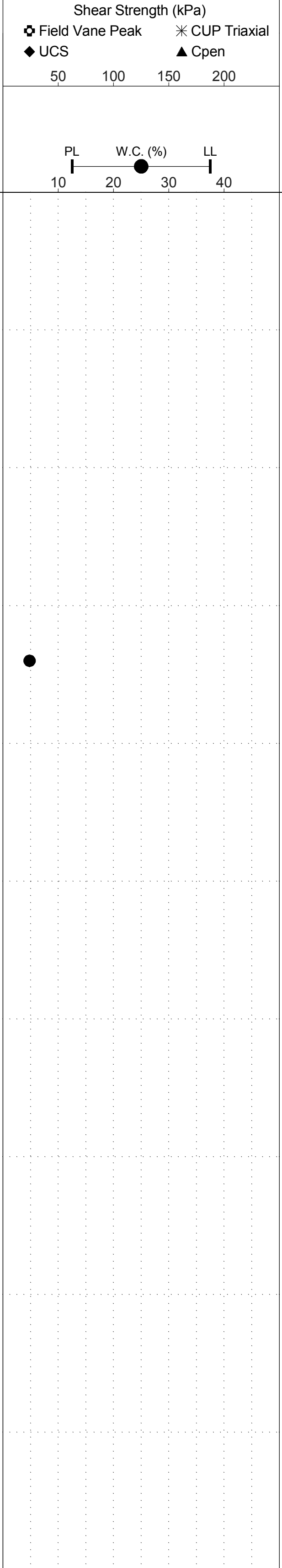
EXCAVATION CO.: Bremner Engineering and Construction Ltd.		
EXCAVATOR TYPE: John Deere 225C LC	COMPILED BY: SKB	COMPLETION DEPTH: 4.8 m
EXCAVATION METHOD: Excavation	REVIEWED BY: JCS	COMPLETION DATE: 18/03/2015
INSPECTOR: THK		

THURBER ENGINEERING LTD.

CLIENT: Town of Canmore	PROJECT: Cougar Creek Project - Stewart Creek Phase 3 Test Pit Program	TEST PIT NO: **TP15-5**
PROJECT NO: 14-264-0	UTM 11 NAD 83, Northing: 5656508.99 m, Easting: 618747.51 m	ELEVATION: 1370.26 m

SAMPLE TYPE: ▥ Grab Sample

BACKFILL TYPE:



DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	REMARKS	MUSCS / ISRM	DESCRIPTION
0				TPS	TOPSOIL, silty, clayey, some gravel, dark brown, moist, cobbles at surface
				ML	SILT, gravelly, some clay, low plastic, brown, dry, containing frequent cobbles, subangular to subrounded, up to 200 mm, containing roots
			Difficult to excavate below 1.5 m	GM	GRAVEL, sandy, silty, some clay, low plastic, well graded, compact, brown, dry, containing frequent cobbles and occasional boulders, subrounded to subangular, up to 400 mm - becoming dark brown, dense to very dense
	▥	G-1	Sieve Analysis Gravel = 31.3% Sand = 27.5% Silt & Clay = 41.2%		
					END OF HOLE at 5.1 m - dry upon completion - backfilled with excavated material

DEPTH (m): 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

ELEVATION (m): 1370, 1369, 1368, 1367, 1366, 1365, 1364, 1363, 1362, 1361

THURBER ENGINEERING LTD.

EXCAVATION CO.: Bremner Engineering and Construction Ltd.		
EXCAVATOR TYPE: John Deere 225C LC	COMPILED BY: SKB	COMPLETION DEPTH: 5.1 m
EXCAVATION METHOD: Excavation	REVIEWED BY: JCS	COMPLETION DATE: 19/03/2015
INSPECTOR: SKB		Page 1 of 1

CLIENT: Town of Canmore	PROJECT: Cougar Creek Project - Stewart Creek Phase 3 Test Pit Program	TEST PIT NO: **TP15-6**
PROJECT NO: 14-264-0	UTM 11 NAD 83, Northing: 5656441.58 m, Easting: 618835.45 m	ELEVATION: 1366.09 m

SAMPLE TYPE: ▥ Grab Sample

BACKFILL TYPE:

DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	Shear Strength (kPa) ▲ Cpen 50 100 150 200 PL W.C. (%) LL 10 20 30 40	REMARKS	MUSCS / ISRM	SOIL SYMBOL	DESCRIPTION	ELEVATION (m)
0					TPS		TOPSOIL, silty, clayey, dark brown, moist	1366
				Difficult to excavate below 0.2 m	ML		SILT, clayey, trace gravel, low plastic, very loose to loose, brown, dry, containing occasional cobbles, subrounded, up to 180 mm	
1	▥	G-1			GC-GM		GRAVEL, sandy, silty, some clay, well graded, very dense, dark brown, containing frequent cobbles and occasional boulders, subrounded to subangular, up to 450 mm	1365
							END OF HOLE at 1.4 m - dry upon completion - backfilled with excavated material	
2								1364
3								1363
4								1362
5								1361
6								1360
7								1359
8								1358
9								1357
10								

THURBER ENGINEERING LTD.

EXCAVATION CO.: Bremner Engineering and Construction Ltd.		
EXCAVATOR TYPE: John Deere 225C LC	COMPILED BY: SKB	COMPLETION DEPTH: 1.4 m
EXCAVATION METHOD: Excavation	REVIEWED BY: JCS	COMPLETION DATE: 19/03/2015
INSPECTOR: SKB		Page 1 of 1

CLIENT: Town of Canmore	PROJECT: Cougar Creek Project - Stewart Creek Phase 3 Test Pit Program	TEST PIT NO: **TP15-7**
PROJECT NO: 14-264-0	UTM 11 NAD 83, Northing: 5656473.01 m, Easting: 618879.21 m	ELEVATION: 1358.58 m

SAMPLE TYPE: ▥ Grab Sample

BACKFILL TYPE:

Shear Strength (kPa)

▲ Cpen

50 100 150 200

PL W.C. (%) LL

10 20 30 40

DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	REMARKS	MUSCS / ISRM	SOIL SYMBOL	DESCRIPTION	ELEVATION (m)
0				ML		SILT, gravelly, sandy, trace clay, low plastic, reddish brown, dry, containing cobbles and boulders, subrounded to subangular, up to 500 mm	1358
1	▥	G-1 G-2		GM		GRAVEL, sandy, trace silt, trace clay, well graded, compact to dense, brown, dry, containing frequent cobbles and occasional boulders, subrounded to subangular - becoming moist, containing discontinuous seams of cleaner gravel to 1.7 m	1357
2						END OF HOLE at 2.0 m - dry upon completion - backfilled with excavated material	1356

DEPTH (m): 0 1 2 3 4 5 6 7 8 9 10

ELEVATION (m): 1358 1357 1356 1355 1354 1353 1352 1351 1350 1349

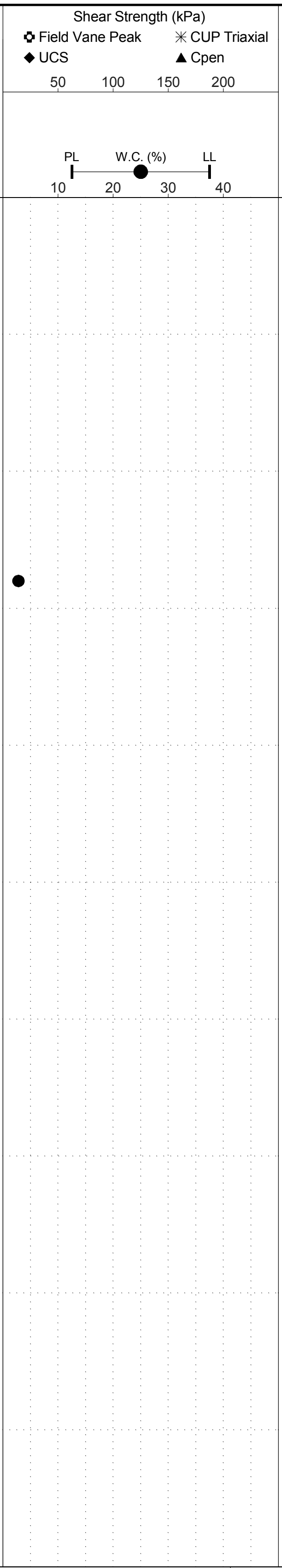
THURBER ENGINEERING LTD.

EXCAVATION CO.: Bremner Engineering and Construction Ltd.		
EXCAVATOR TYPE: John Deere 225C LC	COMPILED BY: SKB	COMPLETION DEPTH: 2.0 m
EXCAVATION METHOD: Excavation	REVIEWED BY: JCS	COMPLETION DATE: 19/03/2015
INSPECTOR: SKB		Page 1 of 1

CLIENT: Town of Canmore	PROJECT: Cougar Creek Project - Stewart Creek Phase 3 Test Pit Program	TEST PIT NO: **TP15-8**
PROJECT NO: 14-264-0	UTM 11 NAD 83, Northing: 5656400.13 m, Easting: 618900.28 m	ELEVATION: 1369.01 m

SAMPLE TYPE: ▥ Grab Sample

BACKFILL TYPE:



DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	REMARKS	MUSCS / ISRM	DESCRIPTION	ELEVATION (m)
0				TPS	TOPSOIL, silty, clayey, medium plastic, dark brown, damp, containing roots	
				SM	SAND, gravelly, some silt, trace clay, poorly graded, fine grained, loose, brown, dry, containing frequent cobbles and occasional boulders	
1				GM	GRAVEL, sandy, silty, trace clay, well graded, compact to dense, brown, dry, containing frequent cobbles and occasional boulders, subrounded to subangular, up to 600 mm - becoming dark brown	1368
2						1367
3	▥	G-1	Bulk sample taken from 2.8 m to 3.0 m Sieve Analysis Gravel = 34.2% Sand = 29.6% Silt & Clay= 36.2%			1366
4						1365
4.5					END OF HOLE at 4.5 m - dry upon completion - backfilled with excavated material	
5						1364
6						1363
7						1362
8						1361
9						1360
10						

THURBER ENGINEERING LTD.

EXCAVATION CO.: Bremner Engineering and Construction Ltd.		
EXCAVATOR TYPE: John Deere 225C LC	COMPILED BY: SKB	COMPLETION DEPTH: 4.5 m
EXCAVATION METHOD: Excavation	REVIEWED BY: JCS	COMPLETION DATE: 19/03/2015
INSPECTOR: SKB		Page 1 of 1

THURBER ENGINEERING LTD.
Suite 180, 7330 Fisher Street S.E., CALGARY, AB T2H 2H8 T. (403) 253-9217 F. (403) 252-8159 www.thurber.ca

ATTERBERG LIMITS REPORT

Client: Town of Canmore
Project: Cougar Creek Project - Stewart Creek Phase 3 Tes
Project No.: 14-264-0

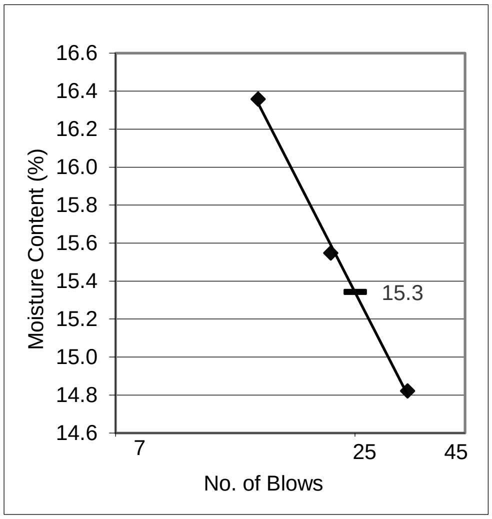
Date Tested: 31-Mar-15
Date Sampled: 18-Mar-15
Tested By: SKD

Sample Source:
Sample Location: TP15-2

Sample No.:
Depth: 3.0-4.5m

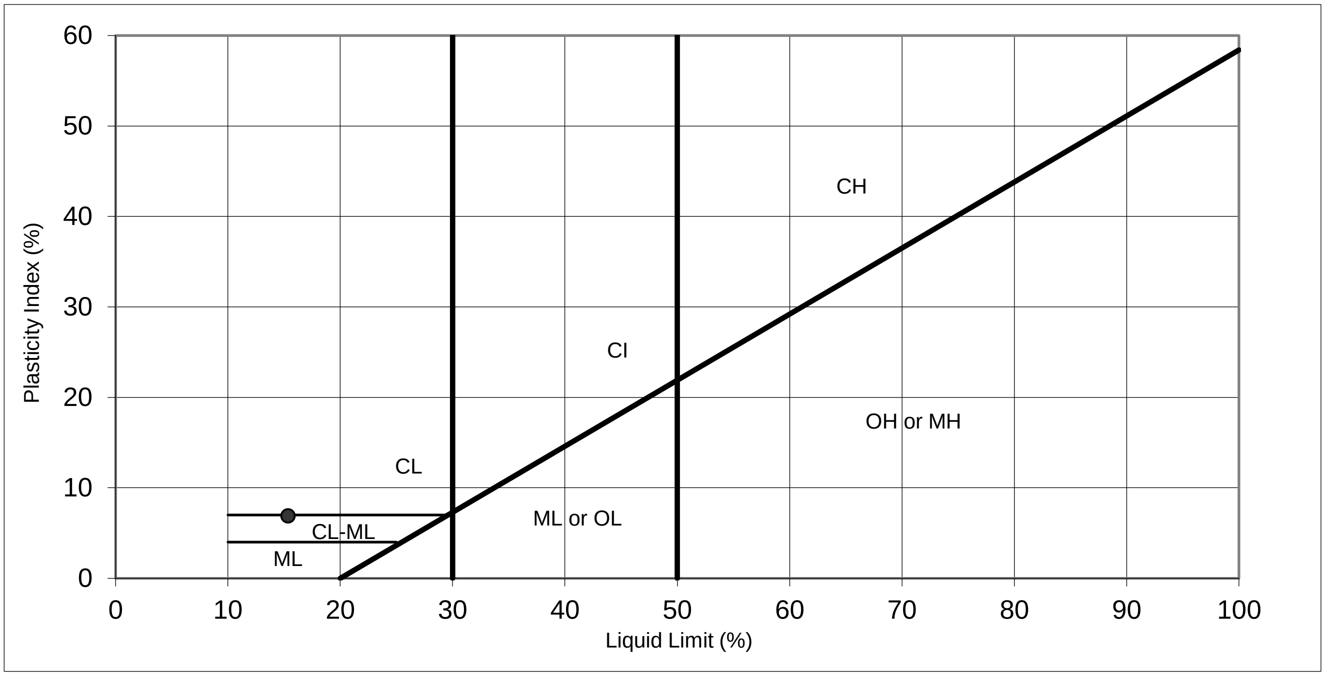
LIQUID LIMIT

Trial No.	1	2	3	4
No of Blows	33	22	15	
Container No.				
Wt. of Container - g	1.11	1.09	1.12	
Wet Soil + Container - g	38.76	33.64	35.12	
Dry Soil + Container - g	33.90	29.26	30.34	
Moisture Content (%)	14.8	15.5	16.4	



PLASTIC LIMIT

	1	2		AVERAGE
Container No.				
Wt. of Container - g	1.01	1.08		
Wet Soil + Container - g	6.06	6.23		
Dry Soil + Container - g	5.61	5.89		
Moisture Content (%)	9.8	7.1		**8.4**



Remarks:

Checked By: THK

Liquid Limit - %:	**15**
Plastic Limit - %:	**8**
Plasticity Index -%:	**7**
USC Classification:	**CL-ML**

Tested in accordance with ASTM Designation D4318 unless otherwise noted

THURBER ENGINEERING LTD.

Suite 180, 7330 Fisher Street S.E., CALGARY, AB T2H 2H8   T. (403) 253-9217   F. (403) 252-8159   www.thurber.ca

GRAIN SIZE DISTRIBUTION REPORT

Client: Town of Canmore

Date Tested: 30-Mar-15

Project: Cougar Creek Project - Stewart Creek Phase 3 Test Pitti

Date Sampled: 18-Mar-15

Project No.: 14-264-0

Sampled By: THK

Tested By: AMM

Sample Source:

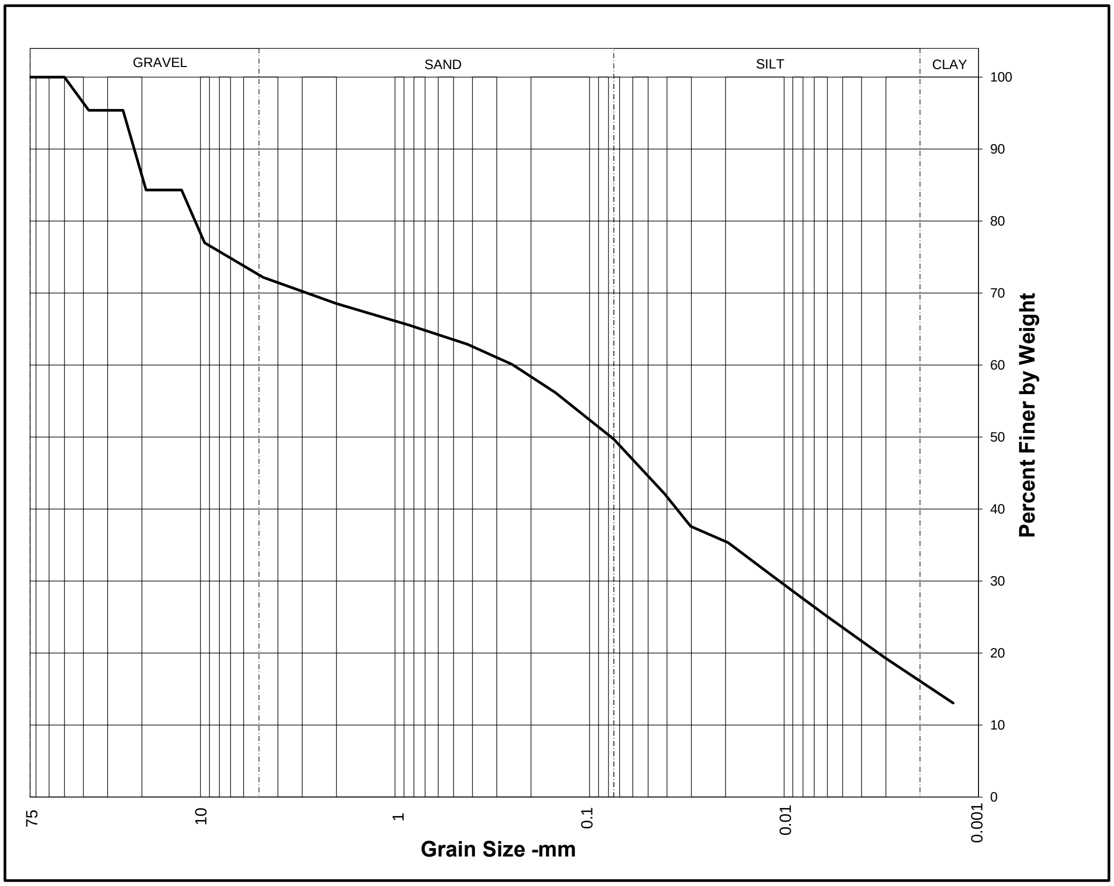
Sample No.:

Sample Location: TP15-2

Depth: 3.0-4.5m

Sample Description: GRAVEL, silty, sandy, some clay

Sieve Size -mm	Percent Finer
100.0	100.0
75.0	100.0
62.5	100.0
50.0	100.0
37.5	95.4
25.0	95.4
19.0	84.3
12.5	84.3
9.5	77.0
4.75	72.2
2.00	68.5
0.850	65.6
0.425	62.9
0.250	60.1
0.150	56.2
0.075	49.7
0.041	42.2
0.030	37.6
0.019	35.3
0.012	30.8
0.008	27.9
0.006	25.1
0.003	19.4
0.001	13.1



Distribution	
Cobbles	0.0%
Gravel	27.8%
Sand	22.5%
Silt	34.2%
Clay	15.5%

Coefficients	
D10	
D30	
D60	
Cu	
Cc	

Atterberg Limits	
LL	15 %
PL	8 %
PI	7 %

UCS
GC-GM

Remarks:

Checked By: THK

ATTERBERG LIMITS REPORT

THURBER ENGINEERING LTD.
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Client: Town of Canmore
Project: Cougar Creek Project - Stewart Creek Phase 3 Tes
Project No.: 14-264-0

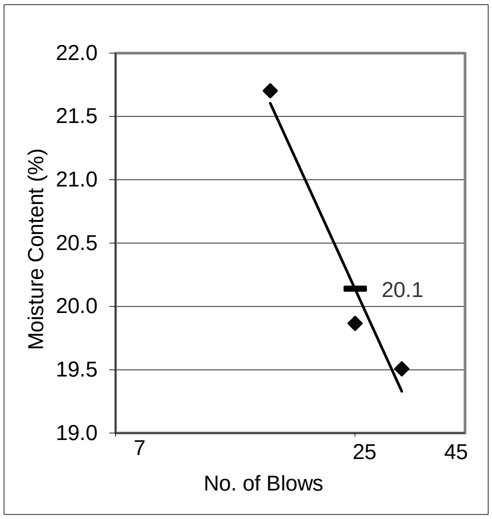
Date Tested: 31-Mar-15
Date Sampled: 18-Mar-15
Tested By: RMF

Sample Source:
Sample Location: TP15-3

Sample No.:
Depth: 1.5-3.0m

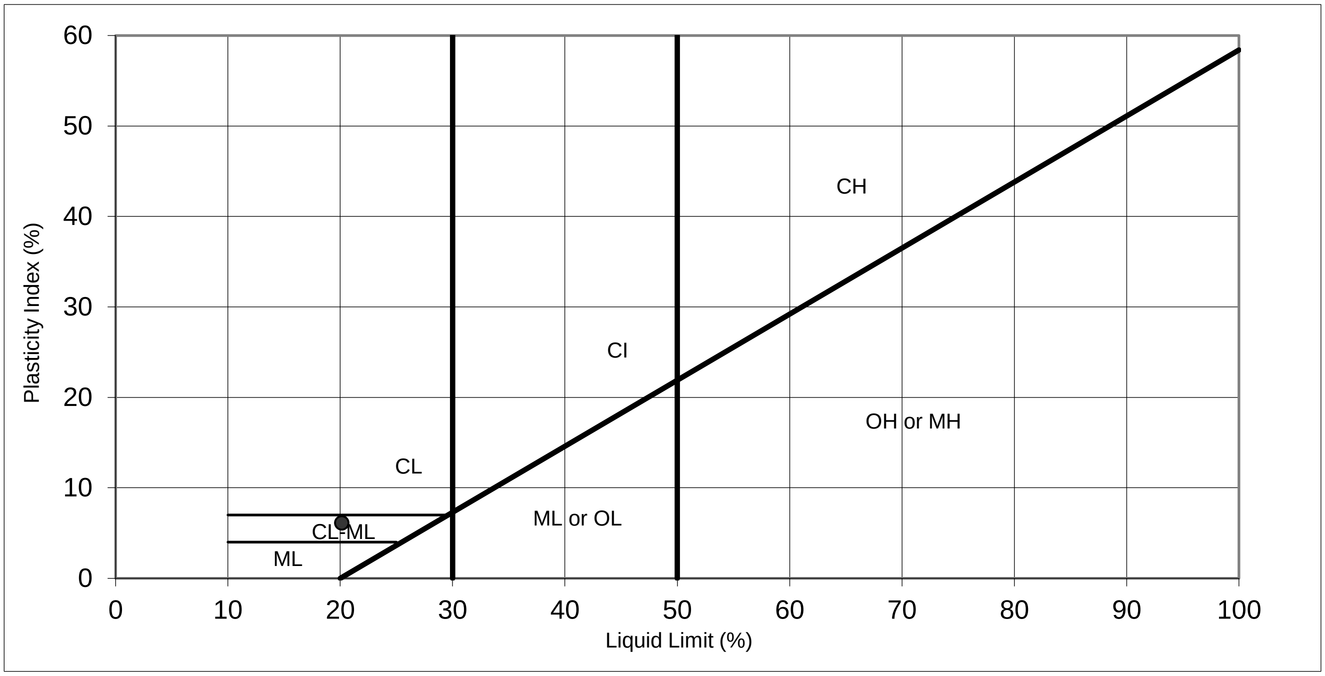
LIQUID LIMIT

Trial No.	1	2	3	4
No of Blows	32	25	16	
Container No.				
Wt. of Container - g	1.03	1.16	1.09	
Wet Soil + Container - g	25.23	27.83	29.69	
Dry Soil + Container - g	21.28	23.41	24.59	
Moisture Content (%)	19.5	19.9	21.7	



PLASTIC LIMIT

		1	2		**AVERAGE**
Container No.					
Wt. of Container - g		1.05	1.07		
Wet Soil + Container - g		7.54	7.51		
Dry Soil + Container - g		6.74	6.72		
Moisture Content (%)		14.1	14.0		**14.0**



Remarks:

Checked By: THK

Liquid Limit - %:	**20**
Plastic Limit - %:	**14**
Plasticity Index -%:	**6**
USC Classification:	**CL-ML**

Tested in accordance with ASTM Designation D4318 unless otherwise noted

THURBER ENGINEERING LTD.

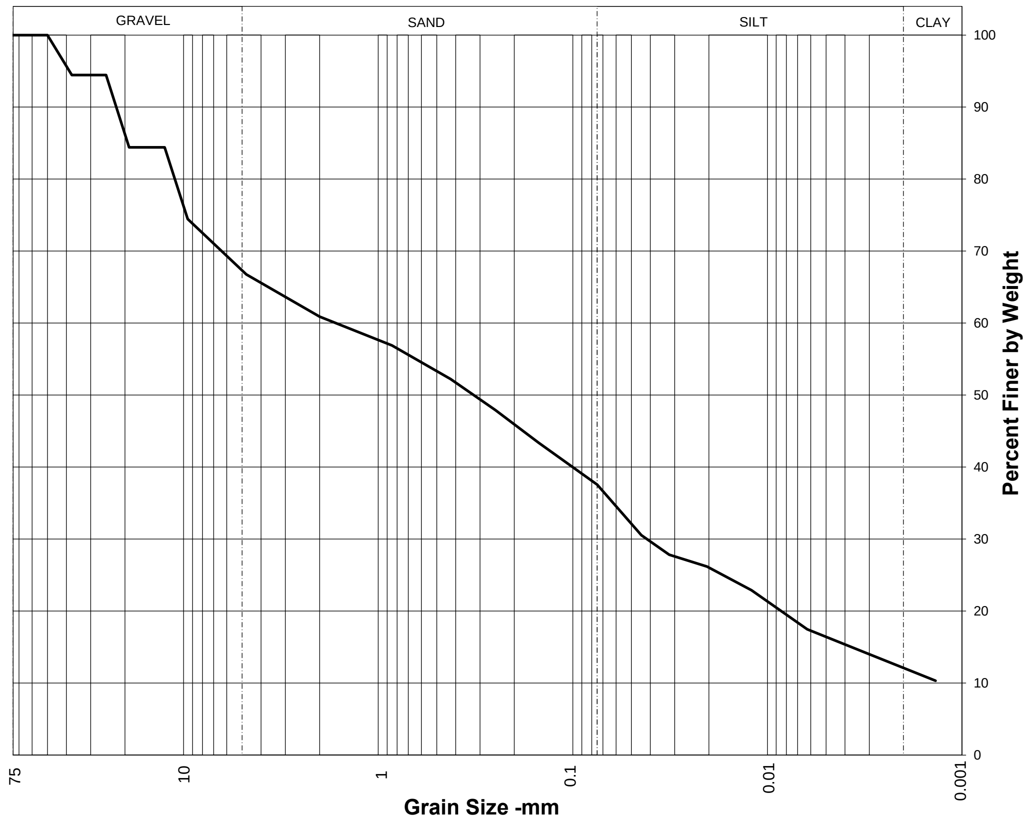
Suite 180, 7330 Fisher Street S.E., CALGARY, AB T2H 2H8   T. (403) 253-9217   F. (403) 252-8159   www.thurber.ca

GRAIN SIZE DISTRIBUTION REPORT

Client: Town of Canmore
Date Tested: 30-Mar-15
Project: Cougar Creek Project - Stewart Creek Phase 3 Test Pitti
Date Sampled: 18-Mar-15
Project No.: 14-264-0
Sampled By: THK
Tested By: KNL/AMM

Sample Source:
Sample No.:
Sample Location: TP15-3
Depth: 1.5-3.0m
Sample Description: GRAVEL, sandy, silty, some clay

Sieve Size -mm	Percent Finer
100.0	100.0
75.0	100.0
62.5	100.0
50.0	100.0
37.5	94.5
25.0	94.5
19.0	84.4
12.5	84.4
9.5	74.5
4.75	66.8
2.00	60.9
0.850	56.9
0.425	52.2
0.250	47.9
0.150	43.4
0.075	37.6
0.044	30.5
0.032	27.8
0.020	26.2
0.012	22.9
0.009	20.2
0.006	17.5
0.003	14.2
0.001	10.3



Distribution	
Cobbles	0.0%
Gravel	33.2%
Sand	29.2%
Silt	25.8%
Clay	11.7%

Coefficients	
D10	
D30	
D60	
Cu	
Cc	

Atterberg Limits	
LL	20 %
PL	14 %
PI	6 %

UCS
GC-GM

Remarks:

Checked By: THK

ATTERBERG LIMITS REPORT

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Client: Town of Canmore
Project: Cougar Creek Project - Stewart Creek Phase 3 Tes
Project No.: 14-264-0

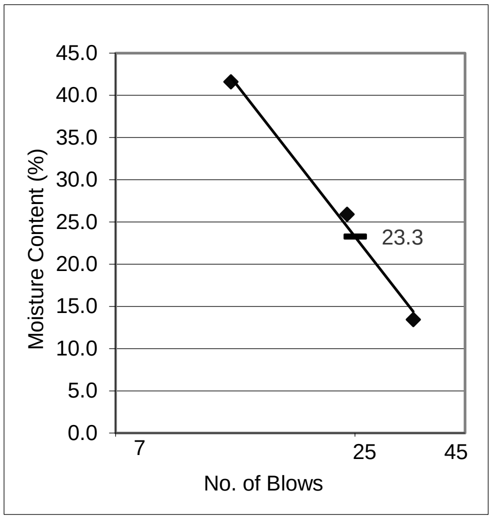
Date Tested: 01-Apr-15
Date Sampled: 18-Mar-15
Tested By: RL

Sample Source:
Sample Location: TP15-4

Sample No.:
Depth: 3.2-3.8m

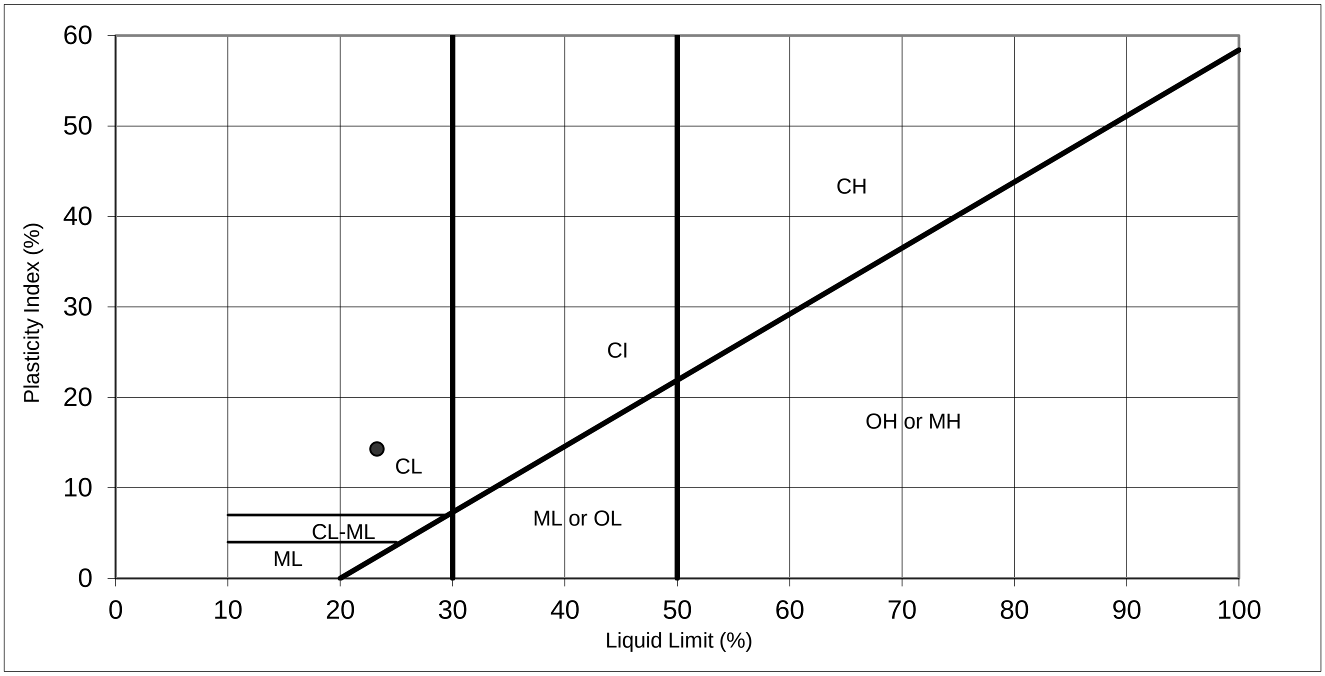
LIQUID LIMIT

Trial No.	1	2	3	4
No of Blows	34	24	13	
Container No.				
Wt. of Container - g	1.23	1.08	1.13	
Wet Soil + Container - g	25.37	27.89	25.84	
Dry Soil + Container - g	22.51	22.37	18.58	
Moisture Content (%)	13.4	25.9	41.6	



PLASTIC LIMIT

	1	2		**AVERAGE**
Container No.				
Wt. of Container - g	1.10	1.03		
Wet Soil + Container - g	7.45	6.84		
Dry Soil + Container - g	6.93	6.36		
Moisture Content (%)	8.9	9.0		**9.0**



Remarks:

Checked By: THK

Liquid Limit - %:	**23**
Plastic Limit - %:	**9**
Plasticity Index -%:	**14**
USC Classification:	**CL**

Tested in accordance with ASTM Designation D4318 unless otherwise noted

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GRAIN SIZE DISTRIBUTION REPORT

Client: Town of Canmore

Date Tested: 31-Mar-15

Project: Cougar Creek Project - Stewart Creek Phase 3 Test Pitti

Date Sampled: 18-Mar-15

Project No.: 14-264-0

Sampled By: THK

Tested By: KNL/AMM

Sample Source:

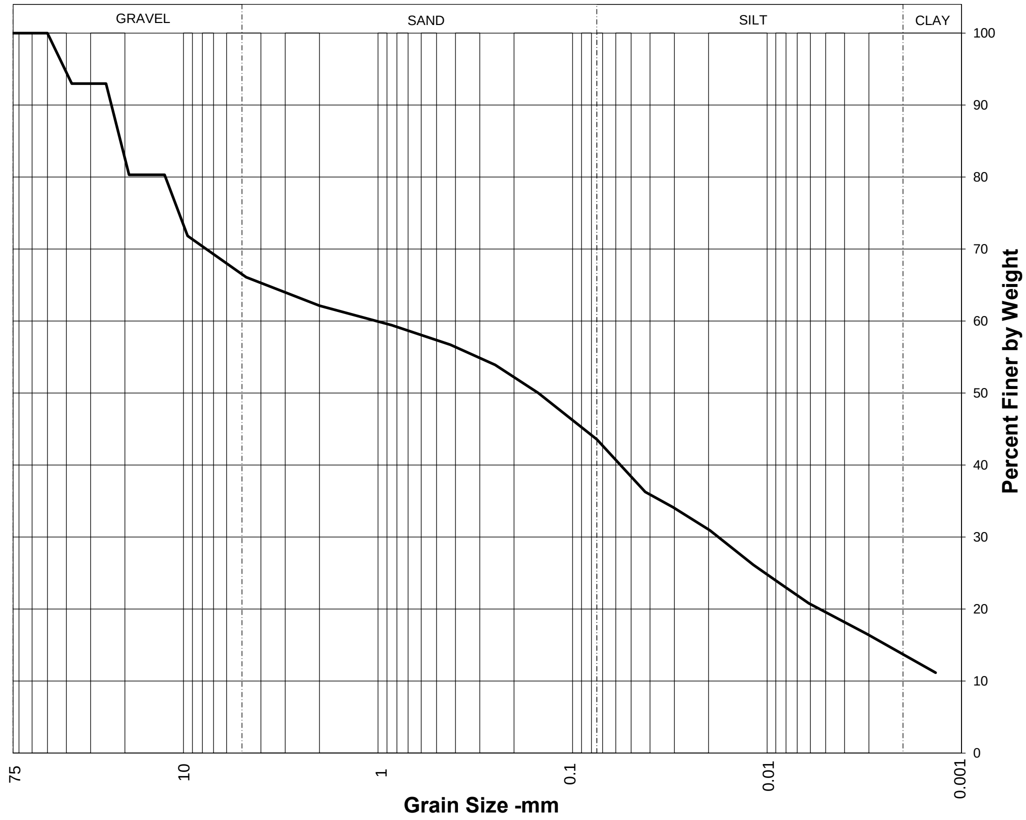
Sample No.:

Sample Location: TP15-4

Depth: 3.2-3.8m

Sample Description: GRAVEL, sandy, silty, some clay

Sieve Size -mm	Percent Finer
100.0	100.0
75.0	100.0
62.5	100.0
50.0	100.0
37.5	93.0
25.0	93.0
19.0	80.3
12.5	80.3
9.5	71.8
4.75	66.1
2.00	62.1
0.850	59.5
0.425	56.7
0.250	53.9
0.150	50.0
0.075	43.6
0.042	36.3
0.030	34.2
0.020	31.0
0.012	26.2
0.008	23.5
0.006	20.8
0.003	16.6
0.001	11.2



Distribution	
Cobbles	0.0%
Gravel	33.9%
Sand	22.5%
Silt	30.4%
Clay	13.2%

Coefficients
D10
D30
D60
Cu
Cc

Atterberg Limits	
LL	23 %
PL	9 %
PI	14 %

UCS
GC

Remarks:

Checked By: THK

THURBER ENGINEERING LTD.

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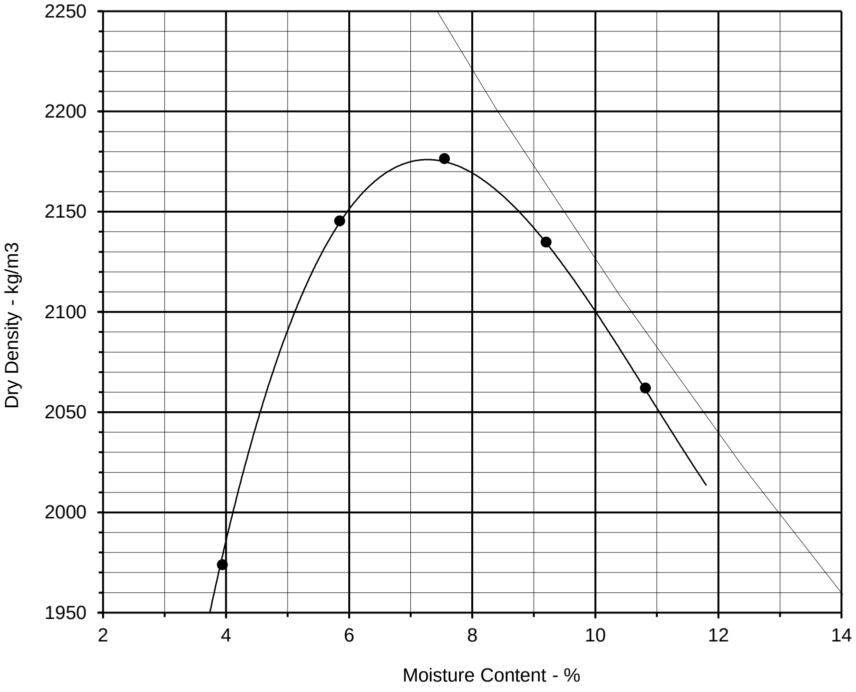
MOISTURE - DENSITY RELATIONSHIP (PROCTOR) REPORT

Client: Town of Canmore
Date Tested: 31-Mar-15
Project: Cougar Creek Project - Stewart Creek Phase 3 Test Pitting
Date Sampled: 18-Mar-15
Project No.: 14-264-0
Sampled By: THK
Tested By: HAS

Sample Source: N/A
Sample No.:
Sample Location: TP15-2
Depth: 3.0-4.5m
Sample Description: GRAVEL, sandy, silty, some clay
Oversized Material: 16.1% retained on the 4.75 mm sieve
As-Rec'd Moisture: 4.8%

Wet Density - kg/m3	2052	2271	2341	2331	2285		
Dry Density - kg/m3	1974	2145	2176	2135	2062		
Moisture - %	3.9	5.8	7.5	9.2	10.8		
Pocket Pen. (kg/cm²)	4.5+	4.50	3.50	1.00	0.00		



Maximum Dry Density: 2177 kg/m³
Optimum Moisture: 7.3%

Corrected Maximum Dry Density: **2242 kg/m³**
Corrected Optimum Moisture: **6.1%**

Note: Rock Corrected for 16.1% on the 4.75 mm sieve

Specific Gravity of Oversize: 2.65
Preparation: Dry
Compaction Std.: ASTM D698
Test Method: A
Rammer Type: Manual

Sampled By: THK
Project Eng.: MPS

Zero Air Voids Curve plotted for a Specific Gravity of 2.70

Remarks:

Rock Corrections:

5	%	R.C.	2197	kg/m³ at	6.9%
10	%	R.C.	2217	kg/m³ at	6.6%
20	%	R.C.	2258	kg/m³ at	5.8%
30	%	R.C.	2300	kg/m³ at	5.1%

Report Checked By: THK

Tested in accordance with ASTM Designation D698 or D1557 unless otherwise noted

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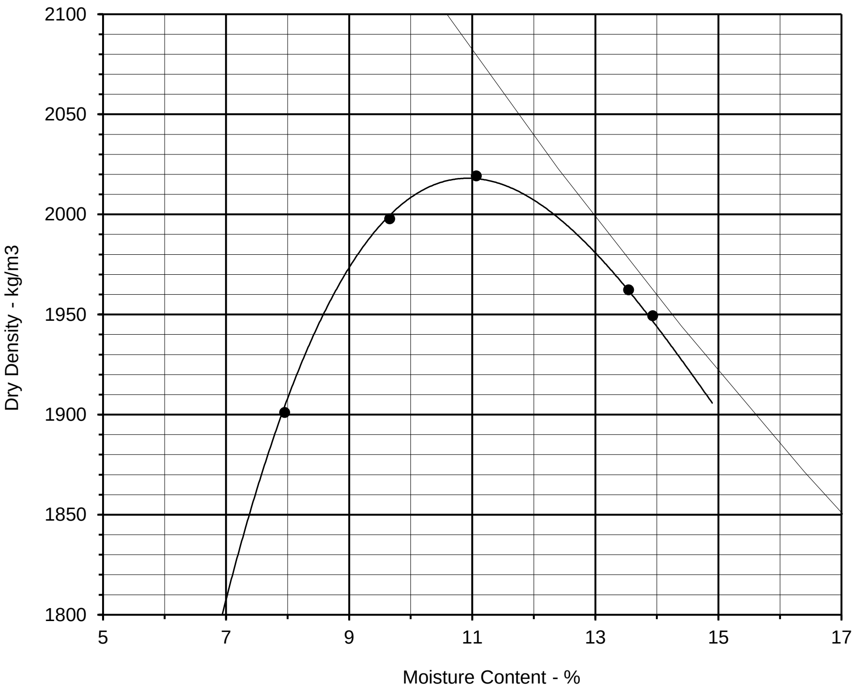
MOISTURE - DENSITY RELATIONSHIP (PROCTOR) REPORT

Client: Town of Canmore
Date Tested: 01-Apr-15
Project: Cougar Creek Project - Stewart Creek Phase 3 Test Pitting
Date Sampled: 18-Mar-15
Project No.: 14-264-0
Sampled By: THK
Tested By: RL

Sample Source: N/A
Sample No.:
Sample Location: TP15-3
Depth: 1.5-3.0m
Sample Description: GRAVEL, sandy, silty, some clay
Oversized Material: 14.6% retained on the 4.75 mm sieve
As-Rec'd Moisture: 6.8%

Wet Density - kg/m3	2052	2191	2243	2228	2221		
Dry Density - kg/m3	1901	1998	2019	1962	1949		
Moisture - %	8.0	9.7	11.1	13.5	13.9		
Pocket Pen. (kg/cm²)							



Maximum Dry Density: 2019 kg/m³
Optimum Moisture: 11.0%

Corrected Maximum Dry Density: **2092 kg/m³**
Corrected Optimum Moisture: **9.4%**

Note: Rock Corrected for 14.6% on the 4.75 mm sieve

Specific Gravity of Oversize: 2.65
Preparation: Dry
Compaction Std.: ASTM D698
Test Method: A
Rammer Type: Manual

Sampled By: THK
Project Eng.: MPS

Zero Air Voids Curve plotted for a Specific Gravity of 2.70

Remarks:

Rock Corrections:

5 %	R.C.	2043	kg/m³ at	10.5%
10 %	R.C.	2068	kg/m³ at	9.9%
20 %	R.C.	2120	kg/m³ at	8.8%
30 %	R.C.	2174	kg/m³ at	7.7%

Report Checked By: THK

Tested in accordance with ASTM Designation D698 or D1557 unless otherwise noted

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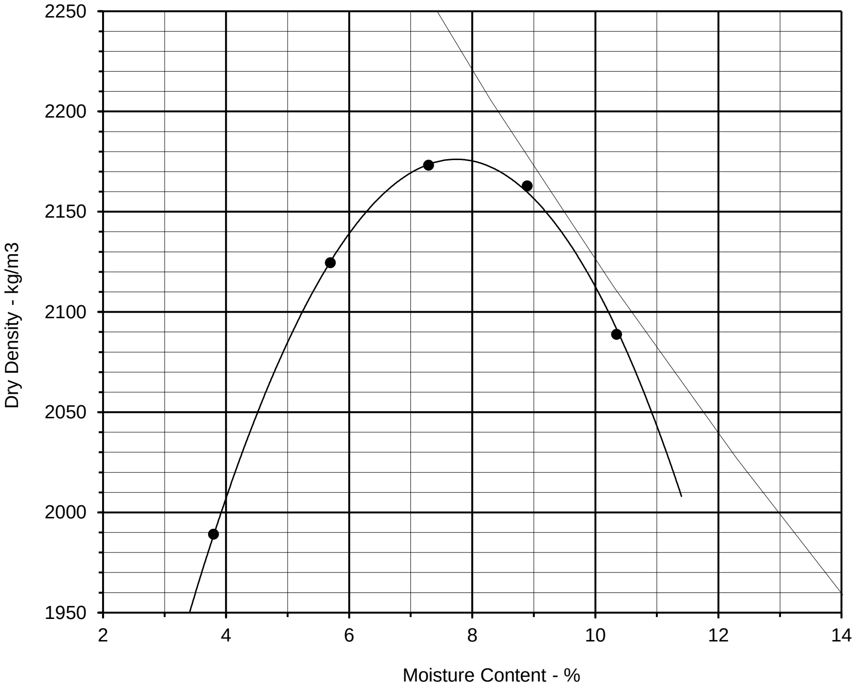
MOISTURE - DENSITY RELATIONSHIP (PROCTOR) REPORT

Client: Town of Canmore
Date Tested: 31-Mar-15
Project: Cougar Creek Project - Stewart Creek Phase 3 Test Pitting
Date Sampled: 18-Mar-15
Project No.: 14-264-0
Sampled By: THK
Tested By: AMM

Sample Source: N/A
Sample No.:
Sample Location: TP15-4
Depth: 3.2-3.8m
Sample Description: GRAVEL, sandy, silty, some clay
Oversized Material: 19.2% retained on the 4.75 mm sieve
As-Rec'd Moisture: 4.9%

Wet Density - kg/m3	2065	2245	2332	2355	2305		
Dry Density - kg/m3	1989	2125	2173	2163	2089		
Moisture - %	3.8	5.7	7.3	8.9	10.3		
Pocket Pen. (kg/cm²)							



Maximum Dry Density: 2178 kg/m³
Optimum Moisture: 6.8%

Corrected Maximum Dry Density: **2255 kg/m³**
Corrected Optimum Moisture: **5.5%**
Note: Rock Corrected for
19.2% on the 4.75 mm sieve

Specific Gravity of Oversize: 2.65
Preparation: Dry
Compaction Std.: ASTM D698
Test Method: A
Rammer Type: Manual

Sampled By: THK
Project Eng.: MPS

Zero Air Voids Curve plotted for a Specific Gravity of 2.70

Remarks:

Rock Corrections:

5	%	R.C.	2198	kg/m³ at	6.5%
10	%	R.C.	2217	kg/m³ at	6.1%
20	%	R.C.	2258	kg/m³ at	5.4%
30	%	R.C.	2301	kg/m³ at	4.8%

Report Checked By: THK

Tested in accordance with ASTM Designation D698 or D1557 unless otherwise noted

GRAIN SIZE DISTRIBUTION REPORT

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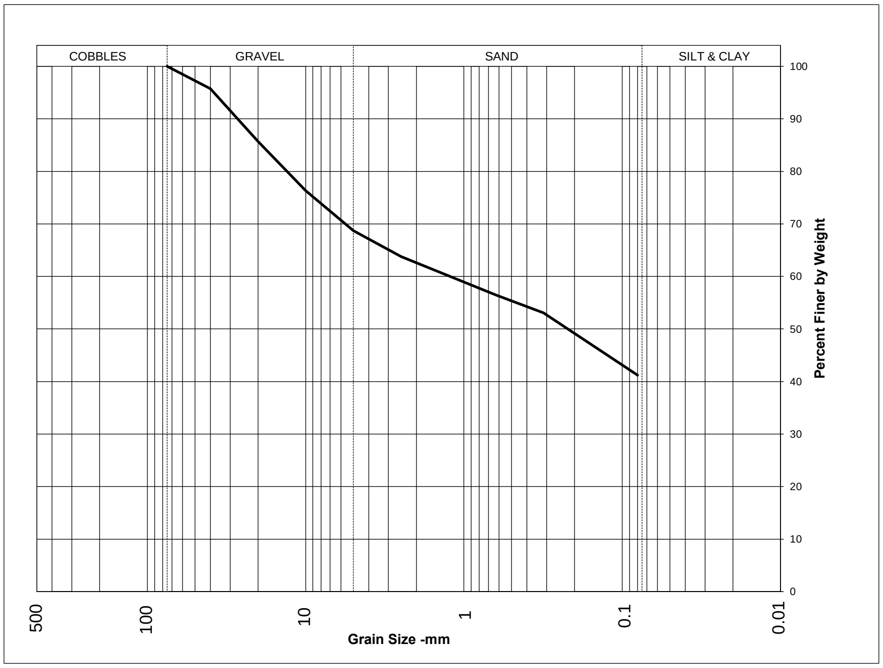
Client:	Town of Canmore	Date Tested:	31-Mar-15
Project:	Cougar Creek Project - Stewart Creek Phase 3 Test Pitting	Date Sampled:	18-Mar-15
Project No.:	14-264-0 Sampled By: THK	Tested By:	KNL

Sample Source:		Sample No.:	
Sample Location:	TP15-5	Depth:	3.3-3.5m
Sample Description:	GRAVEL, sandy, sily, trace clay		

Sieve Size -mm	Percent Finer	Spec. Limits *		Pass ?
		Min	Max	(X=No)
75.0	100			
40.0	96			
20.0	86			
10.0	76			
5.0	69			
2.5	64			
0.630	56			
0.315	53			
0.080	41.2			



*

Distribution		
Cobbles		%
Gravel	31.3	%
Sand	27.5	%
Silt & Clay	41.2	%

Coefficients
D10
D30
D60
Cu
Cc

Atterberg Limits	
LL	%
PL	%
PI	%

UCS

Remarks: Visual Classification: GM

Checked By: THK

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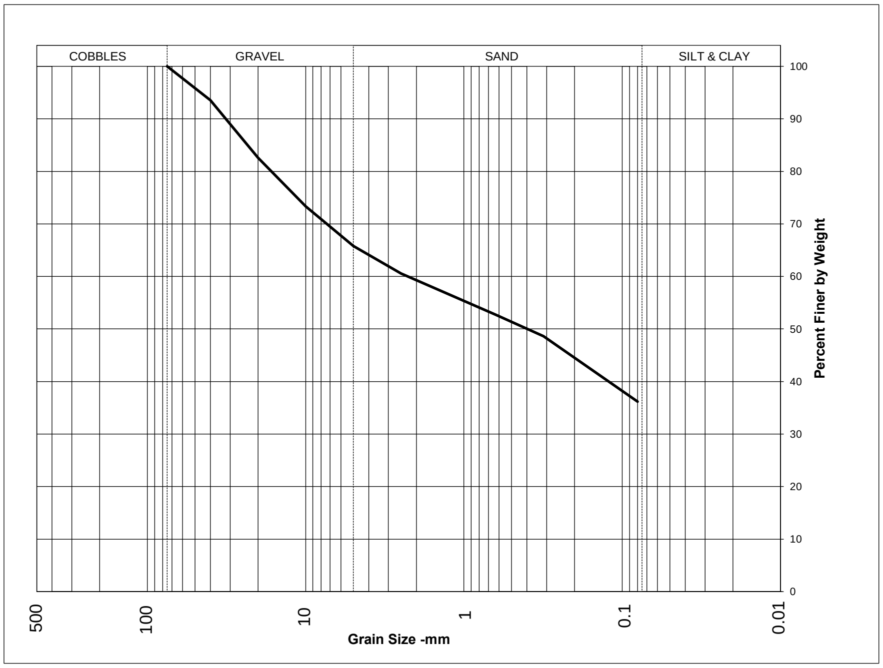
GRAIN SIZE DISTRIBUTION REPORT

Client: Town of Canmore
Date Tested: 31-Mar-15
Project: Cougar Creek Project - Stewart Creek Phase 3 Test Pitting
Date Sampled: 18-Mar-15
Project No.: 14-264-0
Sampled By: THK
Tested By: KNL

Sample Source:
Sample No.:
Sample Location: TP15-8
Depth: 2.8-3.0m
Sample Description: GRAVEL, sandy, silty, trace clay

Sieve Size -mm	Percent Finer	Spec. Limits *		Pass ?
		Min	Max	(X=No)
75.0	100			
40.0	94			
20.0	83			
10.0	73			
5.0	66			
2.5	61			
0.630	53			
0.315	49			
0.080	36.2			



*

Distribution		
Cobbles		%
Gravel	34.2	%
Sand	29.6	%
Silt & Clay	36.2	%

Coefficients
D10
D30
D60
Cu
Cc

Atterberg Limits	
LL	%
PL	%
PI	%

UCS

Remarks: Visual Classification: GM

Checked By: THK

Appendix 113-2

Stewart Creek Phase 3 Test Pit Program, Chemical Analysis

Exova
Bay #5, 2712-37 Avenue N.E.
Calgary, Alberta
T1Y-5L3, Canada

T: +1 (403) 291-2022
F: +1 (403) 291-2021
E: Calgary@exova.com
W: www.exova.com

Report Transmission Cover Page

Bill To: Town of Canmore
Report To: Town of Canmore
902 7 Ave
Canmore, AB, Canada
T1W 3K1
Attn: Felix Camire
Sampled By: FC/CM
Company: Town of Canmore

Project:
ID: 1445
Name: Cougar Creek
Location: Stewart Creek
LSD:
P.O.:
Acct code:

Lot ID: **1188187**
Control Number: C0055246
Date Received: Feb 24, 2017
Date Reported: Mar 3, 2017
Report Number: 2170867

Contact & Affiliation	Address	Delivery Commitments
Accounts Payable Town of Canmore	902 7 Ave Canmore, Alberta T1W 3K1 Phone: (403) 678-1507 Fax: (403) 678-1524 Email: payables@canmore.ca	On [Lot Approval and Final Test Report Approval] send (Invoice) by Email - Single Report
Felix Camire Town of Canmore	902 7 Ave Canmore, Alberta T1W 3K1 Phone: (403) 678-1512 Fax: (403) 678-1524 Email: fcamire@canmore.ca	On [Lot Verification] send (COA, COC) by Email - Single Report On [Report Approval] send (Test Report, COC) by Email - Merge Reports On [Lot Approval and Final Test Report Approval] send (Invoice) by Email - Single Report
T Riva Town of Canmore	902 7 Ave Canmore, Alberta T1W 3K1 Phone: (403) 678-1512 Fax: (403) 678-1524 Email: triva@canmore.ca	On [Report Approval] send (Test Report, COC) by Email - Merge Reports

Notes To Clients:

- Weed Seed analysis was performed on samples 1 & 2 by a subcontract laboratory. See attached reports 1022552-01 & 1022553-01, respectively.

Exova
Bay #5, 2712-37 Avenue N.E.
Calgary, Alberta
T1Y-5L3, Canada

T: +1 (403) 291-2022
F: +1 (403) 291-2021
E: Calgary@exova.com
W: www.exova.com

Analytical Report

Bill To: Town of Canmore
Report To: Town of Canmore
902 7 Ave
Canmore, AB, Canada
T1W 3K1
Attn: Felix Camire
Sampled By: FC/CM
Company: Town of Canmore

Project:
ID: 1445
Name: Cougar Creek
Location: Stewart Creek
LSD:
P.O.:
Acct code:

Lot ID: **1188187**
Control Number: C0055246
Date Received: Feb 24, 2017
Date Reported: Mar 3, 2017
Report Number: 2170867

Reference Number	1188187-1	1188187-2
Sample Date	Feb 17, 2017	Feb 17, 2017
Sample Time	15:00	15:15
Sample Location		
Sample Description	West / Open Field / 20-30 / 3.4C / cm	East / Open Field / 20-30 / 3.4C / cm
Matrix	Soil	Soil

Analyte		**Units**	**Results**	**Results**	**Results**	Nominal Detection Limit
Aggregate Organic Constituents						
Organic Matter	LOI	% by weight	<0.1	3.7		0.1
Available Nutrients						
Nitrate - N	Available	ug/g	<10	<10		2
Phosphorus	Available	ug/g	<20	<20		5
Potassium	Available	ug/g	<120	<120		25
Sulfate-S	Available	mg/kg	10	20		1
Ammonium - N	Available-dry basis	ug/g	<0.3	0.5		0.3
Nitrate - N	Farmsoil	ppm	<10	<10		2
Phosphorus	Farmsoil	ppm	<20	<20		5
Potassium	Farmsoil	ppm	<120	<120		25
Sulfate-S	Farmsoil	ppm	<10	20		1
Copper	FS Micro-nutrients	ppm	1.1	1.1		0.1
Iron	FS Micro-nutrients	ppm	21.6	21.3		2
Manganese	FS Micro-nutrients	ppm	8.0	4.5		0.1
Zinc	FS Micro-nutrients	ppm	<5	<5		0.5
Base saturation	FS Base Saturation	%	100	100		
Calcium	FS Base Saturation	%	97.1	96.1		
Magnesium	FS Base Saturation	%	2.9	3.9		
Sodium	FS Base Saturation	%	<0.9	<0.8		
Potassium	FS Base Saturation	%	0.0	0.0		
TEC	FS Base Saturation	meq/100 g	75.6	86.5		
Calcium	FS Macro-nutrients	ppm	14700	16700		30
Magnesium	FS Macro-nutrients	ppm	270	410		5
Sodium	FS Macro-nutrients	ppm	<150	<150		30
Boron	FS Micro-nutrients	ppm	<1.0	<1.0		0.1
Hot Water Soluble						
Boron	FS Micro-nutrients	ppm	<1.0	<1.0		0.1
Metals Strong Acid Digestion						
Arsenic	Strong Acid Extractable	mg/kg	2.4	3.0		0.2
Barium	Strong Acid Extractable	mg/kg	49	102		1
Beryllium	Strong Acid Extractable	mg/kg	0.2	0.1		0.1
Cadmium	Strong Acid Extractable	mg/kg	0.28	0.50		0.01
Chromium	Strong Acid Extractable	mg/kg	14.9	14.4		0.5
Cobalt	Strong Acid Extractable	mg/kg	2.0	2.4		0.1
Copper	Strong Acid Extractable	mg/kg	4.8	9.4		1

Analytical Report

Bill To: Town of Canmore
Report To: Town of Canmore
902 7 Ave
Canmore, AB, Canada
T1W 3K1
Attn: Felix Camire
Sampled By: FC/CM
Company: Town of Canmore

Project:
ID: 1445
Name: Cougar Creek
Location: Stewart Creek
LSD:
P.O.:
Acct code:

Lot ID: **1188187**
Control Number: C0055246
Date Received: Feb 24, 2017
Date Reported: Mar 3, 2017
Report Number: 2170867

Reference Number	1188187-1	1188187-2
Sample Date	Feb 17, 2017	Feb 17, 2017
Sample Time	15:00	15:15
Sample Location		
Sample Description	West / Open Field / 20-30 / 3.4C / cm	East / Open Field / 20-30 / 3.4C / cm
Matrix	Soil	Soil

Analyte		**Units**	**Results**	**Results**	**Results**	Nominal Detection Limit
Metals Strong Acid Digestion - Continued						
Lead	Strong Acid Extractable	mg/kg	3.1	2.7		0.1
Molybdenum	Strong Acid Extractable	mg/kg	<1.0	<1.0		1
Nickel	Strong Acid Extractable	mg/kg	13.8	14.3		0.5
Selenium	Strong Acid Extractable	mg/kg	<0.3	0.4		0.3
Thallium	Strong Acid Extractable	mg/kg	0.07	0.06		0.05
Vanadium	Strong Acid Extractable	mg/kg	10.0	13.8		0.1
Zinc	Strong Acid Extractable	mg/kg	31	29		1
Physical and Aggregate Properties						
Texture			Loam	Loam		
Sand	50 µm - 2 mm	% by weight	43.3	36.7		0.1
Silt	2 µm - 50 µm	% by weight	33.3	37.7		0.1
Clay	<2 µm	% by weight	23.3	25.7		0.1
Salinity						
pH	Saturated Paste	pH	8.1	7.8		
Electrical Conductivity	Saturated Paste	dS/m	0.32	0.53		0.01
SAR	Saturated Paste		0.2	0.1		
% Saturation		%	49	67		
Calcium	Saturated Paste	meq/L	2.20	4.86		0.01
Calcium	Saturated Paste	mg/kg	21.6	65.5		
Magnesium	Saturated Paste	meq/L	1.29	1.40		0.02
Magnesium	Saturated Paste	mg/kg	7.7	11.4		
Sodium	Saturated Paste	meq/L	0.28	0.22		0.04
Sodium	Saturated Paste	mg/kg	3	3		
Potassium	Saturated Paste	meq/L	0.06	0.07		0.03
Potassium	Saturated Paste	mg/kg	1	2		
TGR	Saturated Paste	T/ac	<0.1	<0.1		
Soil Acidity						
pH	1:2 Soil:Water	pH	8.6	8.5		
Electrical Conductivity	Sat. Paste equiv based on 1:2	dS/m at 25 C	0.29	0.52		0.02
Water Soluble Parameters						
Chloride	Available	mg/kg	3	4		0.5
Lime Requirement						
pH	SMP	pH	Not Required	Not Required		
Lime		T/ac	0	0		

Analytical Report

Bill To: Town of Canmore
Report To: Town of Canmore
902 7 Ave
Canmore, AB, Canada
T1W 3K1
Attn: Felix Camire
Sampled By: FC/CM
Company: Town of Canmore

Project:
ID: 1445
Name: Cougar Creek
Location: Stewart Creek
LSD:
P.O.:
Acct code:

Lot ID: **1188187**
Control Number: C0055246
Date Received: Feb 24, 2017
Date Reported: Mar 3, 2017
Report Number: 2170867

		Reference Number	1188187-1	1188187-2		
		Sample Date	Feb 17, 2017	Feb 17, 2017		
		Sample Time	15:00	15:15		
		Sample Location				
		Sample Description	West / Open Field / 20-30 / 3.4C / cm	East / Open Field / 20-30 / 3.4C / cm		
		Matrix	Soil	Soil		
Analyte		**Units**	**Results**	**Results**	**Results**	Nominal Detection Limit
VOC Screen - Soil						
Acetone	Dry Weight	mg/kg	<0.25	<0.25		0.25
Acetonitrile	Dry Weight	mg/kg	<0.25	<0.25		0.25
Acrylonitrile	Dry Weight	mg/kg	<0.25	<0.25		0.25
Allyl Chloride	Dry Weight	mg/kg	<0.25	<0.25		0.25
Benzene	Dry Weight	mg/kg	<0.01	<0.01		0.01
Bromobenzene	Dry Weight	mg/kg	<0.01	<0.01		0.01
Bromochloromethane	Dry Weight	mg/kg	<0.01	<0.01		0.01
Bromodichloromethane	Dry Weight	mg/kg	<0.01	<0.01		0.01
Bromoform	Dry Weight	mg/kg	<0.01	<0.01		0.01
Bromomethane	Dry Weight	mg/kg	<0.1	<0.1		0.10
2-Butanone (MEK)	Dry Weight	mg/kg	<0.25	<0.25		0.25
n-Butylbenzene	Dry Weight	mg/kg	<0.01	<0.01		0.01
sec-Butylbenzene	Dry Weight	mg/kg	<0.01	<0.01		0.01
tert-Butylbenzene	Dry Weight	mg/kg	<0.01	<0.01		0.01
Carbon Tetrachloride	Dry Weight	mg/kg	<0.01	<0.01		0.01
Chlorobenzene	Dry Weight	mg/kg	<0.01	<0.01		0.01
Chloroethane	Dry Weight	mg/kg	<0.1	<0.1		0.10
2-Chloroethyl Vinyl Ether	Dry Weight	mg/kg	<0.01	<0.01		0.01
Chloroform	Dry Weight	mg/kg	<0.01	<0.01		0.01
Chloromethane	Dry Weight	mg/kg	<0.1	<0.1		0.10
2-Chlorotoluene	Dry Weight	mg/kg	<0.01	<0.01		0.01
4-Chlorotoluene	Dry Weight	mg/kg	<0.01	<0.01		0.01
Dibromochloromethane	Dry Weight	mg/kg	<0.01	<0.01		0.01
1,2-Dibromo-3-Chloropropane	Dry Weight	mg/kg	<0.01	<0.01		0.01
1,2-Dibromoethane	Dry Weight	mg/kg	<0.01	<0.01		0.01
Dibromomethane	Dry Weight	mg/kg	<0.01	<0.01		0.01
1,4-Dichloro-2-Butene(cis)	Dry Weight	mg/kg	<0.25	<0.25		0.25
1,4-Dichloro-2-Butene(trans)	Dry Weight	mg/kg	<0.25	<0.25		0.25
1,2-Dichlorobenzene	Dry Weight	mg/kg	<0.01	<0.01		0.01
1,3-Dichlorobenzene	Dry Weight	mg/kg	<0.01	<0.01		0.01
1,4-Dichlorobenzene	Dry Weight	mg/kg	<0.01	<0.01		0.01
1,1-Dichloroethane	Dry Weight	mg/kg	<0.01	<0.01		0.01
1,2-Dichloroethane	Dry Weight	mg/kg	<0.01	<0.01		0.01
1,1-Dichloroethene	Dry Weight	mg/kg	<0.01	<0.01		0.01

Analytical Report

Bill To: Town of Canmore
Report To: Town of Canmore
902 7 Ave
Canmore, AB, Canada
T1W 3K1
Attn: Felix Camire
Sampled By: FC/CM
Company: Town of Canmore

Project:
ID: 1445
Name: Cougar Creek
Location: Stewart Creek
LSD:
P.O.:
Acct code:

Lot ID: **1188187**
Control Number: C0055246
Date Received: Feb 24, 2017
Date Reported: Mar 3, 2017
Report Number: 2170867

Reference Number	1188187-1	1188187-2
Sample Date	Feb 17, 2017	Feb 17, 2017
Sample Time	15:00	15:15
Sample Location		
Sample Description	West / Open Field / 20-30 / 3.4C / cm	East / Open Field / 20-30 / 3.4C / cm
Matrix	Soil	Soil

Analyte		**Units**	**Results**	**Results**	**Results**	Nominal Detection Limit
VOC Screen - Soil - Continued						
1,2-Dichloroethene(cis)	Dry Weight	mg/kg	<0.01	<0.01		0.01
1,2-Dichloroethene(trans)	Dry Weight	mg/kg	<0.01	<0.01		0.01
Dichlorodifluoromethane	Dry Weight	mg/kg	<0.1	<0.1		0.10
1,2-Dichloropropane	Dry Weight	mg/kg	<0.01	<0.01		0.01
1,3-Dichloropropane	Dry Weight	mg/kg	<0.01	<0.01		0.01
2,2-Dichloropropane	Dry Weight	mg/kg	<0.1	<0.1		0.10
1,1-Dichloropropene	Dry Weight	mg/kg	<0.01	<0.01		0.01
1,3-Dichloropropene(cis)	Dry Weight	mg/kg	<0.01	<0.01		0.01
1,3-Dichloropropene(trans)	Dry Weight	mg/kg	<0.01	<0.01		0.01
Ethylbenzene	Dry Weight	mg/kg	<0.01	<0.01		0.01
Ethyl Methacrylate	Dry Weight	mg/kg	<0.25	<0.25		0.25
Hexachlorobutadiene	Dry Weight	mg/kg	<0.01	<0.01		0.01
Hexachloroethane	Dry Weight	mg/kg	<0.01	<0.01		0.01
2-Hexanone	Dry Weight	mg/kg	<0.25	<0.25		0.25
Iodomethane	Dry Weight	mg/kg	<0.01	<0.01		0.01
p-Isopropyltoluene	Dry Weight	mg/kg	<0.01	<0.01		0.01
Methacrylonitrile	Dry Weight	mg/kg	<0.25	<0.25		0.25
Methyl t-Butyl Ether	Dry Weight	mg/kg	<0.01	<0.01		0.01
Methylene Chloride	Dry Weight	mg/kg	<0.1	<0.1		0.10
Methyl Methacrylate	Dry Weight	mg/kg	<0.25	<0.25		0.25
4-Methyl-2-Pentanone (MIBK)	Dry Weight	mg/kg	<0.25	<0.25		0.25
Naphthalene	Dry Weight	mg/kg	<0.05	<0.05		0.05
Pentachloroethane	Dry Weight	mg/kg	<0.01	<0.01		0.01
Propionitrile	Dry Weight	mg/kg	<0.25	<0.25		0.25
iso-Propylbenzene	Dry Weight	mg/kg	<0.01	<0.01		0.01
n-Propylbenzene	Dry Weight	mg/kg	<0.01	<0.01		0.01
Styrene	Dry Weight	mg/kg	<0.01	<0.01		0.01
1,1,1,2-Tetrachloroethane	Dry Weight	mg/kg	<0.01	<0.01		0.01
1,1,2,2-Tetrachloroethane	Dry Weight	mg/kg	<0.01	<0.01		0.01
Tetrachloroethene	Dry Weight	mg/kg	<0.01	<0.01		0.01
Toluene	Dry Weight	mg/kg	<0.01	<0.01		0.01
1,2,3-Trichlorobenzene	Dry Weight	mg/kg	<0.01	<0.01		0.01
1,2,4-Trichlorobenzene	Dry Weight	mg/kg	<0.01	<0.01		0.01
1,1,1-Trichloroethane	Dry Weight	mg/kg	<0.01	<0.01		0.01
1,1,2-Trichloroethane	Dry Weight	mg/kg	<0.01	<0.01		0.01

Analytical Report

Bill To: Town of Canmore
Report To: Town of Canmore
902 7 Ave
Canmore, AB, Canada
T1W 3K1
Attn: Felix Camire
Sampled By: FC/CM
Company: Town of Canmore

Project:
ID: 1445
Name: Cougar Creek
Location: Stewart Creek
LSD:
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Sample Time	15:00	15:15
Sample Location		
Sample Description	West / Open Field / 20-30 / 3.4C / cm	East / Open Field / 20-30 / 3.4C / cm
Matrix	Soil	Soil

Analyte		**Units**	**Results**	**Results**	**Results**	Nominal Detection Limit
VOC Screen - Soil - Continued						
Trichloroethene	Dry Weight	mg/kg	<0.01	<0.01		0.01
Trichlorofluoromethane	Dry Weight	mg/kg	<0.01	<0.01		0.01
1,2,3-Trichloropropane	Dry Weight	mg/kg	<0.01	<0.01		0.01
1,2,4-Trimethylbenzene	Dry Weight	mg/kg	<0.01	<0.01		0.01
1,3,5-Trimethylbenzene	Dry Weight	mg/kg	<0.01	<0.01		0.01
Vinyl Chloride	Dry Weight	mg/kg	<0.1	<0.1		0.10
Total Xylenes (m,p,o)	Dry Weight	mg/kg	<0.01	<0.01		0.01
VOC - Soil - Surrogate Recovery						
Dibromofluoromethane	EPA Surrogate	%	95	97		80-120
Toluene-d8	EPA Surrogate	%	97	97		81-117
Bromofluorobenzene	EPA Surrogate	%	102	102		74-121
Sterilants in Soil						
Atrazine	Dry Weight	mg/kg	<0.005	<0.005		0.005
Bromacil	Dry Weight	mg/kg	<0.008	<0.008		0.008
Chlorotoluron	Dry Weight	mg/kg	<0.02	<0.02		0.02
Cyanazine	Dry Weight	mg/kg	<0.02	<0.02		0.02
Diuron	Dry Weight	mg/kg	<0.02	<0.02		0.02
Fenuron	Dry Weight	mg/kg	<0.02	<0.02		0.02
Isoproturon	Dry Weight	mg/kg	<0.02	<0.02		0.02
Linuron	Dry Weight	mg/kg	<0.02	<0.02		0.02
Metoxuron	Dry Weight	mg/kg	<0.02	<0.02		0.02
Monolinuron	Dry Weight	mg/kg	<0.02	<0.02		0.02
Simazine	Dry Weight	mg/kg	<0.02	<0.02		0.02
Tebuthiuron	Dry Weight	mg/kg	<0.005	<0.005		0.005
Subcontracted Analysis						
Subcontractor Report Id	Biovision		Report 1022552-01	Report 1022553-01		

Approved by:

Michael Yohemas, BSc
Laboratory Operations Manager

Methodology and Notes

Bill To: Town of Canmore
Report To: Town of Canmore
902 7 Ave
Canmore, AB, Canada
T1W 3K1
Attn: Felix Camire
Sampled By: FC/CM
Company: Town of Canmore

Project:
ID: 1445
Name: Cougar Creek
Location: Stewart Creek
LSD:
P.O.:
Acct code:

Lot ID: **1188187**
Control Number: C0055246
Date Received: Feb 24, 2017
Date Reported: Mar 3, 2017
Report Number: 2170867

Method of Analysis

Method Name	Reference		Method	Date Analysis Started	Location
Ammonium-N (Extractable) in Soil	Carter	*	Extraction of NO3-N and NH4-N with 2.0 M KCl, 6.2	27-Feb-17	Exova Edmonton
Ammonium-N (Extractable) in Soil	McKeague	*	Nitrate and Ammonium Extractable by 2N KCl, 4.35	27-Feb-17	Exova Edmonton
Boron in farm soil	McKeague	*	Hot Water Soluble Boron - Azomethine-H Method, 4.61	28-Feb-17	Exova Edmonton
Chloride in farmsoil	SSSA Book Series, no. 3	*	Testing Soils for Sulfur, Boron, Molybdenum, and Chlorine, Chapter 10	28-Feb-17	Exova Edmonton
Macronutrients in Farm Soils	McKeague	*	Ammonium Acetate Extractable Cations, 4.51	28-Feb-17	Exova Edmonton
Metals ICP (Hot Block) in soil	EPA	*	Sample Preparation Procedure for Spectrochemical Determination of Total Recoverable Elements, October 1999, 200.2	28-Feb-17	Exova Edmonton
Metals ICP (Hot Block) in soil	US EPA	*	Determination of Trace Elements in Waters and Wastes by ICP-MS, 200.8	28-Feb-17	Exova Edmonton
Micronutrients in Farm Soil	APHA	*	Inductively Coupled Plasma (ICP) Method, 3120 B	28-Feb-17	Exova Edmonton
Micronutrients in Farm Soil	McKeague	*	DTPA-TEA Extractable Elements, 4.65	28-Feb-17	Exova Edmonton
Nutrients in Farm Soil	Comm. Soil Sci. Pl. Anal.	*	Modified Kelowna Soil Test, Vol 26, 1995	28-Feb-17	Exova Edmonton
Nutrients in General Soil	Comm. Soil Sci. Pl. Anal.	*	Modified Kelowna Soil Test, Vol 26, 1995	28-Feb-17	Exova Edmonton
Organic Matter by Ignition	McKeague	*	Loss on Ignition (LOI), 3.8	28-Feb-17	Exova Edmonton
Particle Size Analysis - GS	Carter	*	Hydrometer Method, 55.3	28-Feb-17	Exova Edmonton
Particle Size Analysis - GS	McKeague	*	pH in 0.01M Calcium Chloride, 3.11	28-Feb-17	Exova Edmonton
pH and Conductivity in farm soil	McKeague	*	1:2 Soil:Water Ratio, 4.12	28-Feb-17	Exova Edmonton
Saturated Paste in General Soil	Carter	*	Electrical Conductivity and Soluble Ions, Chapter 15	28-Feb-17	Exova Edmonton
SMP Lime Requirements	Carter	*	Shoemaker-Mclean-Pratt Single-Buffer Method, 12.2	28-Feb-17	Exova Edmonton
Sterilants - Soil	Cotteril	*	Methanol for Extraction of Some Herbicides from Soil, -	28-Feb-17	Exova Calgary
Sublet to Biovision	Ext. Lab		See attached test report,	02-Mar-17	Biovision Seed Research Ltd.
Sulfate in Farm Soil	McKeague	*	Sulfate Extractable by 0.1M CaCl2, 4.47	28-Feb-17	Exova Edmonton
Sulfate in General Soil	McKeague	*	Sulfate Extractable by 0.1M CaCl2, 4.47	28-Feb-17	Exova Edmonton
VOC - Soil	US EPA	*	US EPA method, 8260B/5035	28-Feb-17	Exova Calgary
VOC - Soil	US EPA	*	Volatile Organic Compounds by GCMS / Purge and Trap for Aqueous Samples, 8260B/5030B	28-Feb-17	Exova Calgary

** Reference Method Modified*

Methodology and Notes

Bill To: Town of Canmore
Report To: Town of Canmore
902 7 Ave
Canmore, AB, Canada
T1W 3K1
Attn: Felix Camire
Sampled By: FC/CM
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Project:
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Date Reported: Mar 3, 2017
Report Number: 2170867

References

APHA	Standard Methods for the Examination of Water and Wastewater
Carter	Soil Sampling and Methods of Analysis.
Comm. Soil Sci. Pl.	Communications in Soil Science and Plant Analysis
Cotteril	Cotteril, Edward G.
EPA	Environmental Protection Agency Test Methods - US
Ext. Lab	External Laboratory
McKeague	Manual on Soil Sampling and Methods of Analysis
SSSA Book Series,	Soil Testing and Plant Analysis
US EPA	US Environmental Protection Agency Test Methods

Comments:

- Weed Seed analysis was performed on samples 1 & 2 by a subcontract laboratory. See attached reports 1022552-01 & 1022553-01, respectively.

BioVision
SEED LABS

Work Order 1022552-01

Received 2/28/2017 Completed 3/1/2017

Tested By: BioVision Seed Labs
Unit 310, 280 Portage Close
Sherwood Park, Alberta T8H 2R6
P 1 (780) 436-8822
CFIA Acc #1172

SENIOR MEMBER OF
COMMERCIAL SEED ANALYSTS ASSOCIATION CANADA INC.
119 CRYSTAL DENTMAN

Submitted By:
Exova (Calgary)
Bay #5, 2712 - 37 Avenue NE
Calgary, AB CA T1Y 5L3
P (403) 291-2022
E calgary@exova.com

Sample of: Soil
Designated: POC 101267
Sample ID: 1188187-1, Site ID - West

REPORT OF ANALYSIS

*Soil Seed Analysis 50g	Completed: 3/1/2017		Method	**OTH**

None Found 0

*Advisory test - - Method not CFIA M&P prescribed.
Method(s) used for promoting germination of dormant seed.

BioVision
SEED LABS

Work Order 1022553-01

Received 2/28/2017 Completed 3/1/2017

Tested By: BioVision Seed Labs
Unit 310, 280 Portage Close
Sherwood Park, Alberta T8H 2R6
P 1 (780) 436-8822
CFIA Acc #1172

SENIOR MEMBER OF
COMMERCIAL SEED ANALYSTS ASSOCIATION CANADA INC.
119 CRYSTAL DENTMAN

Submitted By:
Exova (Calgary)
Bay #5, 2712 - 37 Avenue NE
Calgary, AB CA T1Y 5L3
P (403) 291-2022
E calgary@exova.com

Sample of: Soil
Designated: POC 101267
Sample ID: 1188187-2, Site ID - East

REPORT OF ANALYSIS

*Soil Seed Analysis 50g	Completed: 3/1/2017		Method	**OTH**

None Found 0

*Advisory test - - Method not CFIA M&P prescribed.
Method(s) used for promoting germination of dormant seed.

Appendix 144-1

Sign Examples

CAUTION

GEOTECHNICAL INVESTIGATION IN PROGRESS

Expect ongoing work until the end of September

TRAILS ARE OPEN

PLEASE USE CAUTION AROUND EQUIPMENT.

Town of
CANMORE

Give plants a chance!

Revegetation in progress.

Please stay off berms.

Enjoy the path instead.

Cougar Creek Debris Net: Short Term Mitigation

Town of
CANMORE

General Information

Throughout the world, people live at the bottom of mountain creeks, because they are usually picturesque, relatively flat areas. These areas are known as alluvial fans, a fan shaped deposit of sediment crossed and built up by streams. They are dynamic and change over time. As development occurs on alluvial fans, the space for their dynamic and sometimes dramatic development is restricted.

Alluvial fans and the mountain creeks on them are subject to a variety of movement processes including debris flows and debris floods.

- **A debris flow** usually starts high up in a mountain creek and can pick up an enormous amount of material, some very large, as it moves down. They usually contain between 50 - 70% debris. A debris flow can sever infrastructure and damage or destroy roadways and physical structures.
- **A debris flood** is characterized by only 10 - 20% debris, with the rest being water. As a debris flood comes down a creek, the channel can degrade rapidly, causing the creek to jump out of its bed.

Cougar Creek experiences debris flows in the watershed in steep tributaries, and debris floods in the main channel where the creek impacts the community.

canmore stands strong canmore stands strong

A Short Term Solution

Before you stands a debris net, manufactured by Geobrugg, a company based in Switzerland. This flexible ring net acts as a barrier keeping debris, like trees and boulders, out of the creek channel where development exists and from blocking culverts at crossings. As flow volume in the creek increases, the net stops solid materials, causing them to pile up behind the net, while water is allowed to continue through.

During the 2013 flood, it is estimated that there was 90,000 m^3 of material in Cougar Creek during the flood. The net will stop 20,000 m^3, removing problematic woody debris and giving the Town more time to prepare and react during a debris flood event. The net will allow water to move through the creek and culverts, but minimizing the amount of debris material that led to erosion, shifting of the channel, and culvert back-ups in the 2013 event. This net will be used for a few years until a long term solution can be developed and constructed. The plan is to use the debris net either as an additional measure or in a different location after long term mitigation in Cougar Creek is in place.

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How it Works

The net is 40 meters wide and six meters tall. There are 74 anchors into rock and soil, each over eight meters in length that hold the net in place.

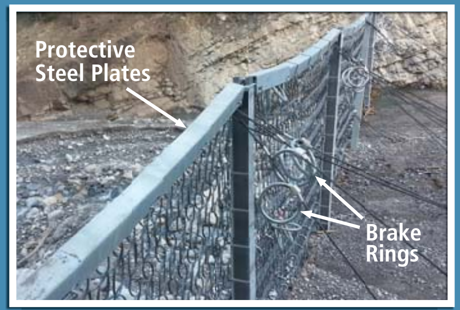
Each of the net's rings is made one-by-one by coiling high tensile strength wire into a loop. These rings absorb the energy of debris flows and debris floods, avalanches, and rockfalls. Once filled, both sediment and water will overtop the structure where heavy steel plates protect the cable.

Debris floods can send surges of water and debris down the canyon. This flash flooding creates significant impact forces on the debris net structure, posts, and foundations. Large break rings deform under load absorbing the force of the flow and protecting the anchors from failure.

There is a 2 metre wide by 3 metre tall opening in the net as well as a ramp that goes over it to let animals and humans freely go up and down the canyon. The opening will be closed off during run-off and high-rain events to provide maximum safety.

Facts About the Net

Sediment Volume	**20,000 m^3**
Size	**40 m wide | 6 m tall**
Number of anchors	**74**
Anchor Depth	**8 meters**



For more information on the work completed and the upcoming long-term mitigation visit **www.canmore.ca Flood Information**

Cougar Creek Mitigation After the 2013 Flood

Town of
CANMORE

2013 Flood Event

An intensive rainstorm (three low pressure systems converged on Canmore at the same time) from June 19 - 21, 2013 combined with frozen ground and snow melt to initiate hundreds of debris flows and debris floods on a number of creeks in Canmore: Cougar Creek, Echo Creek, Pigeon Creek, Three Sisters Creek, Stewart Creek, Stoneworks Creek, Stone Creek, and some unnamed creeks. Cougar Creek is the most developed creek in Canmore so the destruction and impact was most visible.

Some 265 millimetres of rain fell on the 43 square kilometer watershed of Cougar Creek over the course of three days. The result was significant flows of both water and debris like rock, trees and sediment. This caused the creek to migrate outside of its channel, eroding banks past property lines, undermining building foundations and supports for decks and balconies, as well as destroying roadways and infrastructure. When the water receded, 44 properties along Cougar Creek were deemed too unsafe to occupy.

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2013 Flood Event

Rainfall (Kananaskis Station)	265 mm in 3 days
Estimated peak discharge	64 m^3/s
Snowmelt contribution	12-29 % of total runoff
Sediment volume	~90,000 m^3

Watershed Characteristics

Watershed Area	43.5 km^2
Fan area	3.1 km^2
Minimum Elevation	1404 m
Maximum Elevation	2820 m
Average Channel Gradient	5.5 %
Average Gradient on Fan	4.2 %

Flood Impacts

- Approximately 1200 evacuation orders
- Approximately $16 million in initial damage to Town infrastructure
- 44 properties along Cougar Creek deemed unsafe to occupy immediately after the event
- $4 million estimated impact on businesses
- 30 businesses directly impacted
- More than 7,000 calls received at EOC call centre in 1 week
- 14 day boil water advisory
- Trans Canada Highway closed for 7 days
- Benchlands Trail closed for two months
- Canadian Pacific Railway shut down for several days

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Short Term Mitigation

Within less than one year, $14 million had been spent on the short term mitigation of Cougar Creek, the majority of this funding coming from the Province of Alberta. Long term mitigation planning is currently underway. Over 45,000 square meters of articulated concrete mats, which were manufactured in the Bow Valley, were installed along the creek channel. These mats are a series of concrete blocks that are linked together with a stainless steel cable. The mats extend into the channel and wrap around into the top of the berm acting as a continuous and secured blanket of protection. They work to prevent erosion during a flood. They reduce the amount of additional armouring needed as part of the long term mitigation work.

While the creek is dry for much of the year, during run-off the majority of water flow will be in contact with the bottom of the creek. Only the edges of the flow will contact the mats. Flow speed will be similar to what it was in the previous channel and will still be erosive. The mats are designed to have significantly greater erosion control capacity than before, when the banks were armoured with big rock. The current design could begin to fail under extreme conditions, but it will not make conditions any worse than had the mats not been in place. The mats are expected to dramatically reduce the rate of erosion, even in a situation where the mats are damaged. Over time, seed should take on the articulated concrete mats. The berms will be landscaped as well.

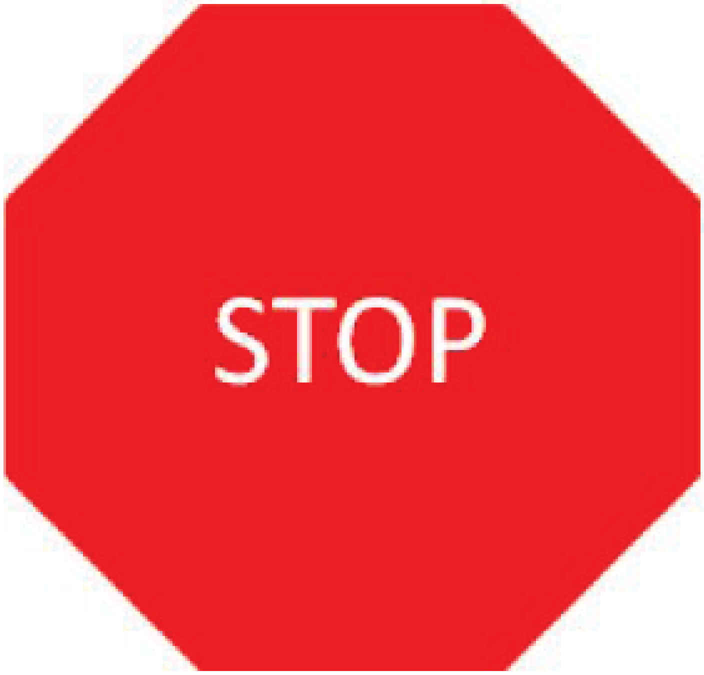
For more information on the work completed and the upcoming long-term mitigation visit **www.canmore.ca Flood Information**

NOTICE

LANDSCAPING TEST PLOTS IN PROGRESS

PLEASE STAY OFF

Town of
CANMORE



Watch for
Pedestrians and
Cyclists Crossing

Appendix 146-1

Screening Level Human Health Risks Assessment

SCREENING LEVEL HUMAN HEALTH RISK ASSESSMENT

FINAL REPORT

May 15, 2017

Prepared For: **Town of Canmore**
902 – 7th Avenue
Canmore, AB, T1W 3K1

Suite 1060, 736 8th Avenue SW, Calgary, AB, Canada T2P 1H4
Tel: 403-237-0275 ▪ www.intrinsik.com

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Table of Contents

List of Tables

Figures

1.0 INTRODUCTION

Information contained herein serves to address the health-related supplemental information requests for the Town of Canmore's proposed Cougar Creek Debris Flood Retention Structure Project ("project"). Specifically, SIRs 146-147, 149 and 151-154 are addressed through a screening level human health risk assessment (SLHHRA), while SIR 148 and SIR 150 are addressed outside the SLHHRA. The SLHHRA was completed by Intrinsik Corp. while the air quality dispersion modelling was completed by Matrix Solutions.

The SLHHRA involved all standard stages of a health risk assessment: problem formulation, exposure assessment, toxicity assessment and risk characterization. The uncertainty analysis was completed as part of the risk characterization. Each stage of the SLHHRA is described below.

2.0 PROJECT OVERVIEW

The project was described in Section 4 of the Environmental Impact Assessment. Heavy rains in the Bow Valley in 2013 caused a debris flood on Cougar Creek that resulted in widespread damage to municipal infrastructure, homes, businesses, the Trans-Canada Highway, Highway 1A and the Canadian Pacific Railway (CPR). To mitigate the impacts of another flood event, Canmore is proposing to construct a permanent debris flood retention structure on Cougar Creek at the site of the existing debris net (implemented as a short-term mitigation measure). Construction of the project is expected to take 2 to 2.5 years. The Structure will not permanently hold water and is designed to manage a debris flood over a variety of return period and rainfall duration scenarios. Ultimately, the Project will significantly increase the safety of the public and downstream infrastructure.

3.0 PROBLEM FORMULATION

This stage of the SLHHRA includes:

- A chemical (emission) inventory for the Project and identification of the chemicals of potential concern (COPC) for the SLHHRA
- A description of the receptors of concern (i.e., people potentially at risk)
- Identification of applicable/operable exposure pathways and completion of a conceptual exposure model

Details on these aspects of the Problem Formulation are described below.

Project emission inventory and identification of the COPC

Consistent with guidance provided by Alberta Health (2011), the focus of the SLHHRA is on those chemicals that will be emitted from the Project. As there are not emissions/releases to water associated with the Project, identification of the COPC began by developing an inventory of chemicals that are expected to be emitted to air.

Heavy equipment used during construction activities may affect air quality. Potentially toxic chemicals associated with heavy equipment emissions are listed in Table 3.1. These emissions were identified as chemicals of potential concern (COPC) and carried forward into the exposure assessment.

Table 3-1 Chemical emissions associated with construction of the project[(a)]

Common air contaminants (CACs)	*Volatile Organic Compounds (VOCs)*	*Aldehydes*	*Polycyclic Aromatic Hydrocarbons (PAHs)*	*Metals/Metalloids*	*Other*
CO	Benzene	Acrolein	Acenaphthene	Antimony	DPM[(b)]
NO_2	Toluene	Acetaldehyde	Acenaphthylene	Arsenic	
$PM_{2.5}$	Ethylbenzene	Formaldehyde	Benz(a)anthracene	Barium	
SO_2	Xylenes		Benzo(b,j,k)fluoranthene	Cadmium	
	1,3-butadiene		Benzo(a)pyrene	Copper	
			Benzo(g,h,i)perylene	Indium	
			Chrysene	Lanthanum	
			Dibenz(a,h)anthracene	Lead	
			Fluoranthene	Nickel	
			Fluorene	Palladium	
			Indeno(1,2,3-cd)pyrene	Silver	
			Naphthalene	Tin	
			Phenanthrene		

(a) Emission inventory provided by Matrix Solutions air quality team
(b) DPM = Diesel Particulate Matter

Receptors of Concern

The receptors of concern or people potentially at risk are individuals whose health might be adversely affected as a result of exposure to the COPC emissions from the Project. The people who are most likely to experience adverse health effects are those who receive the highest chemical exposures and who are regarded as sensitive or susceptible to chemical exposures.

As shown on Figure 12-1 in the response to SIR 12, the nearest residence is 450 m from the flood retention structure. By assuming ongoing exposure at this location, this residence was selected to represent the reasonable worst case receptor.

As described in Alberta Health's 2011 "Guidance on Human Health Risk Assessment for Environmental Impact Assessment in Alberta", consideration was given to individuals within the area who may be at greater risk (e.g., pre-existing health conditions). Such individuals were accounted for in the SLHHRA through the "use of safety of uncertainty factors incorporated in the exposure limits" (Alberta Health 2011).

Identification of Exposure Pathways

Exposure pathways refer to the various avenues by which chemical emissions might "travel" from the Project to people living in the area or those who might frequent the area. Since the emissions will be released directly to the air from various sources, an obvious pathway by which people could be exposed is inhalation.

Direct inhalation of air (i.e., the primary pathway of exposure) was assumed to be an applicable exposure pathway for all people in the area. Both acute (short-term) and chronic (long-term) exposures were considered in the SLHHRA.

Area residents might also be exposed to the chemical emissions on a long-term basis through secondary exposure pathways (e.g., soil ingestion). Some chemicals emitted to air will be deposited onto soils surrounding the Project. Depending on the volatility of the COPC, deposition could affect local soil concentrations. As such, exposure through soil-related pathways was included in the SLHHRA. This was accomplished by comparing predicted soil concentrations to Alberta's Tier 1 health-based soil quality guidelines (AEP 2016). These guidelines account for people coming into direct contact with soil through incidental ingestion, dermal contact or inhalation of air-born soil particles (AEP 2016). In addition, the health-based guidelines account for indoor vapour inhalation and the protection of domestic use aquifers. Recognizing that people can be exposed to the COPC through other exposure pathways (e.g., food related), the soil quality guidelines incorporate a soil allocation factor in order to ensure that exposure to potentially impacted soil "represents only a portion of the overall allowable exposure" (AEP 2016). As there are no surface water bodies nearby, water-related exposure pathways were not assessed in the SLHHRA.

The exposure pathways considered in the SLHHRA are shown in Table 3-2. In addition, the conceptual exposure model for the SLHHRA is presented as Figure 3-1.

Table 3-2 Applicable exposure pathways for people potentially at risk

Exposure Pathway	***Area Residents/Users***	***Rationale***
Inhalation		
Inhalation of air	✓	COPC will be emitted directly to air.
Inhalation of dust	✓	Accounted for in soil quality guidelines.
Ingestion		
Ingestion of soil (inadvertent)	✓	Accounted for in soil quality guidelines.
Ingestion of drinking water	✗	Although not explicitly addressed, soil quality guidelines do account for the protection of domestic use aquifers.
Ingestion of surface water while swimming	✗	No water bodies nearby.
Ingestion of home-grown produce	✗	Although not explicitly addressed, soil quality guidelines indirectly account for this through the use of soil allocation factors.
Ingestion of wild game	✗	Although not explicitly addressed, soil quality guidelines indirectly account for this through the use of soil allocation factors.
Ingestion of fish	✗	No water bodies nearby.
Dermal contact		
Dermal contact with soil	✓	Accounted for in soil quality guidelines.
Dermal contact with water while swimming	✗	No water bodies nearby.

4.0 EXPOSURE ASSESSMENT

The primary objective of the exposure assessment is to estimate, based on the use of reasonable worst-case assumptions, potential chemical exposures received by the receptors of concern. Since construction emissions will be released directly into air, people could be exposed via the primary exposure pathway of inhalation over the short- and long-term. Potential health risks associated with the inhalation of the chemical emissions are evaluated in the inhalation assessment, discussed in detail below.

To assess the potential health risks associated with possible secondary pathways, it was necessary to identify those chemicals released by the Project that, although only emitted into air, would be expected to deposit onto land and possibly persist or accumulate in the environment in sufficient quantities for people to be exposed via soil-related pathways. As a starting point in this identification process, two general categories of chemicals emitted from the Project were identified:

- *Gaseous chemicals*, which are unlikely to contribute to human exposure via secondary pathways as they will remain airborne for prolonged periods of time and over extended distances (i.e., CO, NO_2, SO_2). In addition, the health effects of these gaseous chemicals are strictly related to inhalation (i.e., these COPC act at the point of contact). Accordingly, the gaseous chemicals were considered only in the inhalation assessment, and were removed from further consideration in the multiple pathway assessment.
- *Non-gaseous chemicals*, which might deposit in the vicinity of the Project and persist or accumulate in the environment in sufficient quantities for people to be exposed via secondary (soil-related) pathways. The deposition of these non-gaseous chemicals onto soils required further consideration.

To identify the non-gaseous chemicals that could deposit nearby and possibly persist or accumulate in the environment, consideration was given to the inherent properties of the chemicals that influence their fate and persistence in the environment, and subsequently their potential occurrence in the secondary pathways of exposure. This was accomplished using the process outlined in Table 4-1.

The premise of this exercise is that if a chemical emitted to the air does not meet any of these criteria, the potential for the chemical to deposit in the vicinity of the Project and persist or accumulate in the environment other than air is likely negligible, and only limited opportunity exists for exposure via secondary pathways. Accordingly, these chemicals were removed from further consideration in the multiple pathway assessment and evaluated as part of the inhalation assessment only. However, if a chemical meets any one of these criteria, sufficient opportunity could be presented for exposure via secondary pathways, and the chemical was evaluated in both the inhalation and multiple pathway assessments.

The relevant physico-chemical properties and fugacity model results for each of the COPC (excluding the gaseous COPC) are summarized in Table 4-2, which also identifies those COPC that are eligible for inclusion in the soil-related pathway assessment. Metals/metalloids were not screened according to their physico-chemical properties, as they were automatically included in the soil-related pathway assessment.

Details on how COPC concentrations in soil were predicted are provided in the worked example that is appended to the SLHHRA.

Table 4-1 Process of identifying chemicals of potential concern for the soil-related pathways

Step	***Approach***
Comparison of physico-chemical properties with established criteria for volatility	The purpose of this step is to identify the chemicals emitted by the Project that are non-volatile, and have a higher likelihood of partitioning to environmental compartments other than air, in accordance with the following criteria from the US EPA (2003): molecular weight >200 g/mol (or 2.0E+02 g/mol) Henry's Law Constant <0.00001 atm-m^3/mol (or 1.0E-05 atm-m^3/mol) vapour pressure <0.001 mm Hg (or 1.0E-03 mm Hg) Physico-chemical properties (i.e., molecular weight, Henry's Law Constant, and vapour pressure) were adopted from Syracuse Research Corp. (SRC 2013) or, if a property was not available from SRC (2013), the EPI Suite program developed by US EPA (2012) was searched.
Comparison of physico-chemical properties with established criteria for bioaccumulation	The purpose of this step is to identify the chemicals emitted by the Project that have the potential to accumulate in living organisms, in accordance with the following criterion from Environment Canada (2003): octanol-water partitioning coefficient (Log K_{ow}) ≥ 5 Again, the octanol-water partitioning coefficient was adopted from Syracuse Research Corp. (SRC 2013), or if it was not available from SRC (2013), the EPI Suite program developed by the US EPA (2012) was searched.
Fugacity modelling	Fugacity modelling was completed to determine the potential relative apportionment of the chemical within environmental compartments other than air. Fugacity model results were based on the "Level III" fugacity model developed by US EPA (2012) that adheres to methods developed by Mackay et al. (1992, 1993). If a COPC was found to be at least 5% in environmental compartments other than air (i.e., water, soil or sediment), the COPC was included in the multiple exposure pathway assessment since it was assumed there was potential for persistence and accumulation within soils, plants or other biota (Boethling et al. 2009; Environment Canada 2003).

Table 4-2 Identification of the COPC for the soil-related pathways

Chemical of Potential Concern[a]	***Volatility***			***Bioaccumulation***	***Fugacity***[b]			***Eligible for Multiple Pathway Assessment***
	Molecular Weight (g/mol)	***Henry's Law Constant (atm-m^3/mol)***	***Vapour Pressure (mm Hg)***	***Log K_{ow}***	***Soil (%)***	***Water (%)***	***Sediment (%)***	
CRITERIA:	***≥2.0E+02***	***≤1.0E-05***	***≤1.0E-03***	***≥5.0E+00***	***≥5.0E+00***	***≥5.0E+00***	***≥5.0E+00***	
Volatile Organic Compounds								
Benzene	7.8E+01	5.6E-03	9.5E+01	2.1E+00	2.9E-01	5.1E-01	4.6E-03	No
Toluene	9.2E+01	6.6E-03	2.8E+01	2.7E+00	3.3E-01	3.3E-01	3.6E-03	No
Ethylbenzene	1.1E+02	7.9E-03	9.6E+00	3.2E+00	4.7E-01	2.8E-01	5.0E-03	No
Xylenes	1.1E+02	6.6E-03	8.0E+00	3.2E+00	5.7E-01	4.2E-01	6.7E-03	No
1,3-Butadiene	5.4E+01	7.4E-02	2.1E+03	2.0E+00	1.1E-02	3.1E-02	1.1E-04	No
PAHs								
Acenaphthene	1.5E+02	1.8E-04	2.2E-03	3.9E+00	**8.4E+00**	**8.1E+00**	2.4E+00	**Yes**
Acenaphthylene	1.5E+02	1.1E-04	6.7E-03	3.9E+00	4.4E+00	**7.9E+00**	1.2E+00	**Yes**
Benz[a]anthracene	**2.3E+02**	1.2E-05	**2.1E-07**	**5.8E+00**	**8.0E+01**	1.4E+00	**1.6E+01**	**Yes**
Benzo[a]pyrene	**2.5E+02**	**4.6E-07**	**5.5E-09**	**6.1E+00**	**8.2E+01**	6.8E-01	**1.6E+01**	**Yes**
Benzo[b,j,k]fluoranthene	**2.5E+02**	**6.6E-07**	**5.0E-07**	**5.8E+00**	**8.0E+01**	7.2E-01	**1.8E+01**	**Yes**
Benzo[g,h,i]perylene	**2.8E+02**	**3.3E-07**	**1.0E-10**	**6.6E+00**	**8.0E+01**	5.0E-01	**1.9E+01**	**Yes**
Chrysene	**2.3E+02**	**5.2E-06**	**6.2E-09**	**5.8E+00**	**8.7E+01**	1.0E+00	**1.1E+01**	**Yes**
Dibenz[a,h]anthracene	**2.8E+02**	**1.4E-07**	**9.6E-10**	**6.8E+00**	**8.0E+01**	5.0E-01	**1.9E+01**	**Yes**
Fluoranthene	**2.0E+02**	**8.9E-06**	**9.2E-06**	**5.2E+00**	**6.5E+01**	4.3E+00	**1.8E+01**	**Yes**
Fluorene	1.7E+02	9.6E-05	**6.0E-04**	4.2E+00	**6.3E+00**	**8.2E+00**	2.3E+00	**Yes**
Indeno[1,2,3 cd]pyrene	**2.8E+02**	**3.5E-07**	**1.3E-10**	**6.7E+00**	**8.0E+01**	5.1E-01	**1.9E+01**	**Yes**
Naphthalene	1.3E+02	4.4E-04	8.5E-02	3.3E+00	4.9E+00	4.8E+00	4.1E-01	No
Phenanthrene	1.8E+02	4.2E-05	**1.2E-04**	4.5E+00	**4.0E+01**	**9.2E+00**	**1.2E+01**	**Yes**

Chemical of Potential Concern[a]	***Volatility***			***Bioaccumulation***	***Fugacity***[b]			***Eligible for Multiple Pathway Assessment***
	Molecular Weight (g/mol)	***Henry's Law Constant (atm-m³/mol)***	***Vapour Pressure (mm Hg)***	***Log K_{ow}***	***Soil (%)***	***Water (%)***	***Sediment (%)***	
CRITERIA:	***≥2.0E+02***	***≤1.0E-05***	***≤1.0E-03***	***≥5.0E+00***	***≥5.0E+00***	***≥5.0E+00***	***≥5.0E+00***	
Aldehydes								
Acetaldehyde	4.4E+01	6.7E-05	9.0E+02	-3.4E-01	1.8E+00	**1.0E+01**	2.0E-02	**Yes**
Acrolein	5.6E+01	1.2E-04	2.7E+02	-1.0E-02	1.0E+00	**8.3E+00**	1.6E-02	**Yes**
Formaldehyde	3.0E+01	**3.4E-07**	3.9E+03	3.5E-01	**6.1E+01**	**2.3E+01**	4.3E-02	**Yes**

NOTES:

Bold values indicate that the physico-chemical parameter meets or exceeds the pre-established criterion and the chemical is eligible for inclusion in the multiple pathway assessment, provided that a defensible exposure limit is available.

[a] With scientific notation, values are expressed either to the negative power (i.e., E-x) or to the positive power (i.e., E+x). For example, the molecular weight for acenaphthene is 1.5E+02 or 150 g/mol.

[b] Physico-chemical parameters for all COPC were obtained from the following sources in the order of priority: SRC (2013) and EPI Suite (US EPA 2012).

5.0 TOXICITY ASSESSMENT

The principal outcome of the toxicity assessment is determining the health-based guidelines (or exposure limits) for each COPC, which refer to the levels of exposure that would not be expected to cause health effects. The limits are typically based on guidelines, objectives or standards established by leading scientific and regulatory authorities responsible for the protection of public health, and typically incorporate a high degree of protection to accommodate vulnerable members of the population.

For the purpose of the SLHHRA, reliance was placed on exposure limits developed or recommended by leading scientific and regulatory authorities as criteria (e.g., objectives, guidelines or standards) for the protection of human health. The exposure limits were obtained from:

- Government of Alberta (GOA)
- Health Canada
- Canadian Council of Ministers of the Environment (CCME)
- United States Environmental Protection Agency (US EPA)
- World Health Organization (WHO)
- United States Agency for Toxic Substances and Disease Registry (ATSDR)
- Massachusetts Department of Environmental Protection (MA DEP)
- Netherlands National Institute of Public Health and the Environment (RIVM)
- California’s Office of Environmental Health Hazard Assessment (OEHHA)
- Texas Commission on Environmental Quality (TCEQ)

Soil quality guidelines were obtained from the 2016 Alberta Tier 1 Soil and Groundwater Remediation Guidelines.

The toxicity of a chemical can vary between acute (short-term) and chronic (long-term) exposure. As such, it is important to differentiate exposure limits on the basis of exposure duration. The two exposure limit durations used in the SLHHRA can be described as follows:

- Acute exposure limit, which represents the amount or dose of a chemical that can be tolerated on a short-term basis without evidence of adverse health effects. These limits are routinely applied to conditions in which exposures extend over several hours or days.
- Chronic exposure limit, which represents the amount of a chemical that is expected to be without effect, even when exposure occurs continuously or regularly over extended periods, lasting for periods of at least a year, and possibly extending over an entire lifetime.

The exposure limits used in the acute and chronic inhalation assessments are presented in Table 5-1 and Table 5-2, respectively. The soil quality guidelines are presented in Table 5-3.

Carcinogenic PAHs represent a unique chemical group that was evaluated using two distinct approaches:

- Approach 1 (“WHO approach”): The mixture of carcinogenic PAHs was evaluated based on its benzo[a]pyrene content. The approach uses benzo[a]pyrene as an indicator of the potency of the mixture. Benzo[a]pyrene was chosen as the indicator PAH as its toxicity is best characterized out of all the carcinogenic PAH compounds. The potential carcinogenic risks for the PAHs were assessed by comparing the benzo(a)pyrene air concentration against the World Health Organization air quality guideline.

- Approach 2 ("Benzo(a)pyrene equivalent approach"): The mixture of carcinogenic PAHs was evaluated by summing each individual PAHs toxic equivalency to benzo[a]pyrene (i.e., the toxic equivalency quotient [TEQ] approach). This approach is consistent with the relative potency approach described by the US EPA (2002), in which the carcinogenic potencies of PAHs are scaled to an index compound (benzo[a]pyrene) using toxic equivalency factors and then added together to calculate the total cancer risk for the mixture. The toxic equivalencies of the PAH groups were determined using potency equivalence factors (PEFs) that have been adopted by Health Canada (2012).

Table 5-1 Exposure limits used in the acute inhalation assessment of the SLHHRA

COPC	*Averaging Time*	*Value (µg/m^3)*	*Critical Effect*	*Agency*
CACs				
CO	1-hr	40,000	Hypoxia	US EPA
NO_2	1-hr	300	Respiratory irritation	AEP
$PM_{2.5}$	24-hr	27	--	CCME
SO_2	1-hr	450	Respiratory irritation	AEP
VOCs				
Benzene	1-hr	580	Immunological effects	TCEQ
Toluene	1-hr	7,600	Neurological effects	ATSDR
Ethylbenzene	1-hr	21,700	Neurological effects	ATSDR
Xylenes	1-hr	7,400	Respiratory irritation and neurological effects	TCEQ
1,3-Butadiene	24-hr	15	Developmental effects	USEPA
Aldehydes				
Acrolein	1-hr	2.5	Eye, nasal, respiratory irritation	OEHHA
Acetaldehyde	1-hr	470	Eye, nasal, respiratory irritation	OEHHA
Formaldehyde	1-hr	50	Eye and nasal irritation	ATSDR
PAHs				
Acenaphthene		--		
Acenaphthylene		--		
Benz(a)anthracene		--		
Benzo(b,j,k)fluoranthene		--		
Benzo(a)pyrene		--		
Benzo(g,h,i)perylene		--		
Chrysene		--		
Dibenz(a,h)anthracene		--		
Fluoranthene		--		
Fluorene		--		
Indeno(1,2,3-cd)pyrene		--		
Naphthalene		--		
Phenanthrene		--		

COPC	***Averaging Time***	***Value (µg/m³)***	***Critical Effect***	***Agency***
Metals/metalloids				
Antimony		--		
Arsenic	1-hr	0.2	Developmental effects	OEHHA
Barium		--		
Cadmium	24-hr	0.03	Nasal and respiratory irritation	ATSDR
Copper		--		
Indium		--		
Lanthanum		--		
Lead		--		
Nickel	1-hr	1.1	Respiratory irritation	TCEQ
Palladium		--		
Silver		--		
Tin		--		
Other				
DPM		--		
“--“ Not available				

Table 5-2 Exposure limits used in the chronic inhalation assessment of the SLHHRA

COPC	***Averaging Time***	***Value (µg/m³)***	***Critical Effect***	***Agency***
CACs				
CO		--		
NO_2	Annual	100	Respiratory irritation	USEPA
$PM_{2.5}$	Annual	8.8	--	CCME
SO_2		--		
VOCs				
Benzene	Annual	1.3	Leukemia (1 in 100,000 risk)	USEPA
Toluene	Annual	3,800	Neurological effects	ATSDR
Ethylbenzene	Annual	260	Kidney effects	ATSDR
Xylenes	Annual	610	Eye and nasal irritation; neurological	TCEQ
1,3-Butadiene	Annual	0.3	Leukemia (1 in 100,000 risk)	USEPA
Aldehydes				
Acrolein	Annual	0.35	Nasal irritation	OEHHA
Acetaldehyde	Annual	17.2	Nasal tumours (1 in 100,000 risk)	HC
Formaldehyde	Annual	0.8	Nasal tumours (1 in 100,000 risk)	USEPA
PAHs				
Acenaphthene		--		
Acenaphthylene		--		
Benz(a)anthracene	Annual	(a)		
Benzo(b,j,k)fluoranthene	Annual	(a)		
Benzo(a)pyrene	Annual	0.00012 or 0.017	Lung tumours (1 in 100,000 risk)	WHO and USEPA
Benzo(g,h,i)perylene	Annual	(a)		
Chrysene	Annual	(a)		
Dibenz(a,h)anthracene	Annual	(a)		

COPC	***Averaging Time***	***Value ($\mu g/m^3$)***	***Critical Effect***	***Agency***
Fluoranthene	Annual	(a)		
Fluorene		--		
Indeno(1,2,3-cd)pyrene	Annual	(a)		
Naphthalene	Annual	3	Nasal irritation	USEPA
Phenanthrene	Annual	(a)		
Metals/metalloids				
Antimony		--		
Arsenic	Annual	0.0016	Lung tumours (1 in 100,000 risk)	HC
Barium	Annual	1	Hematological and cardiovascular	RIVM
Cadmium	Annual	0.002	Lung tumours (1 in 100,000 risk)	OEHAA
Copper	Annual	1	Respiratory and immunological	RIVM
Indium		--		
Lanthanum		--		
Lead		--		
Nickel	Annual	0.0077	Lung tumours (1 in 100,000 risk)	HC
Palladium		--		
Silver		--		
Tin		--		
Other				
DPM	Annual	5	Respiratory irritation	USEPA
Notes: “--“ Not available; (a) = assessed as benzo(a)pyrene equivalent				

Table 5-3 Human health based soil quality guidelines used in the SLHHRA

COPC	***Alberta Tier Surface Soil Guidelines for Residential Land Use (mg/kg)***			***Guideline used in the SLHHRA (mg/kg)***
	Direct Soil Contact	***Vapour Inhalation***	***Protection of Domestic Use Aquifer***	
Aldehydes				
Acrolein	--	--	--	--
Acetaldehyde	--	--	--	--
Formaldehyde	--	--	--	--
PAHs				
Acenaphthene	5,300	3,900	NGR	3,900
Acenaphthylene	--	--	--	--
Benz(a)anthracene	--	--	1.6	1.6
Benzo(b,j,k)fluoranthene	--	--	0.16	0.16
Benzo(a)pyrene	--	--	1.7	1.7
Benzo(g,h,i)perylene	--	--	32	32
Chrysene	--	--	10	10
Dibenz(a,h)anthracene	--	--	1.1	1.1
Fluoranthene	3,500	480,000	NGR	3,500
Fluorene	2,700	8,600	NGR	2,700
Indeno(1,2,3-cd)pyrene	--	--	13	13
Phenanthrene	--	--	--	--
Carcinogenic PAHs (as B(a)P TEQ)	5.3	NGR	IACR<1.0	5.3 and IACR<1.0

COPC	Alberta Tier Surface Soil Guidelines for Residential Land Use (mg/kg)			Guideline used in the SLHHRA (mg/kg)
	Direct Soil Contact	Vapour Inhalation	Protection of Domestic Use Aquifer	
Metals/metalloids				
Antimony	--	--	--	--
Arsenic	21	--	--	21
Barium	--	--	--	--
Cadmium	14	--	--	14
Copper	1,100	--	--	1,100
Indium	--	--	--	--
Lanthanum	--	--	--	--
Lead	140	--	--	140
Nickel	200	--	--	200
Palladium	--	--	--	--
Silver	--	--	--	--
Tin	--	--	--	--

Notes: “--“ Not available; “IACR” = Index of Additive Cancer Risk; “NGR” = no guideline required, values for all exposure pathways that could be calculated are above compound solubility.

6.0 RISK CHARACTERIZATION

The final step of the assessment involves quantifying or otherwise estimating the potential health risks that could be presented to people as a result of exposure to COPC emissions from the construction of the Project. Risk estimates are calculated by comparing exposure estimates (determined as part of the Exposure Assessment) to the corresponding exposure limits (determined as part of the Toxicity Assessment). In this assessment, risk estimates are expressed as risk quotients (RQs) for non-carcinogenic COPC, and as incremental lifetime cancer risks (ILCRs) for carcinogenic COPC.

Non-Cancer Risk Estimates

To calculate risk quotients, predicted levels of exposure for the non-carcinogenic COPC were compared to the respective exposure limits developed by regulatory or scientific agencies. RQs were calculated and interpreted as follows:

$$\text{Risk Quotient} = \frac{\text{Predicted Exposure } (\mu g/m^3)}{\text{Exposure Limit } (\mu g/m^3)}$$

- RQ ≤ 1.0: Indicates that the estimated exposure is less than or equal to the exposure limit (i.e., the assumed safe level of exposure). Risk quotients less than or equal to 1.0 are associated with negligible to low health risks (even in sensitive individuals) given the level of conservatism incorporated in the derivation of the exposure limits and the risk estimates.
- RQ >1.0: Indicates that the exposure estimate exceeds the exposure limit. This suggests an elevated level of risk, the significance of which must be balanced against the degree of conservatism incorporated in the risk assessment.

Cancer Risk Estimates

Regulatory agencies such as Health Canada, AEP and the US EPA assume that any level of long-term exposure to carcinogenic chemicals is associated with some hypothetical cancer risk. On this basis, Health Canada and AEP have specified an incremental (i.e., over and above background) lifetime cancer risk of 1 in 100,000, which these agencies consider acceptable, tolerable or essentially negligible (Alberta Health 2011, Health Canada 2012).

The ILCRs were calculated for the Construction Case as follows:

$$\text{Incremental Lifetime Cancer Risks} = \frac{\text{Predicted Exposure } (\mu g/m^3)}{\text{Carcinogenic Exposure Limit } (\mu g/m^3)}$$

Interpretation of these ILCRs was based on a comparison of the ILCR against the Health Canada (2012) *de minimis* risk level of 1 in 100,000 (i.e., one extra cancer case in a population of 100,000 people).

Exposure and subsequent risks associated with the deposition of COPC onto soil in the area was considered by comparing the predicted soil concentrations against available human health based soil quality guidelines for residential land use.

7.0 ASSESSMENT RESULTS

Because health effects depend, in part, on the duration of exposure, separate assessments were completed for acute and chronic exposure estimates. It is important to distinguish between potential health effects that could result from acute versus chronic exposure. For example, short-term exposure to formaldehyde in air is associated with eye and nasal irritation while long-term inhalation can produce carcinogenic nasal lesions.

In recognition of the influence of duration and pathway of exposure, separate risk estimates are provided for:

- acute inhalation exposure
- chronic inhalation exposure
- chronic multiple pathway exposure (soil-related pathways)

Risks are presented for the nearest residence (450 m away from the Project) as this location represents a reasonable worst case scenario.

Acute Inhalation Risks

Potential acute health risks for the Project, expressed as risk quotients, are presented in Table 7-1. As shown, all of the risk quotients are less than 1.0, indicating that the Project's construction emissions are not expected to result in acute health effects.

No acute exposure limits are available for the PAHs, a number of the metals or diesel particulate matter (DPM). However, the short-term air concentrations for these COPCs are low. Further, the health risks for PAHs and DPM are typically associated with chronic exposure durations. Although the absence of exposure limits for these COPCs does introduce some uncertainty into the acute inhalation assessment, it does not affect the overall conclusions of the SLHHRA (see Section 8.0).

Some of the COPC share common health endpoints (e.g., respiratory irritation for SO_2 and NO_2). Because the risk quotients are so low, adding risk quotients for mixtures of COPC with common endpoints would not result in cumulative risk quotients greater than 1.0.

Table 7-1 Acute inhalation risk quotients for the construction case

COPC	***Predicted Short-term Air Concentration (at 450 m) (µg/m^3)***	***Exposure Limit (µg/m^3)***	***Risk Quotient***
CACs			
CO	624	40,000	0.02
NO_2	90	300	0.3
$PM_{2.5}$	15	27	0.6
SO_2	1	450	0.002
VOCs			
Benzene	0.2	580	0.0003
Toluene	0.2	7,600	0.00003
Ethylbenzene	0.05	21,700	0.000002
Xylenes	0.2	7,400	0.00003
1,3-Butadiene	0.05	15	0.003
Aldehydes			
Acrolein	0.2	2.5	0.08
Acetaldehyde	0.9	470	0.002
Formaldehyde	3	50	0.06
PAHs			
Acenaphthene	0.007	--	--
Acenaphthylene	0.03	--	--
Benz(a)anthracene	0.002	--	--
Benzo(b,j,k)fluoranthene	0.005	--	--
Benzo(a)pyrene	0.001	--	--
Benzo(g,h,i)perylene	0.002	--	--
Chrysene	0.002	--	--
Dibenz(a,h)anthracene	0.0001	--	--
Fluoranthene	0.02	--	--
Fluorene	0.03	--	--
Indeno(1,2,3-cd)pyrene	0.0008	--	--
Naphthalene	0.4	--	--
Phenanthrene	0.1	--	--
Metals/metalloids			
Antimony	0.0003	--	--
Arsenic	0.00003	0.2	0.0002
Barium	0.004	--	--
Cadmium	0.00003	0.03	0.001
Copper	0.0002	--	--
Indium	0.0001	--	--
Lanthanum	0.0002	--	--
Lead	0.001	--	--
Nickel	0.0001	1.1	0.0009

COPC	Predicted Short-term Air Concentration (at 450 m) (µg/m^3)	Exposure Limit (µg/m^3)	Risk Quotient
Palladium	0.00007	--	--
Silver	0.0002	--	--
Tin	0.00007	--	--
Other			
DPM	3	--	--

Chronic Inhalation Risks

The potential chronic inhalation risks are presented in Table 7-2 for the non-carcinogenic COPC an in Table 7-3 for the carcinogenic COPC. As shown, all of the risk quotients are less than 1.0 and the incremental lifetime cancer risks are less than 1 in 100,000, indicating that the Project's construction emissions are not expected to result in chronic inhalation-related health effects.

A number of the COPC do not have scientifically defensible chronic inhalation limits. This is either because health effects associated with these COPC are related predominantly to short-term exposure durations (e.g., SO_2 and CO) or because there are limited to no chronic toxicity data available for these COPC (e.g., acenaphthene, acenaphthylene, fluorene, certain metals). As shown in Table 7-2, the annual air concentrations for these COPCs are low. While the absence of chronic inhalation limits for some of these COPCs introduces some uncertainty into the chronic inhalation assessment, it does not affect the overall conclusions of the SLHHRA (see Section 8.0).

Some of the COPC share common chronic health endpoints (e.g., leukemia for benzene and 1,3-butadiene). Because the risk quotients and incremental lifetime cancer risks are so low, adding the risk estimates for mixtures of COPC with common endpoints would not result in cumulative risk quotients greater than 1.0 or incremental lifetime cancer risks greater than 1.0 in 100,000.

Table 7-2 Chronic inhalation non-carcinogenic risks for the construction case

COPC	Predicted Long-term Air Concentration (at 450 m) (µg/m^3)	Exposure Limit (µg/m^3)	Risk Quotient
CACs			
CO	62	--	--
NO_2	9	100	0.09
$PM_{2.5}$	2.5	8.8	0.3
SO_2	0.1	--	--
VOCs			
Toluene	0.02	3,800	0.00005
Ethylbenzene	0.005	260	0.00002
Xylenes	0.02	610	0.00003
Aldehydes			
Acrolein	0.02	0.35	0.06
PAHs			
Acenaphthene	0.0007	--	--
Acenaphthylene	0.003	--	--
Fluorene	0.003	--	--

COPC	Predicted Long-term Air Concentration (at 450 m) (µg/m^3)	Exposure Limit (µg/m^3)	Risk Quotient
Naphthalene	0.04	3	0.01
Metals/metalloids			
Antimony	0.00003	--	--
Barium	0.0004	1	0.0004
Copper	0.00002	1	0.00002
Indium	0.00001	--	--
Lanthanum	0.00002	--	--
Lead	0.0001	--	--
Palladium	0.000007	--	--
Silver	0.00002	--	--
Tin	0.000007	--	--
Other			
DPM	0.4	5	0.08

Table 7-3 Chronic inhalation carcinogenic risks for the construction case

COPC	Predicted Long-term Air Concentration (at 450 m) (µg/m^3)	Exposure Limit (µg/m^3)	Incremental Lifetime Cancer Risk (per 100,000)
VOCs			
Benzene	0.02	1.3	0.02
1,3-Butadiene	0.008	0.3	0.03
Aldehydes			
Acetaldehyde	0.09	17.2	0.005
Formaldehyde	0.3	0.8	0.4
PAHs			
Benzo(a)pyrene (WHO approach)	0.00011	0.00012	0.9
Benzo(a)pyrene equivalent approach	0.0002	0.017	0.01
Metals/metalloids			
Arsenic	0.000003	0.0016	0.002
Cadmium	0.000005	0.002	0.003
Nickel	0.00001	0.0077	0.001

Risks related to deposition of COPC onto soil

The predicted soil concentrations are compared against human health based soil quality guidelines in Table 7-4. As shown, all of the predicted soil concentrations are considerably less than the soil quality guidelines, indicating that the Project’s construction emissions are not expected to result in adverse health effects related to secondary exposure pathways.

While some of the COPC do not have health-based soil quality guidelines, this does not affect the overall conclusions of the SLHHRA (see Section 8.0). The predicted soil concentrations for these COPCs are low and are not expected to adversely affect the health of the area residents. For example, the analytical detection limit for antimony in soil is 0.2 mg/mg, which is 66 times higher than the maximum predicted concentration of antimony in soil. As such, the contribution emissions are not expected to have a measurable impact on soil concentrations in the area.

Table 7-4 Health risks related to deposition of COPC onto soil

COPC	***Maximum Predicted Soil Concentration (mg/kg)***	***Residential Soil Quality Guideline (mg/kg)***	***Concentration to Guideline Ratio***
Aldehydes			
Acrolein	0.000000008	--	--
Acetaldehyde	0.00000006	--	--
Formaldehyde	0.00000002	--	--
PAHs			
Acenaphthene	0.000002	3,900	0.0000000005
Acenaphthylene	0.00001	--	--
Benz(a)anthracene	0.0006	1.6	0.0004
Benzo(b,j,k)fluoranthene	0.0006	0.16	0.004
Benzo(a)pyrene	0.002	1.7	0.001
Benzo(g,h,i)perylene	0.003	32	0.00009
Chrysene	0.003	10	0.0003
Dibenz(a,h)anthracene	0.0003	1.1	0.0003
Fluoranthene	0.001	3,500	0.0000003
Fluorene	0.00004	2,700	0.00000002
Indeno(1,2,3-cd)pyrene	0.002	13	0.0002
Phenanthrene	0.0007	--	--
Carcinogenic PAHs (as B(a)P TEQ)	0.006	IACR<1.0	0.006
Metals/metalloids			
Antimony	0.003	--	--
Arsenic	0.0003	21	0.00001
Barium	0.03	--	--
Cadmium	0.0004	14	0.00003
Copper	0.002	1,100	0.000002
Indium	0.001	--	--
Lanthanum	0.002	--	--
Lead	0.01	140	0.00007
Nickel	0.001	200	0.000005
Palladium	0.0006	--	--
Silver	0.002	--	--
Tin	0.0006	--	--

8.0 UNCERTAINTY

The intent of the SLHHRA is to evaluate the potential health risks associated with the Project based on the available data and the existing state of knowledge, without underestimating the potential risks to human health. Due to the predictive nature of human health risk assessments, uncertainty is inherent in these types of assessments.

Some of the sources of uncertainty that surround the risk estimates relate to:

- air quality predictions for the construction emissions
- absence of health-based exposure limits for some of the COPC
- absence of health-based soil quality guidelines for some of the COPC
- lack of baseline air quality information

- lack of measured soil concentrations

The ground-level air concentrations of the COPC were estimated using the AERSCREEN model. This model generates site-specific worst-case (conservative) data and is considered suitable for the purposes of a screening level HHRA. The equipment emissions estimates are conservative as it was assumed that all heavy construction equipment would be operating for 12 hours per day, 6 days per week for the duration of the construction period.

Limited to no toxicity information is available for some of the COPC. As a result, health-based exposure limits or soil quality guidelines are not available for these COPC, and the associated health risks cannot be conclusively determined. In spite of this, the predicted air quality concentrations and soil concentrations for these COPC are low enough that the Project's contribution to their presence in the environment would not be measurable. For this reason, the health risks associated with these COPC are determined to be low.

Due to the scope of the application, air quality predictions were not provided for a Baseline Case. In addition, there is no ambient data available for the Town of Canmore that can be used in the SLHHRA. Similarly, there are no measured site-specific soil concentrations available for the COPC. Considering that the predicted air concentrations and soil concentrations for the Project are generally orders of magnitude below their respective exposure limits and soil quality guidelines, the addition of baseline data is not expected to change the overall findings of the SLHHRA.

9.0 CONCLUSIONS

The potential health risks associated with the construction emissions of the Project were assessed using a screening level human health risk assessment approach. Both short-term and long-term inhalation health risks were determined by comparing maximum predicted ground-level air concentrations to health-based exposure limits. Health risks associated with secondary pathways of exposure were determined by comparing maximum predicted soil concentrations to provincial health-based soil quality guidelines. In all cases, predicted air concentrations were less than their exposure limits. Similarly, in all cases, predicted soil concentrations for COPC were less than their soil quality guidelines. In light of the conservative nature of the assessment and the predicted risk estimates, the Project's construction emissions are not expected to have an adverse effect on the health of the area residents.

10.0 REFERENCES

AEP (Alberta Environment and Parks) 2016. Alberta Tier 1 Soil and Groundwater Remediation Guidelines. ISBN: 978-1-4601-2695. February 2, 2016.

Alberta Health 2011. Guidance on Human Health Risk Assessment for Environmental Impact Assessment in Alberta. August 2011.

Boethling R., K. Fenner, P. Howard, G. Klečka, T. Madsen, J.R. Snape and M.J. Whelan. 2009. "Environmental persistence of organic pollutants: guidance for development and review of POP risk profiles." Integr. Environ. Assess. Manag. 5(4):539-556.

Environment Canada. 2003. Guidance Manual for the Categorization of Organic and Inorganic Substances on Canada's Domestic Substances List. Determining persistence, bioaccumulation potential, and inherent toxicity to non-human organisms. Existing Substances Branch, Environment Canada. June 2003.

Health Canada. 2012. Federal Contaminated Site Risk Assessment in Canada. Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA), Version 2.0. Prepared by Contaminated Sites Division Safe Environments Program. Draft for Comment. 2010, revised 2012. ISBN: 978-1-100-1761-0 Cat.: H128-1/11-632E-PDF.

Mackay D., W.C. Shiu and K.C. Ma. 1992. Illustrated Handbook of Physical-Chemical Properties and Environmental Fate for Organic Chemicals: Volumes I-IV. Lewis Publishers. Chelsea, Michigan.

Mackay D., W.C. Shiu and K.C. Ma. 1993. Illustrated Handbook of Physical-Chemical Properties and Environmental Fate for Organic Chemicals: Volume III. Lewis Publishers. Chelsea, Michigan.

SRC (Syracuse Research Corporation). 2013. FatePointers Search Module. Available at: http://esc.syrres.com/fatepointer/search.asp. Accessed: September 2016.

US EPA. 2002. A Review of the Reference Dose and Reference Concentration Processes. Final Report. US EPA Risk Assessment Forum, Washington, DC. EPA/630/P 02/002F, December 2002.

US EPA. 2003. Attachment 1-3 Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs) Evaluation of Dermal Contact and Inhalation Exposure Pathways for the Purpose of Setting Eco-SSLs. OSWER Directive 92857-55. November 2003.

US EPA. 2012. Estimation Program Interface Suite™ for Microsoft® Windows, v 4.11. United States Environmental Protection Agency, Washington, D.C., USA.

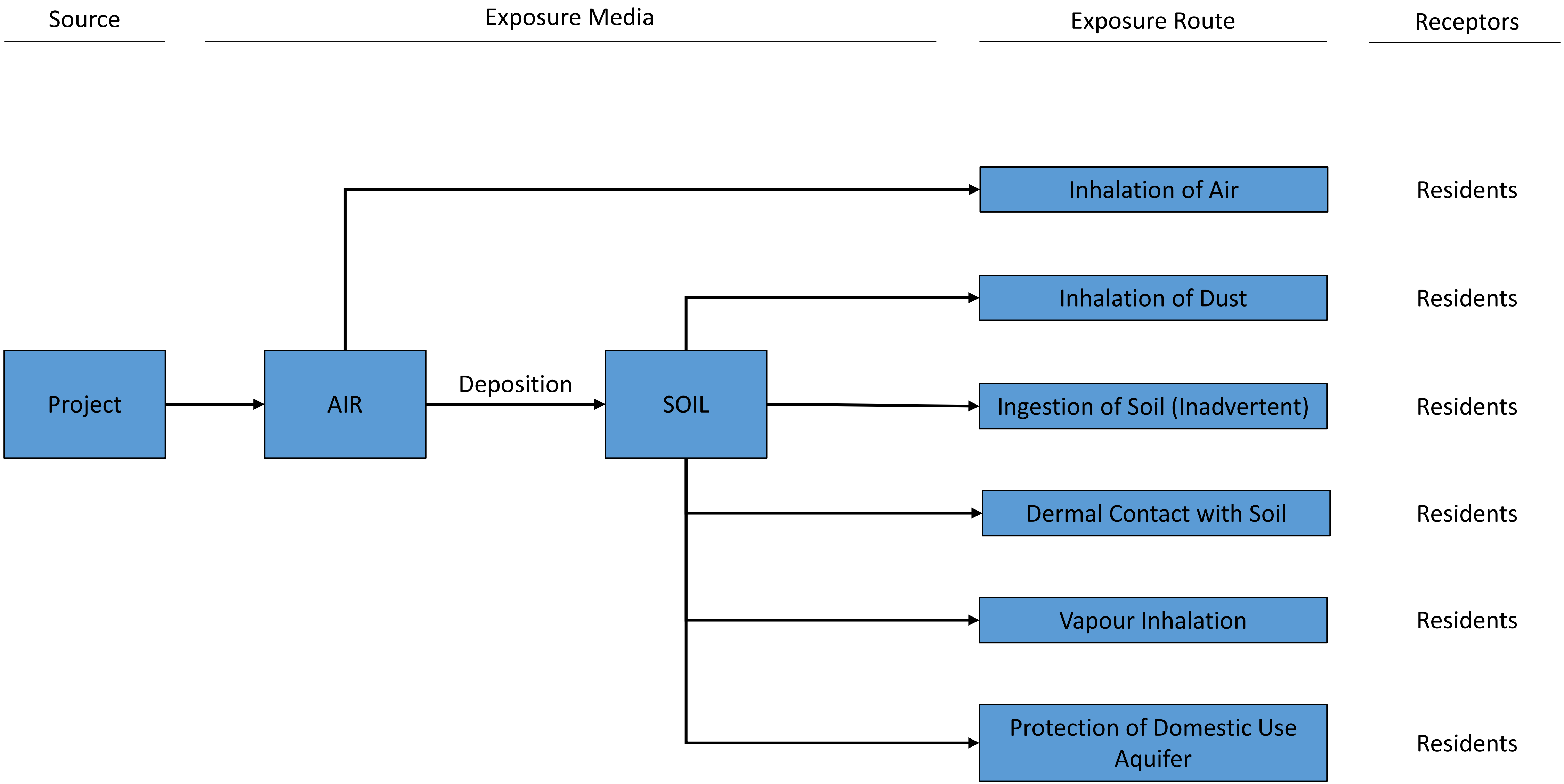


Figure 3-1 Conceptual Site Model

Attachment A

Worked Example

WORKED EXAMPLE

In order to quantify potential human exposures (and associated health impacts) as a result of emissions from the construction of the Cougar Creek debris flood retention structure (the Project), predicted chemical concentrations in soil were required to estimate exposures and characterize risks. Chemical concentrations in soil were estimated using a soil deposition model. The following worked example is presented for formaldehyde at a distance of 450 m from the Project.

Chemical Concentrations in Air

Table 1 presents the formaldehyde air concentration that was used in the worked example to estimate soil concentrations. Maximum annual average air concentrations at a distance of 450 m from the Project were used for the soil deposition model.

Table 1 Formaldehyde Air Concentration used in the Worked Example

Distance from Source	*Concentration (µg/m^3)*	*Comment*
450 m	2.50E-01	Based on maximum annual average at 450 m from the Project

Chemical Deposition

Atmospheric deposition is based on two forms of deposition (i.e., dry and wet) and two chemical phases (i.e., vapour and particulate). The US EPA OSW (2005) recommends calculating chemical deposition based on the following four air model output parameters:

1. Dydv = Unitized yearly average dry deposition from vapor phase (mass/m^2-yr)
2. Dywv = Unitized yearly average wet deposition from vapor phase (mass/m^2-yr)
3. Dydp = Unitized yearly average dry deposition from particle phase (mass/m^2-yr)
4. Dywp = Unitized yearly average wet deposition from particle phase (mass/m^2-yr)

Predicted deposition was simplified by combining the dry vapour and dry particulate phases and combining the wet vapour and wet particle phases since the same deposition rate was applied to both forms and the calculation can be reduced.

A description of the predicted dry and wet chemical deposition is provided below.

Dry Deposition

Dry deposition rates were estimated with the following equation:

$$D_{dry} = C_a \times V_d \times CF1 \times CF2$$

Where:

D_{dry} = deposition rate of COPC (mg/m^2/yr)
C_a = COPC concentration in air (µg/m^3)
V_d = dry deposition velocity for COPC (5.0E-03 m/s, extrapolated from US EPA OSW 2005)
CF1 = conversion factor from seconds per day (31,536,000 sec/year)
CF2 = conversion factor from µg to mg (0.001 mg/µg)

Example 1 Dry deposition rate of formaldehyde

$$D_{dry} = 2.50E\text{-}0.1 \times 5.0E\text{-}03 \times 31{,}536{,}000 \times 0.001$$

$$D_{dry} = 3.94E{+}0.1\ mg/m^2\ /yr$$

Wet Deposition

Wet deposition rates were estimated with the following equation:

$$D_{wet} = C_a \times V_w \times CF1 \times CF2$$

Where:

D_{wet} = deposition rate of COPC (mg/m²/yr)
C_a = COPC concentration in air (µg/m³)
V_w = wet deposition velocity for COPC (4.05E-03 m/s, extrapolated from Mackay 1991)
CF1 = conversion factor from seconds per day (31,536,000 sec/year)
CF2 = conversion factor from µg to mg (0.001 mg/µg)

Example 2 Wet deposition rate of formaldehyde

$$D_{wet} = 2.50E\text{-}01 \times 4.05E\text{-}03 \times 31{,}536{,}000 \times 0.001$$

$$D_{wet} = 3.20E{+}01\ mg/m^2/yr$$

Total Deposition

Total deposition rates were estimated with the following equation:

$$D_{tot} = D_{dry} + D_{wet}$$

Where:

D_{tot} = deposition rate of COPC (mg/m²/yr)
D_{dry} = dry deposition (mg/m²/yr)
D_{wet} = wet deposition (mg/m²/yr)

Example 3 Total deposition rate of formaldehyde

$$D_{tot} = 3.94E{+}01 + 3.20E{+}01$$

$$D_{tot} = 7.14E{+}01\ mg/m^2/yr$$

Chemical Concentrations in Soil

Predicted Chemical Concentrations in Soil

Soil concentrations were estimated based on the calculated chemical-specific deposition rates. Deposition to soil on a mass basis was calculated using the following equation:

$$D_s = \frac{D_{tot}}{Z_s \times BD}$$

Where:

D_s = chemical-specific deposition (mg/kg/yr)
D_{tot} = chemical-specific deposition rate (mg/m^2/yr)
Z_s = soil mixing zone depth (m)

BD = soil bulk density (kg/m³)

For the current assessment, the bulk density was assumed to be 1,500 kg/m³, and soil concentrations were predicted for two mixing depths (i.e., 2 cm and 20 cm) to calculate surface soil and soil concentrations, respectively.

Example 4 Deposition of formaldehyde to surface soil

$$D_s = \frac{7.14E+01}{0.02 \times 1.500}$$

$$D_s = 2.38E+00 \text{ mg/kg/yr}$$

Example 5 Deposition of formaldehyde to soil

$$D_s = \frac{7.14E+01}{0.2 \times 1,500}$$

$$D_s = 2.38E-01 \text{ mg/kg/yr}$$

<u>*Calculating Chemical Loss Constants*</u>

Chemicals may be lost from soil by leaching, runoff, erosion, biotic and abiotic degradation and volatilization. Only abiotic and biotic degradation and volatilization processes were considered for this assessment. The total rate at which a chemical is lost from soil was designated as *kt*.

Chemical Loss via Biotic and Abiotic Degradation

The soil half-life values for abiotic and biotic degradation (i.e., *ks*) were obtained from the US EPA OSW (2005). The US EPA OSW (2005) recommends a soil loss constant (*ks*) of 36 yr^{-1} for formaldehyde.

Chemical Loss via Volatilization

Chemical loss from volatilization was predicted as follows (Swan et al. 1979):

$$t_{1/2} = 1.58E-08 \times \left(\frac{K_{oc} \times S}{VP}\right)$$

Where:

$t_{1/2}$ = soil half-life (days)

K_{oc} = organic carbon partition coefficient (L/kg)

S = water solubility (mg/L)

VP = vapour pressure (mmHg)

The half-life is then converted to a rate constant (yr^{-1}) using the following equation:

$$kv = \frac{0.693}{\left({}^{t_{1/2}}/_{365}\right)}$$

Example 6 *Chemical loss or degradation from soil as a result of volatilization of formaldehyde*

Soil half-life:

$$t_{1/2} = 1.58E\text{-}08 \times \left(\frac{1.00E{+}00 \times 4.00E{+}05}{3.89E{+}03}\right)$$

$$t_{1/2} = 1.62\text{-}06 \text{ days}$$

Loss as a result of volatilization:

$$kv = \frac{0.693}{\left(1.62E\text{-}06/_{365}\right)}$$

$$kv = 1.56E{+}08 \text{ yrs}^{-1}$$

Total Soil Loss Constant

$$kt = ks + kv$$

Where:

kt = chemical-specific soil loss constant as a result of all processes (yrs^{-1})

ks = chemical-specific soil loss constant as a result of abiotic and biotic degradation (yrs^{-1})

kv = chemical-specific soil loss constant as a result of volatilization (yrs^{-1})

Example 7 *Total soil loss constant as a result of all processes for formaldehyde*

$$kt = 3.60E{+}01 + 1.56E{+}08$$

$$kt = 1.56E{+}08 \text{ yrs}^{-1}$$

Calculation of Soil Concentrations

Soil concentrations were calculated on a mass per mass basis (mg/kg) based on the following equation:

$$C_s = \frac{D_s \times [1\text{-exp }(\text{-}kt \times tD)]}{kt}$$

Where:

C_s = average soil concentration over exposure duration (mg/kg soil)

D_s = deposition to surface soil or soil (mg of chemical/kg of soil/yr)

kt = chemical soil loss constant due to all processes (degradation or loss due to volatilization) (yr^{-1})

tD = time period over which deposition occurs (yr)

Project construction is anticipated to take 2.5 years.

Example 8 *Concentration of formaldehyde in surface soil*

$$C_s = \frac{2.38E{+}00 \times [1\text{- exp }(\text{-}1.56E{+}08 \times 2.5}{1.56E{+}08}$$

$$C_s = 1.53E\text{-}08 \text{ mg/kg}$$

Same calculation as above

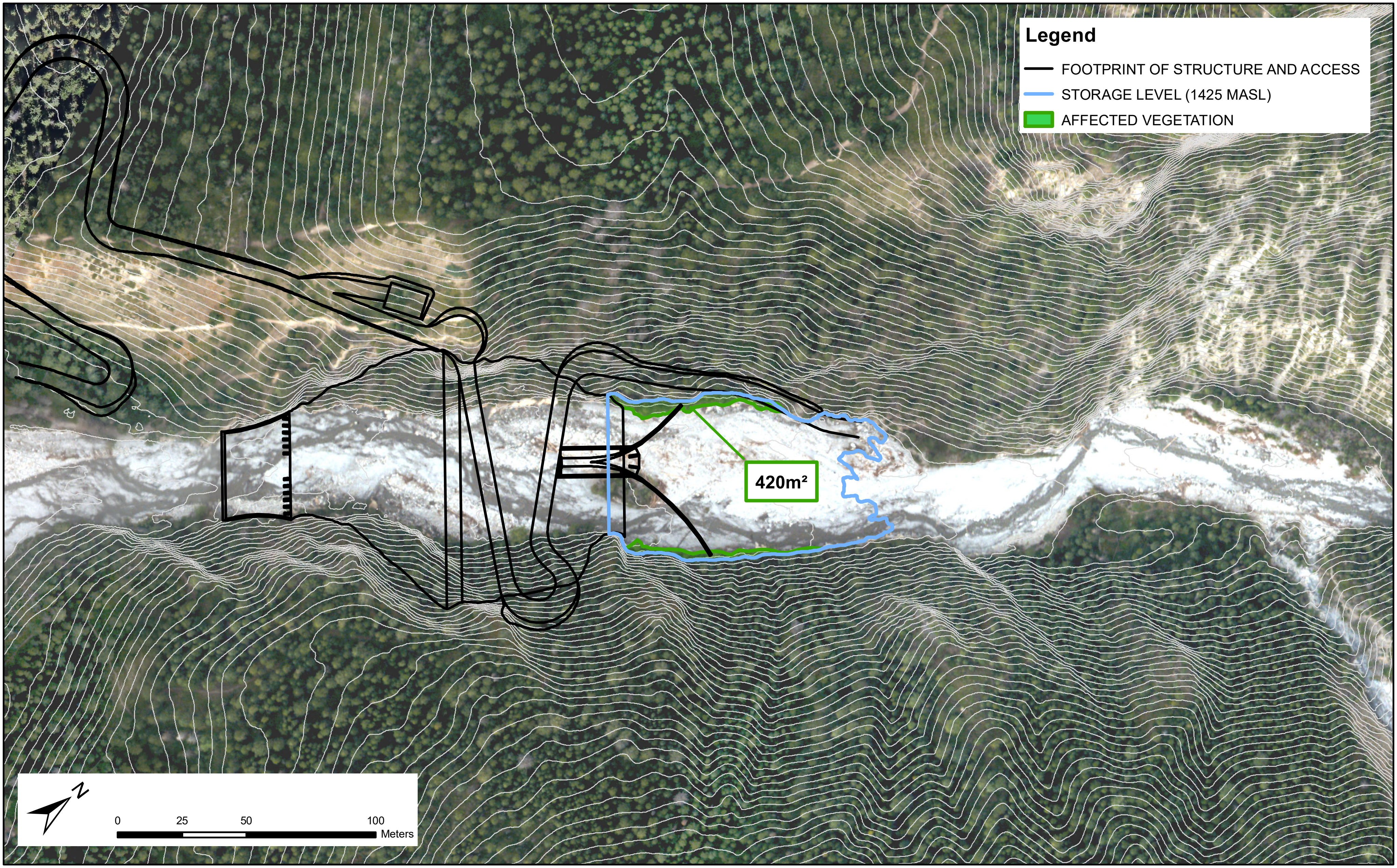
Example 9 Concentration of formaldehyde in soil

$$C_s = \frac{2.38E\text{-}01 \times [1\text{-}\exp(-1.56E{+}08 \times 2.5)]}{1.56E{+}08}$$

$$C_S = 1.53E\text{-}09 \text{ mg/kg}$$

Appendix 169-1

Test Storage Maps



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DESIGN:	MSc/DPo
REVIEW:	MSc
APPROVED:	

PROFESSIONAL SEAL:

APEGA PERMIT NUMBER:
13440

CLIENT:
Town of CANMORE

ENGINEERING:
CANADIAN HYDROTECH CORPORATION

PROJECT:
COUGAR CREEK
DEBRIS FLOOD RETENTION STRUCTURE
ISSUED FOR PERMITTING

CONTENT: PLAN VIEW
TEST STORAGE - IMPOUNDMENT
IMPOUNDED AREA AND AFFECTED VEGETATION
TEST STORAGE LEVEL AT 1425 MASL/1h 08m

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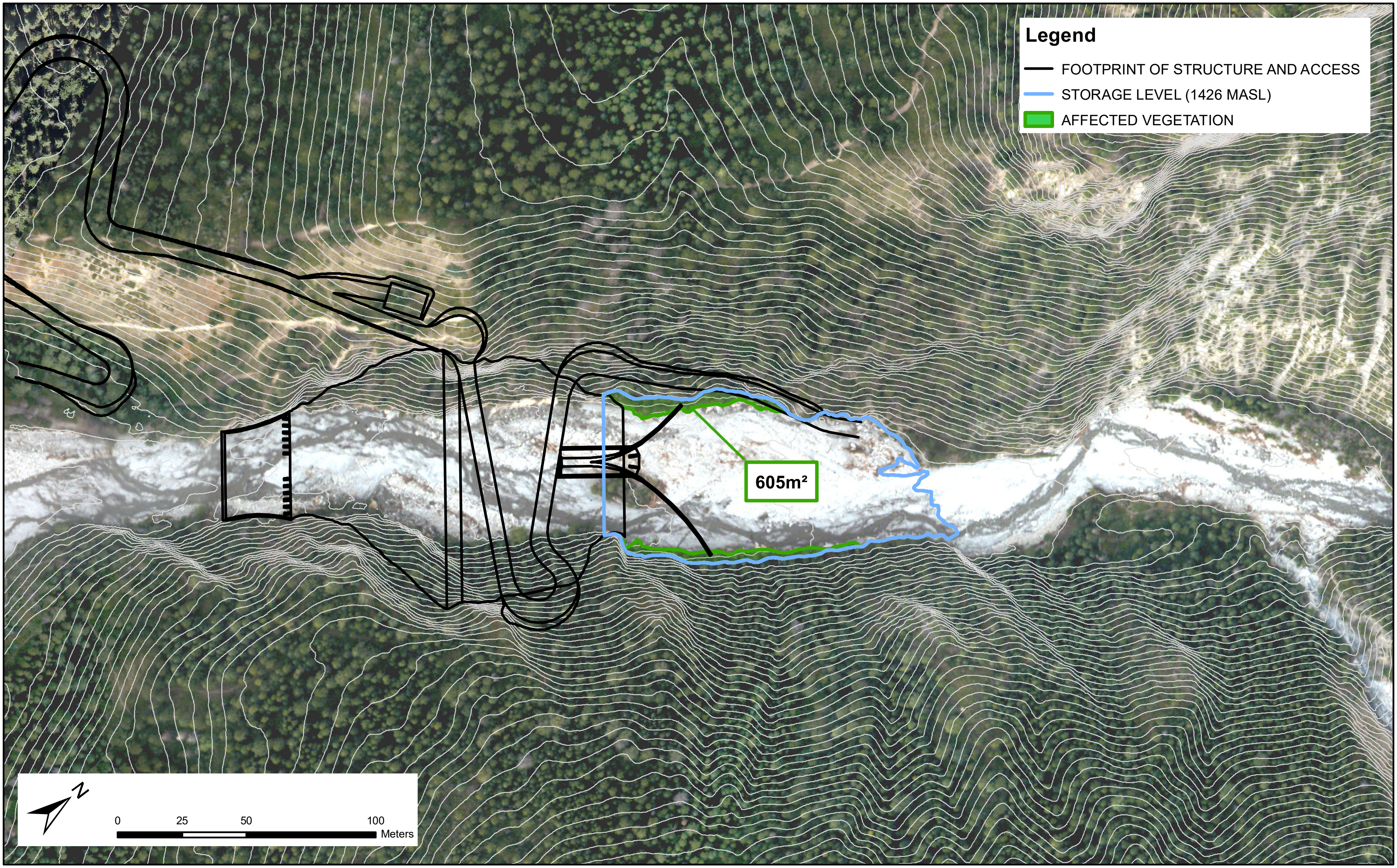

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REVIEW: MSc

APPROVED:

PROFESSIONAL SEAL:

APEGA PERMIT NUMBER: 13440

CLIENT:

Town of CANMORE

ENGINEERING:

CANADIAN HYDROTECH CORPORATION

PROJECT:

COUGAR CREEK
DEBRIS FLOOD RETENTION STRUCTURE
ISSUED FOR PERMITTING

CONTENT: PLAN VIEW

TEST STORAGE - IMPOUNDMENT
IMPOUNDED AREA AND AFFECTED VEGETATION
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DRAWING No.:

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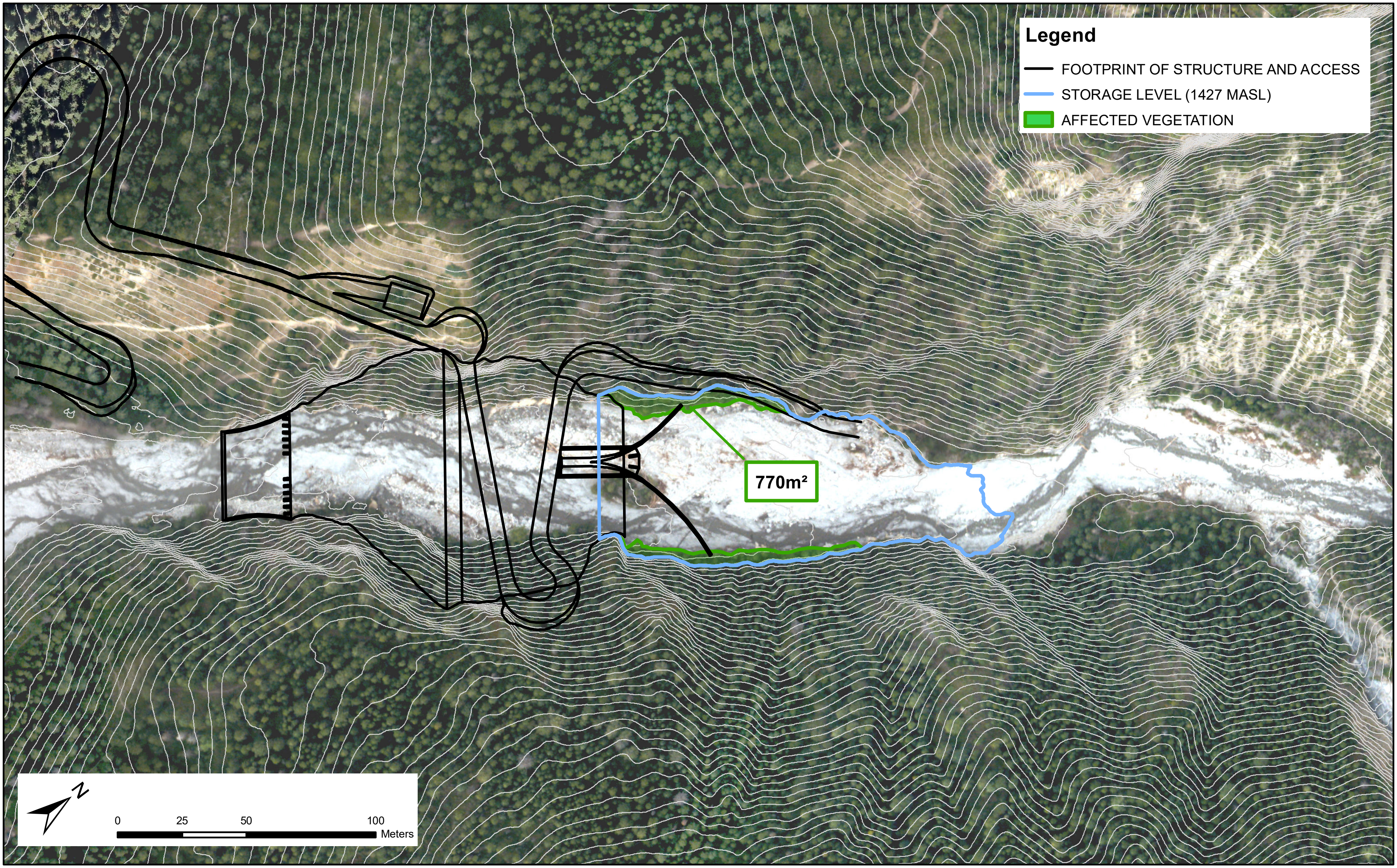

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DESIGN: MSc/DPo

REVIEW: MSc

APPROVED:

PROFESSIONAL SEAL:

APEGA PERMIT NUMBER: 13440

CLIENT:

Town of CANMORE

ENGINEERING:

CANADIAN HYDROTECH CORPORATION

PROJECT:

COUGAR CREEK
DEBRIS FLOOD RETENTION STRUCTURE
ISSUED FOR PERMITTING

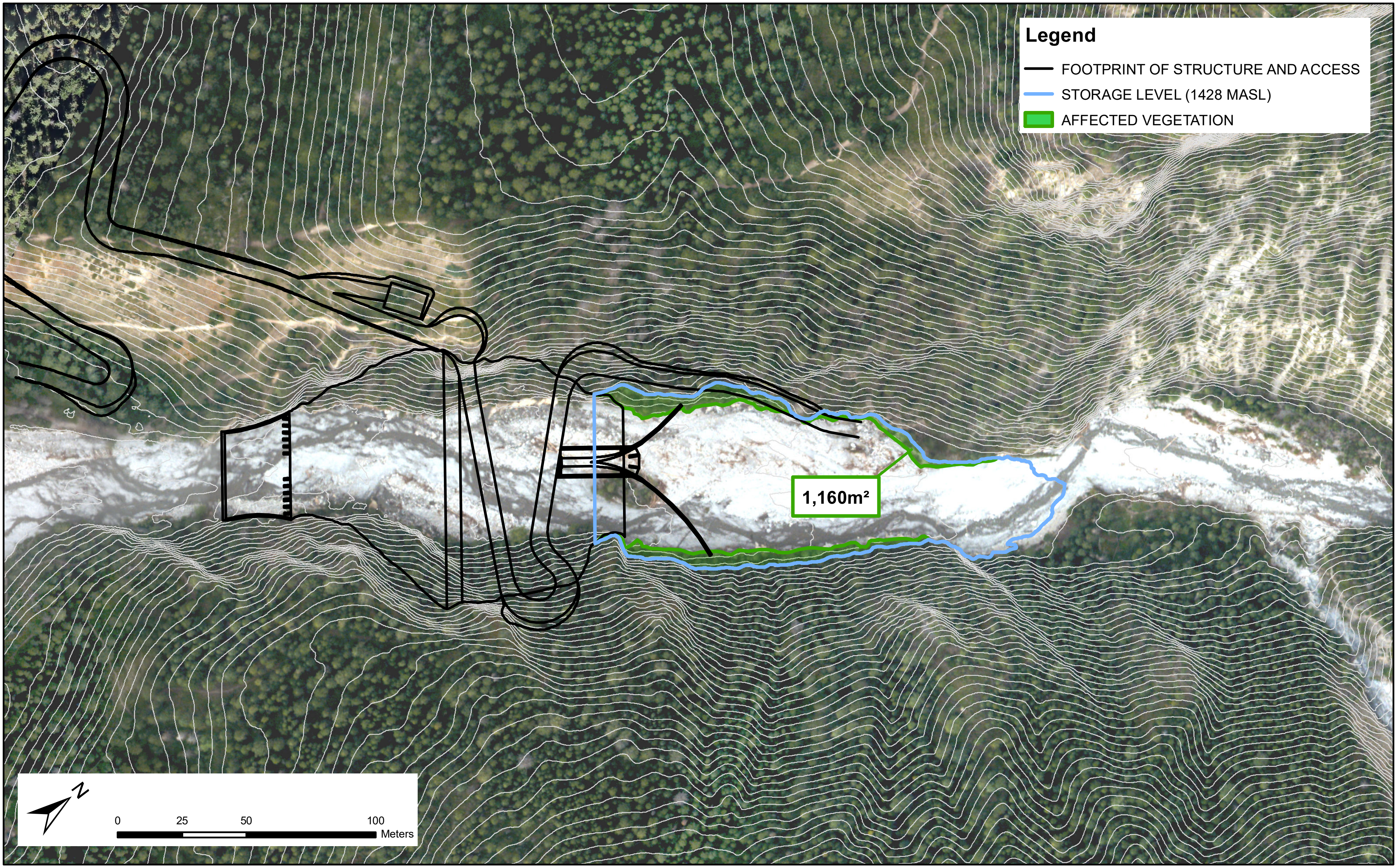
CONTENT: PLAN VIEW

TEST STORAGE - IMPOUNDMENT
IMPOUNDED AREA AND AFFECTED VEGETATION
TEST STORAGE LEVEL AT 1427 MASL/3h 39m

PROJECT No.: 16494

DRAWING No.:

REV: 00



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DATE: 2016/10/12

DRAWING: DPo

DESIGN: MSc/DPo

REVIEW: MSc

APPROVED:

PROFESSIONAL SEAL:

APEGA PERMIT NUMBER: 13440

CLIENT:

Town of CANMORE

ENGINEERING:

CANADIAN HYDROTECH CORPORATION

PROJECT:

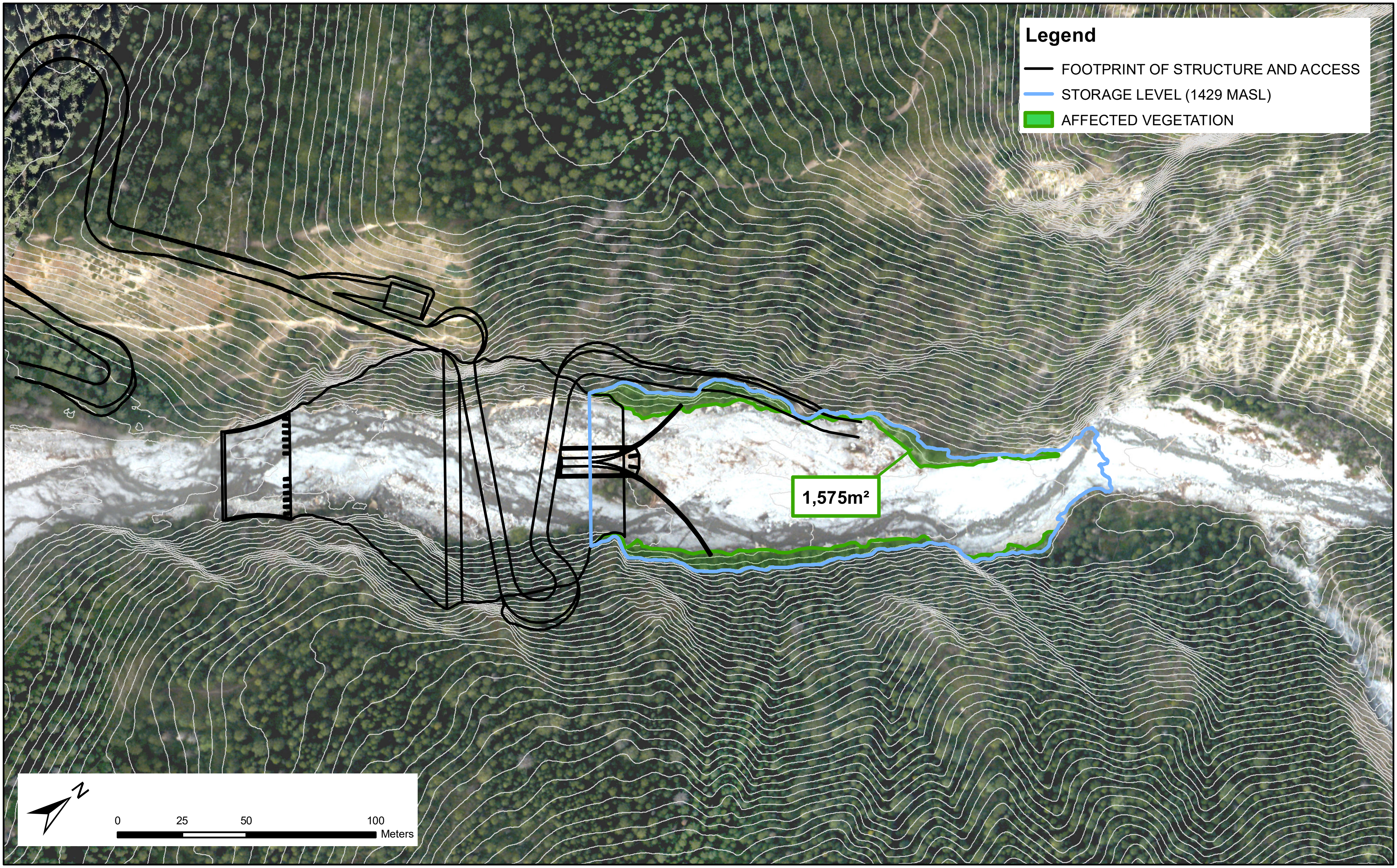
COUGAR CREEK
DEBRIS FLOOD RETENTION STRUCTURE
ISSUED FOR PERMITTING

CONTENT: PLAN VIEW
TEST STORAGE - IMPOUNDMENT
IMPOUNDED AREA AND AFFECTED VEGETATION
TEST STORAGE LEVEL AT 1428 MASL/5h 39m

PROJECT No.: 16494

DRAWING No.:

REV: 00



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SCALE: 1:2,000

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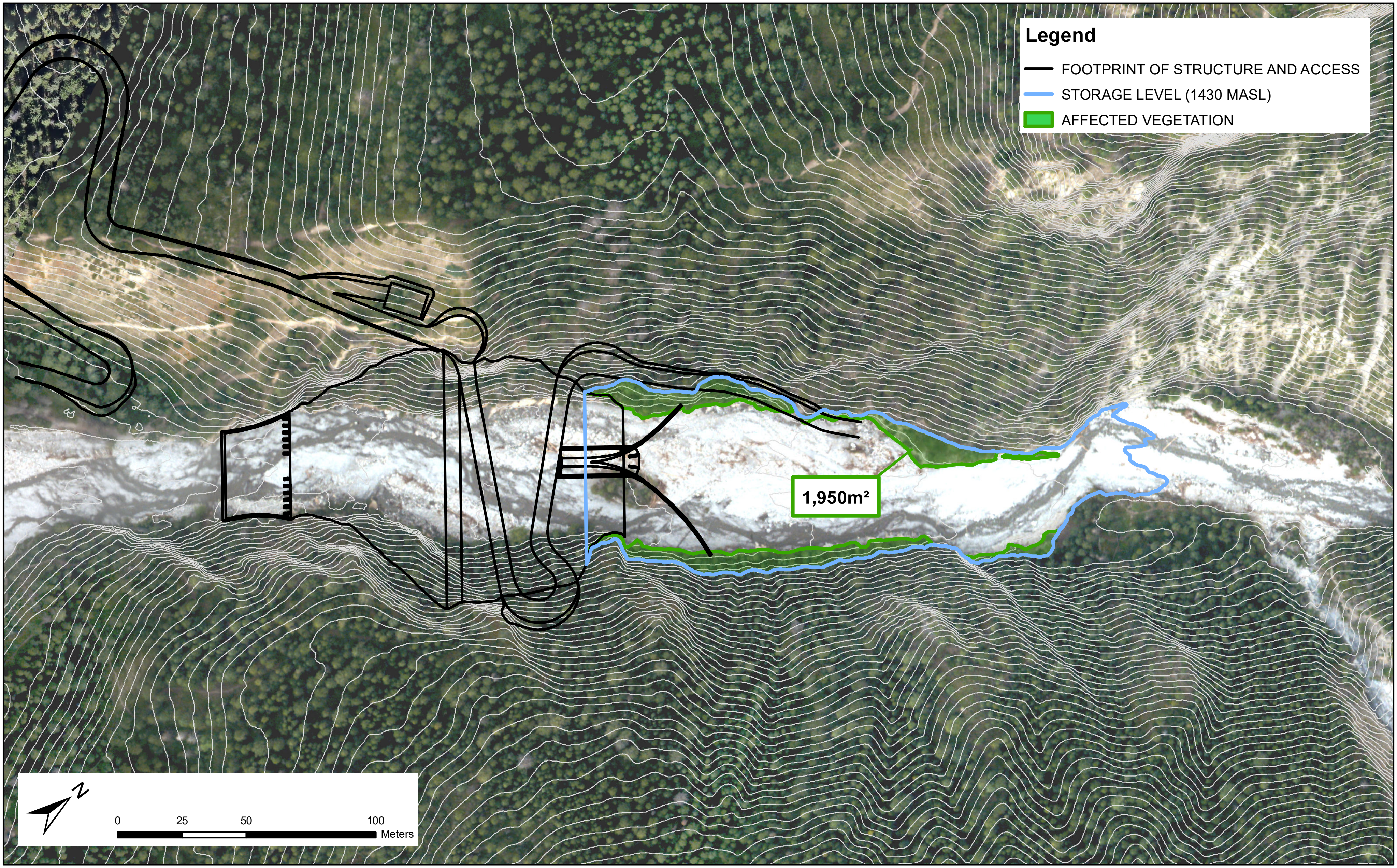
PROJECT:
COUGAR CREEK
DEBRIS FLOOD RETENTION STRUCTURE
ISSUED FOR PERMITTING

CONTENT: PLAN VIEW
TEST STORAGE - IMPOUNDMENT
IMPOUNDED AREA AND AFFECTED VEGETATION
TEST STORAGE LEVEL AT 1429 MASL/8h 12m

PROJECT No.: 16494

DRAWING No.:

REV: 00



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PROJECT:

COUGAR CREEK
DEBRIS FLOOD RETENTION STRUCTURE
ISSUED FOR PERMITTING

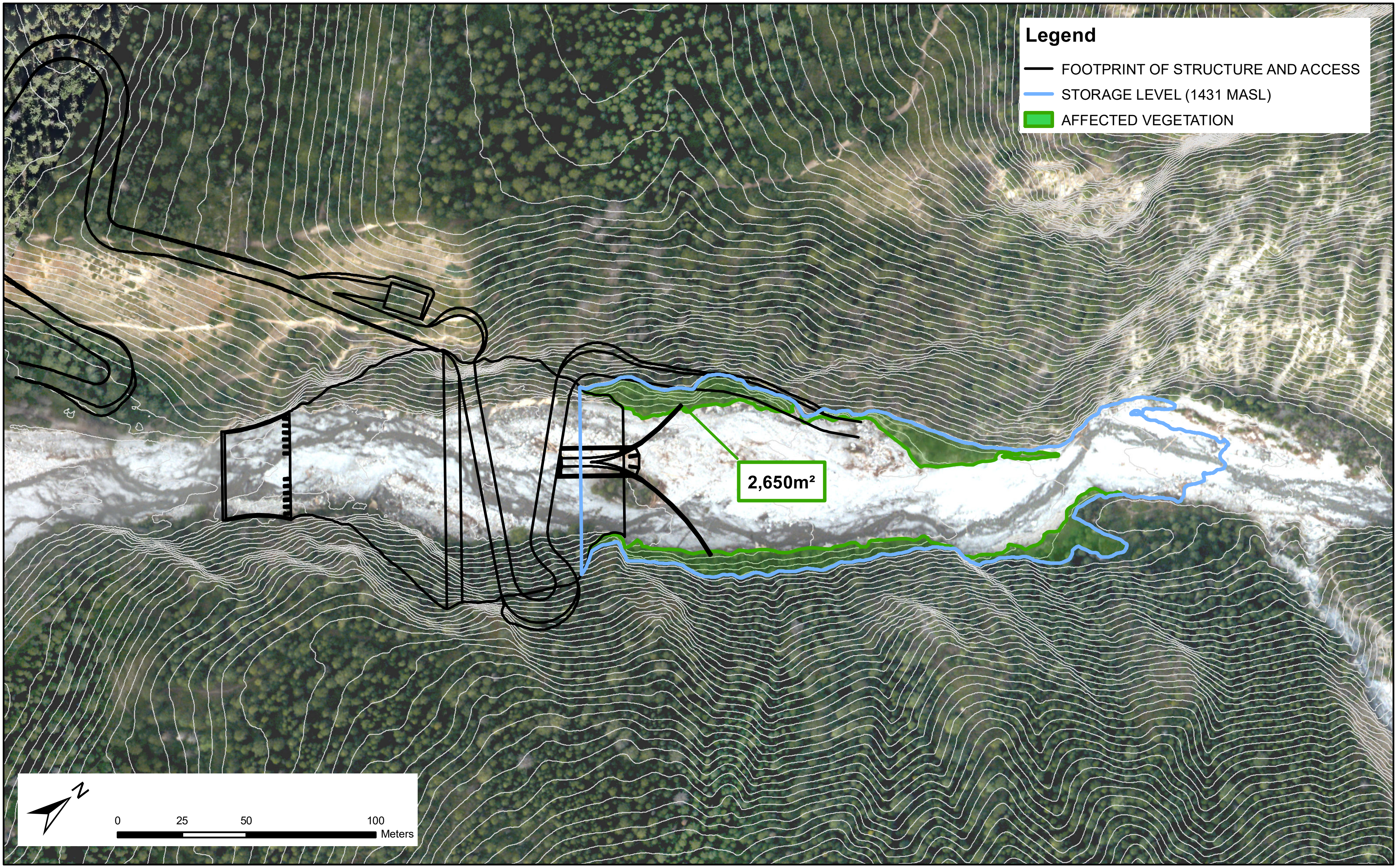
CONTENT: PLAN VIEW

TEST STORAGE - IMPOUNDMENT
IMPOUNDED AREA AND AFFECTED VEGETATION
TEST STORAGE LEVEL AT 1430 MASL/11h 24m

PROJECT No.: 16494

DRAWING No.:

REV: 00



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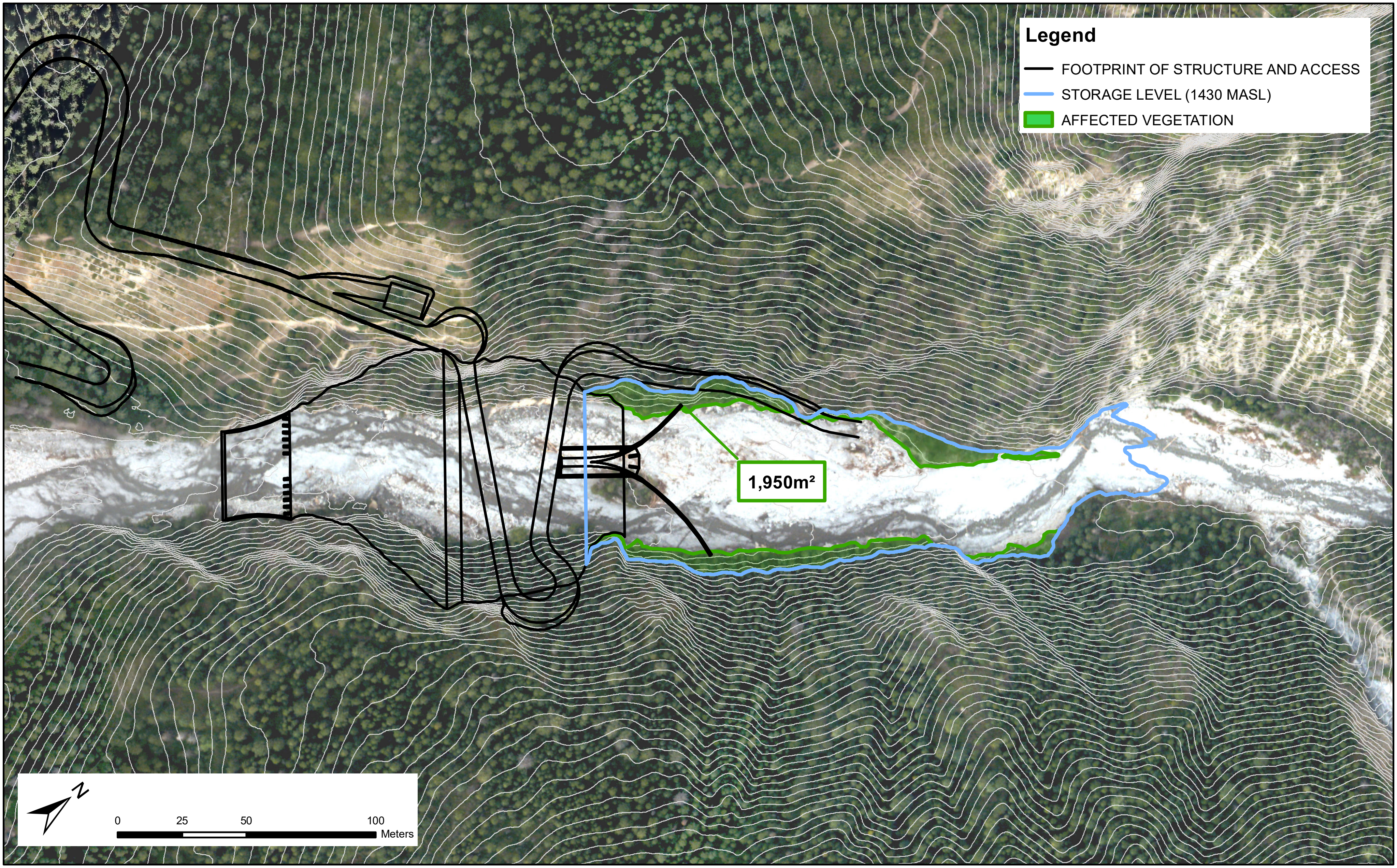
PROJECT:
COUGAR CREEK
DEBRIS FLOOD RETENTION STRUCTURE
ISSUED FOR PERMITTING

CONTENT: PLAN VIEW
TEST STORAGE - IMPOUNDMENT
IMPOUNDED AREA AND AFFECTED VEGETATION
TEST STORAGE LEVEL AT MAXIMUM HEIGHT 1431 MASL/15h 20m

PROJECT No.: 16494
DRAWING No.:
REV: 00



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DATE: 2016/10/12

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CLIENT: Town of CANMORE

ENGINEERING: **CANADIAN HYDROTECH CORPORATION**

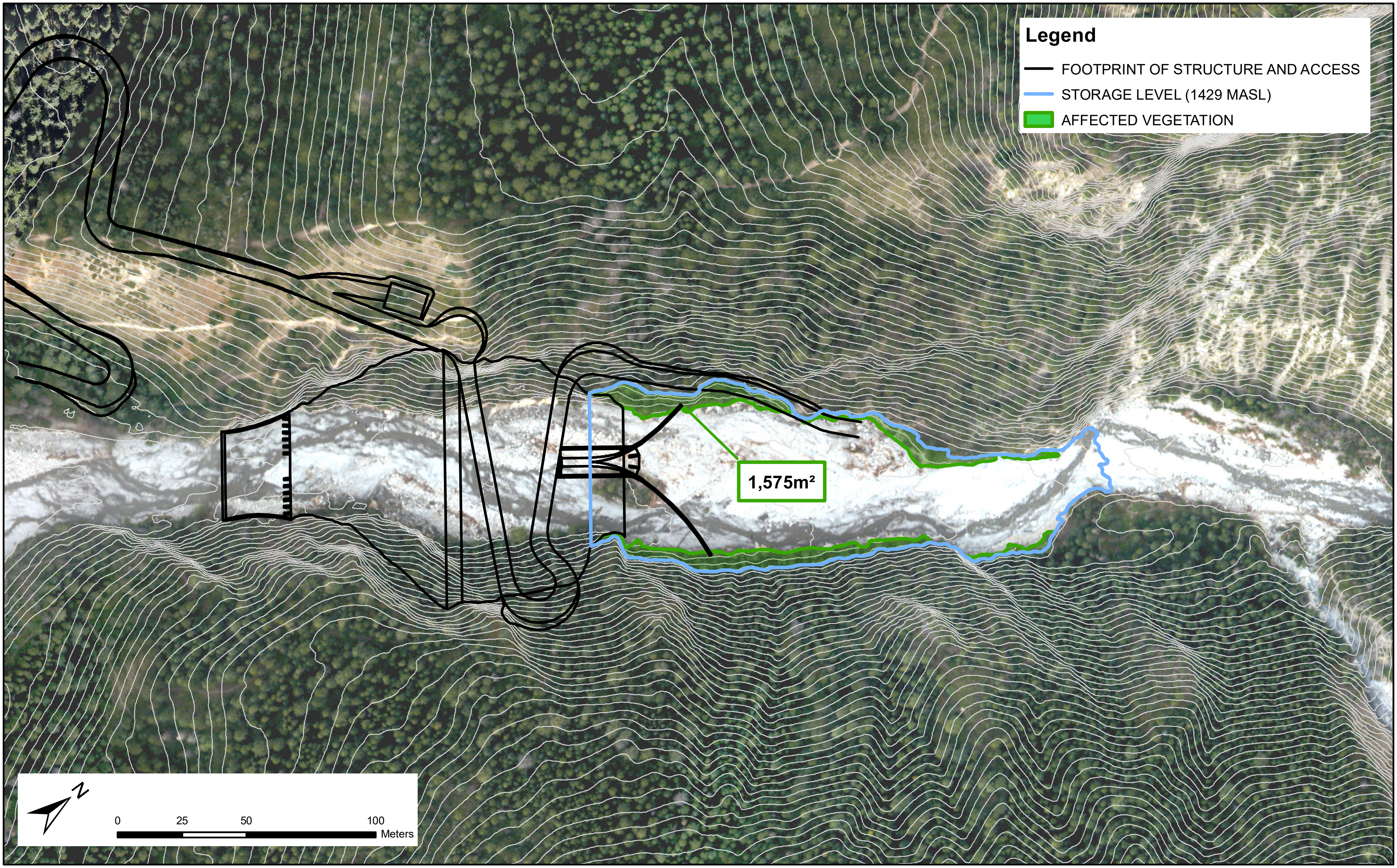
PROJECT:
COUGAR CREEK
DEBRIS FLOOD RETENTION STRUCTURE
ISSUED FOR PERMITTING

CONTENT: PLAN VIEW
TEST STORAGE - DRAWDOWN
IMPOUNDED AREA AND AFFECTED VEGETATION
TEST STORAGE LEVEL AT 1430 MASL/19h 17m

PROJECT No.: 16494

DRAWING No.:

REV: 00



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CLIENT: Town of CANMORE

ENGINEERING: **CANADIAN HYDROTECH CORPORATION**

PROJECT:

COUGAR CREEK
DEBRIS FLOOD RETENTION STRUCTURE
ISSUED FOR PERMITTING

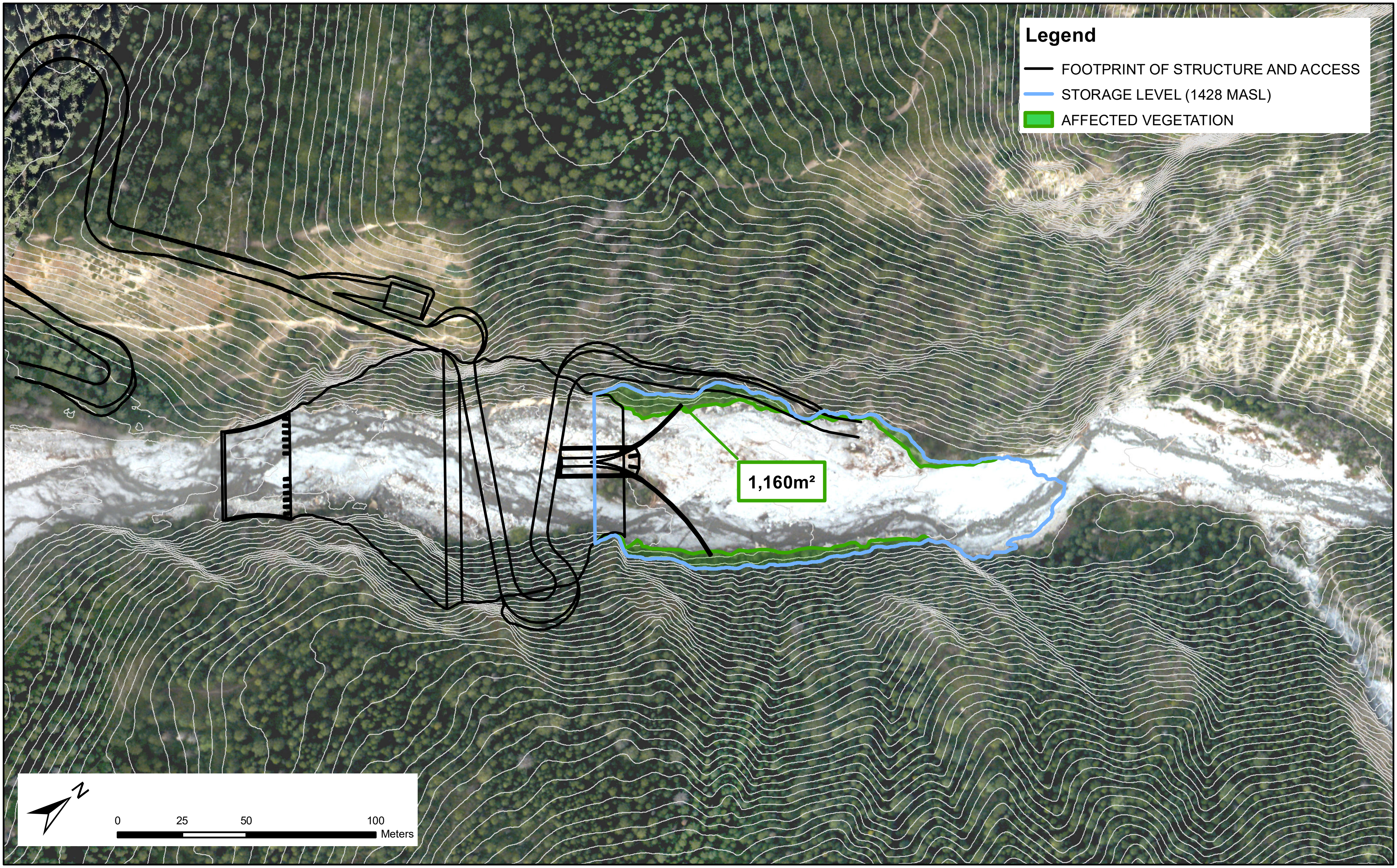
CONTENT: PLAN VIEW

TEST STORAGE - DRAWDOWN
IMPOUNDED AREA AND AFFECTED VEGETATION
TEST STORAGE LEVEL AT 1429 MASL/22h 29m

PROJECT No.: 16494

DRAWING No.:

REV: 00



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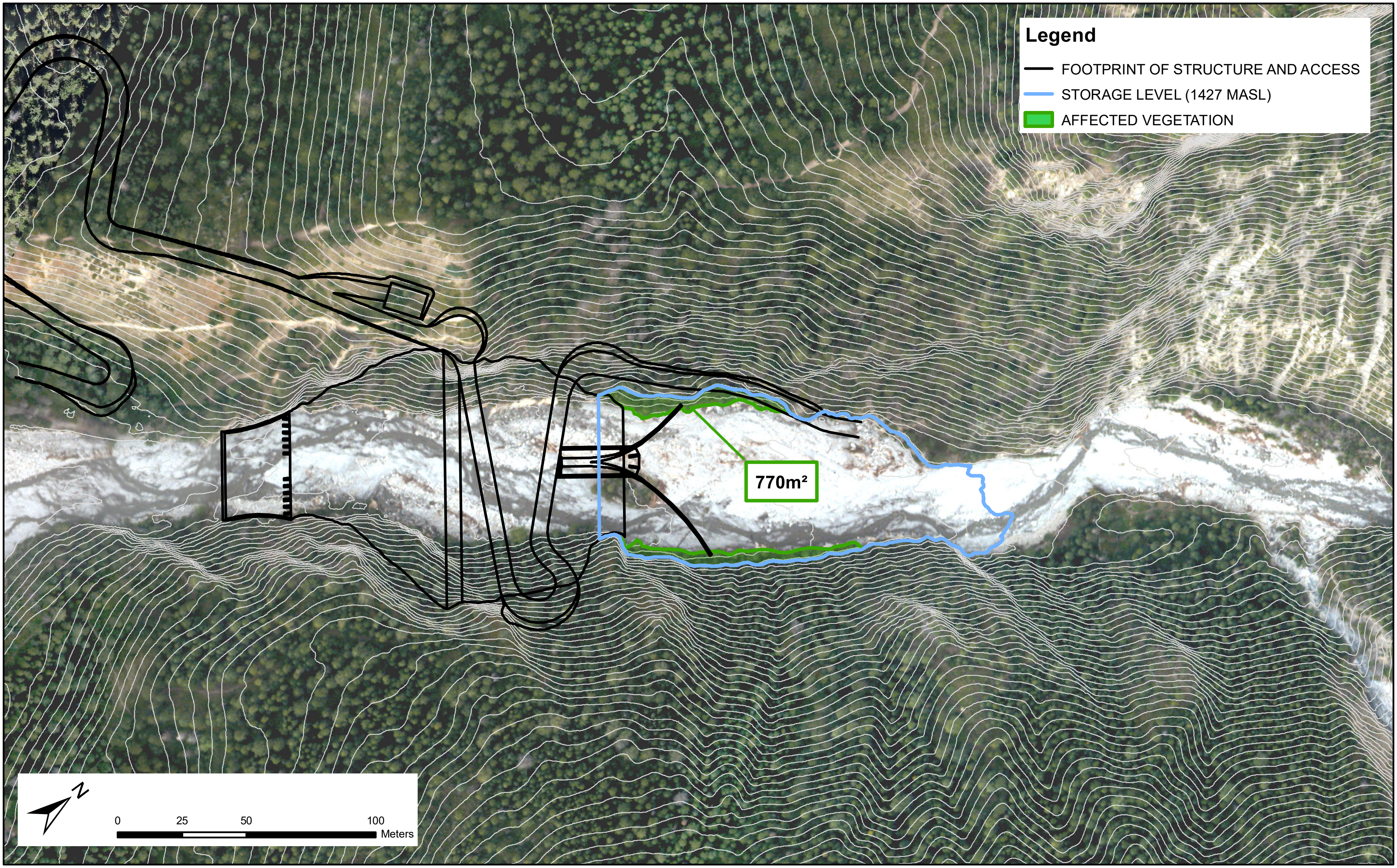
PROJECT:
COUGAR CREEK
DEBRIS FLOOD RETENTION STRUCTURE
ISSUED FOR PERMITTING

CONTENT: PLAN VIEW
TEST STORAGE - DRAWDOWN
IMPOUNDED AREA AND AFFECTED VEGETATION
TEST STORAGE LEVEL AT 1428 MASL/25h 02m

PROJECT No.:	DRAWING No.:	REV:
16494		00



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APEGA PERMIT NUMBER: 13440

CLIENT: Town of CANMORE

ENGINEERING: CANADIAN HYDROTECH CORPORATION

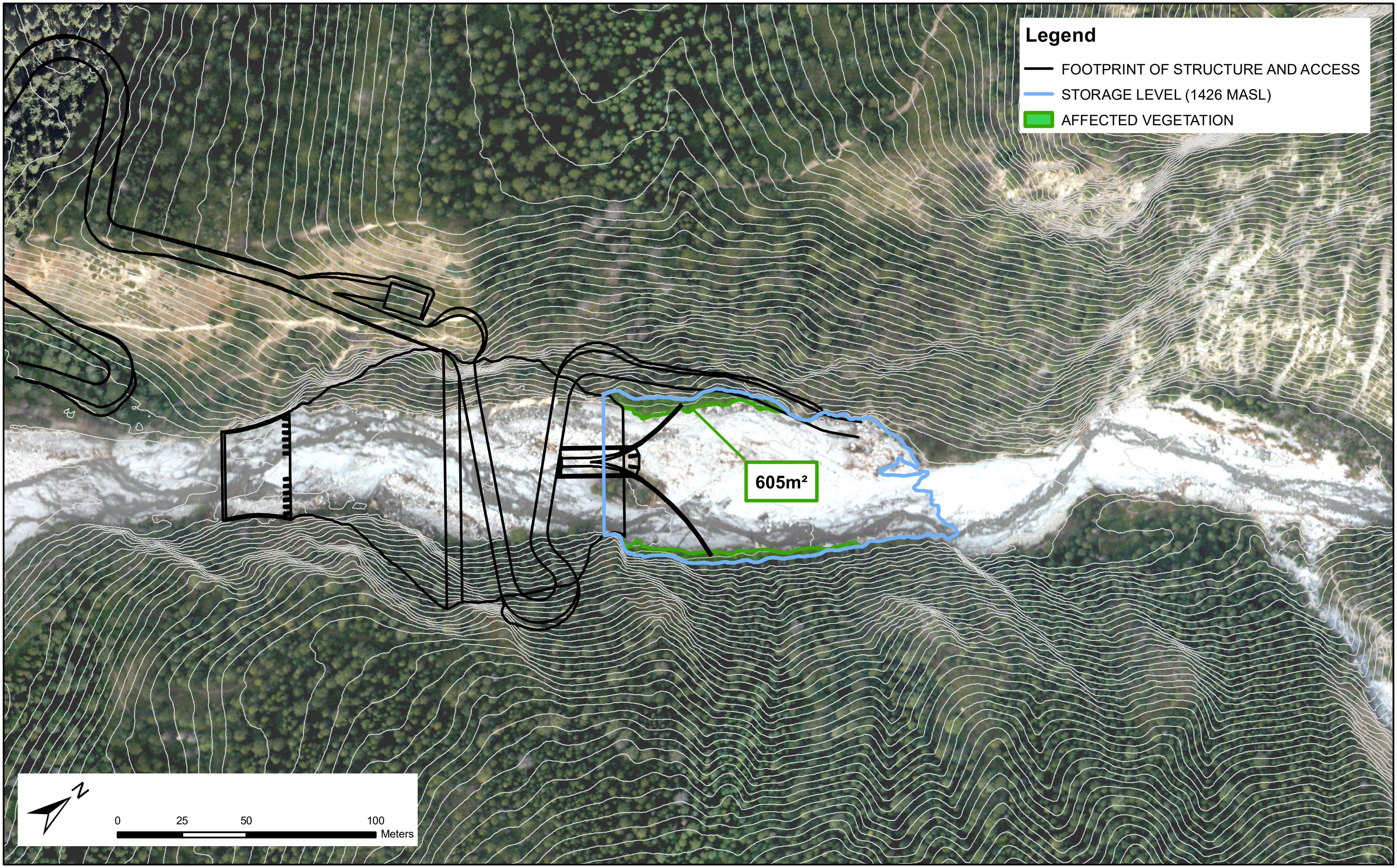
PROJECT:
COUGAR CREEK
DEBRIS FLOOD RETENTION STRUCTURE
ISSUED FOR PERMITTING

CONTENT: PLAN VIEW
TEST STORAGE - DRAWDOWN
IMPOUNDED AREA AND AFFECTED VEGETATION
TEST STORAGE LEVEL AT 1427 MASL/27h 02m

PROJECT No.: 16494

DRAWING No.:

REV: 00



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ENGINEERING: **CANADIAN HYDROTECH CORPORATION**

PROJECT:

COUGAR CREEK
DEBRIS FLOOD RETENTION STRUCTURE
ISSUED FOR PERMITTING

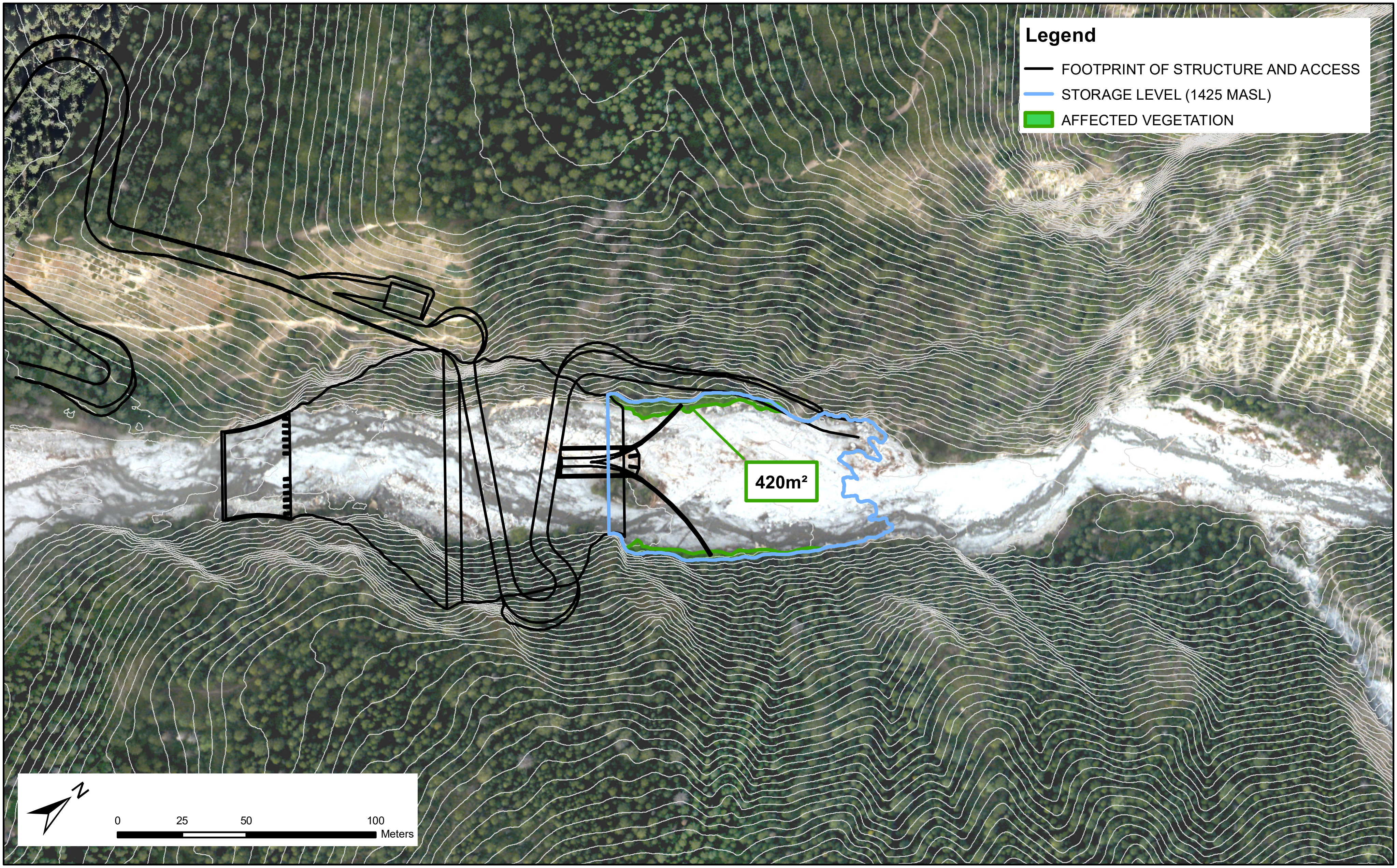
CONTENT: PLAN VIEW

TEST STORAGE - DRAWDOWN
IMPOUNDED AREA AND AFFECTED VEGETATION
TEST STORAGE LEVEL AT 1426 MASL/28h 31m

PROJECT No.: 16494

DRAWING No.:

REV: 00



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CONTENT: PLAN VIEW
TEST STORAGE - DRAWDOWN
IMPOUNDED AREA AND AFFECTED VEGETATION
TEST STORAGE LEVEL AT 1425 MASL/29h 33m

PROJECT No.: 16494

DRAWING No.:

REV: 00