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OUR FILE No. 154436 /IMO

YOUR FILE No. 80101

September 21, 2020

EMAIL TO iaac.grassymountain.aeic@canada.ca

Grassy Mountain Coal Project Joint Review Panel
c/o Canadian Environmental Assessment Agency
160 Elgin Street, 22nd Floor
Ottawa Ontario Canada K1A 0H3

Attention: Samantha Sabo, Acting Panel Manager

Dear Madam:

**Re: Benga Mining Limited/Riversdale Resources - Grassy Mountain Coal Project
AER Application Nos. 1844520 and 1902073
Impact Assessment Agency of Canada Reference No. 80101
Submissions of the Coalition of Alberta Wilderness Association and the Grassy Mountain Group**

Please find attached the submissions of the Coalition of Alberta Wilderness Association and the Grassy Mountain Group ("Coalition"). There are 16 appendices (A to P) attached to the Coalition's submissions. Due to the size of Appendix A – Landowners Statements (over 13MB), Appendix A will be filed separately under a separate cover letter. Appendices B to P are attached to this submission.

Yours truly,

ACKROYD LLP

Original signed by

IFEOMA M. OKOYE
IMO/sl
Encls.

JOINT REVIEW PANEL

IN THE MATTER OF the *Coal Conservation Act Application Nos. 1844520, 1902073, Environmental Protection and Enhancement Act Application No. 001-00403427;*

IN THE MATTER OF the *Water Act Application Nos. 001-00403428, 001-00403429, 001-00403430, 001-00403431,* and *Public Lands Act Application Nos. MSL160757, MSL160758, LOC160841, LOC160842, and LOC970943*; and

IN THE MATTER OF Benga Mining Limited Grassy Mountain Coal Project Impact Assessment Agency of Canada Reference No. 80101.

Submissions of the Coalition of Alberta Wilderness Association and Grassy Mountain Group ("the Coalition")

September 21, 2020

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Counsel for the Coalition

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I. INTRODUCTION

1. These are the written submissions filed on behalf of the Coalition of the Alberta Wilderness Association and Grassy Mountain Group ("Coalition") with respect to the Joint Review Panel's ("JRP" or the "Panel") consideration of Benga Mining Limited's ("Benga") applications[1] under the Impact Assessment Agency of Canada's ("IAAC") Reference No. 80101 for the Grassy Mountain Coal Project ("Project").

2. The Project involves a steelmaking coal mine, a coal handling and preparation plant with associated infrastructure, an overland conveyor system paralleling an existing access corridor and connecting to a rail load out facility and a new section of rail track.[2] The Project will be located in southwest Alberta, approximately 150km southwest of Calgary in the Crowsnest Pass and will cover areas within Townships 08 and 09 and Ranges 03 and 04 West of the 5th Meridian. The steelmaking coal processing facility will be located approximately 7km north of Blairmore.[3]

II. DESCRIPTION OF INTERVENERS

3. The Coalition consists of two groups – a landowner group and a public interest association. The landowner group named Grassy Mountain Group is comprised of individuals, families, and corporations who own and occupy lands within, adjacent to or in close proximity to the mine boundary and its associated infrastructures. The public interest association named Alberta Wilderness Association ("AWA") is a not for profit association dedicated to the protection and conservation of Alberta's wilderness and endangered species. The role of the AWA in this proceeding has been and remains to provide support to the Grassy Mountain Group and to ensure that Alberta's wilderness

[1] The applications are: Coal Conservation Act Application Nos. *Coal Conservation Act Application Nos. 1844520, 1902073, Environmental Protection and Enhancement Act Application No. 001-00403427;* the *Water Act Application Nos. 001-00403428, 001-00403429, 001-00403430, 001-00403431,* and *Public Lands Act Application Nos. MSL160757, MSL160758, LOC160841, LOC160842, and LOC970943*
[2] Benga's Application, CIAR 42, Doc 115588E, Section A, page A-1.
[3] Benga's Submissions dated August 2020, Doc Ref 503, #135835E pdf 4.

and endangered species and their habitats are protected and conserved for generations to come.

4. The Grassy Mountain Group and the AWA elected to coordinate their interventions, shared interests and concerns as a group in this proceeding before the Panel in order to create efficiencies and reduce overlap in their individual interventions. The Coalition members are concerned about the adverse impacts of the proposed Project. They are opposed to the potential approval of the Project as has been applied for by Benga.

5. The Coalition was granted full participation rights in this matter by the Panel on June 29, 2020 in the Panel's June 29 letter and confirmed in the August 10, 2020 letter[4].

6. The members of the Coalition, the descriptions of their lands and locations relative to the mine permit boundary are as follows:

No	**Name**	**Legal Land Description** (if applicable)	**Location relative to the mine permit boundary**
1	Fran Gilmar, Mitch and Rose Bonertz	SW30-8-3-W5M	Within mine boundary
2	Larry and Barb Donkersgoed, Donkersgoed Feeders Ltd.	SW19-8-3-W5M	Within mine boundary
3	Ed and Shannon Donkersgoed, Berdina Farms Ltd.	SW19-8-3-W5M	Within mine boundary
4	Norman and Connie Watmough, Tyler Watmough, Sun Cured Alfalfa Cubes Inc.	SE19-8-3-W5M	Adjacent to the mine boundary
5	Shirley Kirby	Plan 1014575 Block 19 Lot 25	7km south of the mine boundary
6	John and Rae Redekopp	Plan 991 2103 Block 2 Lot 1	2 to 3 km southeast of the mine boundary
7	David Rothlin and Kari Lehr	Plan 9811164, Block 1 Lot 1	3 to 4 km southeast of the mine boundary
8	Vern Emard	SE30-8-3-W5M	Adjacent to the mine

[4] JRP's letter to Ackroyd LLP on behalf of the Coalition, Doc Ref 474, Document 135729E.

			boundary
9.	Alberta Wilderness Association	N/A	N/A

III. NATURE AND SCOPE OF INTENDED PARTICIPATION

7. As stated in previous correspondence to the Panel, the Coalition will participate fully in the hearing process and at the hearing before the Commission. Members of the Coalition will attend the hearing and testify and present evidence at the hearing. They intend on calling their expert witnesses, who will also testify and provide evidence to the Panel at the hearing.

8. The Coalition will cross-examine witnesses put forward by Benga through their counsel. The Coalition will present argument in this proceeding.

IV. REASONS FOR OBJECTION

9. The members of the Coalition will be directly and adversely affected by the outcome of Benga's applications for the proposed Project. The Coalition submits that the approval and development of the Project will have significant adverse social, economic and environmental effects.

10. The Coalition submits that approval of the proposed Project is not in the public interest and ought to be denied in accordance with the Panel's authority as the Alberta Energy Regulator ("Regulator" or "AER").

V. REQUESTED DISPOSITION

11. The Coalition respectfully requests that the Panel as the Regulator under the *Responsible Energy Development Act ("REDA")* deny Benga's applications for approval of the Project.

12. The Coalition further requests that the Panel as a review panel under CEAA 2012 determine that the Project is likely to cause significant adverse environmental effects despite the proposed mitigations for the Project.

VI. ISSUES

13. The Coalition has identified the following concerns and issues with Benga's applications which will be addressed in further detail in these submissions below:

    a. Land Use, Access, and Residential Impacts;

    b. Property devaluation;

    c. Water Impacts, including ground water and surface water impacts, inflow needs assessment and water chemistry, impacts on aquatic resources including Westslope Cutthroat Trout, and climate change;

    d. Wildlife, biodiversity and habitats impacts assessment;

    e. Noise and air pollution impacts;

    f. Socio-economic effects; and

    g. Coal quality

VII. FACTS TO BE SHOWN IN EVIDENCE

A. Overview

14. The Coalition intends to rely on the facts set out in this submission, as well as other materials they have filed or will file with the Panel. These include but are not limited to the statements of Coalition members, attached as **Appendix "A",** as well as other information that the Coalition members have filed with the Panel in the Project's Registry. The group also intends to rely on the oral evidence of its members, the oral evidence of their expert witnesses.

15. The Coalition may also rely on the written and oral evidence of other interveners' experts whose evidence may address the Coalition's concerns in this proceeding before the Panel.

16. The Coalition may also rely on some of the assertions contained in Benga's application materials for the Project, Benga's responses to Information Requests, Benga's submissions, and any facts, information, and materials that have been filed by or brought forward by any participant in this proceeding.

B. Land Use, Access and Residential Impacts

17. The Coalition members have expressed concerns about the adverse residential and social impacts including land use and access restrictions that will be experienced on an ongoing basis should the proposed Project be approved and developed. The members have expressed concerns about diminution in their use and enjoyment of their lands as a result of the Project being approved. Some members have lived on or operated a farm or ranch in the area for many years. Some use their lands for recreational activities. The members have commented on the beauty and wildness of the area and the destruction that will result if the Project is approved.

18. Coalition members such as Norman, Connie and Tyler Watmough indicate that they graze cattle on their lands and reside on their property seasonally. They host family and social gatherings on their lands as well as fish and camp on their lands with their children and grandchildren. All these uses and recreational benefits that they derive from the lands will be lost if the Project is allowed to proceed. They will also lose the opportunity of passing on the land, which they consider to be their family's legacy, to their future generations if the Project is allowed to proceed.[5]

19. Other Coalition members have expressed concerns about the impacts of the Project's potential approval in terms of loss of a place where they can be truly one with nature[6] and a dream place where they can enjoy hiking, biking and fly fishing.[7] Similar concerns have been expressed by other Coalition members such as Larry and Ed Donkersgoed and Fran Gilmar.

[5] Appendix A, Submissions of Norm and Connie Watmough, pdf 2.
[6] Appendix A, Submissions of Larry and Ed Donkersgoed, pdf 21.
[7] Appendix A, Submissions of Kari Lehr and David Rothlin, pdf 38.

20. Some members of the Coalition such as Norman and Connie Watmough,[8] Larry and Ed Donkersgoed[9], Vern Emard,[10] and Fran Gilmar[11] have expressed concerns about land use and access restrictions that this Project will impose on them if this Project is approved. Access to these members' lands is through Section 24-8-4-W5M, which is within the open pit mine licence boundary[12], within the South Rock Disposal licence boundary[13] and the Central Rock Disposal Mine licence boundary,[14] and partially affected by the Coal Handling Processing Plant and Infrastructure.[15] Blockage and restriction of access to these members lands will make their lands unusable and worthless. These members have also expressed concerns that current activities carried out by Benga in the Project area have already limited their access to their lands and have negatively affected their livestock grazing operations.

21. Members of the Coalition have also expressed concerns about the reduction in their use and enjoyment of their lands as a result of the noise, dust and air pollution that the Project will bring.

C. Property Devaluation

22. The Coalition members have expressed concerns about the impacts of the Project on their property values. They believe that the approval of the Project will devalue their properties and, in some cases, make their lands totally worthless, especially where access to their properties is removed.

23. The Coalition has retained Brian Gettel, of Gettel Appraisals Ltd., to assess the potential effects on real estate values which the Project may exert on improved residential properties within the Municipality of Crowsnest Pass. Mr. Gettel has extensive

[8] Appendix A, Submissions of Norm and Connie Watmough, pdf 1.
[9] Appendix A, Submissions of Larry and Ed Donkersgoed, pdf 22.
[10] Appendix A, Submissions of Vern Emard and Family, pdf 108-109.
[11] Appendix A, Submissions of Fran Gilmar, pdf 43.
[12] CIAR Ref # 42, Doc. 115588E, p. A-12, Table A.4.0-3,
[13] CIAR Ref # 42, Doc. 115588E, p. A-13, Table A.4.0-4,
[14] CIAR Ref # 42, Doc. 115588E, p. A-13, Table A.4.0-5
[15] CIAR Ref # 42, Doc. 115588E, Figure A.1.0-2.

experience with different property appraisals and has appeared before various administrative tribunals and courts on real estate appraisal matters. Mr. Gettel's report and curriculum vitae are attached as **Appendix "B"** to these submissions.

24. Mr. Gettel conducted a literature review, reviewed recent aerial photography of the surrounding area, relied on his over 10 years of experience of the Project area and the Municipal District of Crowsnest Pass, and his extensive appraisal experience of over 40 years in preparing his report. In his report, Mr. Gettel noted that factors such as dust concerns, increased vehicular traffic, introduction of rail loading facilities with their attendant noise and safety concerns and potentials for spills or train derailment, and fear of water or soil contamination could exert an impact on real estate values for properties adjoining the mine. Of all the factors highlighted, Mr. Gettel notes that dust is the number one problem associated with surface coal mines. Dust problems appear to be very common despite mitigation programs.

25. Mr. Gettel further noted that proximity to mines exerted influence on property values. The closer the proximity, the greater the value loss.

26. Mr. Gettel notes that dust overall is a key factor that can impact residential real values within Crowsnest Pass through the development of the Project. As prevailing winds are from the west and northwest. This implies potential dust problems for properties south and southeast of the proposed mine. The dust impact can carry for an extended area.

27. Value losses could be placed into 3 categories – low impacts (0 – 10%), moderate impacts (10-15%) and high impacts (15-50%). Mr. Gettel further noted that losses at the upper end of the high impact scale are observed only in rare instances and typically involve extreme cases.

28. Based on Mr. Gettel's experience, property devaluation typically occurs at two points in time. One point is during pre-construction when apprehension about potential value

impacts cause concerns before a facility is commenced. The second point is when the facility is operational, and concerns become reality. Pre-construction apprehension regarding property value impacts has been reflected in reduction in sales activity for higher end and recreational housing but no value losses has occurred.

29. In terms of post construction value impacts, based on the research conducted, Mr. Gettel concluded that projected problems from dust would fall within the low impact category range of 0 to 5%. However, higher end housing that are typically more sensitive to negative externalities and value losses will experience value losses in the order of 10% or more.

30. Mr. Gettel further concluded that the value losses would be greatest for properties closest to the mine and this would include housing within communities such as Blairmore, Frank, Hillcrest Mines and Bellevue as well as residential acreage properties within the same general area. Also, the actual negative effects from the mine will evolve over a period of time. The best-case scenario is that there will be little or minimal impact resulting in the value losses towards the low end of the range (0-10%). The worst-case scenarios would result in losses towards the upper end of the range.

31. Mr. Gettel further concluded that individual landowners with access restrictions such as the Donkersgoed, the Watmoughs, Fran Gilmar and Vern Emard would experience much more significant value impacts. The greatest impact would occur if access is closed off for the properties, which could render the lands unsaleable.

D. Water Impacts

i. Groundwater, groundwater-surface water interactions, and climate change

32. The Coalition members have expressed concerns regarding the impacts of the Project on groundwater, their water wells, surface water at Gold Creek and Oldman River headwaters and the related impacts to fish and other aquatic resources that have their

habitats in these surface water resources. Kari Lehr and David Rothlin have expressed their concerns this way:

> "In Valley Ridge Estates where we live, we rely on well water, and it is terrifying to me that the purity of our groundwater is at risk by a company who hasn't bothered to show any consistent and serious effort to abide by the requirements which have been outlined time and time again in the environmental regulations. Our greater community is at risk as well – we don't have to look far to see what has been happening in Sparwood with the concerns raised in Canada and the US over toxic selenium levels in the Elk River. We are very concerned that contamination of water in our area could also leave us with a beautiful home which would have no commercial value, should we be forced to move."[16]

33. Kari Lehr and David Rothlin's concerns capture the concerns of other residents and members of the Coalition who will be directly impacted by the Project. Members of the Coalition have also expressed concerns about the discharge of wastewater into Gold Creek and its harmful effects on fish and water quality.

34. The Coalition retained Jon Fennell (Ph.D.) to review the geology, hydrogeology, groundwater-surface water interaction, geochemistry and climate change implications of the Project. Dr. Fennell has over 30 years experience in the natural resource sector examining geology, hydrogeology, surface water and groundwater interaction and climate change implications. Dr. Fennell's report and curriculum vitae are attached at **Appendices "C"** and **"D"** respectively to these submissions.

35. Dr. Fennell notes in his report that there are several challenges that remain unresolved or unmitigated with the Project from a hydrogeological, hydrological, geochemical and climate change perspective.

36. Dr. Fennell noted the following concerns with the groundwater modelling and water quality assessment that was done:

[16] Appendix A, Submissions of Kari Lehr and David Rothlin, pdf 38.

a. While Benga correctly noted that the Project area is geologically complex and subject to folding, faulting and fracturing in relation to historical mountain building processes, Benga constrained its investigation of the physical and chemical properties of the rock formations and their hydraulic characteristics to the coal-bearing layers leaving some doubts as to the properties of the other layers.

b. Benga's groundwater numerical model is a gross simplification of a complex system, with assumptions that do not match with the reality of the Project area. Benga's unrealistic assumptions regarding the role of faults and fractures in the movement of groundwater from the upland areas to the creeks severely hampers the numerical model projections provided. For instance, the claim that the north to south thrust faults would present a hydraulic barrier to flow was not tested to confirm this assumption. It is clear from the geological configuration of the Project area that the west to east striking faults can provide open pathways for groundwater flow because they present as strike-slip features. Similarly, the role of local springs and their contributions to flows in both Blairmore and Gold Spring as well as the magnitude of the lasting impact that remaining drawdown will have once large portions of the mountain are removed were not considered in the modelling. This lack of investigation calls into question the veracity of the impact assessment process and the significance of the ratings provided.

c. While the water table below Grassy Mountain will be permanently lowered by up to 430m, Benga simulated the extent of the drawdown impact associated with lowering the water table to remain within 400 m of the mine pit boundary. This restriction in the simulation of drawdown impacts plus the lack of consideration of the west to east striking faults present in the Project area and the unconfirmed assumption that the north to south striking thrust faults are inactive pathways for groundwater flow amounts to a minimization of drawdown impacts. Furthermore, lowering of the water table will impact important non-assessed tributary creeks conveying water from Grassy Mountain down to Blairmore and Gold Creek valleys.

d. Benga's groundwater numerical model does not provide a good correlation between simulated versus measured water levels and monthly baseflow variability. The monthly baseflow variability is consistently under-represented leading to concern regarding the accuracy of baseflow projections for Blairmore and Gold Creeks. Monthly baseflow reductions will be much more than the "average" 10% communicated by Benga due to the under-representation of actual baseflow conditions in the model. The actual timing of when the reductions in baseflow will occur in relation to known bio-periods of Westslope Cutthroat Trout (WSCT) is germane to the impact assessment and could lead to threatening conditions especially in the hotter summer low-flow months. Given a scenario of extreme low flow conditions, reduced baseflow contribution to regulate water temperatures (due to mine dewatering effects), and consecutive extreme hot days, this could lead to water temperatures being higher than have been modelled. In such an instance, dissolved oxygen conditions would be pushed lower and thermal shocks could occur leading to impacts to sensitive aquatic species sustaining the WSCT or possibly the WSCT population itself. Considering that certain reaches of water courses such as Gold Creek are indicating a possible change in baseflow of up 20% under currently simulated conditions, this calls into question the appropriateness of the significance rating of "Not Significant" provided by Benga.

e. A review of stream flow conditions in Gold Creek at the WSC station near Frank Alberta shows that flow conditions can be highly variable from year to year and low flow conditions can persist for several years, up to 8 years at least. Benga did not include this level of variability and its extended nature in the impact modelling conducted to date leading to a concern that the assessment results are under-representing changes that can occur in the future in relation to erosion of disturbed land, sedimentation issues, functioning of mine water management features and water quality issues. There are concerns regarding whether the proposed monitoring and mitigation will be sufficient to detect and respond to deviations from the conditions modeled, the longevity of the monitoring systems and the need for perpetual maintenance. If reliance on adaptive management is the last defense to protect sensitive water courses and associated habitat, then the proposed mitigation systems and strategies will need to be robust enough to last well into the future, with no intervention at some point once mine closure has occurred.

f. Benga's statement that the only loss of water from the project will be associated with the residual moisture contained in the coal itself is misleading. Considerable loss of water will occur via disruption to the landscape, increased evaporation from barren lands, sedimentation ponds, surge ponds and the end pit lake. Benga's statement regarding water loss suggests that it did not model this leading to additional doubt regarding the overall water balance that was reported.

g. The reported elevated levels of certain trace elements like aluminum, arsenic, cadmium, mercury, selenium and zinc in both water and sediments at concentrations in excess of Alberta guideline values is a direct indication that these elements have been mobilized into the aquatic environment. While Benga's plan to use saturated backfill zones (SBZs) as a selenium and nitrate management approach has the ability to work under the right conditions, there remains a concern regarding what other reactions might occur within or below the SBZs once they are established and anoxic conditions are achieved. Further, it is not clear if the dosing applied to reduce the selenium levels will have to continue into perpetuity to ensure continued sequestration of selenium. While anoxic conditions in the SBZs may be favourable for precipitation of elemental selenium, it may result in the mobilization and increase in the toxicity of other trace elements such as arsenic. The potential and risk of this mobilization of arsenic occurring has not been assessed or resolved.

h. Dr. Fennell noted other geochemical risks that could occur that were not assessed such as the potential for installed monitoring wells to miss contaminant plumes or to catch only a part of the plumes; the potential stratification of the end pit lake and the creation of anoxic conditions at the base of the end pit lake; and how resulting geochemical effects from changing oxidation-reduction potential conditions from oxic to anoxic and back to oxic in the future might manifest themselves.

i. Dr. Fennell questioned the success of the mitigation measures that were proposed. He noted further concerns regarding how climate change has been incorporated into the application. Shifting conditions under a changing climate will influence hydroclimate conditions beyond what we currently believe. Simply using 1 in 10 or 1 in 20-year return period scenarios to capture this variability is not reasonable given what has been experienced in the past. As such, Benga's simulations do not provide a reasonable representation of the anticipated variability given that the probability of extreme events occurring in the future is expected to increase. Dr Fennell noted that that what is considered 1 in 10-year event today may become 1 in a 5-year event in the future given climate data distribution. Benga has not conclusively demonstrated that its model simulations will accommodate a change in probability of extreme weather events or what the change in probability to return events will be in the future.

37. It is the role of an applicant to assess impacts using conservative or worst-case scenarios so that a reasonably accurate assessment of potential impacts can be provided, and unintended consequences can be avoided. What Benga has provided is an optimistic assessment where impacts from the Project are being considered "Not Significant". If a more conservative approach had been used, it is likely that some of the significance ratings would have been less favourable.

38. Dr. Fennell concluded that given the magnitude of disruption that Benga is seeking permission to inflict on Blairmore and Gold Creek watersheds, the limited nature of the

field reconnaissance, instrumentation and physical and chemical measurements of springs, wetlands and other supporting water features done to support the impact assessment process is disappointing. Leaving impact assessments up to poorly constrained models will only lead to results similar to the Elk Valley, BC situation where actions will be taken only after the damage is already done. Since the uncertainty in the projections is being left up to adaptive management to mitigate, this application should not be approved. The risk of creating unintended consequences is too great to ignore.

ii Environmental Flows – inflow needs assessment

39. The Coalition retained Allan Locke to review Benga's environmental flows, also known as instream flow needs assessments and evaluate the potential for flow related effects on the species of interest, Westslope Cutthroat Trout in Blairmore and Gold Creeks. Mr. Locke's report and curriculum vitae are attached at **Appendices "E"** and **"F"** respectively.

40. Mr. Locke notes that understanding how aquatic ecosystems function, modelling the various components' response to natural or anthropogenic inputs, and managing them for the intended outcomes necessarily incurs relatively high degrees of uncertainty. The level of effort conducted by Benga adequately addresses much of the inherent uncertainties in the environmental flows. Mr. Locke further notes that recognizing that low flows, or subsistence flow periods create limiting habitat conditions, even under natural flow regimes, a recommended instream flow regime should not result in an increase in the frequency, duration or magnitude of naturally limiting habitat conditions.

41. Mr. Locke concludes that additional assessment using existing data is necessary. The further assessment should include:

a. In in addition to micro-habitat data, include meso-habitat data to develop a percent of flow reduction criterion,

b. develop several metrics and thresholds to assess effects of changes in flow for chronic (long-term) impacts, intermediate (medium-term) impacts, and acute (short-term) impacts, and

c. develop an ecosystem baseflow criterion that will be included in the environmental flow recommendation for Blairmore and Gold Creeks using both micro- and meso-habitat data.

42. Mr. Locke further recommended that the discussions for developing a fully protective environmental flow regime for Blairmore and Gold Creek include Benga, the provincial and federal regulators, the Coalition and any other interested party. As members of the public for whom public resources are maintained, the public has a legitimate right and responsibility to be involved in the water management decision-making process.

iii Surface Water Quality – Water Chemistry

43. The Coalition retained Lorne Fitch to review the Project's impacts on water chemistry, sedimentation, and the water chemistry impacts on Westslope Cutthroat Trout's habitat. Mr. Fitch's report and curriculum vitae are attached at **Appendices "G"** and **"H"** respectively.

44. In his report, Mr. Fitch discussed the life history and current status of Westslope Cutthroat Trout (WSCT) in Gold Creek. Mr. Fitch noted a 2019 study by Benson that confirmed the presence of and use of the Gold Creek as a habitat for both winter refuge and summer use. Gold Creek is the last major tributary of the Crowsnest River that still contains concentrations of pure-strain WSCT in the Crowsnest River watershed.

45. Mr. Fitch further notes that WSCT generally have high fidelity to specific stream sections and do not undertake extensive migratory movements, sometimes undergoing all their life cycle within a few hundred meters of the site of spawning and overwintering pools. Mr. Fitch noted that the Gold Creek would be impacted by this Project thereby affecting the

habitat for WSCT and their survivability. WSCT is currently vulnerable to existing land uses, which are beyond the range of natural variation that these native trout evolved with and adapted to. The Project will put the WSCT at even greater risk.

46. Mr. Fitch also notes that Blairmore Creek provides potential habitat for recovery efforts to meet the requirements of the threatened and at risk WSCT. Mr. Fitch noted the following primary objective recovery strategy for WSCT:

> "To protect and maintain the existing ≥0.99[%] pure populations at self-sustaining levels and re-establish additional pure populations at self-sustaining levels, within the species original distribution in Alberta" (Fisheries and Oceans Canada 2014). Populations with less genetic purity (more introgression) as is the case with trout in Blairmore Creek, still rate as important since these form the basis of recovery efforts to improve purity through a number of strategies and expand the population, which is an integral part of species at risk recovery efforts (Alberta Westslope Cutthroat Recovery Team, 2013).[17]

47. Mr. Fitch observes that as watersheds shift from natural undisturbed conditions to increasing levels of human disturbance, the ecological mechanisms for controlling nutrient and sediment flux become more complicated and less understood. The ability to accurately quantify or predict interactions between land use and aquatic conditions or responses becomes less precise and more uncertain. Benga's modelling work that indicates that the impacts on stream flow from mine operations will remain within the range of natural variability may not affect overall runoff volumes, but it will influence the seasonality and rate of delivery to receiving streams. This has implications for continued survival of WSCT populations.

48. Furthermore, sediments from Project's operations and transport of sediments will affect water quality. Benga's plans of redirecting overland flow with ditches underneath spoil piles into natural drainages are unclear as to how water quality from such facilities will

[17] Appendix G, Evidence of Lorne Fitch, pdf 4.

be dealt with. Because roads and ditches increase peak flows, all linear drainage features for mine operations and existing and new roads must be assessed cumulatively before Benga can assert that these will have no "significant hydrologic effect."

49. Mr. Fitch further notes issues with assertions from Benga regarding Project's impacts on WSCT habitat and hydrologic conditions such as the assertion that logging will not affect hydrologic conditions. There is no evidence for Benga's assertion that historic or legacy coal mining has had no adverse impact on trout habitat. There is no evidence that Benga has considered the additive impact of physiological stress to WSCT from mining operations.

50. Mr. Fitch also identified flaws or gaps in the sedimentation impacts analysis that was done by Benga in relation to impacts on WSCT in Gold Creek and Blairmore Creek. After reviewing incidences of sediment pond failures and erosion impacts on water quality from other mines in Alberta and BC, Mr. Fitch notes that Benga's assertions that water quality issues from mining operations will not impact downstream reaches containing WSCT to be based on best case scenarios that assume everything works as planned, designed, constructed and maintained..

51. Mr. Fitch concludes that the proposed mine will negatively impact the existing Westslope cutthroat trout population of Gold Creek and the potential of Blairmore Creek as a suitable habitat for recovery efforts.

52. Mr. Fitch further concludes that Benga's proposed monitoring strategy is not rigorous, robust or sensitive enough to detect changes and impacts in a timely manner for correction. The likelihood of mitigation success is based on several assumptions most of which are unaccounted for by Benga. The proposed mitigation and compensation actions are untested, unproven, unsuitable, theoretical and overly optimistic to ensure Westslope cutthroat trout populations persist and are allowed to recover.

53. Mr. Fitch further concludes that the risk to water quality, to the aquatic environment and to WSCT populations from the Project is understated, despite evidence from other coal

strip mines in Alberta and adjacent ones in BC that show the risks to WSCT populations cannot be successfully mitigated. Therefore, the potential for an irreversible loss of a pure strain population of WSCT that is locally adapted to Gold Creek is of such significance that this potential loss must become a dominant consideration in evaluating the advisability of the Project. A compromise decision to allow mining but with conditions of mitigation and/or compensation, given the considerable uncertainties in both, presents substantial risk to the persistence of the last significant WSCT population in the Crowsnest River watershed and to recovery efforts for the species.

iv. Impacts on Westslope Cutthroat Trout

54. The Coalition retained John R. Post, Ph.D. to review and assess Project's impacts on WSCT as they relate to WSCT's distribution, population viability, critical habitat loss, cumulative effects and the proposed mitigation and offsetting plan. Dr. Post's report and curriculum vitae are attached at **Appendices "I"** and **"J"** respectively.

55. Dr. Post in his report noted the following:

a. WSCT are a unique genetic stock of cutthroat trout that were assessed as threatened by COSEWIC and subsequently listed under the *Species at Risk Act.* The listing triggered a series of legislated prohibitions and the proposed coal mine project involves activities that are currently prohibited under the legislation. The Project has a high likelihood of severely compromising the distributional and population viability objectives as laid out in the "Westslope Cutthroat Trout: Recovery Strategy and Action Plan". Recent status assessments and studies show that the population of WSCT in Gold Creek has only a 74% probability of long term persistence and that mining within the southern east slopes within the footprint of the current operations will cause a 31-70% decline in abundance of WSCT over the next three generations. The prognosis for viable WSCT will worsen if the footprint of mining development in the east slopes of Alberta is enlarged.

b. the project involves a permanent loss of WSCT critical habitat, both instream and riparian. In addition to this planned habitat destruction, Benga ignores the downstream impairment to habitat quality due to upstream Critical Habitat destruction. Therefore, the actual losses of functional habitat are understated in the proposal. It should be noted that the current level of critical habitat of WSCT in Alberta is insufficient to ensure recovery.

c. The analysis of the cumulative impacts of the project on WSCT is flawed and underrepresents the true cumulative impact on long-term viability of WSCT within the project's footprint. Analysis of cumulative effects of threats must incorporate all threats, model their synergies and incorporate uncertainties to be credible. Benga's EIA did not do any of these.

d. Benga has not shown the effectiveness of its mitigation plan in offsetting the critical habitat that will be destroyed by the Project. Without clear evidence of an ability to offset the destruction of critical habitat, the project fails to ensure the distributional and population objectives for this listed species.

56. Dr. Post concludes that the Project will destroy critical habitat for WSCT. Although offsetting is proposed, there is no evidence that it will be effective in supporting the short or long term persistence of the species. Without proof of the effectiveness of Benga's proposed monitoring plan, it will only be useful as documentation of a further reduction in the viability of one of the largest of the remaining locally adapted populations of WSCT in Alberta.

E. Wildlife, biodiversity and habitat impacts

57. The Coalition has expressed concerns about the Project's impacts on wildlife and their habitats as well as impacts of the Project on biodiversity. For instance, Ms. Gilmar has

reported sightings of various wildlife such as Grizzly Bears, Golden Eagles and others from her lands and the potential presence of snake hibernacula within the Project area.[18]

58. The Coalition retained Cliff Wallis of Cottonwood Consultants Ltd to evaluate the impacts of the Project on biodiversity, primarily terrestrial, with a focus on Environmentally Significant Areas ("ESAs") and Species at Risk as well as habitats and other species of conservation concern. Mr. Wallis is professional biologist with over 50 years of experience in conducting biodiversity assessments. Mr. Wallis is personally familiar with the Project lands through field work conducted in the region since the late 1970s and work conducted in the neighbouring Pincher Creek. Mr. Wallis visited the Project area in August 2020. Mr. Wallis' report and curriculum vitae are attached as **Appendices "K"** and **"L"** respectively to these submissions.

59. Mr. Wallis notes that from a biodiversity perspective, much of the Project boundary is in one or more ESAs. Species at risk, such as endangered Whitebark Pine are present in significant quantities in the soil salvage area boundary and will be directly harmed by the Project. Benga's failure to identify the full extent of distribution of endangered species at risk such as Whitebark Pine raises issues related to the adequacy of the field work and the resulting environmental assessment.

60. Further, cumulative effects of the Project are not addressed considering other proposed coal mining projects such as the Atrum Elan South Coal Project in the immediate vicinity. Portion of the Project (soil salvage areas) occur on public land inside areas mapped as intact native grasslands in the South Saskatchewan Regional Plan (SSRP). This is in contravention of the SSRP. Without a consideration of other projects' impacts on Whitebark Pine plus the long timeframes for restoration of Whitebark Pine, Benga's conclusion that cumulative effects of the Project on these species are neutral, positive or not significant is not supported by evidence.

[18] Appendix A, Submissions of Fran Gilmar, pdf 44.

61. Mr. Wallis further note that there are multiple species at risk facing numerous threats such as disease, loss of habitat and climate change effects that approving a Project located in ESAs will result in destruction of these species at risk (e.g. Whitebark Pine) or their supporting habitat. In most cases, restoration techniques for such habitats such as the rough fescue grassland and Whitebark Pine are unproven and attempts at restoration have resulted in complete failure. Mr. Wallis further noted incomplete mapping of Whitebark pine distribution within the mining area and areas mapped as rock disposal areas.

62. Mr. Wallis further note that given the difficulties of reclaiming certain vegetation types in any reasonable time frame, e.g. rough fescue grassland and Whitebark Pine, and Benga's acknowledgment that the richness of native species will be lower after reclamation, it is improper to characterize the residual effects as "not significant". Therefore, anywhere that Benga has classified residual effects as being of high magnitude and for long term duration, should actually be classified as significant at some level.

63. Benga's approach of classifying residual effects from the Project as "not significant" is not supported by evidence of continued declining populations of many species. Further, developing a project that would result in the elimination of tens of thousands of individual Whitebark Pine trees is at odds with the range-wide Whitebark Pine recovery strategy which is focused on protecting high value trees. The magnitude of the potential clearing of Whitebark Pine trees is high.

64. In addition to the destruction of the Whitebark Pine trees, the Project would remove a variety of productive habitats for Little Brown Myotis for decades or longer. A significant portion of high or moderate suitability habitat for Little Brown Myotis is within the soil salvage area. This is evident from the significant number of bats passes for Little Brown Myotis in survey stations A7 and A10, for example. A robust bat sampling of the soil salvage area has not occurred; therefore, the impacts to Little Brown Myotis is understated. Similar to the Whitebark Pine, Benga did not assess the cumulative effects of new mining operations on Little Brown Myotis that included an assessment of

contribution from the Atrium Elan South Coal Project. Mr. Wallis noted the difficulty of reconciling the approval of the Project with Environment Canada 2015's conservation objective of maintaining current Little Brown Myotis population levels when the Project would effectively remove a variety of their productive habitats for decades or longer.

65. Mr. Wallis also noted as a significant omission the lack of attention to the ecological effects of drawdown from pit dewatering on adjacent wetland areas, riparian areas, and spring dependent plant communities.

66. Mr. Wallis concluded that when considered in the context of regulatory guidance, there are compelling reasons to deny this Project given its direct impact on tens of thousands of endangered Whitebark Pine trees within potential critical habitat as well as intact foothills fescue grasslands. Mr. Wallis recommended that the Project not be approved in its current configuration.

F. Noise and air pollution impacts

67. The Coalition members have expressed concerns regarding the noise that this Project will create and its interference with their use and enjoyment of their properties. Some Coalition members (see for example, the submissions of John and Rae Redekopp, Shirley Kirby, and Kari Lehr and David Rothlin) who reside in the mountain valleys (i.e. Valley Ridge Estates, have also expressed concerns about air pollution arising from dust from Project operations.

68. Shirley Kirby, for instance, noted concerns with the air quality assessment that was done. In Ms. Kirby's views, the air quality assessment and the proposed mitigations of impacts are unreliable, ethically questionable, incomplete and inadequate. It also lacks commitment to the environment and to the people of Crowsnest Pass.[19]

69. The Coalition has retained James Farquharson of FDI Acoustics Inc. to provide expert evidence regarding the noise, noise impacts, and noise impact assessments conducted by

[19] Appendix A, Submissions of Shirley Kirby, pdf 113.

Benga in relation to this Project. Mr. Farquharson has extensive experience with the AER's Directive 038 and noise impact assessments in Alberta. Mr. Farquharson's reports and curriculum vitae are attached as **Appendices "M" and "N"** respectively to these submissions.

70. In his noise impact assessment review report, Mr. Farquharson provides a discussion of the requirements for noise impact assessments and reviews the noise impact assessment ("NIA") that was conducted on behalf of Benga. He noted that assessing noise impacts of mining operations on select years over the life of the project was acceptable as FDI Acoustics had used such strategy in mine impacts assessments in the past. Mr. Farquharson also noted agreement with the general mitigation measures described in the noise impact assessment for dealing with blasting, vehicle back-up alarm systems and rock disposal.

71. Mr. Farquharson further noted that the results of the noise impact assessment were contingent on the noise emissions of the facilities built by, and the equipment used by, Benga Mining at the Project. The octave band sound power levels of the facilities and equipment that Benga proposes to use are listed in Appendix I of the NIA. Mr. Farquharson recommended that Benga retain a qualified acoustical consultant to confirm the mine equipment sound power levels after the equipment are purchased to ensure that the sound power levels match the levels in Appendix I of the NIA. Where the confirmation program reports an exceedance of values, Mr. Farquharson recommends a reporting of the necessary mitigation measures proposed to deal with the exceedance and/or a recompletion of the NIA using the new values.

72. Mr. Farquharson further recommended an independent review of the noise emissions of the final designs of the conveyor system and the proposed coal rail loadout systems to be used as these systems would be significant noise sources to the community. Should the Panel consider approving the Project, Mr. Farquharson recommends that the Panel attach a condition of approval requiring Benga to file 5-year mine plan noise impact assessments with the AER. This condition will ensure that the noise impact assessment

reflects the operations and the equipment actually used at the mine. Any noise complaint after commencement of operations must be reported to the AER together with an action plan on addressing the complaint.

G. Socio-economic effects

73. The Coalition members have expressed concerns about the need for this Project and questions Benga’s assessment of the socio-economic benefits and impacts of this Project. In the Coalition’s view, Benga’s socio-economic impacts assessment is inadequate, unreliable and does not provide sufficient information for the Panel to decide if the Project is in the public interest.

74. The Coalition has retained John Thompson of Watrecon Consulting Inc., to review Benga’s evidence related to the socio-economic impacts and Project benefits. Mr. Thompson has extensive experience assessing economic impacts and economic benefits of coal mine projects. Mr. Thompson’s report and curriculum vitae are attached as **Appendices “O” and “P”** to these submissions respectively.

75. In his report, Mr. Thompson examined Benga’s evidence relating to project benefits and economic impacts and evidence related to population changes and resulting socio-economic effects. Mr. Thompson found that while Benga had listed the “benefits” of the Project in its application, it had not quantified the socio-economic effects in a way that would allow the Panel to conclude whether the Project benefits were of significant magnitude to justify any adverse effects arising from the Project. While Benga attempted to quantify the socio-economic benefits by quantifying the total impacts in terms of effects on GDP (Gross Domestic Product), labour income and employment referring to operations n Alberta and BC, and describing property tax revenues to regional governments in Alberta, there was no quantification of regional effects on employment or labour income at a regional level.

76. Mr. Thompson further noted the following as the reasons why the information in the socio-economic portion of the application did not clearly or accurately portray the benefits of the project:

a. The measures of the project benefits contained a combination of economic impacts and economic benefits which can cause significant confusion in interpretation;

b. There was no discussion about the reliability of the estimates used;

c. There was insufficient information about the methodology used to estimate Project impacts for the validity of the estimates to be verified;

d. The impact indicators used double count project effects;

e. The methods used to present some benefit indicators misrepresent actual effects.

77. After examining the above reasons in detail, Mr. Thompson concludes that there is insufficient evidence for the Panel to conclude that there will be large or significant regional or provincial economic benefits. Benga's analysis does not describe Project benefits, but instead confuses benefits with impacts, such that the so called "benefits" have been mischaracterized or misinterpreted and are misleading in the context of understanding the Project's economic effects. Furthermore, since the results of the analysis cannot be replicated, are based on assumptions that have not been made apparent, and contain inconsistent information, the Panel does not have sufficient reliable information to understand the nature or magnitude of the Project's economic benefits.

78. Mr. Thompson further notes that while Benga's socio-economic assessment claims that the Project "will create employment opportunities at both the regional and provincial population level"[20] there is no quantification of the extent of these regional effects nor is there any information about Benga's future commitments to ensure these regional effects

20 See Section 4.5.9 of Consultant Report #11 of Volume 7 of the Application (CIAR#42).

actually occur. Therefore, in the absence of a strategy to encourage regional participation in the labour force and to facilitate procurement of goods and services from local and regional businesses, it is unclear as to how Benga will achieve any of the regional benefits it claims will support its Project.

79. Mr. Thompson found several critical problems with Benga's information related to population effects and demand for housing. They include:

a. Lack of information regarding the number of jobs that are expected to be filled by the existing residents of the Regional Study Area (RSA);

b. The assertions relating to population effects are unclear. In the initial application, population figures show 2.2 times increase over the estimated number of in-migrants with no explanation. A later amendment reduced the population numbers in line with the 2016 census numbers but there was still a 30% increase over the number of in-migrants estimates that was not explained;

c. The assumption that all the in-migrants would settle in the RSA, with 490 settling in Alberta portion of the RSA and 320 settling in the BC portion of the RSA without any explanation for the choice of the numbers is problematic. The problems with the assumption are evident in the context of payment of labour income considering that the calculated average wage in BC is well below the provincial average for the coal mining industry as well as in reality considering the number of workers at the BC mines who chose to live in Crowsnest Pass and commute to work; and

d. Lack of clarity regarding how Benga arrived at the assertion that a total number of 277 new housing units would be required to support the Project. Mr. Thompson noted that this number does not match Benga's projected population increase and statistical information. The potential effects on housing show that there are too many unknowns and uncertainties to determine that the effects will not be significant as Benga proposes.

80. Mr. Thompson further noted issues with Benga's assessment of potential impacts on social services and infrastructure. In relation to social services, Mr. Thompson noted that since Benga's prediction of impacts on social services was based on a flawed population change assumption, the potential effects on social services could be much larger than predicted. Also, since Benga's understanding of availability of social services in the RSA was based on information from 2015, it is not known if conditions have changed since then. Furthermore, Benga's assessment of no significant effects is based on heavy reliance on the relevant government bodies investing in social services expansion and revenue sharing between the MD of Ranchlands #66 and the Special Municipality of Crowsnest Pass. Without a back up support plan, reliance on these bodies is not a justification for rating the impacts on social services as insignificant.

81. Mr. Thompson noted issues with Benga's assessment of impacts on infrastructure. In Mr. Thompson's view, Benga's assessment of impacts on infrastructure is heavily reliant on the actions of municipal government being able to make the necessary investments in a timely manner. Therefore, if the investments do not materialize and adverse effects occur, Benga does not see it as being their responsibility.

82. Mr. Thompson then concludes that Benga has not provided sufficient information to enable the Panel to make a public interest determination in favour of its application. Due to the flaws and unsupportable information presented by Benga, Mr. Thompson recommended that the Project be denied pending the receipt of additional information related to whether the project is in the public interest. Mr. Thompson listed the additional information that would be required before the Panel makes a public interest determination, should the Panel decide to proceed in this manner.

83. Mr. Thompson further recommended the following terms and conditions should the Panel decide that it has received sufficient information during the hearing to make a public interest determination:

a. Develop a Project economic enhancement strategy and provide annual reports to demonstrate the success of the strategy.

b. A detailed Project housing strategy needs to be developed in consultation with potentially affected municipalities. Benga should be directed to assist with financing to ensure that sufficient housing is available in a timely manner and completed with the understanding that any financial investment made at the outset would be recovered through reduced municipal taxes in future years. Annual reporting of housing issues would be required.

c. Benga is expected to work with municipal governments to develop a plan for financially supporting the development of services and infrastructure, including municipal tax offsets for investments made prior to or during the early years of operations.

d. Work with Teck in BC to understand the nature of its financial supports to Sparwood and commit to providing similar supports proportional to the size of its workforce that chooses to live there.

e. Insist that a draft of the revenue sharing agreement between the MD of Ranchland #66 and the Specialized Municipality of Crowsnest Pass be tabled with the Panel so that it can ensure revenue sharing proportional to project costs.

H. Coal Quality

84. Some members of the Coalition have noted concerns with the quality of coal that Benga estimates will be recovered from Grassy Mountain. In her submission, Ms. Gilmar traces the history of coal mining on Grassy Mountain and similar claims made by other coal mining companies regarding the quality of the coal to be recovered from Grassy Mountain.[21] The Coalition questions the accuracy of Benga's assertion that the quality of

[21] Appendix A, Submissions of Fran Gilmar, pdf 41.

coal from Grassy Mountain is of great quality. The Coalition relies on the expert evidence of other interveners' experts regarding the quality of coal from the Project.

VIII. REASONS FOR PROPOSED OUTCOME

85. The Coalition respectfully submits that Benga's application for the proposed Project fails to appropriately, adequately, or fully address the concerns of the Coalition, whether of the group broadly or those of the individual members. The Coalition further submits that the Project, as has been applied for, is not in the public interest, when assessed against the adverse impacts that will be created, including but not limited to those raised in these submissions.

86. The Coalition respectfully requests that relief be granted by the Panel in the form of a denial of the applications for the Project.

IX. LIST OF WITNESSES AND TIMING ESTIMATES FOR EVIDENCE PRESENTATION

87. The Coalition presents below its list of witnesses and timing estimates for presentation of evidence.

Nos.	Name	Area of expertise	Timing Estimates for Evidence Presentation (in minutes)
Technical Witness Panel			
1	Jon Fennell, Ph.D.	Groundwater, groundwater-surface water interaction, climate change, geochemical impacts	50

2.	Allan Locke, P.Biol.	Environmental Flows (Instream flows)	40
3	Lorne Fitch	Water Chemistry, sedimentation, and water chemistry impacts on water quality with specific impacts on WSCT	40
4.	John Post, Ph.D.	Impacts on WSCT distribution, population viability, critical habitat loss, cumulative effects, and proposed mitigation and offsetting plan	30
5	Brian Gettel	Property Devaluation	30
6.	Cliff Wallis	Biodiversity primarily terrestrial, ESAs, Species at risk, habitats and other species of conservation concern	50
7.	James Farquharson	Noise	30
8.	John Thompson	Socio-economic impacts	40
Landowners Witness Panel			
9.	Fran Gilmar		30

10	Tyler Watmough and Norman Watmough	30
11	Larry Donkersgoed and Ed Donkersgoed	30
12	Kari Lehr and David Rothlin	30
13	Rae and John Redekopp	30
14	Shirley Kirby	30
15	Vern Emard	30

ALL OF WHICH IS RESPECTFULLY SUBMITTED THIS 21st DAY OF SEPTEMBER 2020.

COALITION OF ALBERTA WILDERNESS ASSOCIATION AND GRASSY MOUNTAIN GROUP

by its legal counsel,

ACKROYD LLP

<Original signed by>

Ifeoma M. Okoye and Richard C. Secord

X. APPENDICES

A. Landowners Submissions

B. Evidence and CV of Brian Gettel

C Evidence of Jon Fennell, Ph.D.

D Curriculum Vitae of Jon Fennell, Ph.D.

E. Evidence of Allan Locke, P.Biol.

F Curriculum Vitae of Allan Locke

G Evidence of Lorne Fitch

H Curriculum Vitae of Lorne Fitch

I Evidence of John Robert Post

J Curriculum Vitae of John Post

K Evidence of Cliff Wallis, P.Biol.

L Curriculum Vitae of Cliff Wallis, P.Biol.

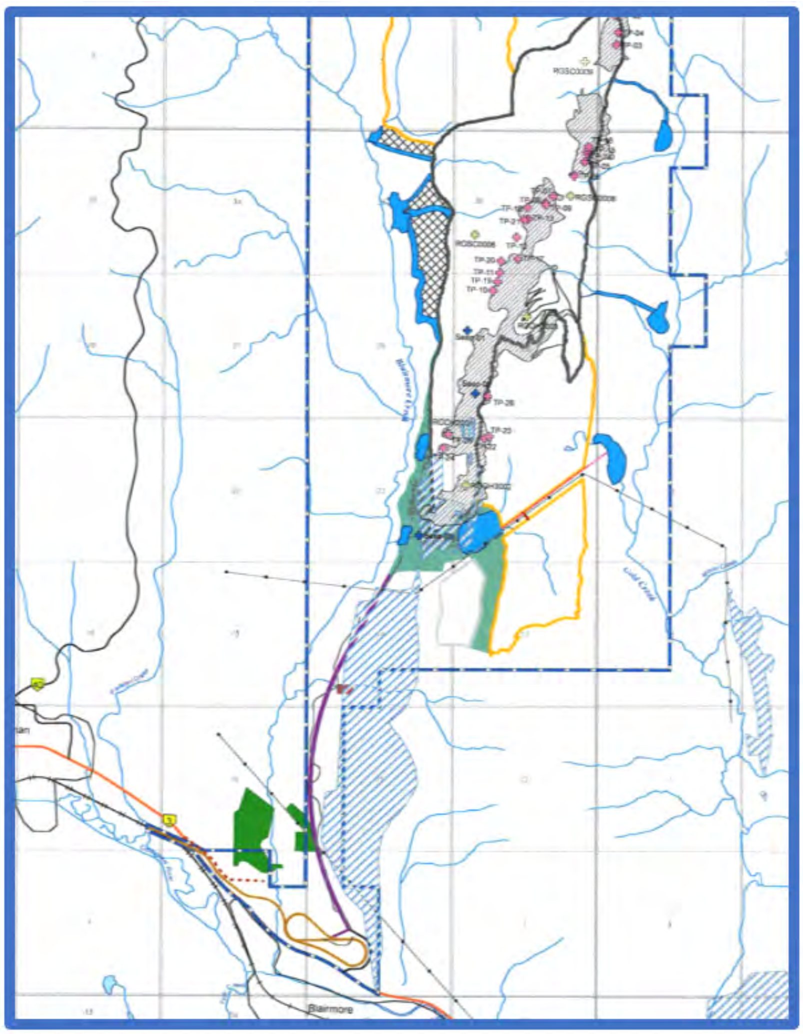
M. Evidence of James Farquharson

N. Curriculum Vitae of James Farquharson

O. Evidence of John Thompson

P. Curriculum Vitae of John Thompson

Real Estate Impact Assessment
Grassy Mountain Coal Project
Townships 8 & 9
Ranges 3 & 4 – W5th Meridian
Municipality of Crowsnest Pass
And
M.D. of Ranchlands



Prepared For
Ackroyd LLP

September 2020

Gettel Appraisals
Real Estate Valuation

GETTEL APPRAISALS
Real Estate Valuation

OUR FILE: 21375

September 18th,2020

Ackroyd LLP
#1500 First Edmonton Place
10665 Jasper Avenue
Edmonton, Alberta
T5J 3S9

Attention: Ifeoma Okoye

Dear Madam:

RE: Real Estate Impact Assessment
Grassy Mountain Coal Project.

In accordance with your instructions, I herewith submit the following "Real Estate Impact Assessment" which relates to the potential effect on real estate values which the Grassy Mountain Coal Project may exert on improved residential properties within the Municipality of Crowsnest Pass. This analysis has been undertaken pursuant to an application to the Joint Review Panel, Impact Assessment Agency of Canada reference number 80101.

The Grassy Mountain Coal Project will involve a surface coal mine to be developed within the Municipality of Crowsnest Pass and adjoining M.D. of Ranchlands. The Municipality of Crowsnest Pass involves a number of smaller communities that were amalgamated into one municipality and which generally adjoin the Highway 3 corridor within southwestern Alberta. The proposed mine will be developed approximately seven kilometers north of Blairmore and Highway 3.

10129 – 161 Street, Edmonton, Alberta T5P 3H9
Phone: 780.429.2323 • Fax: 780.429.3300 • Email: brian@gettel.ca

The basic objective of this analysis is to assess the impact on real estate values which the surface coal mine may exert on improved residential properties located within the Municipality of Crowsnest Pass. Over the past three decades Gettel Appraisals Ltd. have been highly involved in addressing the real estate impacts which some form of negative externality can exert on surrounding properties. Our experience in terms of the latter along with surface coal mines within the Province of Alberta will be relied upon, and a “Literature Review” has also been undertaken focusing on the impacts of surface coal mines and similar facilities.

I hereby certify that the statements contained in this report are true and correct and that I have no present or contemplated interest in any properties within the Municipality of Crowsnest Pass. The reader is referred to the following report for the results of the investigation completed.

Respectfully submitted,

<Original signed by>

Brian S. Gettel, B.Comm., AACI

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 PURPOSE AND OBJECTIVE OF STUDY

Gettel Appraisals Ltd. have been retained by Ackroyd LLP on behalf of a land ownership group which will potentially be affected by the Grassy Mountain Coal Project. The basic objective in undertaking this study is to formulate an opinion of the potential impacts which the proposed project could exert on adjoining residential property values. This analysis has been prepared to assist landowners in proceedings before the Joint Review Panel, Impact Assessment Agency of Canada.

1.2 SCOPE OF STUDY

Initially, a general overview of the proposed surface coal mine has been completed. This has involved a review of materials provided by Riversdale Resources.

A general inspection of the proposed mine site was not undertaken. Gettel Appraisals Ltd. however has familiarity with the Municipal District of Crowsnest Pass having completed several appraisal assignments within the area over the past decade. This has included work completed for the Municipality of Crowsnest Pass. The author of this report is familiar with the various communities which comprise the Municipality as well as the acreage type developments which have been developed in the surrounding area. Recent aerial photography of the surrounding area was also reviewed as a component of this analysis.

To assist in completing the Real Estate Impact Assessment, our experiences in dealing with properties adjacent to surface coal mines within the Province of Alberta will be outlined. A “Literature Review” has also been undertaken with regard to the effect of surface coal mines on adjoining property values and potential nuisances associated with being in close proximity to a surface coal mine. This Literature Review has included similar facilities such as gravel pits or other types of mines. Our extensive background in addressing the effect of negative externalities on real estate values province wide dealing with a number of different facilities has also been relied upon.

Through a correlation of the data analyzed, an overall assessment of the impact on real estate values will be undertaken.

1.3 DEFINITIONS/TERMS

1.3.1 PROPERTY RIGHTS APPRAISED

No specific individual properties are being considered within the context of this analysis although commentary will be directed to two individual sites. The review is primarily focusing on the impact on single family residential properties, improved multi-family residential properties and rural residential acreage properties within the Municipality of Crowsnest Pass and M.D. of Ranchlands. The property rights typically held by individuals owning real estate such as that noted above are those of the "Fee Simple Estate." Fee Simple ownership includes a "bundle of rights", which embraces the right to use the property, to sell it, to lease it, to enter it, or to give it away. It also includes the right to refuse to take any of these actions. Powers of government limit these rights and privileges as this relates to taxation, eminent domain, police power and escheat.

1.3.2 EFFECTIVE DATE OF ANALYSIS

For the purposes of this analysis, an effective date of September 1st, 2020 has been adopted.

1.3.3 MARKET VALUE DEFINED

For the purposes of this report, the term "market value" is defined as follows:

"The most probable price in terms of money which a property should bring in a competitive and open market as of the specified date under all conditions requisite to a fair sale, the buyer and seller, each acting prudently, knowledgeably and assuming the price is not affected by undue stimulus. Implicit in this definition is the consummation of a sale as of a specified date and the passing of title from seller to buyer under conditions whereby:

1. Buyer and seller are typically motivated.
2. Both parties are well informed or well advised, and each acting in what they consider their own best interest.
3. A reasonable time is allowed for exposure in the open market.
4. Payment is made in terms of cash in Canadian dollars or in terms of financial arrangements comparable thereto; and
5. The price represents the normal consideration for the property sold unaffected by special or creative financing or sales concessions

granted by anyone associated with the sale." [1]

1.3.4 EXPOSURE TIME

Exposure time may be defined as follows:

"The estimated length of time the property interest being appraised would have been offered on the market prior to the hypothetical consummation of a sale at market value on the effective date of the appraisal; a retrospective estimate based upon an analysis of past events assuming a competitive and open market."[2]

Exposure time is different for various types of real estate and under various market conditions. It is noted that the overall concept of reasonable exposure encompasses not only adequate, sufficient and reasonable time but also adequate, sufficient and reasonable effort. This statement focuses on the time component.

The fact that exposure time is always presumed to occur prior to the effective date of the appraisal is substantiated by related facts in the appraisal process: supply/ demand conditions as of the effective date of the appraisal; the use of current cost information; the analysis of historical sales information (sold after exposure and after completion of negotiations between the seller and buyer); and the analysis of future income expectancy estimated from the effective date of appraisal.

Our estimate of the most probable exposure time is based upon consideration of one or more of the following:

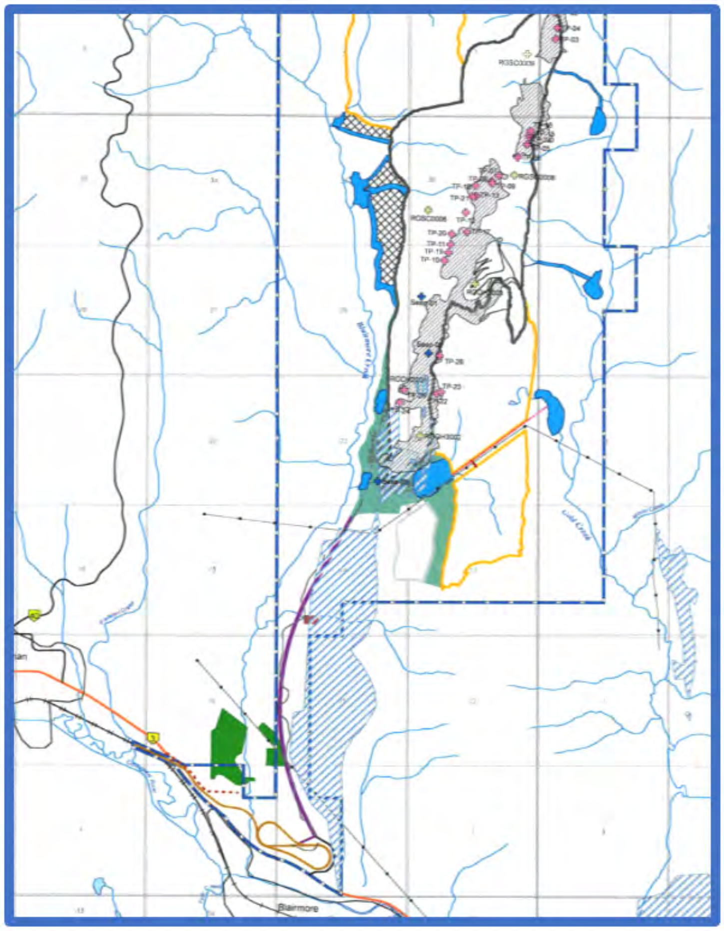
- Statistical information about the time properties are exposed on the open market;
- Information gathered through sales verification;
- Interviews of market participants.

The estimated exposure time for residential properties within the study area is forecast to be 1 to 3 months.

[1] 2020 Canadian Uniform Standards of Professional Appraisal Practice

[2] 2020 Canadian Uniform Standards of Professional Appraisal Practice

2.0 GRASSY MOUNTAIN COAL PROJECT



2.1 PROPOSED LOCATION

The Grassy Mountain Coal Project will involve a surface coal mine which will be located in Townships 8 and 9, Ranges 3 and 4, West of the 5th Meridian. The mine will be located within the Municipality of Crowsnest Pass and adjoining M.D. of Ranchlands. The project will be developed on deeded lands and Crown lease lands.

The project will be located approximately seven kilometers directly north of Blairmore, which represents one residential enclave forming part of the Municipality of Crowsnest Pass. The project will be located approximately seven kilometers north of Highway 3.

2.2 Mining Operations

The Grassy Mountain Coal Project will involve a surface mine. The mining method will be a large scale integrated truck and excavator operation. The mine life is expected to be 24 years. Initial production is expected to be approximately 1.9 million CMT in the first production year escalating to 4.5 million CMT by the fourth year of production. Mine operations are scheduled for 24 hours per day, 360 to 365 days per year.

Mine activities include open pit truck and shovel mining operation areas, waste rock disposal areas, internal haul roads and topsoil storage areas.

The coal handling and processing plant will exhibit a number of facilities including a raw coal receivable bin where mine trucks dump the mine coal. There will be raw coal stackers and stockpiles and an overland conveyor. There will be a train loading bin and a road system.

A new rail linkage with the Canadian Pacific Rail line will be developed as part of the project, and a rail loading area will be developed north of Highway 3 adjoining the mine access road. This rail loading area will link with the Canadian Pacific main rail line a short distance to the west.

The primary access road will extend north of Highway 3 through to the mine. The Highway 3 linkage will be near 107th Street within the community of Blairmore.

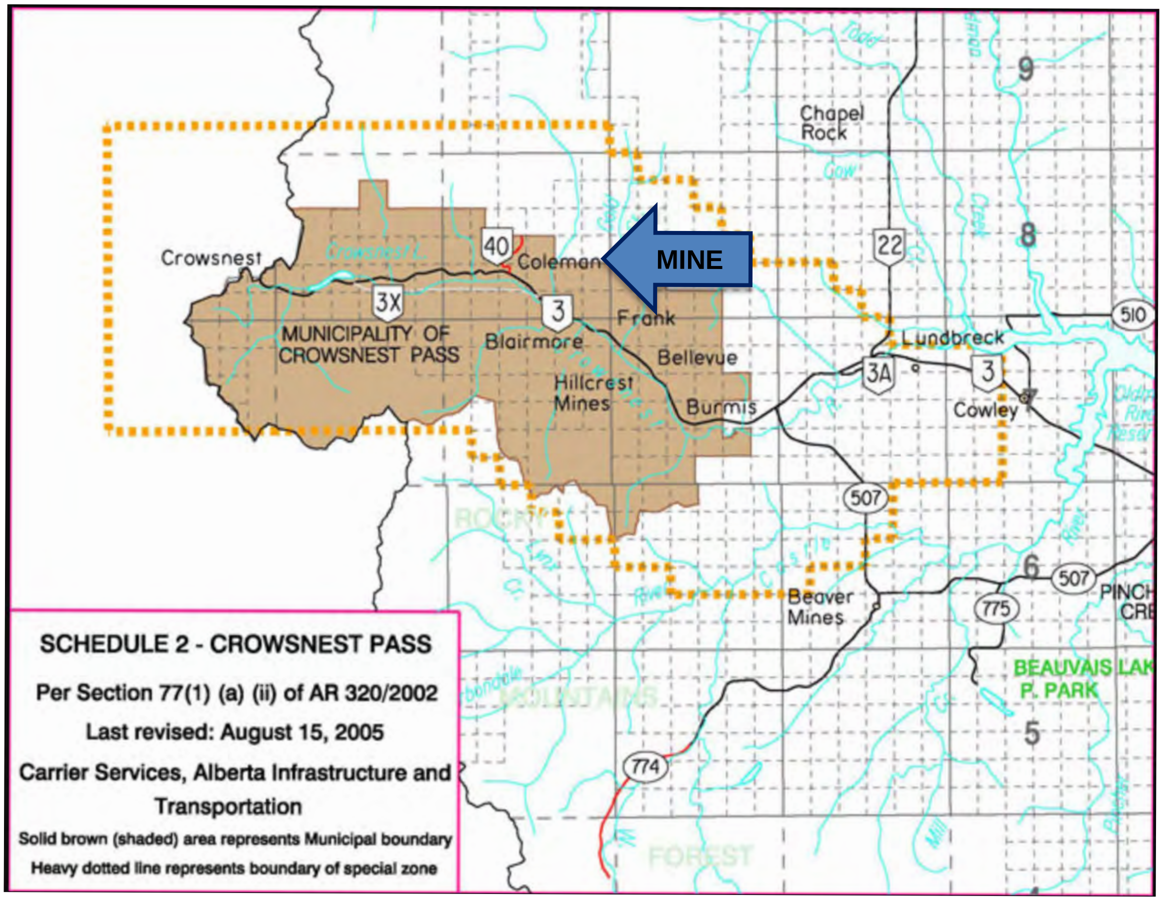
2.3 Risk Factors Associated With Mining Activities

The writer has reviewed the submissions of Riversdale Resources pertaining to the development of the Grassy Mountain Coal Project. A literature review pertaining to the effects of coal mining on adjoining properties has also been completed. The following will summarize factors which could exert an impact on adjoining real estate values:

- Dust concerns (both road dust, waste disposal dust and coal dust)
- Increased vehicular traffic (noise and safety concerns)
- Introduction of rail loading facilities (noise and safety concerns, concerns over hazardous substance spills or train derailment)
- Fear of water or soil contamination

Each of these risk factors will be examined in more detail in a later section of the report.

3.0 MUNICIPALITY OF CROWSNEST PASS OVERVIEW



3.1 GENERAL OVERVIEW

The Municipality of Crowsnest Pass is located in the extreme southwest portions of the Province of Alberta. The Municipality is expansive and generally extends north and south of Highway 3 from the British Columbia border through to the intersection with Secondary Highway No. 507. The Municipality is located approximately 269 km south-west of the City of Calgary and lies 144 km west of the City of Lethbridge. The M.D. of Ranchlands extends north of Crowsnest Pass.

The Town of Crowsnest Pass was originally incorporated on January 1st, 1979 and represented an amalgamation of the towns and villages of Hillcrest Mines, Bellevue, Frank, Blairmore and Coleman. On January 1st, 2008, the centre converted from a town to a special municipality which incorporates both urban and rural areas.

Crowsnest Pass comprises a valley running east to west through the Crowsnest Ridge. Development within the area commenced in 1897 when the Canadian Pacific Railway built a rail line from Lethbridge, Alberta through to Nelson, British Columbia. The line was built to develop coal deposits in the Elk River Valley and in 1900, the Frank Mine opened. Other mines quickly opened and coal mining was the mainstay of the community for many years.

Leading through to 2020, coal mining remains a prominent economic base for the area although all operating mines are currently located in British Columbia. All mines within the Province of Alberta closed several years ago with the last closure being in 1983. With the closing of the mines, the economic base of the area has been non growth orientated over the past two to three decades. In conjunction with mining, tourism is of importance and over the past decade, the community has emerged as a popular tourist area as well as an emerging area for second recreational homes. Additional economic stimulus is derived from the lumber or forestry industry as well as gas processing.

3.2 POPULATION TRENDS

The most recent census was completed in 2016 by the Federal Government. The following chart will highlight trends in population growth within the Municipality over the last 35 years:

YEAR	POPULATION	% CHANGE
1981	7,340	-
1986	6,912	-5.83%
1991	6,679	-3.37%
1996	6,356	-4.83%
2001	6,262	-1.47%
2006	5,749	-8.19%
2011	5,565	-3.2%
2016	5,589	+0.43%

As per earlier discussions, the coal mines within the area were closed several years ago and had long represented the economic base for the community. The population steadily declined up until 2011 and as of 2016, stability was evident with a slight increase in population actually occurring. From 1981 to 2016, the overall population decline was just under 25%. The adjoining M.D. of Ranchlands has a 2016 population of 92 persons, up from 79 persons in 2011.

3.3 ECONOMIC PROFILE

As evidenced by the significant decline in population, the local economy has not been growth orientated over the last two to three decades. Mining activity which had previously been the economic mainstay is now located in British Columbia. Additional economic activity is related to the forestry sector and gas processing. Crowsnest Pass has long been a popular tourist destination, and over the past fifteen years, interest in this regard has increased. Crowsnest Pass is being viewed as a lower cost alternative to the popular Canmore area west of Calgary and has been evolving as a centre featuring second homes utilized for recreational purposes. Over the past several years, several projects both small and large have been targeting second home buyers. The larger projects did not proceed beyond the planning stages.

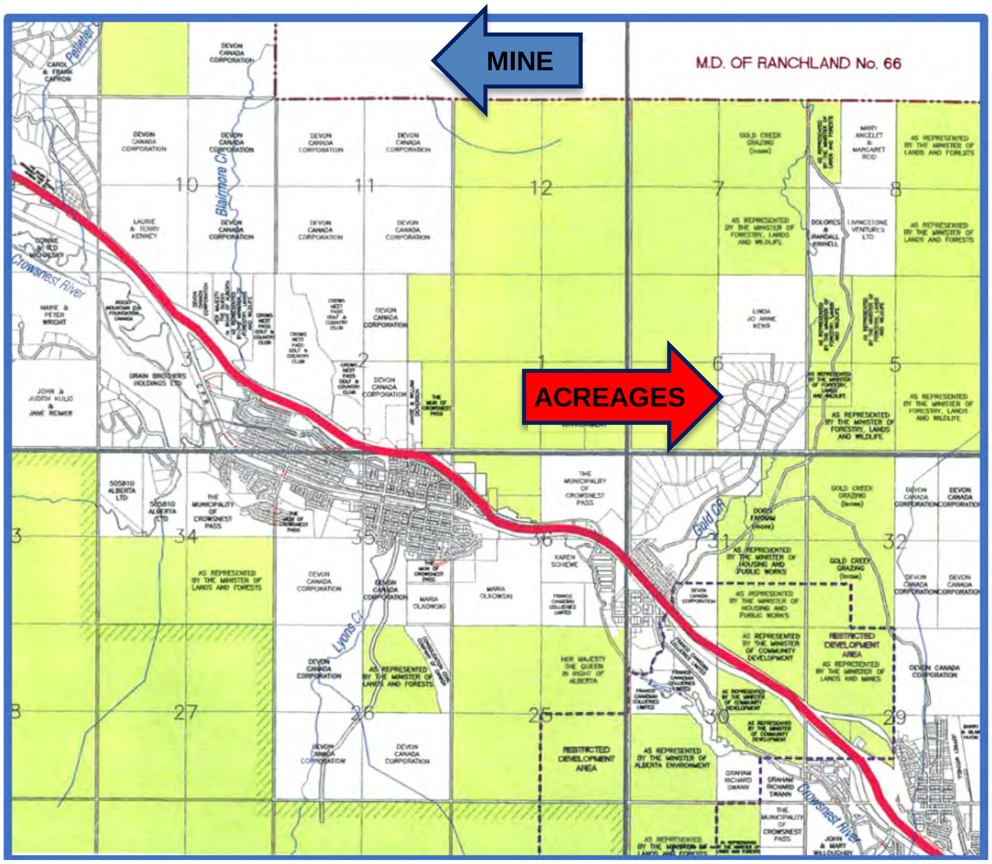
3.4 RESIDENTIAL MARKET

As of 2018, the Municipality reported a total of 3,883 dwelling units. Of this total, 84.2% would represent single family dwellings.

Given the low growth scenario that has been evident for several years, much of the existing housing stock is older. Over the past decade, there has been an increase in activity with regard to new home construction and this has included both single family dwellings, rural residential acreages and some higher density projects as well.

The rental market within the local community is not extensive. As of 2018, the Municipality was reporting a residential vacancy rate of 18.3%, up from 9.1% in 2017. The average rent for a two bedroom apartment unit is $664.00 per month.

3.5 BLAIRMORE AREA



Blairmore is the largest of the communities which make up the Crowsnest Pass. Blairmore has developed immediately south of Highway 3 and is located directly south of the proposed mine.

Residential development within Blairmore primarily comprises single family dwellings, typical of much of the Municipality. There is also some higher density housing and once again, much of the housing is older.

There are a series of acreage type developments lying to the north of Highway 3 and to the east of Blairmore. These acreage developments feature typical country residential type homes and are located directly southeast of the proposed mine.

The communities of Frank and Hillcrest Mines lie to the southeast of Blairmore and south of Highway 3. Bellevue also lies to the southeast and is located to the north of Highway 3. All of the latter communities would lie south and east of the proposed mine.

3.6 HIGHWAY 3 OVERVIEW

Highway 3 is the primary highway servicing the Municipality of Crowsnest Pass. Highway 3 generally represents the north limits of Blairmore.

As Blairmore is the largest of the communities within the Crowsnest Pass, traffic volumes tend to be at the highest levels surrounding the community. At the east Blairmore access, traffic volumes as of 2019 were 9,950 vehicles per day. In the summer, this increases to 12,650 vehicles per day. The latter highlights the significance of tourism to the area. The west Blairmore access had traffic volumes in 2019 of 8,470 vehicles per day, increasing in the summer months to 10,770 vehicles per day.

Highlighting the growth in tourism that has been evident within the area, traffic volumes at the east Blairmore access in 2009 were reported at 8,680 vehicles per day. At the west Blairmore access, traffic volumes were reported at 6,640 vehicles per day.

An extension off Highway 3 at 107th Street will be the primary access to the mine.

4.0 LITERATURE REVIEW - IMPACT OF COAL MINING & MINES ON RESIDENTIAL PROPERTY USE & VALUES

A two part literature review has been conducted. The initial aspect of the analysis has keyed on a review of publications which outline the negative impacts caused by coalmines and other similar types of mining activities on residential property use. The intent of this exercise has been to identify those factors which can cause an impact. The second aspect of the analysis will focus on studies which have been completed and which have addressed the impacts of negative factors on residential property values.

4.1 LITERATURE REVIEW – NEGATIVE IMPACTS OF COAL MINING ON RESIDENTIAL LAND USE

A series of three separate publications have been reviewed under this heading.

4.1.1 DUST CONTROL, BEST PRACTICE ENVIRONMENTAL MANAGEMENT IN MINING, ENVIRONMENT AUSTRALIA, 1998

The following are quotes from this publication:

4.1.1.1 "DUST IS AN INEVITABLE PROBLEM FOR ALMOST ALL FORMS OF MINING."

4.1.1.2 "DUST IS ONE OF THE MOST VISIBLE, INVASIVE AND POTENTIALLY IRRITABLE IMPACTS AND ITS VISIBILITY OFTEN RAISES CONCERNS WHICH ARE NOT NECESSARILY IN DIRECT PROPORTION TO ITS IMPACT ON HUMAN HEALTH AND THE ENVIRONMENT."

4.1.1.3 "MINE DUST CAN RESULT IN A SERIOUS NUISANCE AND LOSS OF AMENITY FOR POPULATIONS LIVING IN THE VICINITY OF A MINE."

4.1.2 AIR POLLUTION EMISSIONS 2008 – 2011 FROM AUSTRALIAN COAL MINING – IMPLICATIONS FOR PUBLIC AND OCCUPATIONAL HEALTH, M. HENDRYX ET AL, FEBRUARY 2020

The following are quotes from this publication:

4.1.2.1 "RESULTS FROM COMMUNITY-BASED MONITORING STATIONS INDICATED SIGNIFICANTLY HIGHER POPULATION PM10 (PARTICULATE MATTER 10

MICROMETERS) EXPOSURE IN COAL MINING COMMUNITIES THAN IN NON-COAL MINING COMMUNITIES."

4.1.2.2 "IN ADDITION TO OCCUPATIONAL RISKS, COAL MINING ALSO AFFECTS SURROUNDING COMMUNITIES. SURFACE MINING IN PARTICULAR CONTRIBUTES TO LOCAL AIR POLLUTION, WITH DOCUMENTED GENOTOXIC EFFECTS AND INCREASED RISKS FOR CANCER, CARDIOVASCULAR DISEASE AND RESPIRATORY DISEASE AMONG COMMUNITY POPULATIONS."

4.1.3 ELKFORD OPPOSED TO TECK COAL LICENSE APPLICATION, MY EAST KOOTENAY NOW, MARCH 11, 2020

The Elkford area is a prominent community adjoining coal mines within the southeastern portions of British Columbia, lying west of the Crowsnest Pass. The article focused on an application to expand coal mining.

This article indicated that the District of Elkford has voiced opposition to two coal license applications made by Teck to the B.C. Government. The Mayor of Elkford indicated the main concern raised by the municipality was that of water quality. The proposed mine expansions were next to the groundwater immediately downstream from the Elk River, which is the key water source for the District of Elkford. Coal dust was also raised as a concern and the district indicated that they were looking to mitigate the economic benefit of the coal mines with residential quality of life. The Mayor went on to indicate that they were getting more and more dust from the Greenhills operation and that they have concerns about dust from a further expansion.

4.1.4 CONCLUSIONS

The review completed has identified dust from mining operation as being the key negative factor that arises from coal mines in relation to surrounding population centres. Dust problems can arise from actual mining, conveyancing and loading as well as dust arising from haul roads or from waste disposal. Coal dust in particular is a general nuisance and potential health concern.

4.2 LITERATURE REVIEW – RESIDENTIAL PROPERTY VALUE LOSS STUDIES

The literature review conducted revealed that there has not been an abundance of studies completed with regard to the effect of surface coal mines on adjoining property values. Two studies will be reviewed. Three other studies will also be addressed. One of these pertains to the effects of a surface precious metals mine and the other two will relate to the effects of gravel quarries.

4.2.1 EFFECTS OF LONGWALL MINING ON REAL PROPERTY VALUES AND THE TAX BASE OF GREENE AND WASHINGTON COUNTIES, PENNSYLVANIA, KERN, ET AL, DECEMBER 2002

This study focused on mining in more rural or remote areas of Greene and Washington Counties. The study found that close proximity to an active mine was not a major factor with regard to real estate values. The study did however note that assessed values, which are based on market value, had been downwardly adjusted in some instances based on close proximity to the mine. The study also noted that some land owners situated close to the mine had been compensated for impacts by the coal mining company.

4.2.2 THE IMPACT OF SURFACE COAL MINING ON RESIDENTIAL PROPERTY VALUES: A HEDONIC PRICE ANALYSIS, WILLIAMS, 2011

This study examined the effects of surface coal mines on residential property values on a very broad basis and was based on data obtained from thirteen US states. This study found that the addition of a surface mine decreased median property values on a broad basis. Value losses of $7,526,981.00 to $14,779,928.00 were noted. The study went on to indicate that this was a relatively significant decrease in values. In terms of the decrease on value in individual homes, the losses were very minor. The study noted value influencing factors such as lower water and air quality and a decline in recreational activities.

4.2.3 AN ECONOMETRIC ANALYSIS OF THE EFFECT OF MINING ON LOCAL REAL ESTATE VALUES, SUN

This paper focused on an open pit precious metal mine in South Carolina where gold and silver were mined. This study found that there was a significant negative impact on property values and the negative impact increased the closer any given property was to the mine. No specific levels of property value loss were documented.

4.2.4 SUMMARY ANALYSIS: IMPACT OF OPERATIONAL GRAVEL PIT ON HOUSE VALUES, DELAWARE COUNTY, OHIO, HITE, 2006

The negative impacts arising from close proximity to gravel pits can be similar to those associated with open pit coal mines. Dust problems would be of particular concern. This study examined the effects of close proximity to a 250 acre gravel mine and was based on the sale prices of 2,552 residential properties which had sold between 1996 and 1998. This study found that the closer a residential property was to the gravel mine, the greater the value loss. Properties within one half mile of a gravel mine could experience a 20% reduction and this would increase to 14.5% being one mile from the mine. At two miles, the loss was 8.9% and at three miles, the loss was 4.9%.

4.2.5 DIMINUTION IN PRICE (IF ANY) TO RESIDENTIAL REAL ESTATE IF LOCATED IN THE VICINITY OF AN EXISTING OR PROPOSED ONTARIO PIT OR QUARRY, LANSINK, JANUARY 2014.

This study examined the effects of gravel pits on adjoining property values in Ontario. The study focused on residential properties which were within an influence area of a proposed pit or quarry and haul roads. A range in property losses was observed varying between 8.5% and 39.36%. An average value loss of 23.19% was observed.

4.2.6 CONCLUSIONS

The two studies reviewed with regard to coal mines indicated nil to very modest potential value losses. One study indicated no major concerns within a rural or remote location. The Longwall Mining Study however did indicate that assessed values had been reduced based on close proximity to the mines and that in some instances, land owners had been compensated for value losses by mining companies. The semi precious metals mine was noted as causing significant losses. Relatively substantial losses were noted in the two gravel mining studies. Proximity to mines is a highly influential factor. The closer the proximity, the greater the value loss.

5.0 GETTEL APPRAISALS LTD. COAL MINE COMMENTARY – OTHER CASE STUDIES

Within this section of the report, the experiences of Gettel Appraisals Ltd. with regard to surface coal mines and property values will be outlined. The experiences of Gettel Appraisals Ltd. in examining other value loss scenarios will also be addressed.

5.1 GETTEL APPRAISALS LTD. EXPERIENCE WITH SURFACE COAL MINES

There are two major surface coal mines operated within the greater Edmonton metropolitan area. This includes a coal mine operated by Capital Power within the Genesee area of Leduc County where coal is mined for the Genesee Power Plant. A similar mine exists within Parkland County which is operated by TransAlta Utilities Ltd. for the Keephills, etc. power plants.

The experience which Gettel Appraisals had with regard to these surface coal mines basically relates to property acquisitions which have occurred through the need for mine expansion or where negative impacts on adjoining lands occurred which resulted in acquisitions being undertaken. These acquisitions were not premised on any property value losses occurring rather, full buy-outs were undertaken.

With regard to the Genesee mine acquisitions, problems noted by land owners included dust and noise. Dust was a particular concern and was noted as exacerbating problems associated with respiratory conditions such as asthma.

With regard to the TransAlta mines in Parkland County, problems associated with dust and fly ash were noted as being problems.

As a general comment, it is to be highlighted that both the Genesee and Parkland County coal mines are situated in very rural areas where there is not an abundance of residential development or, high concentrations of population. Discussions with assessors for both Leduc County and Parkland County indicated that there had been no requests for reduced assessed values based on negative impacts from either mine.

5.2 GETTEL APPRAISALS LTD. – OTHER PROPERTY LOSS CASE STUDIES

Gettel Appraisals Ltd. has long been extensively involved in areas such as expropriation, surface rights work, general real estate litigation and presentations to the Alberta Utilities Commission, Municipal Government Board, etc. Through our activities in these areas, case studies examining value losses caused by negative externalities have been completed for a wide variety of projects or facilities both existing and proposed. The following is a sampling of these projects or facilities:

- Landfills
- Sewage lagoons
- Sewage holding stations
- Public trails
- Highways and arterial roads
- Light rail transit systems
- Freight rail lines
- Overhead power transmission lines
- Pipelines
- Large scale confined livestock operations
- Adjacency to schools
- Adjacency to commercial facilities
- Adjacency to high density residential projects
- Adjacency to major parkades
- Neighbourhood blight
- Effects of flooding
- Effects of environmental contamination
- Effects of sour gas facilities

Our involvement in the above noted areas over an extended period of time has provided a wealth of knowledge as to how the market reacts to negative externalities. Through our experience, we would typically relegate value losses into three categories or, low impacts, moderate impacts and high impacts. The following will generally summarize the types of value losses observed on a percentage basis with regard to these three categories of loss:

- Low impact: 0 – 10%
- Moderate impact: 10 – 15%
- High Impact: 15 – 50%

Losses at the upper end of the high impact scale are observed only in rare instances and typically involve extreme cases.

6.0 IMPACT CONCLUSIONS – GRASSY MOUNTAIN COAL PROJECT

Earlier in this analysis, a series of factors were addressed which could result in an impact on property values. This included vehicular traffic, introduction of a new rail line and new rail loading facilities, environmental concerns and issues with dust. Each of these will be addressed in more detail in this conclusion section of the report.

6.1 INCREASED VEHICULAR TRAFFIC

The primary access route to the coal mine will be Highway 3 at Blairmore. This is one of the highest traffic count locations within the Crowsnest Pass. A traffic impact assessment was completed by Riversdale Resources. This traffic impact assessment indicated that there would be an increase in traffic as a result of the mine and that an additional 54 vehicle trips would be generated daily. This included 32 inbound trips (into the mine site) and 22 outbound trips (out of the mine site). In relation to an area where traffic counts are already 8,000 vehicles per day or more, this is considered to be minor and this is not an area where any impact on real estate values is forecast to arise.

6.2 NEW RAIL FACILITIES

A new rail line and rail loading facility will be developed as a component of the mine which will tie into the Canadian Pacific line which exists along the Highway 3 corridor. The introduction of new rail facilities and a loading area indicates potential for increased noise and issues such as a train derailment or waste spillage. As there are already rail facilities within the area and in acknowledging the intermittent use of rail, this is not deemed to be a major concern with regard to real estate values.

6.3 ENVIRONMENTAL CONCERNS

Concerns along these lines would relate to variables such as water or soil contamination. For proposed projects, there can be a general fear or apprehension within the real estate market pertaining to environmental considerations. It has been the writer’s experience that such fears or apprehensions for this type of contamination will not cause any major concerns within the real estate market. Rather, concerns only emerge once contamination actually exists. As the Grassy Mountain Coal Project is proposed, the writer does not envision any major value impacts arising from the fear of potential contamination. In the event that contamination issues evolve after the mine is developed, this can be a major consideration.

6.4 DUST

As per the literature review completed, dust is the number one problem associated with surface coal mines. Dust once again is also consistent with mining, conveyancing, loading, waste disposal and haul roads. Problems with dust are also consistent with the experiences of Gettel Appraisals Ltd. with regard to surface coal mines within the greater Edmonton metropolitan region.

Dust is a general irritant or nuisance and also has associated health risks and this is particularly true for coal dust. Coal dust is noted as a health concern with regard to respiratory ailments, cardiovascular disease and cancer. It has been the writer's experience that whether the health risks are true or not, these fears can manifest in the real estate market and property devaluation can occur. This is a variable that must be recognized by a property analyst. The coal mine in this instance will be located approximately seven kilometers north of Blairmore. Blairmore is located directly south of the mine and to the south and east are country residential subdivisions and residential enclaves such as Frank, Bellevue and Hillcrest Mines. Winds within the Crowsnest Pass area are influenced by terrain, but the general prevailing winds come from the west and northwest. Winds within the Crowsnest Pass can be very intense and this has the potential to carry dust an extended distance.

Riversdale Resources indicate that various dust mitigation programs will be in place. This will include covers over conveying systems, the use of dust suppression sprays, etc. This would appear to be a typical dust mitigation program. Based on the literature review, dust problems appear to be very common despite mitigation programs.

6.5 CONCLUSIONS

Based on the review completed, the writer has formulated the opinion that the dust will be the key factor that could impact residential real estate values within the Crowsnest Pass relating to the development of the Grassy Mountain Coal Project. As per earlier discussions, prevailing winds within the area primarily come from the west and northwest. This would imply potential dust problems for properties south and southeast of the proposed mine. Due to the strength of winds within the area, the impact could carry for an extended area.

Based on the writer's involvement in property devaluation scenarios over the past several years, value impacts typically occur at two points in time. One point is pre-construction. Apprehension can often emerge within the market about potential value impacts and this can create concerns before a facility is even commenced. The second point in time is after the facility is operational where concerns become reality.

Discussions with parties active in the local real estate market would indicate that there has been some apprehension with regard to the real estate market based on the pending construction of a coal mine. This has particularly been a factor for higher end recreational housing. While the local market has been active this year, higher end housing developments have been more sensitive. It has been the writer's experience that value losses will typically not occur during pre-construction. Rather, the effect is a slowing in sales activity, and this appears to have occurred within the Crowsnest Pass with regard to higher end recreational housing.

In terms of post construction value impacts, based on the research conducted, the writer has concluded that projected problems from dust would fall within the low impact category. For mainstream residential properties, the writer would anticipate value losses ranging between zero to 5%. However, it has been the writer's long standing experience that higher end housing tends to be much more sensitive to negative externalities, and value losses in the order of 10% or more could occur for this type of housing. The impact is anticipated to be greatest for those properties closest to the mine and this would include housing within communities such as Blairmore, Frank, Hillcrest Mines, and Bellevue. This would also include country residential acreage properties within the same general area. The actual negative effects which can arise from the mine will evolve over a period of time. The best case scenario is that there will be little or minimal impact and this would result in value losses towards the low end of the range. The worst case scenario would reflect losses towards the upper end of the range.

The writer has also given consideration to individual circumstances. To this end, the writer has had an opportunity to review the submissions of Norman, Connie and Tyler Watmough and those of Donkersgoed Feeders Ltd. and Berdina Farms Ltd. These parties own the SE-19 and SW-19-8-3-W5 respectively. These owners are very close to the mine and have expressed concerns about dust and pollution and also have very significant concerns with regard to access. Access to these properties could be restricted or potentially closed. Value impacts could be much more significant for these two individual properties. The greatest impact would occur in the event that access is closed off for both properties. The latter scenario could render the lands as being unsaleable. Two other individuals share the same concern in the immediate area including Vern Emard (SE-30-8-3-W5) and Fran Gilmar (SW-30-8-3-W5).

7.0 CONSULTANT'S CERTIFICATION

I certify to the best of my knowledge and belief that:

- The statements of fact contained in this report are true and correct.
- The reported analyses, opinions and conclusions are limited only by the reported assumptions and limiting conditions, and are my personal unbiased professional analyses, opinions and conclusions.
- I have no past, present or prospective interest in the property that is the subject of this report, and I have no personal interest or bias with respect to the parties involved.
- My engagement in and compensation for the assignment were not contingent upon developing or reporting predetermined results, the amount of the value estimate, or a conclusion favoring the client.
- My analyses, opinions and conclusions were developed, and this report has been prepared in conformity with the Canadian Uniform Standards.
- I have the knowledge and experience to complete the assignment competently.
- No one provided significant professional assistance to the person signing this report.
- The Appraisal Institute of Canada has a Mandatory Continuing Professional Development Program for designated members. As of the date of this report I have fulfilled the requirements of this Program.

Respectfully submitted,

<Original signed by>

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Brian S. Gettel, B.Comm., AACI

Dated: __September 18th, 2020____

ADDENDA

EXHIBIT A
APPRAISER QUALFICATIONS

APPRAISAL & CONSULTANT QUALIFICATIONS

Brian S. Gettel, B.Comm., AACI

EDUCATION/ACCREDITATIONS

- University of Alberta, 1974 - Bachelor of Commerce Degree.
  Majors: Economics & Marketing

- AACI, Accredited Appraiser Canadian Institute, 1981

- Professional Development Seminars include:
  - Farm Management Course, Olds College
  - Soils Analysis & Agricultural Appraisal Course, Olds College
  - Real Estate Taxation
  - Investment Analysis, U of A
  - Land Use Planning, U of A
  - Investment Analysis, Appraisal Institute of Canada
  - Analysis of Partial Takings, International Right-Of-Way Association
  - Market Analysis, Urban Land Institute
  - Environmental Assessments, Environmental Assessment Assoc.
  - Land Development, U of A

EXPERIENCE

- Loans Officer, Alberta Agricultural Development Corporation, Grande Prairie, Barrhead and Camrose, 1974 - 1978. Duties included appraisal of farmland and buildings for loan security purposes.

- Appraiser, Alberta Environment, Land Assembly Division, Edmonton, 1978 - 1979. Duties related to appraisal of agricultural, recreational and urban periphery lands.

- Appraiser, MICC Appraisals & Inspections Limited, Edmonton 1979. Fee appraisal work in a variety of fields including residential, agricultural, commercial, industrial and investment properties.

- Appraiser, Fraser Bourgeois & Co., Edmonton, 1980 - 1981. Fee appraisal work primarily in the agricultural, commercial, industrial and investment sectors.

- Appraiser - Partner, Gettel & Dezman Appraisal Consultants Ltd., Edmonton, 1981 - 1996. Fee appraisal work in the agricultural, commercial, industrial and investment sectors.

- Appraiser - Owner, Gettel Appraisals Ltd. 1996 - Present.
  Fee appraisal work in the agricultural, commercial, industrial and investment sectors.

- Owner, The Network 1997 - Present.
  Commercial real estate data base service for the greater Edmonton area.

PROFESSIONAL MEMBERSHIPS

- Appraisal Institute of Canada

- International Right-Of-Way Association

- Urban Land Institute

- Alberta Expropriation Association (past President)

APPRAISAL EXPERTISE

- Appraised commercial properties (office buildings, shopping centres, general retail buildings), industrial properties (owner/user warehouses, multi-bay warehouses, manufacturing plants), multi-family properties (condominium projects, row house projects, walk-up and high-rise apartments) and institutional properties (schools, hospitals, office buildings) for mortgage financing, foreclosure, sale/acquisition, litigation, taxation, etc.

- Appraised a wide variety of agricultural properties (grain farms, cattle operations, dairy farms, hog operations, orchards, etc.) for mortgage financing, foreclosure, valuation day, sale/acquisition, litigation, etc.

- Assessed compensation under the Expropriation Act and Surface Rights Act for a wide variety of urban and rural property types for the purposes of road/highway development/widening, rail line development, developing drainage canals, power lines, pipelines, sewage lagoons, land fill sites, etc.

- Conducted studies on highway/rail line proximity damages, devaluation studies relating to the impact of power lines, pipelines, sewage lagoons, land fill sites, etc.

- Extensive experience appraising environmentally contaminated properties for compensation - devaluation and sale - purchase purposes.

- Conducted feasibility/market analysis on urban development land, multi-family, commercial and industrial projects.

- Conducted/supervised semi-annual vacancy studies relating to the City of Edmonton office, retail (shopping centre) and industrial markets on a semi-annual basis since 1983.

- Conducted an insurance appraisal on all buildings and structures owned by the City of Medicine Hat for fire insurance purposes.

EXPERT WITNESS EXPERIENCE

- Alberta Land Compensation Board
- Alberta Surface Rights Board
- Alberta Energy & Utilities Board
- Alberta Court of Queen's Bench
- British Columbia Supreme Court
- Alberta Assessment Appeal Board/Municipal Government Board
- Various Arbitration Boards/Panels

ARTICLES PUBLISHED

- The Canadian Appraiser
  "Site Valuation - A Reassessment Of The Adjustment Process"

- Co-wrote Appraisal Institute Student Manual - 2200 - Appraisal Of Service Stations

- Expropriation Digest

GUEST SPEAKING ENGAGEMENTS

- International Right-Of-Way Association
- Alberta Expropriation Association
- Appraisal Institute of Canada
- Edmonton Real Estate Board
- Conference Board of Canada

Grassy Mountain Coal Project Hearing Submission

Review of geology, hydrogeology, groundwater-surface water interaction, geochemistry, and climate change implications

Prepared by:

Dr. Jon Fennell, M.Sc., Ph.D., P.Geol.
Hydrogeologist and Geochemist
Water Security | Climate Resiliency

On behalf of:

The Coalition of the Alberta Wilderness Association and Grassy Mountain Group

For:

The Joint Review Panel, Impact Assessment Agency of Canada
Project Reference No. 80101

September 21, 2020

Executive Summary

A proposal has been put forward to the Joint Review Panel for the Impact Assessment Agency of Canada and the Alberta Energy Regulator to develop a new coal mine within the Blairmore and Gold Creek watersheds north of Blairmore AB. The plan is to strip mine coal-bearing bedrock formations underneath Grassy Mountain and place the waste rock in large rock disposal areas outside of the mine workings. Up to 430 vertical metres of the mountain will be lost, with the final base of the mine being situated about 110 m below Blairmore Creek and about 40 m below Gold Creek. As required under provincial and federal laws, and the Terms of Reference for this application, the applicant has assessed the potential impacts to the air, land, water, and biodiversity. This review provides commentary on issues relating to hydrogeology, geochemistry, groundwater-surface water interactions and climate change implications.

The impact assessment provided by the applicant relies heavily on models to project changes to the water balance (FEFLOW) and water quality (GoldSim). By their admittance, the applicant points out that the area is geologically complex and subjected to folding, faulting, and fracturing in relation to historical mountain-building processes. The majority of investigation regarding physical and chemical properties of the rock formations and their hydraulic characteristics has been constrained to the coal-bearing layers, leaving some doubt regarding the properties of the others. The groundwater numerical model can only be described as a gross simplification of this complex system, with assumptions that do not match with the reality of the Project area. Although the model has been described as having a "good" match between simulated and observed changes to groundwater levels at a limited number of locations, and protracted records of baseflow in both Blairmore and Gold creeks, this is not completely true for all parts of the model domain. The lack of spatial and temporal data used to constrain the model in relation to the very large geographical area, combined with the unrealistic assumptions regarding the role of faults and fractures in the movement of groundwater from the upland areas to the creeks, severely hampers the numerical model projections provided.

It is clear that the water table below Grassy Mountain will be <u>permanently</u> lowered by up to 430 m. The extent of drawdown impact associated with this effect has been simulated to remain within 400 m of the mine pit boundary. It is hard to believe that such a limited extent of drawdown will occur, but it is understandable how this conclusion has been reached given the favourable configuration of model parameters. For example, no accommodation has been made for the presence of west to east striking faults, which are likely present in the Project area as evidenced by the trellis-style drainage pattern. Similarly, the north to south striking thrust faults have been assumed to be inactive pathways for groundwater flow. Recharge to the upper layers of the model is also unrealistically high in certain parts of the model domain, particularly along Gold Creek, compared to documented values. These, and other, features of the model are resulting in a minimization of drawdown impacts and baseflow reductions in the local creeks. Despite the shortcomings of the applicant's model, reductions in baseflow have been projected to be as high as 20% along some reaches of the creeks. However, this could have been much higher if a more conservative approach honouring the actual physical and climatic conditions (including historical variability) had been employed.

Taking into consideration the expected variability in the geologic and hydrogeologic conditions, as well as critical input parameters like precipitation, negative impacts to the water balance in the Project area have been understated leading to overall favourable results for the application. The significant and permanent reduction in hydraulic head following the removal of a mountain <u>will</u> result in upland springs ceasing to flow and associated seepage areas and wetlands drying up. Lowering of the water table will also likely affect important non-assessed tributary creeks conveying water from Grassy Mountain down to the Blairmore and Gold creek valleys. Given the limitations of the model, and the associated field work and

measurements to calibrate, it is anticipated that the water balance of the area will be affected much more negatively than currently being communicated.

The applicant is also indicating that the release of selenium from the waste rock will be an issue, much like what has occurred in the Elk Valley to the west. This will require a mitigation strategy of engineered saturated backfill zones (SBZs) to sequester the selenium from mobilizing to aquatic receptors. This will require the SBZs to become deficient of oxygen (anoxic) through natural or artificial means. It remains unclear whether the SBZs will require perpetual dosing with an organic substrate to promote and maintain the anoxic conditions necessary to precipitate elemental selenium. It is equally unclear whether the selenium will be sequestered permanently, or whether there will be a risk of remobilization in the future. There is further concern that the development of anoxic conditions could inadvertently mobilize other harmful trace elements, like arsenic, which are known to be present in the area. The concern of element mobilization extends to the sedimentation ponds and end pit lake, which is deep enough to stratify and become anoxic at its base (under the right conditions). Unfortunately, these aspects were not assessed beyond the water quality modelling conducted by the applicant, which did in fact indicate that certain trace elements could reach concentrations in excess of Alberta guidelines for the protection of freshwater aquatic life (FWAL). Considering the likely under-representation of drawdown and reductions in groundwater contributions to the local water features, this calls into question the "not significant" projections of future discharges from the mine water features to Blairmore and Gold creeks. Under a scenario of greater baseflow reductions (than currently projected) the ability of the local creeks to dilute effluent to the "safe" values projected will be severely hampered. This calls into question the impact ratings provided for the almost 100% genetically pure (and threatened) West Slope Cutthroat trout populations and associated aquatic habitat supporting them.

Lastly, the assessment of future changes to the hydroclimate of the region, due to increasing global temperatures, has been impaired by the reliance on "average" conditions as opposed to extremes. The applicant had, at their disposal, access to historical records spanning decades to hundreds of years to frame the range of variability, but instead relied on short-term averages and 1 in 10-year wet and dry periods (and later a 1 in 20-year dry period). Unfortunately, worst case scenarios like an extended dry period (i.e. hydrological drought) combined with more consecutive hot days, extreme low flow conditions extending longer into the season, and a permanent baseflow reduction of significant magnitude was not considered. Such a scenario could lead to stream temperatures exceeding optimal values for aquatic life, and lead to sub-optimal dissolved oxygen conditions during critical bioperiods for fish and the aquatic invertebrates they rely on. Equally, the significant reduction in winter baseflow along certain reaches of the creeks, combined with severs long-term freezing temperatures, could reduce already threatened over-wintering habitat and place pressure on an already threatened fish species. Creating habitat is one way to mitigate these risks, but that assumes a good working knowledge of groundwater-surface water exchange dynamics, including where. This has not been demonstrated to the degree necessary to ensure perpetual success.

Given the magnitude of disruption the applicant is seeking permission to inflict on the Blairmore and Gold creek watersheds, it is disappointing how limited the amount of field reconnaissance, instrumentation, and physical and chemical measurements of springs, wetlands and other supporting water features has been to support the impact assessment process. The example provided by the Elk Valley to the west is a sobering reminder of how disturbances to natural watersheds, without full knowledge of how they will respond, can provide surprises that can be very difficult (if not impossible) to resolve. Leaving impact assessments up to poorly-constrained models will only lead to similar results, where actions will have to be taken "on the fly" only after the damage is already done. If the uncertainty in this impact assessment's projections is simply being left up to adaptive management to mitigate then it is clear that this application should not be approved. The risk of creating unintended consequences is too great to ignore.

Introduction

The Grassy Mountain Coal Project (the Project) represents a significant opportunity for Alberta to leverage existing coal resources and stimulate economic growth. On the other hand, the project is proposing to remove a large part of a mountain and alter (forever) a significant portion of two natural watersheds resulting in notable and under-represented change. From a hydrogeological, hydrological, geochemical, and climate change perspective there are a number of challenges that remain unresolved or unmitigated with respect to this Project that need suitable clarification to avoid the risk of unintended consequences in future years. These issues have been addressed below according to the following themes:

1. Knowledge of the geological and hydrogeological regime and its influences.
2. The use of "average" conditions.
3. Geochemical implications for waste rock areas, SBZs, and mine-related water bodies.
4. Certainty that mitigation measures will be successful.
5. Climate change considerations.

1. Knowledge of the geological and hydrogeological regime and its influences

Mapping of the regional and local geology has identified a complex arrangement of folded and faulted sedimentary formations that will be the focus of coal mining. The main pattern of faulting identified by the applicant is the north to south striking thrust faults. The conclusion drawn by the applicant regarding this style of faulting (as stated on pg. 22 of the SRK groundwater numerical model 2016 report), with emphasis in bold, is as follows:

> *"While **no testing data exists** for the thrust faults in the area of the Project, it is likely that these faults, which strike parallel to the hogsback ridge, **likely present a hydraulic barrier to flow** perpendicular to them, given the cataclastic nature of these faults and a tendency to form low-permeability fault gouge."* [sic]

It is clear from the preceding statement that no testing to confirm the hydraulic properties of the faults in the Project area was made – only the assumption that they are likely acting as hydraulic barriers.

It is a fact that most fault systems exist as a conjugate set of weakness planes arranged in a pattern either orthogonal to one another or phased at some common angle (e.g. 30°, 60°, etc.). In the Project area the occurrence of conjugate west to east striking faults orthogonal to the north to south striking thrust faults is expected, but unfortunately has not been investigated. Given that the main direction of structural deformation in the region is from west to east, these orthogonal faults will present themselves as strike-slip features and can provide open pathways for groundwater flow. Similarly, the thrust faults may also present themselves as flow pathways along slippage planes due to reverse fault motion (if not filled with fault gouge or secondary mineralization).

The likelihood that there are fault networks facilitating groundwater movement from the mountain to the local drainage courses presents an elusive challenge to the applicant in regards to positively identifying their presence, location, degree of continuity, how they will impact movement of groundwater and associated leachate from mine processing and waste management areas, how the proposed monitoring system will successfully target these features and adequately detect leachate migrating towards receptors, and what the impact might be once contaminants reach the receptors. Equally, the lack of consideration for the role that faults (and associated fractures) in the rocks may play in the groundwater numerical model prepared by SRK (2016) leads to concern regarding the accuracy of baseflow change projections in Blairmore and Gold creeks.

The following statement is made by the applicant (pg. 59 of the SRK groundwater numerical model 2016 report) regarding the groundwater numerical model used to assess impacts on the water balance of the Project area:

> "*Some discrepancies between in-situ conditions and numerical simulations can be observed, with RGSC-009a showing a good match between model and simulation results; while, RGSC-009c, in the same borehole, shows an overall poor match. These* ***discrepancies are the result of the regional nature of the numerical simulation which is <u>unable</u> to capture small-scale vertical and/or horizontal compartmentalization*** *which result from complex localized sedimentary bedding.*" [sic]

This statement calls into question the efficacy of the groundwater numerical model and its ability to adequately project the implications for groundwater-surface water interactions and what this means for important baseflow contributions that support the existing WSCT population, the habitat and food sources they rely on, their continued viability, and the ultimate future of this unique and important enclave for a threatened species.

The lack of attention paid to the importance of local springs, seepages, and associated upland wetlands and their contribution to flow in both Blairmore and Gold creeks is also a concern. The drainage network in the project area is consistent with a "trellis" pattern (Figure 1) running from the upland areas of mountain ranges down towards the water courses in the valley bottoms. Trellis drainage is defined in the Oxford dictionary as follows:

> *"A drainage pattern in which tributaries join at high angles, often approaching right angles, which is common in areas with rocks of different strengths (thus resistance to erosion) and in areas with regular series of folds (anticlines and synclines)."*

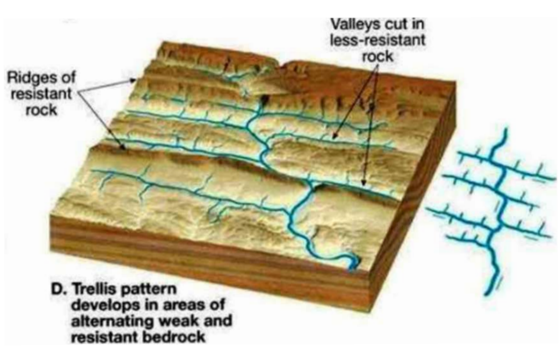

Figure 1. Example of the trellis drainage pattern[1] and drainage style in Project area (left) and the drainage style in the Project area.

[1] http://www.geologyin.com/2014/03/drainage-pattern.html

In mountainous regions like the Project area, most (if not all) the tributary streams that feed mainstem water courses like Blairmore and Gold creeks will have a source connected to an upland spring or seepage area originating along the upper flanks of the mountains. From a review of the configuration of tributary streams on the various figures provided in this application, it is clear that most of the tributaries leading from Grassy Mountain trend in a roughly west to east direction and originate suddenly from a headwater area. This configuration is consistent with the presence of west to east striking faults (or planes of weakness) in the underlying rocks that have formed over time to create drainage-ways for water originating from spring-fed headwater areas down to the mainstem rivers. This configuration supports the occurrence of open and active pathways for groundwater flow to surface and the presence of a conjugate fault system manifesting itself as smaller tributary features leading down to the mainstems of Blairmore and Gold creeks.

The applicant has predicated most of the impact to Blairmore and Gold creeks based on a numerical model attempting to mimic the local geologic and hydrogeologic setting of the Project area. The model assumption that have been made by the SRK modelling team are as follows (with comments in bold provided in brackets):

- For the purposes of the assessment, the entire rock/sediment package may be treated effectively as a homogeneous, anisotropic medium ***(Response: an understandable assumption; however, the complexity of the strata and likely presence of active and open faults and fractures will adversely affect this condition)***.
- The system will largely behave as a confined aquifer, although it can effectively represent unconfined conditions where these occur ***(Response: a reasonable assumption)***.
- On the scale of the assessment, groundwater system flow, which is expected to occur dominantly via fracture flow, can be approximated by an Equivalent Porous Media (EPM) model ***(Response: a reasonable assumption)***.
- K (hydraulic conductivity) is largely anisotropic, with highest K parallel to bedding planes/coal seams and to thrust fault strike with lowest K perpendicular to bedding. In general terms, K, in all orientations, decreases with depth, according to the model proposed by Wei et al. 1995 ***(Response: the presence of faults and fracture networks acting a groundwater flow pathways will adversely affect this assumption)***.
- Apart from preferential flow parallel to fault strike, there is no major fault acting as a significant conduit and no major regional deep flow influences ***(Response: this is an unrealistic assumption; there is no proof to substantiate this claim as no investigation was conducted)***.
- Recharge follows the same spatial trend with elevation as precipitation. The precipitation, evaporation and evapotranspiration mechanisms are not explicitly modeled but assumed to be integrated as "net recharge". It is assumed that this approach will not unduly bias the model ***(Response: the assumption of recharge has not been substantiated with any documented or field-based evidence)***.
- Water level data and creek flow data collected between late 2013 and early 2016 are representative of the pre-mining steady-state conditions and long-term *trends* ***(Response: the time horizon used is in no way representative given the extreme variability noted in creek flows as evidenced by the Water Survey of Canada gauging station "Gold Creek near Frank" provided on pg. 16 of this submission, with data spanning from 1975 to 2012)***.

Table 1 is a summary of model sensitivities to hydraulic head conditions and baseflow to the creeks (excerpted from SRK, 2016 for the Baseline "Linear" model). From a review of the entries in this table it is clear that the model, and its ability to project impacts on baseflow, is very sensitive to recharge and hydraulic conductivity.

It is clear that all of the assumptions made by the modelling team will have an influence on the simulation outputs, including the projections made for spatial extent of drawdown and reductions to baseflow in Blairmore and Gold creeks. For example, lower K values in the west to east direction will limit the extent of drawdown and higher recharge will mute the effects of baseflow reductions. The altering of K by ±50% is not considered conservative enough given the order of magnitude differences noted, as shown in Figure 2 on the following page. Similarly, the assumption of an average of 28% of mean annual precipitation (MAP) as the recharge input to the model is high given documented mountain front/block recharge estimates (i.e. range of <1% to 38%, with an average of around 11% and geometric mean of around 6%)[2]. Also important is the fact that some parts of the model domain receive considerably more recharge than 28% of MAP, like the region east of the proposed mine pit footprint along the Gold Creek valley. The effect of this excessive recharge will serve to reduce the impacts of drawdown from the mine development and baseflow impacts.

Table 3-8: Sensitivity of Baseline "Linear" Model

Parameter	Parameter variation	Effect on Hydraulic Head % NRMSE	Effect on Base Flow
K & R	Reduced by 50%	Null	High
	Increased by 50%	Null	High
K	Reduced by 50%	Null	Null
	Increased by 50%	Medium	Null
Recharge	Reduced by 50%	High	High
	Increased by 50%	Null	High
K anisotropy	Isotropic ($K_{xy} = K_z$, K_{xy} oriented horizontally)	Null	Null
	Isotropic within layers: K decreasing with depth. No influence from bedding and coal seam orientation	High	Null
	Anisotropic: primary K (K_x and K_y) parallel to bedding. No influence from thrust faults	Null	Null
Geological Structure	Low K Thrust faults (barrier to flow): 2.5 order of magnitude lower than background	Null	Null
	Low K Thrust faults (conduit to flow): 2.5 order of magnitude lower than background	Low	Null

Table 1. Summaries of model sensitivities as reported by SRK[3]

Considering the major role that faults and fracture networks play in facilitating groundwater movement in the otherwise competent rock, and the fact that contaminants may inadvertently be released from the Project, the sensitivity analysis used to assess the importance of these water-conveying features does not take into account the increase that would be expected once up to 430 m of mountain overburden is removed. The release of lithostatic pressure on the underlying rock will result in a dilating effect and cause the hydraulic conductivity (K) of the formations, including the faults and fractures running through them, to increase. A relationship of K with depth was provided by SRK in their 2016 groundwater numerical model report and is shown in Figure 2.

[2] *Wilson, J. L., & Guan, H. (2004). Mountain-block hydrology and mountain-front recharge In F. Phillips, J. Hogan, & B. Scanlon (Eds.), in Groundwater recharge in a desert environment, The southwestern United States. Washington, DC: AGU. https://doi.org/10.1029/ 009WSA08*

[3] *SRK groundwater numerical report, 2016 (Appendix C)*

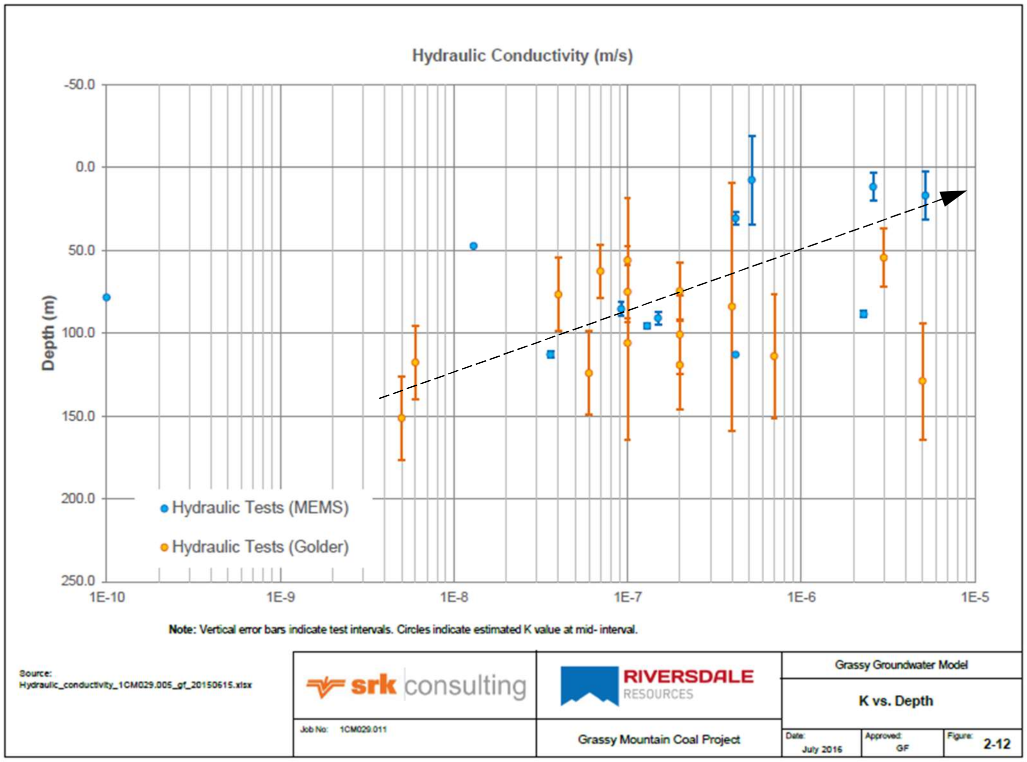

Figure 2. Relationship of hydraulic conductivity (K) with depth, and sensitivities of model inputs.[4]

With the exception of a few measurements, the difference between K values at shallow depth versus 150 m is almost three orders of magnitude (i.e. 10^{-9} to 10^{-6} m/s). Using the same depth relationship as that employed in the model by SRK[5], and assuming a K value of 1 x 10^{-9} m/s at 430 m, removal of this overburden would amount to an increase in K to roughly 4 x 10^{-7} m/s. Unfortunately, this type of K increase has not been applied to the model cells affected. Instead, the sensitivity analysis conducted only accommodates a ±50% change in K for various model layers. This is only one-half an order of magnitude. It is highly likely that the faults and fracture networks are playing a dominant role in the overall permeability of the area, given the style of structural disturbance. The assumption made in the model report (pg. 38) is that:

> *"The K field is anisotropic with a conductivity tensor where K1 and K2 > K3[4] (Figure 3-3). The highest conductivity is parallel to bedding in the north-south direction.* ***The north-south thrust fault systems are modelled to impede flows in the east-west direction****. The complexity of the bedding are reproduced based on geological maps, geological models, and the beds orientations at a regional scale"* [sic]

In addition to this limiting factor, there is no accommodation for presence of west to east conjugate faults, as noted earlier. Therefore, the limited change to K values used in the sensitivity analysis, combined with the lack of fault and fracture influence on the K field, will serve to reduce the lateral extent of drawdown impact simulated by the model and the resulting estimated for baseflow reduction to the creeks.

In addition to the removal of a significant amount of Grassy Mountain, the applicant has indicated that hydraulic heads in the mine area will be lowered by up to 430 m over the course of the Project. This change

[4] *SRK groundwater numerical model report, 2016 (Appendix C)*

[5] *Wei, Z.Q., Egger, P. & Descoeudres, F., 1995. Permeability predictions for jointed rock masses. International Journal of Rock Mechanics, Mineral Science and Geomechanics, Vol. 32, 251-261.*

will be permanent and forever alter the groundwater flow conditions in the areas. It is also stated that some of the drainage that occurs to the Gold Creek watershed will be diverted to the Blairmore Creek watershed. Again, this change will be a permanent. Although the impacts of these alterations are downplayed, they are nevertheless significant in relation to the natural watershed conditions. Although some assessment has been conducted on the mapped tributary streams in the area, there has been no exploration of the role that minor tributaries and local springs have on mainstem flows. As well, the magnitude of the lasting effect that perpetual drawdown will have once local elevations are permanently reduced and altered remains unexplained.

Professional experience in the study area in 2001 to 2003 (on behalf of Devon Canada) identified and investigated flow and water quality conditions at a number of smaller springs and tributaries existing along the Blairmore and Gold Creek valleys. These relatively common discharge features are equally important to the overall water balance of the area as the main tributaries currently mapped. Unfortunately, no exploration or investigation of these features, or their prevalence, flow rates, chemistry and overall dynamics was completed by the applicant. This calls into question the veracity of the assessment process, the supporting models, and the overall impact significance ratings provided.

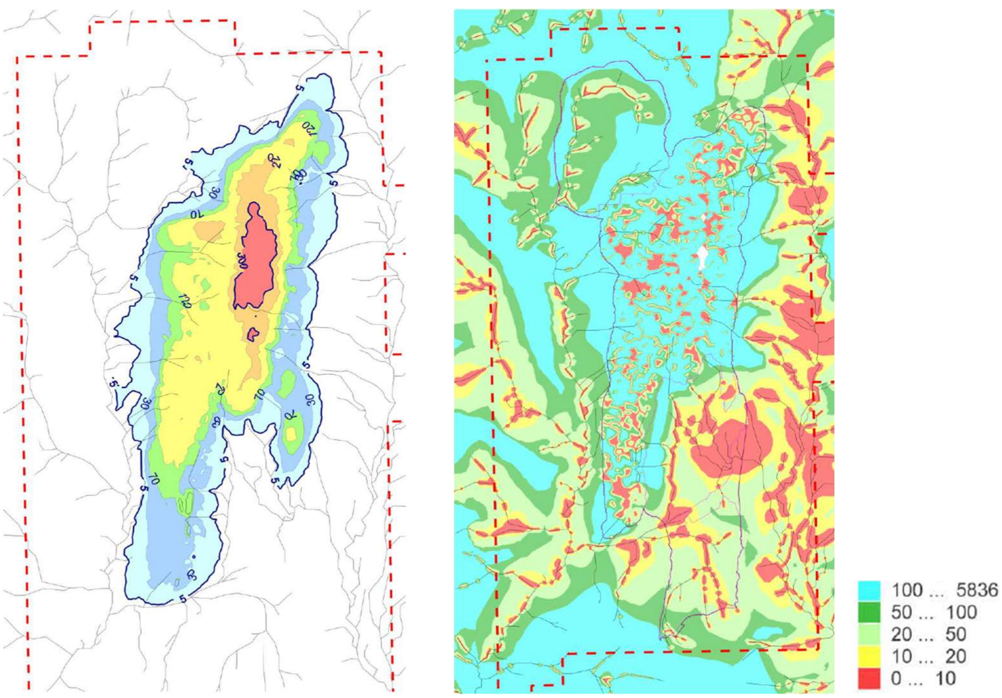

Figure 3. Predicted drawdown in metres at LTC (left) and groundwater residence time in years (right).[6]

There is no doubt that up to 430 m of drawdown will result in upland headwater springs ceasing to flow. This impact will include the drying of upland wetland areas as well, outside of the ones that will be physically removed during the mining process. This will undoubtedly negatively impact flow in Blairmore and Gold creeks. The degree to which this will occur remains unexplained.

[6] *SRK groundwater numerical model report, 2016 (Appendix C)*

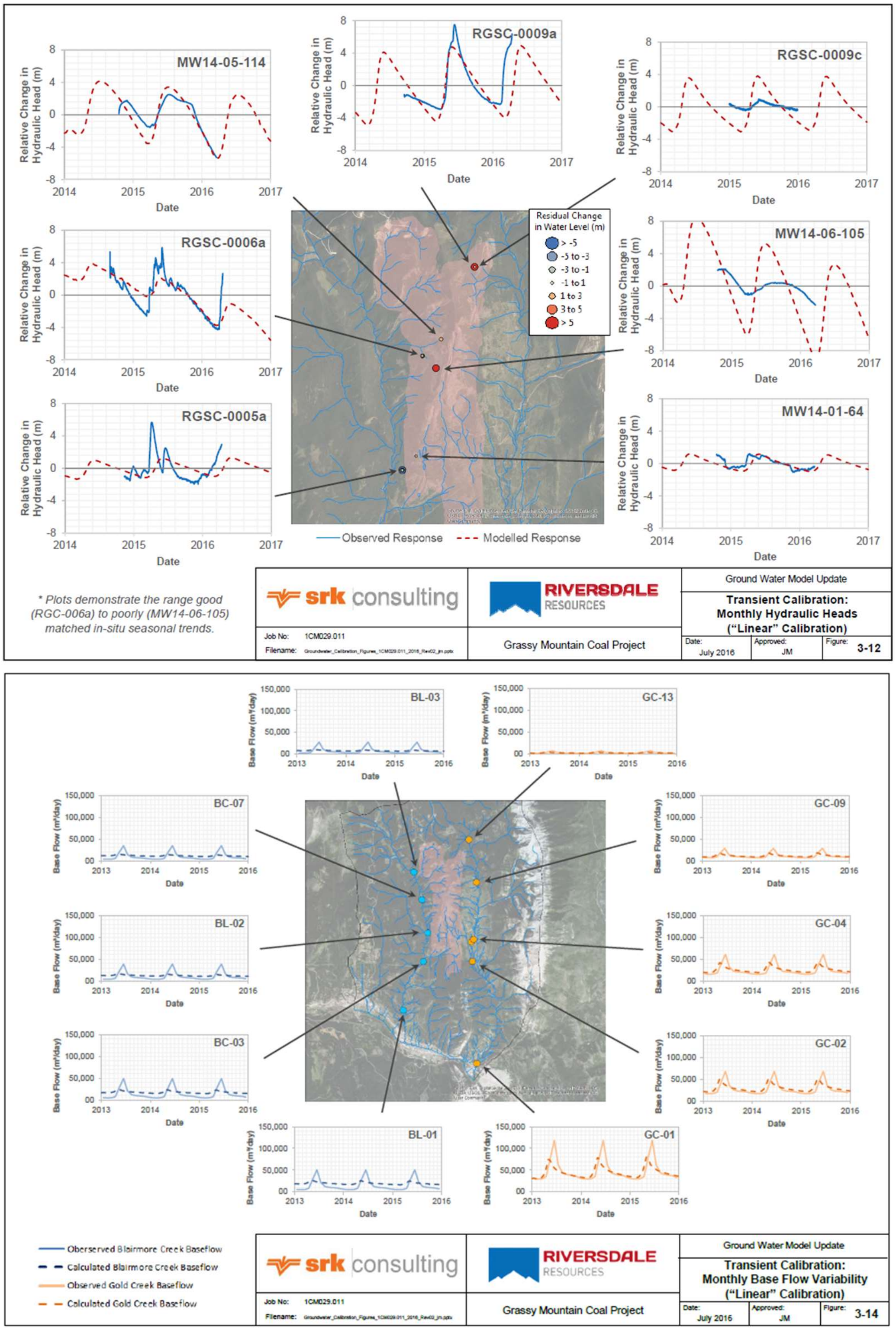

Figure 4. Transient groundwater model calibration for Hydraulic Heads and Monthly Baseflow variability (Note: dotted lines represent simulation results and solid lines represent measured data)[7]

[7] *SRK groundwater numerical model report, 2016 (Appendix C)*

The SRK groundwater numerical model projects that drawdown effects will be limited to within 400 m of the mine pit extent (Figure 3, left image). This is a difficult conclusion to align with considering the concerns related to the model configuration, and results of empirical formula calculations indicating impact distances anywhere from about 1500 m up to 2400 m over a 50-year time span (using a K value consistent with the geometric mean of readings reported for the Mist Mountain Formation, i.e. 1.1 x 10^{-7} m/s)[8,9]. If greater variability in K values and more reasonable recharge had been used in the various model simulations, the results would have been very different (i.e. a greater spatial extent and magnitude of drawdown impact). The same would be expected for the simulated transit times of groundwater reported, which have been stated to be generally in excess of 50 years. It is worth noting that much shorter transit times (0-10 years) are noted in some parts of the model domain, particularly along the south-east flank of Grassy Mountain near the proposed Central and South Rock Disposal Areas (Figure 3 right image) .

Figure 4 on the preceding page is an excerpt of the transient calibration results for the numerically modelled hydraulic heads and monthly baseflow variability under the "Linear" Calibration mode. Although it is stated in Section 3.5.1 of the SRK report (pg. 45) that a total of 32 stations were used to constrain the model (groundwater and surface water combined), it is also important to note that of the 13 monitoring wells established to support this application (which an <u>extremely</u> low number compared to the size of the area and its geologic complexity) only 8 of those wells actually provided useful information regarding groundwater levels and associated water chemistry. The following cautionary statement is made on the same page regarding model certainty:

> *"The overall calibration approach provides an estimate of the regional K, storativity, and recharge vales. However, although calibration is considered reasonable for large-scale approximations, models may exhibit **large uncertainties at the local scale** due to localized heterogeneities not recognized or incorporated into the larger model."*

It has also been stated on page 20 (first full paragraph) of the Millennium's 2016 Hydrogeology report that:

> *"…the complexity of the flow system makes it **impossible** to create regional potentiometric contour maps with any degree of accuracy (Waterline (2013)"* [sic]

Despite the geologic and hydrogeologic complexity of the Project area, and the <u>impossibility</u> to accurately map groundwater flow fields as stated, the applicant has nevertheless tried. And, from a review of the model calibrations some good correlation between simulated and observed responses is obtained (upper panel of Figure 4). However, there are also some notable departures from this "good" correlation. For example, results in the northeast corner of the model domain do not indicate a good match (i.e. calibration points RGSC-0009s and MW14-01-64). Despite the overall normalized root mean squared error of 5.8%, which is considered by the applicant as reasonable, this lack of correlation is clear evidence that parts of the model domain are not adequately reflecting reality. This leads to less confidence for some parts of the model domain versus others. Similarly, the simulated monthly baseflow variability (lower panel of Figure 4) is almost consistently under-representing observed baseflow leading to further questions regarding the accuracy of drawdown projections and associated baseflow reductions.

The implication of these departures from observed versus modelled response calls into question the efficacy of the groundwater numerical model and how the results are being used to frame impact significance. This does not even take into consideration the likely under-representation of more active groundwater flow paths

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8 *Kyrieleis W. and Sichard, W. (1930). Grundwasserabsenkung bei Fundierungsarbeiten. Berlin: Springer.*

9 *Aravin V. and Numerov S.N. (1953). Theory of motion of liquids and gases in undeformable porous media, Gostekhizdat, Moscow.*

and conducive hydraulic properties leading to more system connectivity, active flow conditions, and negative influence from mine development activities.

It is important to keep in mind that models are basically a simplification of complex systems, and that they provide non-unique solutions that can be recreated by simply altering input parameters until a reasonable match is gained between observed and modelled responses. This says nothing of how well the modeler understands, or has constrained, the system he or she is attempting to be mimic, and therefore caution is advised regarding how much faith is placed on the simulation results. It is a fact that model errors propagate within framework domain as well as into future projections, and that those projections can be wildly inaccurate. The applicant has attempted to address this reality through the sensitivity analysis conducted. However, as pointed out earlier, there are legitimate concerns regarding the appropriateness of that analysis to accommodate the actual variability of geological and hydrogeological conditions. This also extends to climate-influenced inputs like recharge.

With all this in mind it is likely that the magnitude of impact to Blairmore and Gold creeks, and the area weighted suitability (AWS) for WSCT habitat, has been under-represented. This leads to further doubt regarding how accurately the models can project the significance of baseflow reductions or water quality impacts. The lack of a suitable groundwater-surface water interaction assessment equally calls into question how well critical habitat areas along both creeks have been mapped and assessed to support the "not significant" impact ratings made and the selection of suitable locations for habitat enhancement (as noted in the Fisheries Offsetting Plan[10]).

2. The use of "average" conditions

Much of the assessment regarding impacts to stream flow and water quality conditions, and the influencing factors such as net precipitation and groundwater contributions, have been predicated on "average" conditions or assumptions of consistency of conditions. Use of average conditions and the assumption of consistency in a complex setting is misleading and will usually result in under-predictions regarding the magnitude of change that can occur. For example, employing a model scenario that uses extreme temperature conditions, extended low flow periods, and longer-term moisture deficits from consistently low snowpacks and hydrological drought conditions would likely lead to a much more conservative result. As it stands, the applicant has communicated that the average decrease to baseflow on Gold Creek will be on the order of 6% (Table 2); however, the model (as indicated previously) is under-representing actual baseflow conditions in the transient calibration and is therefore presenting an overly optimistic conclusion. The fact that much higher reductions are projected for some of the reaches of Blairmore and Gold creeks (at critical flow times) is the point to focus on, and those reductions could be even higher given the challenges noted regarding model accuracy.

From a review of the Table 2 (as presented on pg. 79 of SRK 2016 groundwater numerical model report) , it is clear that monthly baseflow reductions will be much more than the "average" 6% communicated. The actual timing of when these reductions occur in relation to known bioperiods of West Slope Cutthroat Trout (WSCT) is important to the impact assessment and could lead to threatening conditions particularly during the hotter summer low-flow months. Given a scenario of extreme low flow conditions, reduced baseflow contribution to regulate stream water temperatures (due to mine dewatering effects and future drought periods), and consecutive extreme hot days, this could lead to water temperatures higher than have currently been modelled. In such an instance, dissolved oxygen conditions could be pushed lower, and thermal shocks could occur to sensitive aquatic species including the WSCT.

[10] Addendum 8, *Appendix B-1*

Table 3-6: Monthly Base Flow Reduction, Baseline to LTC

Month	D1	BL03	BC07	BL02	BC03	BL01	Blairmore Creek	GC13	GC09	GC04	GC02	GC01	Gold Creek
	15	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*	*27*
	Percent Change	Percent Change	Percent Change	Percent Change	Percent Change	Percent Change	Percent Change	Percent Change	Percent Change	Percent Change	Percent Change	Percent Change	Percent Change
January	0.14%	0.36%	-13.5%	-16.8%		-10.0%	-9.7%	-11.7%	-10.0%	-7.2%	-15.2%	-5.2%	-5.1%
February	0.14%	0.29%	-13.5%	-16.9%	-11.0%	-10.0%	-9.7%	-11.7%	-9.8%	-7.0%	-14.9%	-5.1%	-5.0%
March	0.14%	0.29%	-13.4%	-16.7%	-11.1%	-10.1%	-9.8%	-11.3%	-10.2%	-7.4%	-15.8%	-5.3%	-5.2%
April	0.12%	0.23%	-12.9%	-16.0%	-11.4%	-10.4%	-10.0%	-9.1%	-11.9%	-8.8%	-18.62	-5.9%	-5.8%
May	0.12%	0.20%	-12.6%	-15.7%	-11.3%	-10.2%	-9.8%	-8.2%	-12.5%	-9.6%	-20.0%	-6.3%	-6.2%
June	0.12%	0.21%	-12.8%	-16.0%	-11.1%	-10.1%	-9.7%	-9.6%	-12.5%	-9.5%	-19.3%	-6.4%	-6.3%
July	0.12%	0.21%	-13.1%	-16.2%	-11.1%	-10.1%	-9.7%	-10.3%	-12.2%	-9.2%	-18.6%	-6.3%	-6.2%
August	0.12%	0.21%	-13.2%	-16.3%	-11.1%	-10.1%	-9.7%	-10.8%	-11.9%	-8.9%	-17.9%	-6.2%	-6.1%
September	0.12%	0.21%	-13.3%	-16.5%	-11.0%	-10.0%	-9.7%	-11.1%	-11.5%	-8.6%	-17.4%	-6.0%	-5.9%
October	0.12%	0.21%	-13.4%	-16.6%	-11.1%	-10.1%	-9.8%	-11.4%	-11.2%	-8.2%	-16.8%	-5.8%	-5.8%
November	0.12%	0.18%	-13.5%	-16.7%	-11.1%	-10.1%	-9.8%	-11.6%	-10.8%	-7.9%	-16.3%	-5.7%	-5.6%
December	0.11%	0.21%	-13.5%	-16.8%	-11.1%	-10.1%	-9.8%	-11.7%	-10.6%	-7.8%	-16.0%	-5.6%	-5.5%
Average Transient Change	0.12%	0.23%	-13.2%	-16.4%	-11.1%	-10.1%	-9.8%	-10.7%	-11.3%	-8.4%	-17.2%	-5.8%	-5.7%
Steady State Change	-0.03%	-0.02%	-13.1%	-16.2%	-10.7%	-9.6%	-9.2%	-9.5%	-11.3%	-8.5%	-17.5%	-6.0%	-5.9%

Table 2. Percentage difference between monthly baseflow for baseline and long-term closure.[11]

Considering the spatial and temporal variability of baseflow contributions along Blairmore and Gold creeks it would have been helpful to provide a more comprehensive groundwater-surface water interaction investigation, such as an Infrared camera survey or geophysical reconnaissance (e.g. electromagnetic survey), along with physical measurements of exchange rates and chemistry (via drive point wells or seepage meters). This would have conclusively identified the number, location, size, and relative importance of groundwater discharge zones to these water courses, as opposed to inference.

As indicated previously, the groundwater numerical model is not providing good correlation between observed and modeled water levels and monthly baseflow variability (Figure 3). The most likely explanations are:

- modelling of the north to south striking thrust faults as impediments to groundwater flow, and lack of consideration for the presence of west to east open fault pathways providing a means for groundwater to discharge to the upland springs, wetlands, tributary creeks, and mainstems of Blairmore and Gold creeks;
- lack of assessment regarding the role that defined and diffuse springs, seepage zones, and wetlands on the slopes of Grassy Mountain play in adding to the flows in Blairmore and Gold creeks;
- lack of consideration for the impact that removal of a significant portion of overburden rock comprising Grassy Mountain will have on the distribution of hydraulic conductivity and resulting groundwater flow directions and rates;
- overly optimist recharge being applied to certain parts of the model domain;
- under-representation of anticipated changes to river flow characteristics due to changing hydroclimatic conditions (i.e., increasing temperatures, reduced snowpacks, shorter winter season and earlier spring melt, shifting seasonal precipitation patterns, more winter precipitation occurring as rain, etc.); and

[11] *SRK groundwater numerical report, 2016*

- the overall challenge with trying to represent a complex hydrogeologic system with simplistic models.

Combining all of the possible excursions from "average" conditions used with a lack of understanding regarding how groundwater flow conditions might be impacted following the removal of a good portion of Grassy Mountain (i.e. where, how, and to what degree) and optimist recharge estimates will no doubt change the magnitude of impacts regarding baseflow contributions and, by extension, assimilation of any contaminants mobilized. This will likely lead to greater impacts than currently simulated. Considering that certain reaches of water courses like Gold Creek are indicating a possible change in baseflow of up to 20% under currently simulated conditions, and that this reduction could even be higher, this calls into question the appropriateness of "not significant" ratings communicated by the applicant. All of this will remain to be seen should the application be approved (which is not being recommending here). Given the challenges regarding accuracy of modeling projections versus reality, and the extent of system variability, some of the significance ratings provided should be re-assessed.

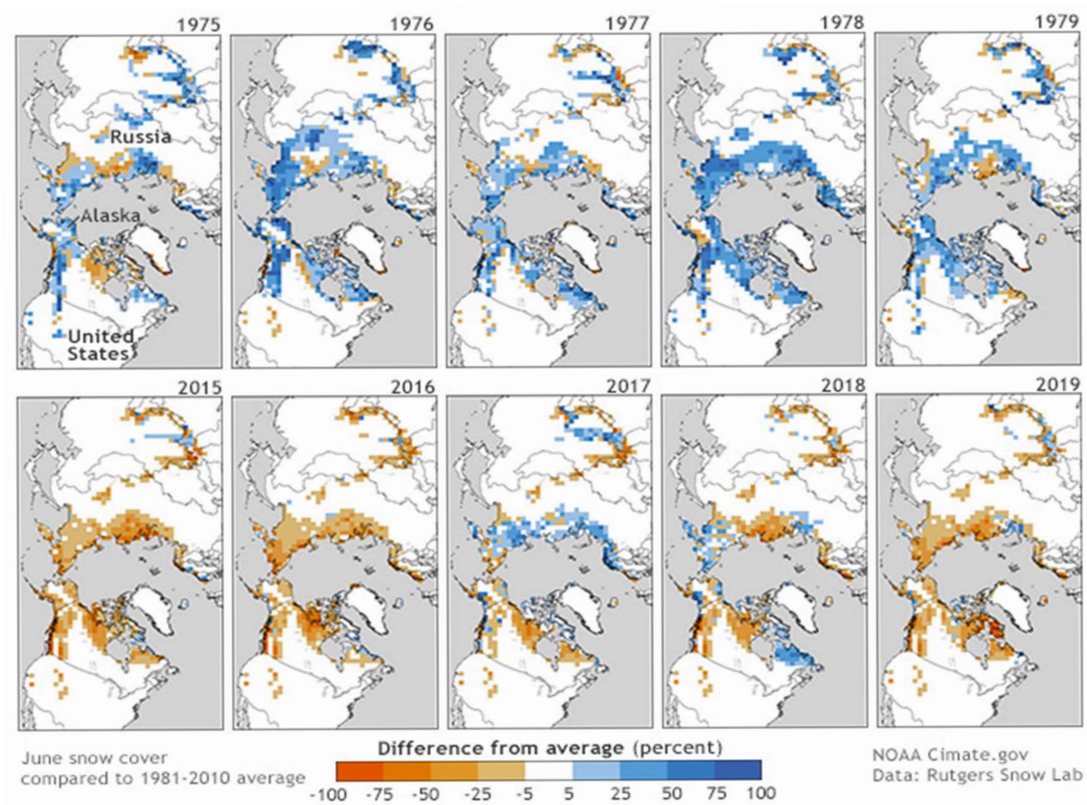

Figure 5. Change in June snow cover over North America from 1975-1979 and 2015-1019[12].

Although an attempt to accommodate some variability in climate conditions has been made by the applicant, using 1 in 10-year wet and dry year scenarios (and later a 1 in 20-year dry condition - Addendum 8, pg. 100), it has not been made clear how this actually represents the type of excursions beyond "average" climate conditions that are expected. According to agencies like NOAA (the National Oceanic and Atmospheric Administration) who track snow accumulation changes from satellite-based systems, the North American snowpack has been declining over the last few decades (Figure 5), and so its role as a source of stored water, that is slowly released during the spring melt to sustain higher flow conditions into

[12] https://www.climate.gov/news-features/understanding-climate/climate-change-spring-snow-cover

the summer months, is decreasing. Changes to seasonal precipitation and streamflow conditions are also expected in the future based on global climate model projections (Figure 6).

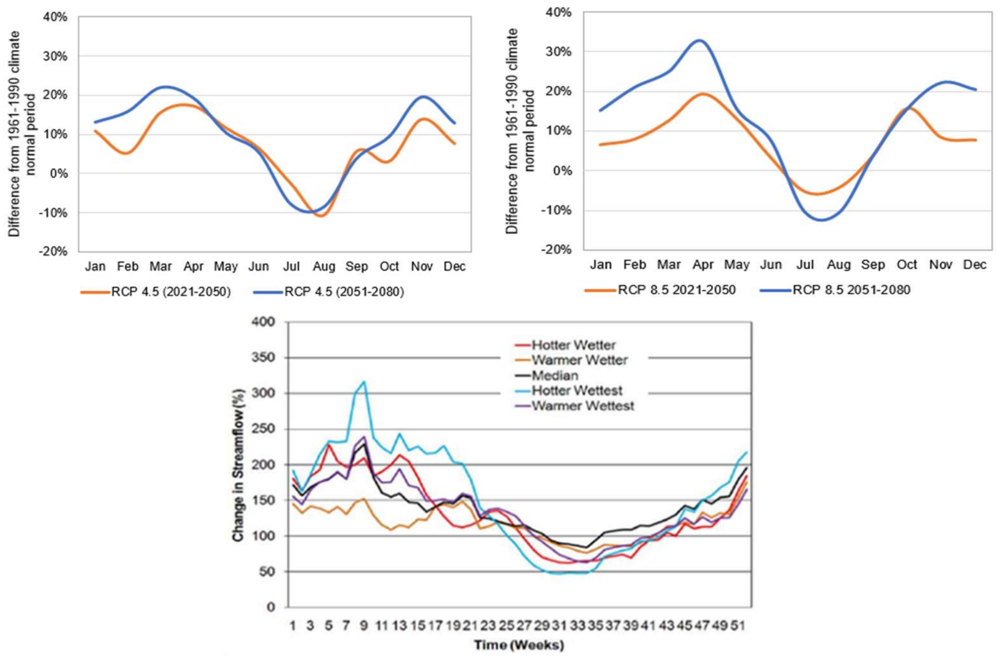

Figure 6. Climate model projections for seasonal precipitation under RCP 4.5 and RCP 8.5 scenarios[13] and anticipated changes to streamflow conditions under various climate scenarios[14] *(Note: 100% for "Change in Streamflow" on the vertical axis represents the baseline period of 1961-1990 from which future deviation of conditions is assessed)*

With respect to precipitation, a shift to earlier and higher amounts (17-32%) is expected, with a greater percentage falling as rain, not snow. With respect to streamflow, deviations from baseline (represented as the 100% line in the lower image of Figure 6), depends on the type of future climate (i.e. warmer-wetter to hottest-wettest). Higher magnitude flows are anticipated to occur roughly 4-6 weeks earlier in the year, plus the magnitude is anticipated to increase by up to 200% or so under the extreme case. The low flow season is also projected to extend over a longer period due to the quicker and more intense spring runoff period, with a decrease in flows anywhere from 15-50%. Based on the modelling provided by the applicant it is unclear whether these types of extreme conditions have been considered and how they would influence the simulated results of baseflow reduction and associated water quality impacts (based on reduced assimilative capacity and dilution factors).

From a review of stream flow conditions in Gold Creek at the WSC station near Frank AB (Figure 7 on the following page) it is clear that they are highly variable from year to year. It is also evident that extended periods of low flow have persisted for several back-to-back years (at least up to 8 years). When one looks at the much longer reconstructed record of water flow for the South Saskatchewan River, as noted in the lower image of Figure 7, it is apparent that there have been periods of several decades in southern Alberta with back-to-back low flow years. Further comparison of high flow periods as measured at the Gold Creek near Frank gauging station with those noted on the flow reconstruction graph indicate that the more recent flow period pales in comparison to some of the high flow periods noted around 1470, 1770, and 1910, to name a few.

[13] https://climateatlas.ca/
[14] *Sauchyn D., Byrne J., and S. Kienzle (2011). Past, Recent and Future Hydroclimatic Variability, North Saskatchewan River. Final Report on an EPCOR – NSERC Collaborative Research and Development Project, January 2011.*

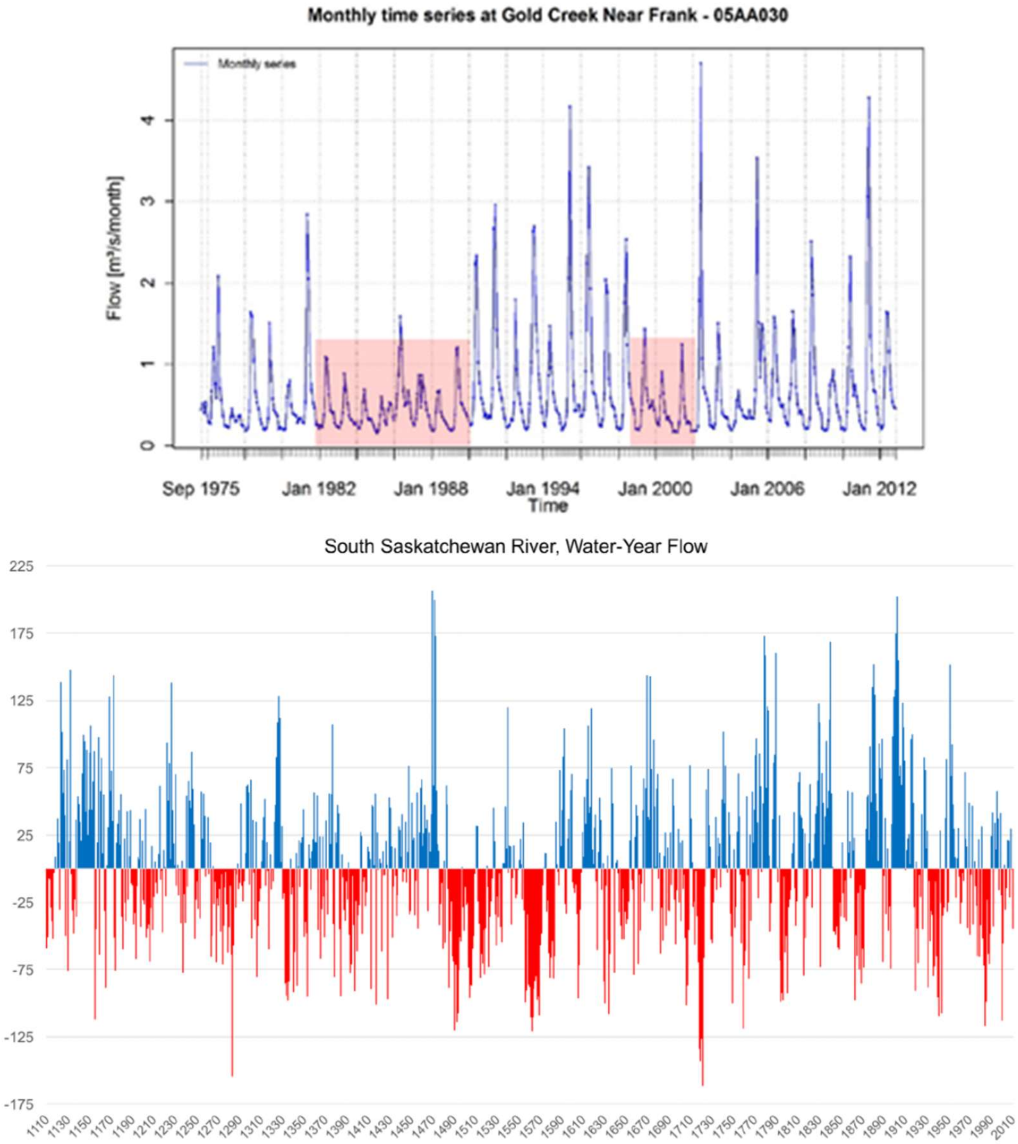

Figure 7. Monthly stream flow record for Gold Creek near Frank, AB[15] and tree-ring reconstruction of water-year flow showing positive (blue) and negative (red) departures from mean water-year flow[16]

This level of variability to high flow conditions and the extended temporal nature has not really been accommodated in the impact modelling conducted by the applicant. This leads to a concern that the assessment results are under-representing the changes that will occur in the future with respect to erosion of disturbed lands, sedimentation issues, functioning of mine water management features, and resulting water quality issues.

Further concerns relate to whether the monitoring and mitigation proposed by the applicant will be adequate to detect and respond to such deviations from modelled conditions. There is also concern regarding the longevity of any mitigation system and the need for perpetual maintenance. If the reliance on adaptive

[15] *SRK 2016, Grassy Mountain Surface Hydrology and Baseline Effects Assessment*
[16] *Sauchyn and Illich 2017, https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2017WR021585*

management is the only thing left to protect sensitive water courses and associated habitat, then the proposed mitigation systems and strategies will need to be robust enough to last well into the future, with no intervention once mine closure has occurred. This will be a challenging task both from a financial and human resource perspective.

The statement is made on pg. 27 of the Surface Hydrology and Baseline Effect Assessment report (Section 5.1) and pg. E-75 of the EIA Summary that:

> *"The only **true loss of water** from the Project area is the **moisture associated with the clean coal** that is shipped off site to market"* [sic]

Such a statement is very misleading as there will be considerable loss of water from the Project area due to increased evaporation from de-vegetated barren lands, evaporation from sedimentation ponds, surge ponds, and the relatively large end pit lake, as well as an overall reduction in moisture retention capability of the Project area. Considering the statement made it can only be concluded that the applicant has not considered these aspects, which adds additional doubt to the overall water balance being reported.

The role of an environmental impact assessment is to explore reasonable "worst-case" upset scenarios and related impact linkages in an integrated and comprehensive manner so that informed decisions can be made regarding a project approval. The resulting impact scenarios and their appropriateness are also important to determine the types and degree of mitigation required to reduce or eliminate project effects. This includes the longevity of such systems and strategies once closure has occurred. Unfortunately, the level of rigor applied in this application, and limited consideration for future variability in hydroclimate conditions in the Project area, has not been sufficient to provide comfort that legacy issues regarding water quantity and quality will not occur post-closure in a significantly altered landscape.

3. Geochemical implications for waste rock areas, SBZs, and mine-related water bodies

There is a concern regarding the effect that this coal, if approved, will have on the release and movement of harmful metals and trace elements in the Project area. From a review of baseline water quality conditions, the applicant has indicated that the presence of elevated concentrations of certain trace elements like aluminum, arsenic, cadmium, mercury, selenium and zinc are present in both the water and sediments at concentrations in excess of Alberta FWAL guidelines (updated in 2018[17]). From experience in the Elk Valley, Teck Resources Limited (Teck) has reported elevated selenium concentrations related to their coal mining operations, as well as cadmium, cobalt, nickel, zinc, and the occasional chromium and uranium concentrations in excess of baseline and FWAL guideline values[18]. There is good reason to believe that the same situation will occur in the Project area if developed, given the that the same geological formations are involved and that similar hydrogeological conditions exist. Whether from natural or other means, the presence of elevated trace element concentrations in the soil and water of Project area is a direct indication that they can, and have been, mobilized into the aquatic environment and are already present at concentrations of concern.

The applicant plans to use saturated backfill zones, or SBZs, as a selenium (and nitrate) management strategy. The goal is to precipitate elemental selenium by artificially lowering the oxidation-reduction condition in the SBZs to a suitable level (i.e. anoxic, or devoid of free oxygen). Considerable information has been provided to substantiate the use of this method of selenium abatement. Experience with similar engineered systems in Teck Resources Limited's (Teck) Elk Valley operations has shown that this

[17] *https://open.alberta.ca/publications/9781460138731*

[18] *https://www.teck.com/responsibility/sustainability-topics/water/water-quality-in-the-elk-valley/research-and-monitoring-reports/*

technique has the ability to work (under the right conditions). Nevertheless, the long-term efficacy of this approach is yet to be proven.

Despite the sharing of all this information by the applicant, there is still concern regarding what other types of reactions might occur within, or below, the SBZs once anoxic conditions are achieved. There is also concern whether the achievement of anoxic conditions will occur naturally or whether dosing with an organic substrate will be necessary. Based on the barrel tests conducted it appears that dosing will be required. Not having to dose the system on the long-term leads to less concern as the physical addition of a substrate will not be required; however, whether or not the reactive beds will continue to sequester selenium into perpetuity, without breakthrough of concentrations or remobilization due to weathering reaction, is still unclear. Although elemental selenium is anticipated to form in the SBZs, it is likely to be present as a more easily weatherable mineral due to lack of crystal maturity. So, without intervention the introduction of oxygenated infiltrating waters into the SBZs in the future may shift the oxidation-reduction conditions from anoxic to oxic and re-mobilize the selenium through weathering reactions. Unfortunately, this possibility has not been assessed and the assumption of permanent sequestration has been made.

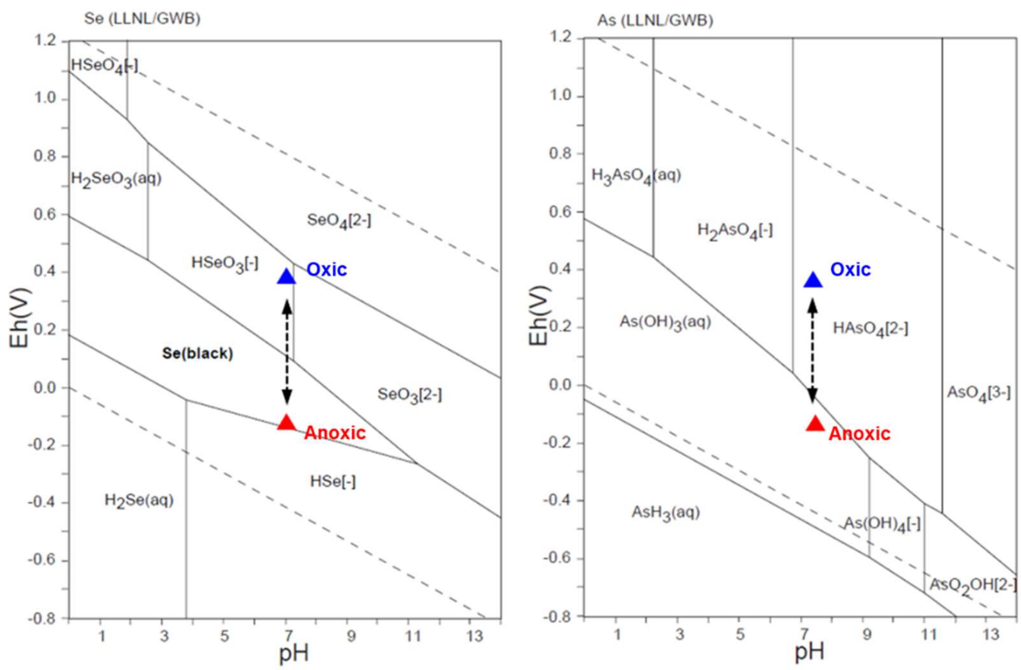

Figure 8. Eh-pH diagrams for selenium (left) and arsenic (right)[19] taken from the "Atlas of Eh-pH diagrams: Intercomparison of thermodynamic databases, Geological Survey of Japan Open File Report No.419. *(Note: blue triangles represent redox conditions consistent with humidity cell experiments; red triangles represent anticipated conditions in SBZs once at an anoxic state)*

Of equal concern is if the SBZs will require dosing with an organic substrate, and whether this will be required into perpetuity to ensure encapsulation of sequestered selenium (i.e. artificial maintenance of anoxic conditions). If perpetual care is required it is unclear how this will be ensured after mine closure, and who will be responsible. It is not common for resource extraction companies to enter into long-term care agreements and perpetual care programs, as they prefer to transfer such liability elsewhere. Unfortunately, the risk of the SBZs not achieving their goal of permanent sequestration of selenium has not

[19] https://www.nrc.gov/docs/ML1808/ML18089A638.pdf

been sufficiently explored or communicated in the application, including how this might affect future aquatic habitat.

As noted earlier it is stated by the applicant that anoxic conditions in the SBZs will be favourable for the precipitation of elemental selenium. These anoxic conditions will also promote other reactions beyond precipitation of elemental selenium and will affect other trace elements present in the waste rock very differently. Figure 8 provides an example of this where the Eh-pH diagram for selenium is provided on the left and Eh-pH diagram for arsenic is provided on the right. The blue triangles show the element speciation where normal geochemical conditions might exist under oxic conditions. Conversely, the red triangles show the element speciation where the geochemical conditions might establish themselves once the SBZs are fully operational (i.e. anoxic conditions). For selenium, it is evident that the red triangle falls in the stability field a selenium-based mineral, i.e. Se (black). At the same conditions, however, the red triangle for arsenic falls within the stability field consistent with its more mobile and toxic form, trivalent arsenic. This would lead to the potential for toxic arsenic to become mobilized as a result of the anoxic conditions. Unfortunately there has been no exploration of this issue in the application with respect to arsenic, or any other potentially harmful trace element for that matter, which leaves this risk unassessed and unresolved.

Additionally, the development of an anoxic plume of groundwater under the SBZs or any other mine-related structures will have the risk of mobilizing potentially harmful trace elements from the waste rock and underlying soil and/or bedrock. In some cases this may be Fernie Group strata, of which there is no information available regarding its trace element chemistry. Once mobilized some of the trace elements will have the ability to be transported significant distances, with relatively reduced transit times due to permeability enhancements from overburden removal, and potentially discharge into nearby aquatic receptors. Trace elements escaping waste rock piles and mine water holding ponds will also have the ability to enter the subsurface due to their upslope, elevated locations leading to the development of downward-driving hydraulic head potentials and the resulting influence on groundwater flow directions and rates. The presence of faults and fracture networks and their degree of influence on groundwater flow conditions is another complication, and one that needs to be sufficiently understood to design a robust enough monitoring and management system to ensure success of mitigation. At the moment this is purely a theoretical exercise based on a numerical model that is constrained by limited information and a sensitivity analysis that does not accommodate the known variability of the geologic, hydrogeologic, or climate conditions and anticipated future states.

The applicant has indicated that they intend to install monitoring wells to sufficiently detect any contaminants that may migrate outside of the SBZs or other potential source areas. This will be quite tricky as it is hard to tell which faults or fractures are active with respect to groundwater flow without substantial examination (e.g. geophysical surveys, interference tests, tracer tests, etc.). Because monitoring wells only intercept a small portion of a groundwater flow field (given their small size – typically 52 mm diameter wells) there is a possibility of positioning monitoring wells in locations that will miss contaminant plumes or only intercept part of a plume that will make concentrations appear lower than they really are.

Of equal concern is the possible creation of anoxic conditions at the base of the end pit lake and resulting geochemical reactions. This lake will have very deep sections (up to 80 m or so), so the chances of this occurring is reasonable. The development of such conditions, in the presence of residual organic substrate like carbonaceous rocks of coal fines, could again mobilize trace elements from bottom sediments and/or rock layers and lead to the mobilization of harmful trace elements known to be present in the Project area. Unfortunately, this risk was not assessed. The Water Quality and Load Balance model prepared by SRK (2016) does, however, show that the concentration of certain trace elements in some of the water containment and management ponds is anticipated to increase, And, in some cases, these changes are significantly above established FWAL guidelines. This includes the surge and sedimentation ponds to the west of Gold Creek, as well as the end pit lake itself. Although the modelling does not project any adverse trace element concentrations in Blairmore or Gold creeks, the lack of accommodation regarding hydrogeologic complexity and variability of climate in the modelling calls into question the projections provided and how representative they are of what actually might occur.

The fact that the applicant is seeking to establish waste rock disposal areas, treatment ponds, and an end pit lake of significant size make it incumbent upon them to provide a comprehensive examination of how resulting effects from changing geochemical conditions from oxic, to anoxic, and possibly back to oxic in the future, might manifest themselves with respect to trace element mobility and toxicity. Unfortunately, this level of assessment has not been provided. What has been provided is a series of GoldSim simulations that identify the potential for a number of harmful trace elements to reach concentrations in excess of aquatic guidelines in various water bodies formed as part of this project. In particular, elements such as arsenic, cadmium, chromium, copper, mercury, molybdenum, nickel, lead, selenium, uranium, and zinc have been identified.

It is clear from the humidity cell tests conducted by SRK (Appendix 10: Geochemistry Reports of the original application documents) that mobilization of elements such as arsenic, chromium, copper, lead, silver, and zinc from rocks associated with the Adanac Member and Cadomin Formation is possible. Unfortunately, the focus of the applicant's assessment has centred on selenium (and nitrate) management given the challenges noted at Teck's Elk Valley operations. This has led to a narrow view of the potential risk posed by other trace elements of concern and the potential for their unintended mobilization into the surrounding water environments. The resulting consequences have not been explored by the applicant beyond the faith they place on the success of a monitoring system to detect water quality changes, and the proposed mitigation systems to remedy any unacceptable excursions from baseline conditions.

One final consideration is the risk of calcite cementing of the Blairmore and Gold creek streambeds. This is an issue that appeared as a result of coal mining in the Elk Valley, prompting Teck to initiate mitigative action. The concern with this application is the role that the SBZs and waste rock areas will play in increasing the risk of calcite precipitation in local streambeds. The creation of anoxic conditions within, and under, these structures has the potential to generate increased carbon dioxide levels in the underlying groundwater. This groundwater, charged with added carbon dioxide, may eventually discharge to local tributaries and creeks raising the concern for regarding calcite cementation and loss of functioning habitat. Unfortunately, this risk has not been adequately assessed.

4. Certainty that mitigation measures will be successful

There is considerable confidence being placed in the proposed monitoring and management systems to detect and respond to unanticipated water quality events, and to do so without causing undue harm to the surrounding aquatic environment (in particular the almost 100% genetically pure WSCT population in Gold Creek). The remaining concern with the proposed approach to long-term care and maintenance of the Project area, once a significant portion of a mountain has been removed forever, is the efficacy of the systems in place to maintain contaminants at acceptable levels into perpetuity.

For example, if the SBZs require dosing with an organic substrate to maintain anoxic conditions to sequester selenium and ameliorate nitrate concentrations it is just left up to faith that the system will function and achieve the goal. At some point there will need to be a walk-away solution, but there will be risk that the encapsulated contaminants may remobilize if geochemical conditions change back to oxic conditions. Capping of these areas may provide some mitigation, but there is a distinct possibility that as the closure landscape adjusts from its manipulated form towards a new equilibrium that legacy issues may develop years after.

Another challenge will be the post-closure landscape and its projected ability to continually deliver on the water balance projections. As noted earlier, the GoldSim model is indicating that certain trace element concentrations in the engineered water containment and treatment structures will exceed existing FWAL guidelines. And, this will likely continue into perpetuity. The concern is that once treatment and management systems are decommissioned the receiving environment will be placed at elevated risk. The considerable amount of panned disturbance to the natural landscape will forever change the water balance, the weathering potential for otherwise intact rock formations, and the resulting physical, chemical, and biological conditions in both Blairmore and Gold creeks, despite the optimistic statements made regarding increased or improved flow conditions, creation of habitat, and reconciliation of legacy mining impacts during reclamation activities. There is considerable faith being placed in the maintenance of flow augmentation systems based on an admitted limited understanding of the geological controls and lack of consideration regarding the scale of climate change impacts and the role they will play. This may be summed up in the applicant's response on page 137 of Addendum 10:

> *"Flow augmentation post closure will not be necessary as the interception of surface water drainage and the lowering of ground water and ground water handling within the mine pit will no longer be necessary.* ***Site contours will be re-established to allow natural drainage to occur and ground water levels will return to normal levels****. Eventually, an end pit lake will form as part of the new landscape and it will drain through to Gold Creek. Flows in Gold Creek* ***should*** *therefore approach pre-mining levels."* [sic]

Unfortunately, the applicant is not acknowledging that the removal of a significant portion of Grassy Mountain will have a permanent effect on both the Blairmore and Gold Creek watersheds, and forever change the dynamics between these two otherwise discrete systems. Equally, it is impossible for groundwater levels to return to "normal" when up to 430 vertical metres of a mountain has been removed and redistributed. It is clear that higher elevation springs, seepage areas and wetlands feeding tributary streams will disappear completely, and that those important landscape features will no longer contribute to streamflows. Hydraulic heads in the subsurface will be significantly reduced as well, which will forever alter natural groundwater-surface water exchange dynamics. The resulting long-term closure topography will result in new groundwater flow directions and exchange dynamics based on hydraulic head conditions that will are altered forever. The confidence being placed on models, constrained by limited information and failure of imagination, is cause for concern. Trusting that adaptive management will provide the panacea to address lasting effects from this highly disruptive activity is short-sighted. Equally, saying that the reclamation process will lead to an "improvement" to the environment is misleading and dismissive of the impacts related to cumulative effects in the area.

5. Climate change considerations

There is concern regarding how climate change has been addressed in this application. Figure 9 shows the anticipated changes to the probability of more extreme temperature conditions in response to a shift in the mean, variability, and symmetry of normal temperature distributions. Similar changes can be anticipated for other climate variables, like precipitation. From a review of Figure 9 (on the following page) it is evident that as the global climates shift towards a new regime in the coming decades the probability of extreme events is anticipated to increase. This means hotter weather and more heat waves leading to increased meteorological and/or hydrological drought risk, and as well as an increase in more extreme wet conditions (increased flood risk and associated environmental concerns). A shift in the intensity, duration and frequency, or IDF, of precipitation events is also anticipated. According to Kuo et al. (2015)[20], projections have been reported as follows:

> *"Future IDF curves show a wide range of increased intensities especially for storms of short durations (≤1-h). Conversely, future* ***IDF curves are expected to shift upward*** *because of increased air temperature and precipitable water which are projected to be about 2.9 °C and 29 % in average by 2071–2100, respectively."*

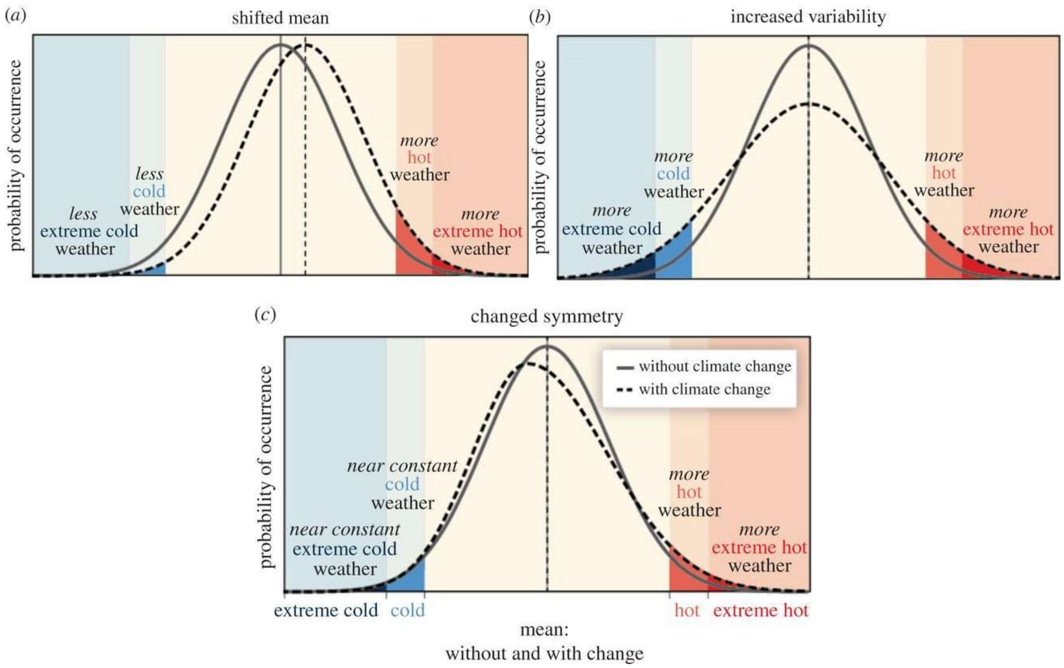

Figure 9. Change in climate mean, variability, and symmetry[21]

All of this supports the concept that shifting temperature and precipitation conditions under a changing climate will influence the hydroclimate beyond what we currently understand or believe. Simply using 1 in 10-year and 1 in 20-year return periods as scenarios to capture this variability is not reasonable enough given what has been experienced in the past (as evidenced by paleo-records). As such, the model simulations, upon which this application and its impact projections are predicated, do not provide a reasonable representation of the anticipated variability, given that the probability of extreme events in the future is expected to increase. What is considered a 1 in 10-year event today may effectively become a 1 in 5-year event in the future due to the shifting mean, variability, and symmetry of the climate data distributions.

The applicant has not conclusively demonstrated that the current model simulations used in this application accommodate the anticipated change in probability of extreme weather events, nor have they assessed what the change in probability to return periods will be in the future. The applicant has simply stated that the scenarios used provide conservative enough projections to adequately frame the anticipated range of

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[20] *https://www.researchgate.net/publication/273450354_Potential_impact_of_climate_change_on_intensity_duration_frequency_curves_of_central_Alberta*

[21] https://royalsocietypublishing.org/doi/10.1098/rstb.2016.0135

conditions, which surprisingly result in "not significant" impact ratings related to baseflow conditions, water temperatures, dissolved oxygen conditions, and the aquatic habitat.

As noted earlier in Figure 6, the expectation is for a shift in river flow characteristics that will favour a more compressed period of runoff in the earlier part of the year (up to 200% higher), followed by a more prolonged and lower flow period (10-50% lower). These lower flow periods will be heavily reliant on contributions from groundwater (baseflow), which will be removed from the area during mine development. When combined with the sustained impacts of a permanently lowered water table following the removal of a significant portion of Grassy Mountain, and a reconfigured water balance in the disturbed post-closure landscape, the implications for baseflow changes to Blairmore and Gold creeks are likely to be worse than the model projections provided. And, in some cases those projected changes are high - approaching a reduction of 20% baseflow in some months (not including the likelihood for even more variability).

It is incumbent on every applicant to assess conservative or "worst-case" scenarios so that a reasonably accurate assessment of potential impacts can be provided, and unintended consequence can be avoided. What exists at the moment is an optimistic assessment where the impacts from this proposed mine development are being considered "not significant". If a more conservative approach had been used it is likely that some of the significance ratings would be less favourable. However, faith in mitigation systems working into the future, and the significantly altered landscape being reintegrated into the local watersheds with little negative change is driving the process.

Closure

It is incumbent on all Albertans, and Canadians in general, to ensure that the development activities we are undertaking are consistent with our governing laws and policies, provincial and federal strategies, international commitments, and societal values. Canada has made its intentions to the international community clear by agreeing to work towards meaningful greenhouse gas reductions to curb the increase in global temperatures (and resulting shift in hydroclimate conditions). Mining of coal, a greenhouse gas intensive resource, to be shipped overseas and burned during the production of steel runs counter to this objective.

Despite this obvious fact, and the lure of economic benefit generated by this Project, we equally have a responsibility and obligation to preserve and protect habitat for future generations. Although there has been legacy coal mining in the Blairmore area, this is not a compelling reason to support approval for this project. The argument that the area has already been disturbed so it is justifiable to disturb it some more is not a legitimate one. Any previous mining that has occurred in the Project area is minimal compared to the scale of disturbance that the applicant plans to inflict on the region. Removal and redistribution of the better part of a mountain to access the coal is significant and will have lasting effects on the surrounding hydrology and habitat for a very long time. The modelled projections provided by the applicant, although helpful in trying to understand what such a disturbance might look like short- and long-term, and the level of significance, are not mindful enough of the degree of uncertainty related to model projections (based on the lack of data required to constrain them), and is therefore cause for concern. Equally concerning is the subjective significance ratings that have been documented, which all lead to favourable results for the applicant. If more conservative scenarios had been employed, taking into consideration the complexity of the setting and the anticipated changes to the future climate, it is likely that less favourable conclusion would have be obtained.

The use of, and reliance upon, adaptive management as a "panacea" solution to the Project challenges identified is somewhat discomforting. By the time something adverse is detected it is usually too late. If adaptive management is the only way to deal with the uncertainties related to this Project, then it would seem prudent to require a more rigorous assessment to reduce this uncertainty so that future generations do not have to deal with a series of unintended consequences. The experiences in the Elk Valley are a sobering reminder that we do not know everything, and that our understanding of complex systems (or lack therefore) can lead to serious ramifications. This application would benefit from a more rigorous review of the uncertainties relating to how hydrologic change will influence an already threatened species (i.e. WSCT) holding on to a diminishing sliver of ever-decreasing amount of habitat in the Crowsnest watershed. Given the multitude of uncertainties related to model projections and related impact significance ratings, the problems experienced in the Elk Valley to the west, and the considerable lasting and permanent disruption to the Blairmore and Gold Creek watershed, approval of this project should not be granted.

Respectfully submitted by,

<Original signed by>

Jon Fennell, M.Sc., Ph.D., P.Geol.
Hydrogeologist & Geochemist

Jonathan Fennell, M.Sc., Ph.D., P.Geol.
Hydrogeology | Geochemistry | Water Resources

Resume

SUMMARY

Dr. Jon Fennell has been a practicing consultant in the natural resource sector for over 30 years. His expertise includes the analysis and development of local and regional-scale groundwater systems, mine assessments and dewatering strategies, water supply and disposal systems, groundwater-surface water interaction assessments, implementation of monitoring and management systems, and environmental forensics including: i) remote sensing, ii) application of geophysical methods, iii) geochemical assessment & modelling, and iv) the application of stable and radiogenic isotopes to support source water tracing, chemical fingerprinting, and age-dating. He has also been involved in a number pf projects requiring expertise in climate variability and climate change assessment, including the role major tele-connections and the development of sustainable adaptation strategies. The bulk of Jon's experience is associated with various oil & gas and mineral resource development projects in Canada and abroad. Over the last decade, Jon has worked closely the Alberta Government through various initiatives to support the Water for Life Strategy and cumulative effects management in the province. A primary area of focus is developing management processes to ensure water security, and communicating the importance of data, information and knowledge as it applies to responsible development.

POSITIONS HELD

2019 to Present	Program support, Expert-in-Residence – SAIT Integrated Water Management Program
2018 to Present	Technical Advisory Committee – Oil Sands Monitoring program (Joint Alberta Environment and Parks/Environment and Climate Change Canada)
2013 to 2017	Department of Renewable Resources, University of Alberta (Adjunct position) Department of Geography, University of Lethbridge (Adjunct position)
2012 to Present	Vice President, Advisory Services (Water Security and Climate Resiliency), Principal Hydrogeologist, Geochemist, and Technical Lead) – Integrated Sustainability, Calgary
2007 to 2012	Director, Water Resources (Canada) – WorleyParsons, Calgary
2005 to 2007	Vice President, Water Resources and Principal Hydrogeologist – WorleyParsons Komex, Calgary
2003 to 2006	Member of the Canadian Management Team – Komex International Ltd., Calgary
2003 to 2007	Group Leader – Komex International Ltd., Calgary
1990 to 2005	Senior Hydrogeologist – Komex International Ltd., Calgary
1985 to 1990	Petroleum Geologist – Industry Consultant, Calgary

EXPERIENCE

Mining

Alberta Environment and Parks

Preparation of oil sands tailings pond seepage review report. Responsibilities included:

- Review of background information pertaining to oil sands produced water (OSPW) seepage research and natural bedrock groundwater discharge studies
- Review of industry-submitted EPEA compliance reports to assess current "state of affairs" regarding monitoring and OSPW detections
- Assessment of seepage management systems
- Review of geological pathways for OSPW migration
- Development of seepage risk profiles for all active tailings ponds

Alberta Environment and Parks

Provision of external expert review for the Implementation Directive for the Surface Water Body Aggregate Policy (SWBAP) for gravel mining in floodplain areas. Responsibilities include:

- Review of relevant Government of Alberta documents relating to aggregate mining in or near surface water bodies and/or floodplain environments
- Use of information from relevant policies in other jurisdictions as well as studies and research (aquatic, terrestrial, river morphology, climate risk) regarding impacts of aggregate mining in floodplain areas
- Identification of gaps regarding goals and objectives of the approval and management process
- Review of risk assessment approach to approving aggregate mines near surface water bodies, and provision of recommendations for monitoring, evaluating and reporting
- Interaction with AEP project team members and presentation of results

Blackbird Mine, Idaho, USA

Completion of a hydrogeological baseline study and associated stable isotope investigation ($\delta^{34}S$, $\delta^{18}O$, and $\delta^{2}H$) to determine the source of acid mine drainage near active underground workings. Responsibilities included:

- Review of existing geochemical data and related mineral equilibria conditions (i.e. baseline and impacted)
- Assessment of geochemical reactions leading to acid mine drainage conditions, including biogeochemical aspects.

Canada's Oil Sands Innovation Alliance (COSIA)

Completion of a tailing pond seepage risk assessment and preparation of a peer-review journal manuscript to place suspected oil sands impacts into perspective. Responsibilities included:

- Review of individual tailings ponds established at the various operating oil sands mines in the Athabasca Oil Sands region

- Application of source-pathway-receptor model in relation to calculated groundwater flow velocities, stand-off distances from receptors, and natural attenuation properties to assess risk associated with each structure
- Preparation of manuscript to place into context natural discharge of low-quality groundwater from bedrock formation versus oil sands seepage

Graymont Western US Inc.

Preliminary development of a mine dewatering and water management strategy for a large limestone quarry located in the eastern from ranges of the Rocky Mountains. Responsibilities included:

- Assessment of baseline hydrogeological and hydrogeochemical conditions in a mountain environment
- Source water fingerprinting and groundwater age-dating
- Fracture and lineament analysis using structural geology and geophysical analysis (GPR, borehole tele-viewer)
- GW-SW interaction assessment (i.e., Bow River)
- Conceptualization of dewatering strategy utilizing oriented and horizontal well technology
- Issues identification and risk analysis

Imperial Oil Ventures Ltd.

Conceptual model design for dewatering scheme in support of mine development. Responsibilities included:

- Assessment of geological conditions
- Boundary assessment
- Parameter selection and optimization
- Assessment of model results

JDS Energy & Mining

Review of mine dewatering and water treatment & disposal strategy for gold mine in Guatemala. Preparation of proposed strategy to assess mitigation strategies (e.g. back pressure system) for hot water up to 160°C entering mine and flashing upon dewatering and subsurface disposal of arsenic-laden mine waters (including transport, fate, and risk assessment).

Suncor Energy

Preparation of an AB Environment approved Groundwater Management Plan at a large oil sands mining operation. Activities included:

- The design of a cost-effective sampling schedule including rationalization of over 300 wells to establish a meaningful monitoring network of 150 wells

- Development of statistically established trigger values for response and mitigation
- Liaison with Government of Alberta during review and approval

Suncor Energy

Various projects:

- D51 disposal monitoring at the Firebag Thermal In Situ Project
- Thermal mobilization assessment
- Preparation of an oil sands mining closure strategy outlining goals, objectives, tasks, timelines, and consulting and research agencies to execute in support of Life of Mine Closure and Reclamation process
- Assistance with Fort Hills Operational Plan regarding preservation of McClelland Lake and wetland complex; review of physical hydrogeology and geochemical setting; assessment of numerical model design and output; review of cut-of wall design and mitigation system; review of adaptive management processes
- Review of Devonian – McMurray interactions at the North Steepbank mine expansion and assistance with investigation program design (including geochemical assessment)
- Completion of geophysical and porewater surveys on the Athabasca and Steepbank Rivers to determine contributions of natural discharge versus industry inputs

Syncrude Canada

Participation on expert hydrogeology panel to review Devonian investigation program for Aurora mine and assess mitigation strategies to control high risk areas (Les Gray - UBC, Carl Mendoza, - UofA, Ken Baxter - Golder, Jon Fennell - WP). Responsibilities included:

- Review of existing baseline data for active mining site
- Identification of high-risk areas to consider for future investigation and monitoring
- Participation in group workshop settings to communicate findings and accumulate input for recommendations refinement
- Participation in internal panel meetings to discuss concepts and develop final recommendation

Talisker Resources Ltd.

Review of mine water balance, dewatering strategy, impact analysis and Arsenic source-tracing (Bralorne Mine, BC) to develop mitigation system for cost-efficient water treatment (including upset conditions of higher flow rates).

Teck Resources Limited

Evaluation of stream response to groundwater interception in support of fisheries habitat offsetting at Line Creek Mine, BC. Responsibilities included:

- Baseline reconnaissance of Line Creek alluvial system and GW-SW water interactions with Line Creek

- Assessment of area springs, shallow groundwater, and creeks to determine geochemical quality and flow conditions (using drive point well technology and data logger systems)
- Completion of ground penetrating radar survey to map thickness and morphology of alluvial deposits
- Water quality fingerprinting using major ion, trace elements (in particular selenium) and stable isotopes to determine interaction of groundwater environment with Line Creek

Assessment of selenium mobilization conditions related to active mine workings and development of a conceptual (passive) mitigation strategy to offset impacts to fisheries habitat

Total E&P

Support for mine dewatering strategy. Responsibilities included:

- Development of baseline hydrogeology
- Liaison with project team and governing agencies
- Joint Panel hearing support
- Selection and phasing of depressurization wells and associated monitoring wells
- Review of deep well injection potential, including geochemical compatibilities of waters
- Development of a performance monitoring system
- Selection of pipeline route
- Preparation of a design-based memorandum with related costs of implementation and long-term operation

Geochemistry

Amoco Canada

Completion of a stable isotope study using $\delta^{34}S$, $\delta^{18}O$, $\delta^{2}H$, $\delta^{13}C$ to determine the source of anomalous groundwater sulphate concentrations (natural vs. anthropogenic)

Canadian Occidental

Completion of a stable isotope studies to determine the source of sulphate impact from two large sour gas processing facilities (Balzac and Okotoks). Responsibilities included:

- Drilling, installation, and testing of monitoring wells
- Development of a conceptual site model
- Review of site-wide geochemistry (soil and groundwater)
- Application of $\delta^{34}S$, $\delta^{18}O$, $\delta^{2}H$, and $\delta^{13}C$ isotopes to resolve natural versus anthropogenic influences

Canada's Oil Sands Innovation Alliance (COSIA)

Completion of regional geochemical assessments in NE Alberta (35,000 km^2 area) supporting the Regional Water Management Initiative. Responsibilities included:

- Collation of regional geological, hydrogeological, and geochemical data using public domain and industry information
- Assessment and interpretation of hydrogeological setting and of conceptual models
- Assessment of traditional and isotope geochemistry to determine source water chemistry to define flow path phenomena areas of aquifer interactions
- Statistical analysis of data to determine groupings and associations (PCA analysis)
- Documentation and presentation of results at various public venues

Cumulative Environmental Management Association (CEMA) and Alberta Environment (AENV)

Assessment of baseline hydrological and hydrogeological conditions and development of a regional-scale groundwater quality monitoring network (18 000 km^2 study area) located in the Athabasca Oil Sands Region of northeast Alberta. Responsibilities included:

- Refinement of conceptual hydrogeological model
- Groundwater-surface water interaction assessment
- Assessment of quality conditions and trends (including statistical analysis)
- Knowledge and data gap analysis
- Pathway identification and vulnerability assessment for sensitive receptors
- Field reconnaissance and well selection
- Isotope interpretation ($\delta^{18}O$, $\delta^{2}H$, $\delta^{13}C$, Carbon-14)
- Groundwater hydrograph analysis
- Report preparation and presentation
- Liaison with government and industry representatives

Department of Environment and Resource Management, Queensland, Australia

Lead for a hydrogeochemical assessment and water fingerprinting exercise in Great Artesian Basin aquifers of the Surat and Bowen basins to support Coal Seam Gas development and cumulative effects analysis. Responsibilities included:

- A comprehensive data and information inventory to facilitate source water fingerprinting and collation of large public-domain data sets to provide a first-of-its-kind database of water quality information
- Review of major ions, metals and trace elements, stable and radiogenic isotopes and dissolved gases to identify recharge phenomenon, cross-formational flow characteristics and distinct water types
- Statistical analysis to assess data groupings and spatial trends

East Calgary, AB

Detailed assessment of hydrogeological and hydrochemical conditions in the vicinity of residential water wells to identify locally used aquifers, variation in water quality, groundwater availability and the potential of impact from nearby sour gas production wells.

Government of Yemen

Hydrogeological and geochemical support for a regional-scale study of water supply potential in the country. Responsibilities included:

- Hydrogeological and hydrogeochemical facies mapping,
- Geochemical assessment and flow path evolution modelling,
- Groundwater flow field assessment and modelling,
- Sustainable yield evaluation
- Groundwater tracing & age dating (trace elements; stable and radiogenic isotopes)

Imperial Oil

Completion of field and bench-scale tests to determine facilitated mobility of metals, trace elements, and dissolved organics resulting from artificial ground heating around thermal in situ wells. Responsibilities included:

- Tracer experiment to determine groundwater flow velocities in a deep (>80 m) confined aquifer. Responsibilities have included:
- Drilling, installation, testing, and sampling (soil and water) from 22 deep (up to 90 m) monitoring wells at a newly established thermal in situ pad to determine baseline geochemistry and groundwater flow directions
- Completion of a tracer test (deuterated water) to determine groundwater flow velocities
- Collection of sediment samples (under anoxic conditions) for bench-scale heating experiments to determine metals mobility and related kinetics
- Review of stable isotopes in groundwater and dissolved gases to determine effects of heating from in-situ thermal wells on local geochemical conditions (inorganic and organic constituents)
- Reaction path modelling to determine processes influencing changes metals concentrations and biological activity resulting from subsurface heating
- Determination of activation energies for metals release, and the role of biogeochemical reactions in facilitating metals release
- Transport and fate modelling to determine the long-term risk of thermal mobilization of metals (and other related constituents) to the surrounding environment
- Documentation of result and liaison with client and regulatory agencies

Imperial Oil Resources

Completion of numerous isotope studies using to determine groundwater flow rates in regional confined aquifers and the source of anomalous groundwater quality conditions and dissolved gas concentrations near a large heavy oil recovery operation using:

- Assessment of $\delta^{18}O$, $\delta^{2}H$, $\delta^{34}S$, $\delta^{11}B$ and $\delta^{13}C$
- Tritium and Carbon-14 for groundwater age-dating

Imperial Oil Resources

Tritium age dating of groundwater in Norman Wells, NWT to determine vertical groundwater flow characteristics in discontinuous permafrost environment

Mobil Oil Canada

Completion of a stable isotope study to determine the source of sulphate impact from a large sour gas processing facility. Responsibilities included:

- Drilling and installation of monitoring wells
- Development of a conceptual site model
- Review of site-wide geochemistry (soil and groundwater)
- Application of $\delta^{34}S$, $\delta^{18}O$, $\delta^{2}H$, and $\delta^{13}C$ isotopes to resolve natural versus anthropogenic influences

Nexen ULC

Design and completion of bench-scale testing to determine the mobilization of metals and trace elements under applied heating. Responsibilities included:

- Conceptual design of experimental process in collaboration with AGAT lab representatives
- Assessment of frozen core samples and selection of appropriate intervals for physical (grain size, mineralogy via XRD) and chemical testing (total metals, leachable metals)
- Assessment of results from sequential batch heating experiments extending from 5-100°C for metals species released to solution
- Geochemical modelling of kinetic experiment results to determine activation energies of metals release
- Completion of attenuation experiments to determine potential for mobilized metals to re-associated with sediments under cooled conditions
- Preparation of a summary report and presentations to the client in support of AER interactions

Suncor Energy

Development of an Athabasca River reconnaissance program to identify and sample natural groundwater-surface water interaction zones discharging waters from the Cretaceous and Devonian formations. Responsibilities included:

- Planning/execution and interpretation of a marine-based geophysical program using EM31 imaging and bathymetric readings

- Development of pore water sampling program including geochemical assessment of waters and source fingerprinting (major ion, trace element, dissolved organics and stable and radiogenic isotopes)
- Interpretation of results and presentation at various venues (government, industry)

Suncor Energy

Groundwater age-dating and source area identification in support of active tailings pond seepage investigations. Responsibilities included:

- Conceptual site model design
- Review of traditional geochemistry to determine end-point water types
- Application of Tritium, $\delta^{18}O$, $\delta^{2}H$, $\delta^{34}S$, $\delta^{11}B$ to resolve geochemical setting and potential areas of seepage

Climate change (International)

Canadian International Development Agency, Catamayo, Ecuador SA

Completion of a baseline soil and groundwater study (physical and chemical) to determine the feasibility of siting an engineered wastewater impoundment for the treatment of municipal sewage treatment (project funded by CIDA). Responsibilities included:

- General site reconnaissance
- Collection of soil and groundwater samples for baseline geochemical quality assessment
- Review of watershed conditions and processes relating to baseline hydrology and hydrogeology
- Assessment of climate aspects to regarding timing and magnitude of river flows, implications of changing conditions and influence of climate cycles
- Submission of recommendations on the suitability of the proposed location and possible approaches to rectify existing limitations

Department of Environment and Resource Management, Queensland, Australia

Lead for water security assessment to assess groundwater and groundwater-dependent ecosystem risks from Coal Seam Gas development in southeast Queensland. Responsibilities included:

- Development of a multi-criteria weighting and ranking system linked with GIS to display areas of highest risk to drawdown including areas users and groundwater dependent ecosystems
- Assessment of major climate modes influencing regional water balances (ENSO, SOI)
- Facilitation of industry and government workshops to present and vet results

Department of Environment and Resource Management, Queensland, Australia

Lead for an aquifer vulnerability assessment to assess groundwater and groundwater-dependent ecosystem risks from Coal Seam Gas development in southeast Queensland. Responsibilities included:

- Development of a multi-criteria weighting and ranking system linked with GIS to display areas of highest risk to drawdown including areas users and groundwater dependent ecosystems
- Facilitation of industry and government workshops to present and vet results

Mexican Soda and Water Company, Monterrey Mexico

Lead for a groundwater evaluation project to supplement beverage making operations a large manufacturing plant in the city of Monterrey. Responsibilities included:

- Review of background geological, hydrogeological and geochemical information across a large study area centered on the Monterrey Metropolitan Area
- Assessment of structural fabric of study area including presence of major folds, faults, and other features (e.g. karst)
- Amalgamation of background data with result from Quantum Geoelectrophysics reconnaissance program to identify prospective drilling targets
- Completion of a 4C report (compare, contrast, correlate, confirm) and selection of prime drilling target for testing and evaluation

Origin Energy, Queensland, Australia

Water resources technical lead for a large-scale coal seam gas project (up to 10,000 wells) located in the headwaters of the Murray-Darling Basin and recharge area for the Great Artesian Basin. Responsibilities included:

- Development of a regional-scale groundwater monitoring system using vulnerability and risk mapping
- Design of a hydrogeological model covering a 173 000 km^2 area (using FEFLOW) to assess groundwater -surface water impacts and cumulative effects from coal seam gas development
- Incorporation of climate variability and climate change aspects to the model conceptualization to forecast natural changes and implication for project effects
- Completion of supporting Technical Report (including risk mapping, injection feasibility, model development) and Environmental Impact Statement chapter
- Liaison with the Queensland Department of Environment and Natural Resources to address needs for the required Environmental Impact Assessment

United Nations, Joint Caribbean Climate Change Partnership

Technical lead for the development of UNFCCC-sanctioned National Adaptation Plans for the countries of Guyana and Belize, with the goal of addressing multi-sector impacts from future climate change. Responsibilities include:

- Review of existing policies and studies supporting climate change adaptation
- Assessment of current adaptation plans for major economic, social, and environmental sectors
- Incorporation of IPCC (Global Climate Models) and PRECIS (Regional Climate Models) output under various RCP scenarios
- Delivery of facilitated in-country workshops for various Ministries
- Provision of recommendations to address gaps identified in current plans
- Liaison with government officials and UNDP organizers
- Completion of climate change risk assessment and options analysis to identify high-value actions
- Preparation of capacity-building plan and 10-yr strategic plan
- Risk and vulnerability assessment (including spatial aspects under various climate change scenarios – SRES and RCP)

Climate change (domestic)

Alberta Environment and Parks (AEP)

Provision of external expert review for the Implementation Directive for the Surface Water Body Aggregate Policy (SWBAP). Responsibilities include:

- Review of relevant Government of Alberta documents relating to aggregate mining in or near surface water bodies and/or floodplain environments
- Use of information from relevant policies in other jurisdictions as well as studies and research (aquatic, terrestrial, river morphology, climate risk) regarding impacts of aggregate mining in floodplain areas
- Incorporation of climate variability (ENSO, PDO) and climate change aspects to define risk to river flow characteristics as a result of future changes to temperature and precipitation regimes
- Identification of gaps regarding goals and objectives of the approval and management process
- Review of risk assessment approach to approving aggregate mines near surface water bodies, and provision of recommendations for monitoring, evaluating and reporting
- Interaction with AEP project team members and presentation of results

Alberta Innovates (AI)

Provision of water resources services for the University of Alberta led study into:

- Resolving human versus Industrial Influences on the water quality of the Lower Athabasca River
  - data synthesis

  - geophysical and geochemical assessment
  - isotope geochemistry source water fingerprinting
  - GW-SW interaction – identification and flux
  - climate implications to river flows
- Predicting Alberta's Water Future (complete estimates of groundwater recharge to Alberta's 2200 sub-basins
  - determining groundwater use projections by major sector to 2050
  - assessing baseflow contributions and groundwater stress area based on analytic element model outputs
  - projected changes to provincial water supplies based on population growth, energy extraction, food production, and land use
  - assessment of climate variability and change on provincial water balance
  - coordinate results with climate change model outputs and SWAT model outputs to generate preliminary Water Risk map for the province.

Alberta Water Research Institute (AWRI)

Completion of an inventory of Alberta's water and its associated dynamics (natural and human-induced). Responsibilities included:

- The development of a partnership model including participants from Universities and Institutes in Beijing, Switzerland, Edmonton, Calgary and Lethbridge
- Completion of a complete inventory of surface water, groundwater and fossil water (glaciers and deep groundwater) to identify current and future risks to water supplies in the province
- Assessment of climate variability and change implications to provincial groundwater water resources

Apache Canada

Completion of watershed analysis and intake siting in support of a Water Act Application on Smoky Lake. Responsibilities included:

- Assessment of Smoke Lake watershed and water supply potential
- Water supply modelling to determine availability and reliability of lake water
- Review of historical flow data and determination of suitable IFN at outlet (i.e. Q80)
- Review of terrestrial, fisheries and water quality data to support water diversion strategy
- Assessment of climate variability and climate change as they apply to water availability and reliability
- Development of proposed monitoring and response plan
- Liaison with AEP and AER representative

Apache Canada

Completion of watershed analysis and intake siting in support of a Water Act Application on Smoke Lake. Responsibilities included:

- Assessment of Smoke Lake watershed and water supply potential
- Water supply modelling to determine availability and reliability of lake water
- Review of historical flow data and determination of suitable IFN at outlet (i.e. Q80)
- Review of terrestrial, fisheries and water quality data to support water diversion strategy
- Assessment of climate variability and climate change as they apply to water availability and reliability
- Development of proposed monitoring and response plan
- Liaison with AEP and AER representative

Bellatrix Exploration Ltd.

Completion of a Water Sourcing study for Rocky Mountain asset. Responsibilities included:

- Review of existing and potential water sourcing options
- Assessment of climate change considerations in ensuring water security
- Development MCA and of GIS tool to assess and map high-value water opportunities
- Completion of a water security plan

Butte Action Committee

Preparation for, and participation in, AEP-led Surface Water Body Aggregate Policy 2017 stakeholder review workshops. Responsibilities included:

- Consultation with stakeholder group
- Review of AEP materials in advance of Airdrie workshop (AEP policies, guides, codes, risk assessment framework)
- Review of other Canadian and International policies and guides to aggregate mining near water bodies
- Review of impact studies related to aggregate mine development near surface water bodies (erosion, pit capture, infrastructure risk, fisheries and riparian area impacts)
- Assessment of climate change implications for streamflow timing and magnitude, as well as intensity, duration, and frequency of storms and related runoff, on 1:100 levels
- Documentation of questions to AEP for clarification and response to AEP questions re: climate change implications

Devon Canada

Completion of detailed studies to define baseline hydrogeological and hydrological conditions in support of a coalbed methane project in the Crowsnest Region of the eastern Rocky Mountains. Responsibilities included:

- Completion of detailed field reconnaissance program
- Establishment of a spring and water well monitoring network
- Investigation of surface water/groundwater interactions

- Review of climate variability and climate change implications for water availability and reliability
- Development of a conceptual water balance model in a mountainous area using geological and geochemical data
- Groundwater age dating of regional confined aquifers using radioactive isotopes (i.e. Tritium and Chlorine-36)
- Public and regulatory liaison

Enerplus

Completion of a Water Security Plan for the Western Canadian assets. Responsibilities included:

- Review of asset operations and water management process
- Assessment of basin water risk conditions and current mitigations in place (including climate variability and climate change)
- Source water and disposal opportunity assessment
- Development of MCA process to rank water risk profile of each asset and provide recommendations for mitigation

Hammerhead Resources

Completion of watershed analysis, flood assessment and intake siting in support of a Water Act Application on the Smoky River. Responsibilities included:

- Assessment of Smoky River watershed and water supply potential
- Review of historical flow data and assessment of Q80 and Q95
- Review of climate variability implications for river flow characteristics
- Flood assessment to determine 1:10 and 1:25 year event levels
- Review of fisheries and bank stability assessment in support of intake siting
- Development of proposed monitoring and response plan
- Liaison with AEP and AER representatives

Husky Oil Operations Ltd.

Completion of a water security plan for the Ansell asset, west-central Alberta. Responsibilities included:

- Review of project water profile and future requirements for hydraulic fracturing
- Assessment of water security in relation to changing climatic conditions
- Facilitation of risk review workshop
- Review of water source opportunities and development of MCA opportunity ranking process

Lakeland Industry and Community Association (LICA)

Assessment of the current health of two large watersheds (covering over 8500 km^2) in response to changing climatic conditions, land use practices, and increased pressure on water resources (surface water and groundwater) by agricultural and industrial users. Responsibilities included:

- The assessment of historical multispectral satellite imagery
- Review of stream and groundwater hydrograph data
- Assessment of effects of climate tele-connections (ENSO, PDS) on basin hydrology
- Review of temporal groundwater and lake dynamics in response to changing conditions

Nexen ULC

Development of a water strategy to service the Aurora LNG project/Dilly Creek asset. Responsibilities included:

- Assessment of development trajectory with respect to water use
- Identification of feasible water supply source to accommodate up to 6.5 million m^3 per year of water
- Review of climate variability and climate change implications for water availability and reliability
- Conceptualization of water storage strategy to reduce pressure on local water sources and minimize physical footprint of development
- Development of a water conveyance strategy utilizing existing rights of way, including Class 5 cost estimation
- Liaison with Fort Nelson first Nations to facilitate development of baseline hydrology monitoring program and facilitation of a Section 10 water licence (following successful EAB appeal of previous licence)

Red Deer River Watershed Alliance (RDWA)

Assistance with development of an Integrated Watershed Management Plan to address future development in the basin. Responsibilities included:

- Groundwater inventory
- Water use patterns
- Effects of land use and climate variability and climate change on basin water balance and storage conditions
- Water quality conditions
- Risk and vulnerability assessment
- Development of beneficial management practices
- Development of a conceptual monitoring system to achieve plan goals and objectives

Shell Canada

Completion of watershed analysis and intake siting in support of a Water Act Application on Iosegun Lake. Responsibilities included:

- Assessment of Iosegun Lake watershed and water supply potential
- Water supply modelling to determine availability and reliability of supply

- Review of historical flow data and determination of suitable IFN at outlet (i.e. Q80)
- Assessment of climate variability and climate change as they apply to water availability and reliability
- Review of terrestrial, fisheries and water quality data to support water diversion strategy
- Development of proposed monitoring and response plan
- Liaison with AEP and AER representatives

Shell Canada

Support for Carmon Creek EIA and assessment of brackish water supply potential in support of heavy oil operations in the Peace River area. Responsibilities included:

- Assessment of baseline hydrogeological conditions and potential impacts from project development
- Preparation of climate change assessment for project development
- Support for SIR submissions and EIA team interactions
- Feasibility assessment of potential for deep formations to produce sustained supplies and conceptual well-field development
- Liaison with regulatory agencies
- Development of a DBM level review for a groundwater well-field development

South McDougall Flats Protection Society

Review of proposed re-zoning for aggregate mine development in historic floodplain of Little Red Deer River in Sundre, AB. Responsibilities included:

- Review of proposed gravel pit re-zoning area
- Air photo assessment and delineation of paleo-floodplain
- Assessment of climate variability and climate changes aspects regarding river flow conditions (flood and low flow)
- Preparation of workshop materials
- Presentation at public forum re: pros and cons of gravel mining (including policy framework review)
- Support for Town Council hearing

Town of Okotoks, AB

Assistance with review of development applications and support for ensuring water security through conjunctive use strategies. Responsibilities included:

- Expert review of development applications assessing cumulative drawdown effects and provision of recommendations to manage effects
- Engagement with Town official on development of a sustainable water management strategy
- Assessment of climate variability and climate change considerations as they relate to water security

- Provision of support for AENV and Environmental Appeal Board process

Town of Okotoks

Completion of a pre-feasibility study to assess aquifer storage and recovery (ASR) and managed aquifer recharge (MAR) as a solution to water supply challenges. Responsibilities included:

- Review of regulatory setting and constraints for ASR and MAR (Canada and international jurisdictions).
- Review of ASR and MAR projects world-wide
- Assessment of local geological and hydrogeological conditions and identification of potential areas to facilitate ASR and MAR success
- Modelling to determine optimal placement of MAR system to enhance baseflow conditions
- GW-SW interaction assessment & climate impact assessment
- Preparation and presentation of pre-feasibility summary to Town Council and Mayor

Town of High River, AB

Lead for the development of a Water Sustainability Plan predicated on risk identification and alternative storage and management options for a large alluvial aquifer system. Responsibilities included:

- Concept and program design
- Execution of vulnerability mapping approach to assess risk to High River from groundwater impacts (e.g. underground storage tanks)
- Development of conceptual hydrogeological framework
- Review of groundwater–surface water interaction and climate variability effects
- Assistance with groundwater model development
- Liaison with town officials, MD Foothills official and other project stakeholders

Tsuut'ina First Nation

Completion of flood analysis (overland and groundwater) for the Redwood Meadow development on the Elbow River floodplain. Responsibilities included:

- Review of river hydrology, flood frequency, and related changes in river morphology
- Assistance with hydrological modelling to address groundwater flooding potential to existing and panned development areas
- Calculation of damage estimates associated with 5, 20,100, 200 and 500-year return periods
- Assessment of climate change aspects regarding river flow characteristics and flood risk
- Liaison with First Nations representatives, Government of AB, and Canadian Environmental Assessment Agency.

Other International

Origin Energy, Queensland, Australia

Groundwater lead for a large-scale coal seam gas project (up to 10,000 wells) located in the headwaters of the Murray-Darling Basin and recharge area for the Great Artesian Basin. Responsibilities included:

- Development of a regional-scale groundwater monitoring system using vulnerability and risk mapping
- Design of a hydrogeological model covering a 173 000 km^2 area (using FEFLOW) to assess cumulative effects from CSG development
- Completion of supporting Technical Report (including risk mapping, injection feasibility, model development) and Environmental Impact Statement chapter
- Liaison with the Queensland Department of Environment and Natural Resources to address needs for the required Environmental Impact Assessment

Texas Petroleum Company, Ecuador, SA

Completion of a baseline groundwater and surface water study in a remote and environmentally sensitive area of the Amazon basin (headwaters area) to support a helicopter-assisted drilling program for oil and gas exploration. Responsibilities included:

- Field reconnaissance to establish the suitability of proposed drilling targets
- Assessment of the suitability of local surface water and groundwater sources for drilling fluid provision (quality and quantity)
- Review of baseline soil quality, site hydrogeology, and geochemical conditions
- Development of recommendations for pit construction and site preparation.

Texas Petroleum Company, Magdalena Valley, Colombia, SA (1994)

Completion of an onsite environmental assessment of oilfield operations in support of the transfer of the Teca Nare, Cocorná, Velásques Oil Fields and the Velásquez-Galan Pipeline. Responsibilities included:

- Phase 1 site assessment of field operations
- Verification of site conditions at all well sites including soil and vegetation conditions prior to property transfer
- Assessment of baseline surface water and groundwater chemical conditions, as wells as environmental quality assessment to determine contamination from oilfield operations
- Provision of summary report including recommendations

Canadian International Development Agency, Catamayo, Ecuador SA

Completion of a baseline soil and groundwater study (physical and chemical) to determine the feasibility of siting an engineered wastewater impoundment for the treatment of municipal sewage treatment (project funded by CIDA). Responsibilities included:

- General site reconnaissance
- Collection of soil and groundwater samples for baseline geochemical quality assessment
- Review of hydrogeological conditions and processes relating to baseline conditions
- Submission of recommendations on the suitability of the proposed location and possible approaches to rectify existing limitations

Other Government

BC Ministry of Energy, Mines and Petroleum Resources

Provision of expert review support for hydraulic fracturing review process. Responsibilities included:

- Preparation of background information pertaining to water quality risks and source-pathway-receptor aspects of hydraulic fracturing operations
- Provision of recommendation regarding geochemical fingerprinting (ion ratios, isotopes, NORMs), risk assessment and mapping techniques, and monitoring
- Appearance at in-camera session to discuss water quality aspects with academic panel members including recommendations.

Alberta Utilities Commission

Provision of expert review support for a wind power application in the Provost AB area. Responsibilities included:

- Review of submitted application documents
- Research on wind vibration implications for shallow aquifer deliverability
- Submission of opinion report

Alberta Environment and Parks (AEP)

Participation on expert hydrogeology panel to development a template for groundwater management frameworks in Alberta. Responsibilities included:

- Assessment of background on Alberta groundwater resources and documents highlighting existing GMFs inside and outside of Canada
- Review of sustainability goals and challenges with groundwater management (quantity and quality)
- Review of prevailing concepts to groundwater management (i.e. surface water capture, risk and vulnerability assessment)
- Identification of data needs and required infrastructure to support cumulative effects management
- Identification of proposed indicators using DPSIR approach
- Participation in external panel and internal AEP team of hydrogeological experts to define aspects of a standardized GMF template

Alberta Environmental Monitoring Evaluation and Reporting Agency (AEMERA)

Assessment of Alberta's groundwater observation well network, including redundancy and gap analysis. Responsibilities included:

- Groundwater risk mapping
- Development of a numerical scoring scheme to prioritize monitoring wells
- Statistical and spatial analysis of provincial water chemistries using information from the Alberta water well information database
- Development of monitoring strategy including analytes and frequency to address key development activities (e.g. hydraulic fracturing, waste disposal, large-scale groundwater extractions)

Alberta Environment and Sustainable Resource Development (ESRD)

Development of a multi-attribute point-scoring system and ArcGIS tool to assist with optimal siting of provincial monitoring wells to address concerns regarding hydraulic fracturing (HF). Responsibilities included:

- Identification of key risks to groundwater resource from HF activities
- Conceptualization and construction of a subsurface risk assessment
- Identification of surface access opportunities in an ArcGIS platform to identify prime locations for monitoring in active and future development areas

Alberta Environment and Sustainable Resource Development (ESRD)

Various projects:

- Northern Athabasca Oil Sands Region groundwater monitoring program. Responsibilities included development of sampling methodology, data evaluation process and program logistics, communication to technical team comprising oil sands operators, ERCB and AEP representatives, development of an on-line visualization tool, and client liaison.
- Review of LARP management plan, supporting Groundwater Management Frameworks and supporting guidance documents re: Thermal Mobilization of Trace Elements during In Situ Developments and Groundwater Monitoring Directive.
- Preparation of summary document for Scientific Advisory Committee of the Oil sands GW working group, and Alberta Environment.

Alberta Land Use Secretariat (LUS)

Assistance with development of land planning scenarios in NE Alberta to guide future development in the Lower Athabasca Regional Plan area pursuant to the goals of the Alberta Land-use Framework. Responsibilities included:

- Presentations to the Land Use Secretariat, Regional Planning Team and Regional Advisory Council

- Development and assessment of modelled results from a cumulative effects simulator, completion of groundwater modelling over a 93 000 km^2 area (using MODFLOW)
- Development of an approach to deal with groundwater resources in the LARP area

Alberta Environment (AENV)

Technical assistance with development of a guidance framework to respond to the implications of thermal mobilization of constituents at in-situ bitumen recovery projects. Responsibilities included:

- Facilitation of team workshops to communicate the physical and chemical aspects of thermal mobilization and the risks posed by ion-situ operations
- Development of a risk-based, phased, approach to assessing thermal mobilization to address source-pathway-receptor aspects
- Development of a draft guidance document and interaction with the AEP communications team
- Support for industry and CAPP consultation meetings to review the draft guidance document

Alberta Environment (AENV)

Completion of vulnerability and risk mapping for the Lower Athabasca Regional Planning area and development of a groundwater management framework. Responsibilities included:

- Assessment of potential cumulative effects from large-scale thermal in-situ bitumen recovery operations and related activities (i.e. water withdrawal for steam generation and down-hole waste disposal
- Facilitation of technical and policy-related work sessions to engage stakeholders (operators, AENV and ERCB) directly affected by changes to provincial water management

Alberta Environment (AENV)

Development of a groundwater management framework within the South Athabasca Oil Sands area of the Lower Athabasca Planning Region. Responsibilities included:

- Completion of an inventory of existing quality and quantity issues, water supply conditions and related environmental policy
- Participation in technical and policy-related work sessions involving various stakeholder representatives

Alberta Environment (AENV)

Development of a groundwater water management framework within the mineable area of the Lower Athabasca Planning Region. Responsibilities included:

- Completion of an inventory of existing quality and quantity issues, water supply conditions and related environmental policy

- Participation in technical and policy-related work sessions involving various stakeholder representatives

Alberta Environment (AENV)

Completion of vulnerability mapping for the Lower Athabasca Regional Planning area and development of a groundwater management framework. Responsibilities included:

- Assessment of potential cumulative effects from thermal in-situ bitumen recovery operations and related activities (i.e. water withdrawal for steam generation; fluid waste injection)
- Facilitation of technical and policy-related work sessions to engage stakeholders (operators, AENV and ERCB) directly affected by changes to provincial water management

Alberta Utilities Commission (AUC)

External review of application to establish a wind farm in east-central Alberta. Responsibilities included:

- Review of project concept and environmental implications
- Assessment of completeness regarding baseline hydrogeological assessment
- Assessment of impact analysis and proposed mitigation
- Identification of gaps and provision supplemental information requests

Other Agencies

Alberta Innovates (AI)

Provision of hydrogeological services for the following University of Alberta led studies:

- Resolving human versus Industrial Influences on the water quality of the Lower Athabasca River (data synthesis; geophysical and geochemical assessment; isotope geochemistry source water fingerprinting, GW-SW interaction – identification and flux)
- Review of Arsenic in Alberta's groundwater (collation of multiple open source and private data bases, GIS platform design; correlation/cluster/factor analysis to determine source/cause/reasons(s), both physical and geochemical, for elevated concentrations, development of a risk mapping tool to identify existing and potential future high risk areas and aquifer intervals)
- Predicting Alberta's Water Future (complete estimates of groundwater recharge to Alberta's 2200 sub-basins; determining groundwater use projection by major sector to 2050; assessing baseflow contributions and groundwater stress area based analytic model outputs; project changes to provincial water supplies based on population growth, energy extraction, food production, land use, and climate variability/change; coordinate results with climate change model outputs and SWAT model outputs to generate preliminary Water Risk map for the province.

Alberta Water Research Institute (AWRI)

Preparation of a report assessing Alberta's inventory of water and its associated dynamics (natural and human-induced). Responsibilities included:

- The development of a partnership model including participants from Universities and Institutes in Beijing, Switzerland, Edmonton, Calgary and Lethbridge
- Completion of a complete inventory of surface water, groundwater and fossil water (glaciers and deep groundwater) to identify current and future risks to water supplies in the province
- Assessment of climate variability and change implications to provincial groundwater water resources

Canada's Oil Sands Innovation Alliance (COSIA)

Completion of a water disposal assessment in NE Alberta (153,000 km^2 area) supporting the Regional Water Management Initiative. Responsibilities included:

- Collation of regional geological, hydrogeological, and water production data using public domain and industry information
- Development of a multi-criteria analysis approach to assessing Injection Potential and Theoretical Injection Rates based on a system of weighted and ranked physical and chemical attributes
- Development of an ArcGIS platform to identify high-value disposal formations in relation to existing and planned in situ developments and pipelines

Canada's Oil Sands Innovation Alliance (COSIA)

Completion of oil sands industry study assessing the risks and benefits of landfills, salt caverns and disposal wells in liquid waste management. Responsibilities included:

- Participation in industry workshops
- Assessment of liquid waste management options
- Documentation and presentation of the results to industry members

Cumulative Environmental Management Association (CEMA)

Preparation of a groundwater monitoring and management plan in support of the State of the Muskeg River Watershed report. Responsibilities included:

- Assessment of baseline groundwater quantity and quality conditions in the study area
- Identification of development stresses and potential short and long-term impacts
- Identification of proposed physical, chemical and state indicators for monitoring
- Interaction in multidisciplinary team

Cumulative Environmental Management Association (CEMA)

Overview of historical, current, and planned groundwater initiatives in the Regional Municipality of Wood Buffalo. Responsibilities included:

- Interviews with relevant industry, government, academia, aboriginal, and non-governmental organization groups
- Identifying and accessing relevant studies, reports, and investigations relating to groundwater and groundwater-surface water interaction
- Development of a useable database with relevant descriptors of content and results

Petroleum Technology Alliance of Canada (PTAC)

Completion of studies and industry workshops assessing:

- Environmental net benefit of saline versus non-saline water use in unconventional oil and gas development
- The role of collaboration in unconventional oil and gas development

Other Industry

Alberta Energy Company

Preparation of an Environmental Operations Manual for all aspects of petroleum exploration and development in Alberta. Contents of the manual included environmental procedures for seismic cutline provision and reclamation, siting and construction of drilling leases and processing facilities, siting and construction of pipeline right of ways, spill response and cleanup, and site reclamation.

Amoco Canada

Review of fresh groundwater usage for steam injection. Responsibilities included assessment of historical monitoring well and lake level readings to evaluate local effects resulting from groundwater withdrawal.

Amoco Canada

Sounding Lake area monitoring program to determine effects from nearby drilling activity. Responsibilities included:

- Interviews with well-owners
- Assessment of the water delivery system
- Short-term aquifer testing
- Sample collection using ultra-clean sampling methods
- Review of the data
- Communication of results to client and owner

Amoco Canada

Completion of environmental site assessments and landfill delineation programs for gas plant divestitures. Responsibilities included:

- Installation, testing and sampling of groundwater monitoring wells
- Completion of soil sampling programs
- Assessment of the results to determine the liability cost associated with property transfer

BP Canada

Resident well sampling program to determine effects from nearby drilling programs and existing gas wells. Responsibilities included:

- Well-owner interviews
- Assessment of the well conditions and water delivery system
- Sample collection using ultra-clean sampling methods
- Data review of communication of results.

Brooks, AB

Assessment of the construction and integrity of groundwater source wells, local hydrogeological and hydrochemical conditions, groundwater usage, assessment of potential impact to local water supply wells in the event of a well failure, and development of a risk management plan.

Delcan Corporation

Conceptual design of dewatering system in support of large sewage treatment facility upgrade. Responsibilities included:

- Review of site geological conditions
- Analytical model construction to determine stand-off distances for DW wells
- Predictive outcome assessment and DW plan development

Devon Canada

Completion of detailed studies to define baseline hydrogeological and hydrological conditions in support of a CBM project in the Crowsnest Region of the eastern Rocky Mountains. Responsibilities included:

- Completion of detailed field reconnaissance program
- Establishment of a spring and water well monitoring network
- Investigation of surface water/groundwater interactions
- Development of a conceptual hydrogeological framework in a mountainous area using geological and geochemical data
- Groundwater age dating of regional confined aquifers using radioactive isotopes (i.e. Tritium and Chlorine-36).

- Public and regulatory liaison

Devon Canada

Development of a thermal mobilization risk model to support development efforts in the Jackfish and Pike oil sands developments. Responsibilities included:

- Review and evaluation of existing geochemical data including metals and trace elements
- Development of conceptual site model using existing geological picks for various identified formations
- Design of Spatial MCA approach to map risk of thermal mobilization from artificial ground heating
- Preparation of summary document and presentation at various public venues

Husky Energy Ltd.

Completion of a Water Security Plan for a 200,000 barrel per day thermal in situ oil sands operation (Sunrise(. Responsibilities included:

- Review of water supply and disposal needs for the duration of the planned project
- Risk and opportunity analysis using multi-criteria analysis to ensure viability of supply and disposal strategies
- Identification of strategies to ensure project viability and project sustainability

Pembina Pipeline Corp.

Provision of expert legal support to review source and cause of industrial chemical contamination at an operating gas plant. Responsibilities included:

- Review of existing site investigations, procedures, and documentation
- Assessment of efficacy of investigations and protocols (field and laboratory)
- Development of conceptual model to explain presence and movement of sulfolane in bedrock deposits
- Review of risk assessment findings and provision of recommendations to close data and information gaps

Imperial Oil Resources

Support for re-licensing of supply wells for oilfield injection using Alberta Environment "Water Conservation and Allocation Guideline for Oilfield Injection" and "Groundwater Evaluation Guideline." Responsibilities included:

- Completion of field-verified surveys
- Review of site geological conditions
- Acquisition and interpretation of aquifer test data
- Assessment of groundwater/surface water interaction
- Determination of long-term sustainable yield using analytical solutions.

Imperial Oil Resources

Hydrogeological lead for a large oil sands mine EIA (Kearl Oil Sands Mine Project). Responsibilities included:

- Analysis and interpretation of water well information and chemical data
- Defining Quaternary stratigraphy
- Temporal water level assessment to determine potential impact to regional groundwater quality and quantity arising from mine development and dewatering
- Support at Joint Panel hearing

Imperial Oil Resources

Design and implementation of dewatering program for large process water ponds. Responsibilities included:

- Review of site geological conditions
- Installation of dewatering wells
- Acquisition and interpretation of aquifer test data
- Design of dewatering system using appropriate theoretical calculations and analytical modelling solution
- Development of dewatering plan and associated performance monitoring

Imperial Oil Resources

Completion of a regional groundwater investigation and development of a regional-scale ground water monitoring network (per EPO 95-07 requirements) in a multi-layer inter-till aquifer system in east-central Alberta. Responsibilities included:

- Assessment and interpretation of Quaternary stratigraphy
- Interpretation of seismic line data and geophysical borehole log analysis
- Regional groundwater flow mapping
- Geochemical facies mapping
- Assessment of regional arsenic concentrations, trends, and potential connection to thermal in situ development activities
- Groundwater age-dating and stable isotope analysis ($\delta^{18}O$, $\delta^{2}H$, $\delta^{34}S$, $\delta^{11}B$ and $\delta^{13}C$: dissolved constituents and gases)
- Preparation of investigation report to address EPO questions (i.e. source and cause of groundwater quality issues)
- Liaison with regulators during investigation and EPO closure process

Imperial Oil Resources

Completion of an environmental liability assessment to determine the cost of decommissioning, abandoning and restoring the area currently occupied by the Norman Wells field. Responsibilities included:

- Completion of a Phase 1 audit of production facilities and supporting infrastructure (i.e. wellheads, pipelines, satellites, batteries and former refinery)
- Design and implementation of a late Fall field program to sample a statistically sufficient number of locations to generate realistic liability costing for field shutdown and closure
- Generation of a summary report
- Assistance with design of liability costing model and summary reporting

Imperial Oil Resources

Development and implementation of a site characterization program at a former refinery and battery (circa 1930s) located approximately 160 km south of the Arctic Circle. Responsibilities included:

- The design and installation of a monitoring network in discontinuous permafrost
- Assistance in development of assessment programs to generate Tier II criteria in support of a human health and ecological risk assessment

Imperial Oil Resources

Cold Lake area monitoring program (Arsenic Investigation – 30 private residents). Responsibilities included:

- Interviews with well-owners
- Assessment of the water delivery system
- Sample collection using ultra-clean sampling methods
- Review of the data
- Communication of results to client, well owner and Alberta Environment

Imperial Oil Resources

Completion of an environmental liability assessment and costing exercise in support of the sale of the Judy Creek field to PenGrowth Corp. to statistically sample a sufficient number of facilities to generate realistic liability cost for property transfer. Responsibilities included:

- Completion of Phase 1 audits of production facilities and supporting infrastructure (i.e. wellheads, pipelines, satellites, and batteries), design and implementation of winter field program to sample facilities to generate realistic liability cost for property transfer

Imperial Oil Resources

Completion of a groundwater modelling study to determine the sustainable yield of a major deep freshwater aquifer in the Cold Lake area. Responsibilities included:

- The provision of hydrogeological support for model conceptualization and design
- Input parameter selection
- Evaluation and communication of results

Imperial Oil Resources

Development and implementation of a regional groundwater quality monitoring network covering an area of 1,200 km^2. Responsibilities included:

- Regular interaction with environmental regulatory agencies and the local landowners
- Installation, testing and sampling of deep (up to 230 m) monitoring wells to assess potential impact to confined aquifers due to production well casing failures
- Design, implementation and interpretation of aquifer tests in support of groundwater remediation programs
- Development of cost-effective approaches towards restoring water quality conditions in deep aquifers influenced by heavy hydrocarbons and associated production fluids

Imperial Oil Resources

Preparation of an AB environment approved Incident Response Plan to deal with groundwater quality issues identified during routine monitoring activities at a large heavy oil recovery scheme. Responsibilities included:

- Design of a cost-effective sampling schedule including rationalization of a 200 well monitoring network to provide a meaningful network of approx. 100 wells
- Development of statistical limits for response and mitigation actions

Japan Canada Oil Sands (JACOS)

Execution of hydrogeological section of an expansion EIA for the Hangingstone Thermal In Situ Oil Sands project. Responsibilities included:

- Development of baseline hydrogeology, EIA sections, and SIR responses
- Liaison with project team and governing agencies
- Stakeholder consultation with First Nations and 3PC

Japan Canada Oil Sands (JACOS)

Completion of a water supply project in support of a heavy oil recovery scheme using Alberta Environment "Water Conservation and Allocation Guideline for Oilfield Injection" and "Groundwater Evaluation Guideline." Responsibilities included:

- Assessment of geophysical logs and EM survey results
- Design and implementation of field programs
- Step test and constant rate test data acquisition and analysis
- Well screen selection and well design
- Well efficiency assessment

- Use of pertinent analytical equations to predict effect of long-term pumping

Petro-Canada

Completion of detailed regional and local baseline studies, and cumulative impact assessment, to establish regional and local hydrogeological and geochemical characteristics in support of a 30,000 bbl/d heavy oil recovery expansion (MacKay River Project). Responsibilities included:

- Defining Quaternary stratigraphy
- Temporal water level assessment to determine potential impact to regional groundwater quality and quantity arising from bitumen recovery operations
- Development of a numerical groundwater model to assess long-term effects of water withdrawal and waste disposal to support project activities
- Completion of climate change assessment formed part of the assessment for project design

Petro-Canada

Conceptualization and design of field program to assess water supply and water disposal for two major heavy oil projects (>30,000 bbl/d). Responsibilities included:

- Selection of drilling locations based on geophysical reconnaissance
- Implementation of field programs
- Step test and constant rate test data acquisition and analysis
- Well efficiency assessment
- Well screen selection and well design
- Use of pertinent analytical equations

Petro-Canada

Review of fresh groundwater use for a water flood project. Responsibilities included interpretation of historical monitoring well data to determine the effects of the groundwater withdrawal from the local aquifer.

Petro-Canada

Assessment of long-term effects of industrial water supply wells used for a water flood scheme. Responsibilities included a review groundwater chemistry and well hydraulic data to determination sustainable production rates.

Petro-Canada

Completion of an environmental operations audit and subsequent industrial landfill delineation to determine the source area of possible groundwater contamination. Responsibilities included completion of a comprehensive intrusive landfill delineation and soil sampling program to determine the extent and volume of landfill contamination.

Petro-Canada

Completion of an industrial landfill delineation project to determine possible sources of groundwater contamination. Responsibilities included completion of a magnetometer survey, follow-up excavation and soil sampling near a decommissioned landfill to determine the presence, extent and volume of residual landfill material.

Procor

Review of operational history of a salt cavern storage facility including an assessment of groundwater quality near the large brine storage ponds and the potential for impact to the Regina Aquifer.

Shell Canada

Development of Groundwater Management Plan and annual monitoring support at Shell's Muskeg River Mine. Responsibilities included:

- Review of site-wide groundwater monitoring network for applicability to EPEA Approval requirements (including gap analysis
- Routine monitoring and reporting per EPEA requirements
- Selection of indicator suites to facilitate routine monitoring, evaluation, and reporting
- Identification of locations with water quality concerns
- Development of approach to statically assessing and responding to data excursions and trends
- Preparation of the GMP for consideration and acceptance by AEP

Shell Canada

Support for Carmon Creek EIA and assessment of brackish water supply potential in support of heavy oil operations in the Peace River area. Responsibilities included:

- Assessment of baseline hydrogeological conditions and potential impacts from project development
- Preparation of climate change assessment for project development
- Support for SIR submissions and EIA team interactions
- Feasibility assessment of potential for deep formations to produce sustained supplies and conceptual well-field development
- Liaison with regulatory agencies
- Development of a DBM level review for a groundwater well-field development

Shell Canada

Development of a regional-scale ground water monitoring network in a multi-layer aquifer system in the Peace River region of Alberta. Responsibilities included:

- Assessment of Quaternary stratigraphy

- Interpretation of seismic line data
- Geophysical borehole log analysis
- Geochemical facies mapping and solution chemistry analysis

Shell Canada

Assistance with the development and construction of an induced infiltration groundwater supply system for the Shell Caroline Gas Plant industrial water supply project. Responsibilities included:

- Drilling and installation of large diameter water production wells
- Borehole geophysical logging and interpretation
- Sand quantification testing and analyses to determine sediment production volumes prior to pipeline construction
- Liaison with client and local landowners

Suncor Energy

Lead subsurface specialist for a multi-criteria decision analysis and life-cycle value analysis in support of a regional brine management strategy in the Athabasca Oil Sands area. Responsibilities included:

- Development of a holistic weighting and ranking approach to address triple-bottom-line assessment of treatment and disposal options for liquid and solid waste streams originating from oil sands mining and in situ assets located across a 30 000 km^2 area
- Facilitation of, and participation in, workshops to assess viable options for treatment and disposal including Class 4 costing
- Development of a constraints mapping approach (vulnerability, risks and opportunities) using ArcGIS to assist in management and disposal options for liquid and solids waste streams

Suncor Energy

Review of existing water supply for Steepbank and Millennium mine operations and development of contingency supply options. Responsibilities included:

- Review of past water resource evaluations
- Development of geophysical investigation program and interpretation of results
- Assessment of contingency water supply (groundwater and operations water)
- Client consultation and liaison with Alberta Environment
- Implementation of horizontal well technology to provide a secure supply of water for continued operations

Union Pacific

Supervision of supply well installation for the Ferrybank water flood scheme and completion of extensive aquifer test to determine the local effects of water withdrawal from the target aquifers.

Various Gas Plants, Batteries and Refineries (AB, SK, BC)

Completion of piezometer network design at numerous operating facilities to assess the potential impact to local groundwater quality resulting from industrial activities and extent of contaminant migration from known source areas (Imperial Oil, Amoco/BP, Shell, Mobil, Canadian Occidental); and, provision of hydrogeological services in support of a gas plant decommissioning (ongoing). Responsibilities include:

- Well installation, testing and sampling
- Involvement in a site-specific risk assessment (ecological and human health)
- Development of sampling protocols
- Assessment of cost-effective remediation techniques to address various contaminant situations in both soil and groundwater

Various Oil and Gas Facilities (AB, SK)

Completion of environmental operations audits and development of waste management plans at numerous oil and gas facilities (Amoco, Petro-Canada, Shell). Responsibilities included:

- Review of historical operations files (spill reports, waste handling procedures, EUB and AENV records)
- Completion of site inspections & historical air photo interpretation

HEARINGS / APPEALS / PANEL EXPERIENCE

McQuiston Gravel Pit, Butte AB (2019-present): Clearwater County re-zoning

Crouch Gravel Pit, Sundre AB (2019-2020): EAB appeal

Phelan Gravel Pit, Fort Assiniboine AB (2016-2019): EAB appeal hearing

BC Scientific Hydraulic Fracturing Review Panel (2018): assessment of water quality issues and presentation to panel members

South McDougall Flats Protection Society (2017): support for re-zoning hearing

Town of Black Diamond (2013): EAB appeal

Town of Okotoks vs. Sandstone Springs Development (2011): EAB appeal

Queensland Government, Dept. of Energy, Resources, and Mine (2010): hydrogeology panel for assessing implication of coal seam gas development

Total Joslyn North Mine – Joint Panel hearing

Imperial Oil Kearl Mine, Athabasca Oil Sands: Joint Panel hearing

Suncor Voyageur, Athabasca Oil Sands: Joint Panel hearing

BlackRock Ventures, Cold Lake: ERCB hearing

Imperial Oil Mahkeses Expansion, Cold Lake: ERCB hearing

EDUCATION

Ph.D. (Geochemistry) – University of Calgary, 2008

M.Sc. (Physical Hydrogeology and Isotope Geochemistry) – University of Calgary, 1994

B.Sc. (Geology: hard rock, sedimentology, mineralogy, structural, geochemical) – University of Saskatchewan, Saskatoon, 1985

REGISTRATIONS / AFFILIATIONS / BOARDS

APEGA (P.Geol. – Alberta)

EGBC (P.Geo. – British Columbia)

APEGS (P.Geo. P.Eng. – Saskatchewan)

NAPEG (P.Geol. – Northwest Territories and Nunavut)

National Ground Water Association (NGWA)

International Association of Hydrogeologists (CNC)

Canadian Water Resources Association (CWRA)

Sustainable Energy Development Program (Univ. of Calgary) – External Advisory Board

Bow River Basin Council (Calgary), Board of Directors (2008-2013), Chair of Monitoring and Modelling committee (2008 to 2012), Member of Legislation and Policy Committee (2006-2011), Member of Integrated Watershed Management Group (2007 to 2010)

SPECIFIC TECHNICAL EXPERTISE / SPECIALIST COURSES

Training Certificates

WHMIS

Petroleum Safety Training

Transportation of Dangerous Goods

ISO 9001:2000 (Management Responsibilities)

Analytical Experience

ICP-MS, GC-MS, Ion chromatography (LC-MS, HPLC, IC)

SEM, XRD (bulk and clays), XRF, EDS and Synchrotron Light (XANES, and EXAFS)

Isotope ratio mass spectrometry (IRMS)

Solid-phase extraction, Alumina fraction, and sequential soil extraction

Toxicity identification evaluation for metals and organics

Selection of appropriate inorganic or organic analytical techniques based on Standard Methods

Statistical analysis (e.g. population testing, trend analysis, control charting, PCA, HCA, spatial analysis)

Multi-criteria analysis (MCA) for decision support

Vulnerability and risk mapping

Climate change analysis (models, tele-connections, impacts to land, water, biodiversity)

Risk assessment (human and ecological)

PUBLICATIONS / PRESENTATIONS

Publications

Fennell J. and Aciszewski T (2019). Current knowledge of seepage from oil sands tailings ponds and its environmental influence in northeastern Alberta. Science of the Total Environment, 686, p. 968-985.

Birks S.J., **Fennell J.W.**, Gibson J.J., Yi. Y., Moncur M.C., and Brewster M. 2019. Using regional datasets of isotope geochemistry to resolve complex groundwater flow and formation connectivity in northeastern Alberta, Canada. Applied Geochemisty, 101 (2019), p. 140-159.

Hatala R., **Fennell J.,** and Gurba G. 2018. Advances in the realm of Hydrogeophysics: The emerging role of Quantum Geoelectrophysics in Aquifer Exploration. Can. Soc. of Expl. Geoph., RECORDER October Focus - Hydrogeophysics: the Past, Present, and Future. Vo. 43, No. 6, p. 32-36.

Birks S.J., Moncur M.C., Gibson J.J., Yi Y., **Fennell J.**, and Taylor E.B. 2018. Origin and hydrogeological setting of saline groundwater discharges to the Athabasca River: Characterization of the hyporheic zone. Applied Geochem., 98, p. 172-190.

Fennell J., 2018. Predictions, perceptions and the precautionary principle: responding to climate change in a realm of uncertainty. Canadian Water Resources Association, Water News, Fall/Winter 2018. Vo. 37, No. 2, p. 6-9.

Fennell J., 2018. Water, Peace, and Global Security: Canada's Place in the World We Want (Sandford and Smakhtin, eds.), Groundwater and Canada's Future – Moving data and information to knowledge and security. Prepared for the United Nations University, Institute for Environment, Water and Health, 17 pp.

Fennell J. 2018. Poison Well: Chasing arsenic in Alberta's groundwater. Water Canada, January/February 2018, p. 20-21.

Fennell J. 2017. Let's make a deal: Canada's vital role in the Columbia River Treaty. Water Canada, September/October 2017. p. 42-43.

Faramarzi M., K. Abbaspour, V. Adamowicz, W. Lu, **J. Fennell**, A. Zehnder and G. Goss 2017. Uncertainty based assessment of dynamic freshwater scarcity in semi-arid watershed of Alberta, Canada. *Journal of Hydrology: Regional Studies*, 9, p. 48-68.

Fennell J. 2015. Disposal in the unconventional oil and gas sector: Challenges and solutions. American Assoc. of Petroleum Geologists, *Environmental Geosciences*, Vol. 22, No. 04, December 2015, p. 127-138.

Fennell J. and O. Keilbasinki 2014. Water, food, and our climate: Is California a harbinger of things to come? *WaterCanada*, July/August 2015, p. 24-25.

Fennell J. and O. Keilbasinki 2014. Water without Borders: What is Canada's role in water security? *WaterCanada*, November/December 2014, p. 50-51.

Gibson J.J., **J. Fennell**, S.J. Birks, Y. Yi, M. Moncur, B. Hansen and S. Jasechko 2013. Evidence of discharging saline formation water to the Athabasca River in the northern Athabasca oil sands region. *Canadian Journal of Earth Sciences*, 50, p. 1244 - 1257.

M.S. Ross, A.S. Santos Pereira, **J. Fennell**, M. Davies, J. Johnson, L. Sliva, and J.W. Martin 2012. Quantitative and Qualitative Analysis of Naphthenic Acids in Natural Waters Surrounding the Canadian Oil Sands Industry. *Environmental Science and Technology*, 46, p. 12796 – 12805.

Fennell J. 2011. Total Water Management – a new and necessary paradigm. Environmental Science and Engineering Magazine, May/June edition.

Fennell J., Klebek M. and Forrest F. 2011. An approach to managing cumulative effects to groundwater resources in the Alberta Oil Sands. World Heavy Oil Congress proceedings, March 2011.

Fennell J. 2010. Protecting water supplies in CSG development. *Water Engineering Australia*, Vo. 4, No. 6, September 2010.

Fennell J. 2008. Effects of Aquifer Heating on Groundwater Chemistry with a Review of Arsenic and its Mobility. Ph.D. thesis, Department of Geoscience, University of Calgary.

Fennell J. Zawazki A. and Cadman C. 2006. Influence of natural vs. anthropogenic stresses on water resource sustainability: a case study. *Water Science and Technology*. Volume 53, No. 10, p 21-27.

William L.B., M.E. Wieser, **J. Fennell**, I. Hutcheon, and R.L. Hervig 2001. Application of boron isotopes to the understanding of fluid-rock interactions in a hydrothermally stimulated oil reservoir in the Alberta Basin, Canada. *Geofluids*, Vol. 1, p. 229-240.

Kellett R., **J. Fennell**, A. Glatiotis, W. MacLeod, and C. Watson 1999. An Integrated Approach to Site Investigations in Permafrost Regions: Geophysics, Soils, Groundwater, and Geographical In-formation Systems. ARCSACC Conference, Edmonton '99.

Gilson E.W., R. Kellett, **J. Fennell**, P. Bauman, and C. Sikstrom 1998. High Resolution Reflection Seismic and Resistivity Imaging of Deep Regional Aquifers for Stratigraphic Mapping. CSEG Conference.

Fennell J. and Bentley L. 1997. Distribution of Sulphate and Organic Carbon in a Prairie Till Setting: Natural versus Industrial Sources. *Water Resources Research*, Vol. 34, No. 7, p. 1781-1794.

Fennell J. and Sevigny J. 1997. Effects of Acid Conditions on Element Distribution Beneath a Sulphur Base Pad (Acid Mobilization Study). Publication submitted to the Canadian Association of Petroleum Producers (CAPP).

Fennell J. 1994. Source and Distribution of Sulphate and Associated Organics at a Sour Gas Plant in Southern Alberta. M.Sc. thesis, Department of Geology and Geophysics, University of Calgary.

Hayes B., J. Christopher, L. Rosenthal, G. Los, B. McKercher, D. Minken, Y. Tremblay, and **J. Fennell** 1994. *Atlas of the Western Canadian Sedimentary Basin – Chapter 19: Cretaceous Manville Group*. Canadian Society of Petroleum Geologists and Alberta Research Council, ISBN 0-920230-53-9.

Presentations / Lectures

COSIA Oil Sands Innovation Summit, June 2019 Calgary AB: Fact or fiction – the truth regarding tailings pond seepage in Canada's oil sands (response to a Free Trade Agreement Challenge)

CWRA Alberta Branch conference, April 2019 Red Deer: Flooding, climate change, and the need for a precautionary approach.

University of Calgary, Sustainable Energy Development Program. February 2019, Decision support processes and tools in sustainable energy development projects.

Mine Water Solutions, June 2018. Total Water Management: Canada's contribution to sustainable mine development.

Canadian Water Resources Association, April 2018, Red Deer, AB. Arsenic and Alberta's Groundwater: the where and why.

Southern Alberta Institute of Technology (water Initiative), February 2018, Calgary AB. Risky business: understanding Alberta water security

Canadian Society of Unconventional Resources (CSUR), January 2018, Calgary AB. Managing through nature's extremes: ensuring water security for successful UCOG operations.

SEAWA, Nov 2017, Medicine Hat AB. Hydrology of riparian areas: the need for protection and preservation.

CWRA National Conference, June 2017, Lethbridge AB. Climate change, the Columbia River Treaty, and considerations for a successful re-negotiation.

Thermal mobilizations and the regulatory response, May 2017, Calgary AB. CHOA forum.

National Ground Water Association, March 2017, Denver CO. Advances in the realm of hydrogeophysics: the role of Quantum Geoelectrophysics in groundwater exploration

Haskayne School of Business IRIS series, Feb 2017. Following the molecules: the importance of water to Canada's future.

BRBC-CEAC, Feb 2017, Cochrane AB, GW-SW interaction and the implication for development in riparian lands.

Watertech, April 2017, Banff AB. Arsenic in Alberta's Groundwater: the where and why; Isotopes and Geochemistry:

National Ground Water Association, Hydrogeophysics for deep groundwater exploration, March 2017, Denver CO. Advances in the realm of Hydrogeophysics: the role of Quantum Geoelectrophysics in Groundwater Exploration

Haskayne School of Business CPC IRIS seminar series, February 2017, Calgary AB. Following the molecules: the importance of water in Canada's future.

Bow River Basin Council/Cochrane Environmental Action Committee Collaborating for Healthy Riparian Lands Engagement Workshop, February 2017, Cochrane AB. Groundwater-Surface water interaction and the implications of human development in riparian lands.

Watertech, April 2016, Banff AB. Predicting Alberta's Groundwater Future & An Integrated Approach to Resolving Complex Hydrogeological Settings.

Canadian Water Resources Association (CWRA), April 2016, Edmonton AB. Natural discharge and its role in Athabasca River water quality.

Canada's Oil Sands Innovation Alliance (COSIA) Water Forum, March 2016, Calgary AB. Natural discharge and its role in Athabasca River water quality.

Canadian Association of Petroleum Geologists (CSPG), March 2016, Calgary AB. Climate, water availability, and the success of Western Canada's Energy Development & Natural discharge and its role in Athabasca River water quality.

Underground Injection Control (GWPC), February 2016, Denver CO. Disposal in the unconventional oil and gas sector: challenges and solutions.

AGAT Environmental Series, Jan/Feb 2016. Calgary and Edmonton, AB. Climate, water availability and the success of Western Canada's energy industry.

International Water Conference, November 2015, Orlando FL. Disposal in the unconventional oil and gas sector: challenges and solutions.

Chemistry Industry Association of Canada, October 2015, Edmonton AB. Water Sustainability: and its importance to successful industry.

EnviroAnalysis, July 2015, Banff AB. Thermal mobilization and Arsenic: implication for the oil sands.

WaterTech, April 2015, Kananaskis AB. Smart Monitoring to address challenges of Unconventional Gas development and an approach to mapping risk related to thermal mobilization of constituents.

Canadian Water Resources Association, April 2015, Red Deer AB. Water, Energy and Canada's Future (keynote address)

Underground Injection Council, February 2015, Austin TX. Monitoring to address challenges of Unconventional Gas development (invited speaker)

National Ground Water Association, Groundwater monitoring for Shale Gas developments workshop, November 2014, Pittsburgh PA. Smart monitoring to address the challenges of Unconventional Gas Development (invited speaker)

Canadian Water Resources Association, June 2014, Hamilton ON. Water disposal in the Oil Sands: challenges and solutions and What is Water Security and Why is it Important.

Water Management in Mining, May 2014, Vancouver BC. Total Water Management: a necessary paradigm for sustainable mining.

CSPG GeoConvention May 2014, Calgary AB. Water disposal in the Oil Sands: challenges and solutions; Placing the risk of thermal mobilization into perspective; What is Water Security and Why is it Important?

WaterTech, April 2014, Banff AB. Water disposal in the Oil Sands: challenges and solutions and Placing the risk of thermal mobilization into perspective.

Canada's Oil Sand Innovation Alliance (COSIA), March 2014, Edmonton AB. Water disposal in the Oil Sands: challenges and solutions and Placing the risk of thermal mobilization into perspective.

International Assoc. of Hydrogeologists, GeoMontreal 2013, October 2013, Montreal QC. The role of subsurface heating in trace element mobility.

Oil Sands Heavy Oil Technology 2013, July 2013, Calgary AB. The role of subsurface heating in trace element mobility.

Watertech, April 2013, Banff AB. The role of subsurface heating in trace element mobility.

International Assoc. of Hydrogeologists World Congress 2012, September 2012, Niagara ON. Session Chair for Hydrogeological Issues in the Oil Sands and presenter: i) Oil Sands overview – economic and environmental setting; ii) Framing groundwater vulnerability in the oil sands: an approach to identify and discern; and iii) Climate: a driving force affecting water security in the oil sands

Water in Mining 2012, June 2012, Santiago Chile. Total Water Management: a necessary paradigm for sustainability.

BCWWA 2012 Annual Conference, April 2012, Penticton BC. The role of inventory, dynamics, and risk analysis in water management: a case study.

WaterTech, April 2012, Banff AB. Plenary Session. Bringing context to the oil sands debate: understanding the role of nature and its environmental effects.

BCWWA Hydraulic Fracturing Workshop, Fort St. John BC, March 2012. Keynote address: Striking a Balance – water resource management versus economic development (keynote address).

CONRAD 2012, March 2011, Edmonton AB. Bringing context to the oil sands debate: understanding the role of nature and its environmental effects.

Alberta Irrigation Projects Assoc., November 2011, Lethbridge AB. Managing what we have: a review of Alberta's water sources, volumes and trends (invited speaker).

Alberta Innovates Technology Talks, November 2011, Calgary AB. Dynamics of Alberta's Water Supply: a review of supplies, trends and risks.

Red Deer River Watershed Alliance Annual General Meeting, October 2011, Red Deer AB. Water in the Red Deer: volumes, patterns, trends and threats.

Land and Water Summit, October 2011, Calgary AB. Total Water Management: a necessary paradigm for water security.

CEMA Groundwater Working Group, June 2011, Fort McMurray AB. Groundwater in the oil sands: facts, concepts and management processes.

CWRA Alberta / Alberta Low Impact Development Annual Conference, April 2011, Red Deer AB. A Review of Alberta's Water Supply and trends.

WaterTech, April 2011, Banff AB. Managing what we have: a review of Alberta's water supply.

World Heavy Oil Congress 2011, March 2011, Edmonton, AB. An approach to managing cumulative effects to groundwater resources in the Alberta Oil Sands.

Engineers Australia, August 2010, Brisbane Qld. CSG development in Australia: an approach to assessing cumulative effects on groundwater (invited speaker).

Joint IAH/AIG meeting, July 2010, Melbourne Vic. Assessing the effects of coal seam gas development on water resources of the Great Artesian Basin (invited speaker).

18th Queensland Water Symposium, June 2010, Brisbane Qld. A cumulative effects approach to assessing effects from coal seam gas development on groundwater resources (invited speaker).

WaterTech, April 2010, Lake Louise AB. Regional Groundwater Monitoring Network Implementation: Northern Athabasca Oil Sands Region.

University of Calgary, December 2009, Calgary AB. What's happening to our water? A review of issues and dynamics.

CSPG Gussow Conference, October 2009, Canmore AB. Water sustainability in the Alberta Oil Sands: managing what we have (invited speaker).

Bow River Basin Council, Legislation and Policy Committee Groundwater Licensing Workshop, March 2009, Calgary AB. Groundwater: the hidden resource

BlueWater Sustainability Initiative, January 2009, Sarnia ON. Planning approaches and forensic tools for large-scale regional monitoring initiatives.

CWRA Technical luncheon session, October 2008, Calgary, AB. Water sustainability in a growing Alberta.

Bow River Basin Council, September 2008, Calgary AB. Basin Monitoring and Management Approaches.

IAH/CGS GeoEdmonton08, Edmonton AB. Coordinator and Chair of Groundwater Development Session.

North American Lake Management Society (NALMS) 2008, Lake Louise AB, Coordinator and Chair of Climate Change Effects to Lakes, Reservoirs and Watersheds section.

EcoNomics™ Luncheon, May 2008, Calgary AB. Water Sustainability in the Hydrocarbon Industry.

WaterTech, April 2008, Lake Louise AB. Effects of climate and land cover changes on basin water balances.

CWRA Annual Conference, April 2008, Calgary AB. Role of climate change and land cover on water supply sustainability.

Bow River Basin Council, March 2007, Calgary AB. Forest Hydrology and the effects of Climate Change.

ALMS/CWRA, October 2006, Lethbridge AB. Reservoir Maintenance Workshop. Climate tele-connections and their effects on basin water supplies

Bow River Basin Council, June 2006, Calgary AB. Groundwater sustainability: the invisible resource (Climate change and basin sustainability)

Engineering Institute of Canada, May 2006, Ottawa ON. CCC2006 Land use and climate change effects at the basin scale.

International Water Association, Watershed and River Basin Management Specialists Group Conference, Calgary, AB, 2005. Basin Water Management Strategies.

Burgess Shale Geoscience Foundation, August 2004 and 2005, Field BC. Water in a Changing Climate: understanding and adapting.

C-CAIRNS, October 2005, Victoria BC, Climate and Fisheries Impacts, Uncertainty and Responses of Ecosystems and Communities, Effects of Climate and the PDO on Hydrology of a Major Alberta Watershed.

North American Lake Management Society, November 2004, Victoria BC. Climate Change and Effects on Water Resources.

Canadian Institute Conference, June 2004, Calgary AB. Water Management Strategies for the Oil and Gas Industry: The challenge and approach

Canadian Society of Petroleum Geologists, Gussow Conference, March 2004, Canmore AB. Understanding the Effects of Natural and Anthropogenic Forcings on Basin Water Resources.

Alberta Environment and EUB, April 2003, Elk Point AB. Climate and Land Use Change Effects on Basin Water Resources in the Lakeland Region - East-central Alberta.

Joint CGS/IAH Conference, June 2001, Calgary AB. A Multidisciplinary Approach to Resolving Complex Hydrogeologic Systems.

Aquatic Toxicity Workshop, October 1996, Calgary AB. Use of site characterization and contaminant situation ranking to focus a risk assessment evaluation at a decommissioned sour gas plant and associated landfill.

Joint GAC/MAC Conference, April 1995, Waterloo ON. Use of geochemical modelling and stable isotopes to determine the source of groundwater quality impacts near a sour gas processing facility.

Joint GAC/MAC Conference, Edmonton AB, 1994. Assessment of depression-focused recharge as a mechanism for variable groundwater and soil chemistry.

GasRep Conference, Calgary AB, 1994. Use of stable isotopes to determine the source of water quality impacts near a sour gas processing facility.

Environmental Flow Recommendation Approach for Blairmore and Gold Creeks, Alberta

Prepared for:

The Coalition of the Alberta Wilderness Association and the Grassy Mountain Group

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Table of Contents

Executive Summary

This report is a technical review of the scientific and technical data, assumptions, and methods used by the Proponent in their instream flow assessment to evaluate the potential for flow-related effects on the species of interest, westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) in Blairmore and Gold Creeks, Alberta. Recommendations for further analysis are presented.

Understanding how aquatic ecosystems function, let alone how modeling the various components will respond to natural or anthropogenic inputs, and then managing them for intended outcomes necessarily incurs relatively high degrees of uncertainty. The level of effort conducted by the Proponent adequately addresses much of the inherent uncertainty in the field of Environmental Flows. This report presents a strategy to use the Proponent's flow and habitat data to carry out further analysis to specifically address low flow conditions, the subsistence flow period, where it is known there are limiting habitat conditions, even under natural flow regimes. A recommended instream flow regime should not result in an increase in the frequency, duration, or magnitude of naturally limiting habitat conditions.

Based on the review of the Proponent's report, it is recommended that additional assessment be carried out using the existing data. Recommendations for further analysis include:

- in addition to micro-habitat data, include meso-habitat data to develop a percent of flow reduction criterion,
- develop several metrics and thresholds to assess effects of changes in flow for chronic (long-term) impacts, intermediate (medium-term) impacts, and acute (short-term) impacts, and
- develop an ecosystem baseflow criterion that will be included in the environmental flow recommendation for Blairmore and Gold Creeks using both micro- and meso-habitat data.

Public involvement and support are critical elements of environmental flow studies. The public has a vested interest in natural resources management because they are the ones for whom natural resources are held in trust. The public has a legitimate right and responsibility to be involved in the water management decision-making process. It is further recommended that all discussions for developing a fully protective environmental flow regime for Blairmore and Gold Creeks includes: the Proponent, the provincial and federal regulators, the Coalition, and any other interested party.

1.0 Introduction

Benga Mining Ltd. (the Proponent) is proposing to develop the Grassy Mountain Coal Project in southwestern Alberta. The Project triggers a federal Canadian Environmental Assessment under the *Canadian Environmental Assessment Act* (2012) and a provincial Alberta Environmental Impact Assessment under the *Environmental Protection and Enhancement Act* (2014). In order to comply with the legislation, and in recognition the project may affect streamflow in Blairmore and Gold Creeks, the Proponent conducted an instream flow assessment to evaluate the potential for flow-related effects on westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) and their habitat (Hatfield Consultants 2017a).

On behalf of the Coalition of the Alberta Wilderness Association and the Grassy Mountain Group (the Coalition), the Proponent's instream flow assessment report, "*Appendix A3 - Instream Flow Assessment: Grassy Mountain Coal Project"* (Hatfield Consultants 2017a) was reviewed. It was determined the report describes in sufficient detail the hydrology and biology component methods. It was also noted that water quality is addressed separately in other reports including one prepared by SRK Consulting (2016). Similarly, geomorphology is addressed in another report prepared by SNC-Lavalin (2016). From the geomorphology report it was noted, *"We therefore conclude that the physical habitat within Blairmore and Gold creeks are not anticipated to change due to water management throughout the mine life (construction, operations, reclamation, closure phases)"* (See page 41 in SNC-Lavalin 2016). Connectivity is not addressed in context of environmental flows in the report. Discussions about connectivity and habitat enhancement to offset changes in flows are discussed in the *Grassy Mountain Coal Project: Preliminary Habitat Offsetting Plan* report prepared by Hatfield Consultants (2017b).

For the hydrology and biology components, the Instream Flow Assessment report:

- described the existing and available information that was used to address geographical and temporal coverage,
- described the use of data and models, and
- suggested steps forward following the completion and acceptance of the report.

The work undertaken as outlined in the Proponent's Instream Flow Assessment report (Hatfield Consultants 2017a) is essential to understand complex aquatic ecological systems and to manage uncertainty. Overall, the level of effort conducted for this study adequately addresses much of the inherent uncertainty in the field of Environmental Flows (EF), also known as instream flow needs, instream flow assessments, or instream flows. The report appropriately acknowledges the uncertainty typical for these types of studies.

As with all environmental flow studies it is widely recognized there is no one universally accepted method to use the fish habitat versus flow information for either making a flow recommendation or evaluating alternative flow scenarios. However, it is generally accepted that low flows, or subsistence flow periods, create potentially limiting habitat conditions, even under natural flow regimes. Based on this premise, it is reasonable a recommended instream flow regime should not result in an increase in the frequency, duration, or magnitude of naturally limiting habitat conditions. The purpose of this report is to present a strategy for a recommended environmental flow regime for both Blairmore and Gold Creeks, that builds upon the work of the Proponent using a percent of flow reduction component, and an ecosystem baseflow component.

2.0 Environmental Flow Recommendation Approach

2.1 Background

Much has been written about the biology and status of westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) in Alberta and impacts to fish and fish habitat in east slope streams (Costello 2006, DFO 2013a, The Alberta Westslope Cutthroat Recovery Team 2013, Benson 2019, Fitch 2020). In Alberta all populations of westslope cutthroat trout are listed as "*Threatened*" (Government of Canada 2020) under the *Species at Risk Act* (Government of Canada 2002). Specifically, the importance of the Blairmore and Gold Creek watersheds to westslope cutthroat trout is also well documented with Gold Creek being the last major tributary of the Crowsnest River that still contains pure-strain westslope cutthroat trout (Alberta Environment and Parks 2020). Through their work the Proponent fully recognizes the status of westslope cutthroat trout in general and specifically in Blairmore and Gold Creeks as is described throughout their instream flow assessment report (Hatfield Consultants 2017a). The Coalition also understands the status of westslope cutthroat trout and believes it is necessary to provide the best protection possible for Blairmore and Gold Creeks. It is therefore recommended that a fully protective environmental flow recommendation should be made for Blairmore and Gold Creeks.

2.2 Percent Flow Reduction Component

The Proponent has stated the *"…Project-related flow changes will cause changes of less than 10% in habitat area (AWS) relative to long-term baseline conditions in all study reaches and all stanzas for WSCT rearing, spawning, fry or overwintering, when averaged across each Project phase."* (See page xii in Hatfield Consultants 2017a). This "average" loss of habitat is suitable as one indicator, but is not sensitive to maximum changes in habitat for within month or within weekly time frames. The habitat gains at one time mask out the habitat losses at other times when only considering average conditions over long periods of time. It is recommended using more metrics to determine the habitat losses and gains. Examples of metrics that can be considered are: maximum weekly average, weekly instantaneous, etc. Given there are unlimited metrics that can be applied, it is recommended that through discussion with the Proponent, the provincial and federal regulators, the Coalition, and any other interested party, a small set of metrics be developed that are relevant to Blairmore and Gold Creeks.

Given the hydrology data is limited to monthly flows, it is recommended the Proponent explore all opportunities to see if hydrology can be generated for a weekly time step to capture significant changes in flow. This is particularly relevant during the rise and fall of the spring freshet.

It is not clear what is meant by, *"Due to the complex hydrological dynamics and predicted flow reductions in Gold Creek as well as the notable predicted flow increases in Blairmore Creek, multiple macro-reaches within both watercourses were assessed below the 10% threshold."* (See page 62 in Hatfield Consultants 2017a) Does this mean there are times when the project flows will be less than 10% of natural flows? Specifically, it is also not clear what is meant by "*…complex hydrological dynamics…*" Presenting flow data in monthly duration curves and tables would be helpful to understand how the project flows compare to the natural flows.

2.3 Ecosystem Baseflow Component

It is well known that low-flow periods create bottlenecks with respect to aquatic ecosystem production. Low flows during late summer may limit available fish-rearing habitat and low flows in the fall may limit spawning habitat. Perhaps most important for east slope streams in Alberta, low flows during winter limit over-wintering habitat for the free-swimming life stages of fish and may limit suitable conditions for incubation of eggs. During these low-flow events space becomes limited for aquatic organisms and the further reduction in habitat through the taking of water exacerbates an already critical condition.

A constant percent-flow reduction factor will not protect the aquatic ecosystem during periods of very low flows. For example, when flows are naturally below a critical threshold, continued withdrawal of water will result in an increased magnitude and duration of flows that are below the threshold. Given the stress on the aquatic system is greatest during low flows, a percent-of-flow factor by itself does not provide for adequate protection of the aquatic ecosystem.

Ecosystem base flows (EBF), also known as: subsistence flows, base flows, passby flows or low-flow cut-offs, are designed to protect the aquatic ecosystem during critically low-flow conditions. The EBF represents a flow at which further human-induced reductions in flow would result in unacceptable levels of risk to the health of the aquatic resources. A definition for a subsistence flow put forward by the National Academy of Sciences is,

> *Subsistence flow is the minimum stream flow needed during critical drought periods to maintain tolerable water quality conditions and to provide minimal aquatic habitat space for survival of aquatic organisms"* (See page 33 in National Research Council 2005).

The Proponent uses a 10% flow threshold as a significance screening based on recommendations from recent publications, notably Richter et al. (2012) and DFO (2013b). These are excellent papers and are two of many publications on desktop environmental flow standards. It is noted that three of the four case studies reviewed by Richter et al. (2012) had cut-off flows for protection of a variety of ecosystem health components including water quality. However, Richter et al. (2012) provide no explanation as to why their placeholder recommendation, or "presumptive standard" did not include a cut-off flow.

The Department of Fisheries and Oceans Canada (DFO) *Framework for Assessing the Ecological Flow Requirements to Support Fisheries in Canada* provides two criteria:

- *Cumulative flow alterations <10% in amplitude of the actual (instantaneous) flow in the river relative to a "natural flow regime" have a low probability of detectable impacts to ecosystems that support commercial, recreational or Aboriginal fisheries. Such projects can be assessed with "desktop" methodologies.*

- *Cumulative flow alterations that result in instantaneous flows < 30% of the mean annual discharge (MAD) have a heightened risk of impacts to fisheries.* (See page 2 in DFO 2013b)

The Proponent did not provide any information on whether project flows exceeded the 30% of the mean annual discharge criterion. It should also be noted in their *Framework for Assessing the Ecological Flow Requirements to Support Fisheries in Canada,* Fisheries and Oceans Canada states:

> *A floor value or 'cut-off limit' should be part of the overall prescription to conserve and protect fisheries, and should not simply be considered during low flow events. Some jurisdictions in Canada currently have established methodologies to specify this 'cut-off limit'. In general, the development of such policy guidance is encouraged (refer to Linnansaari et al. 2013 for further information on various Canadian jurisdictions).* (See page 3 in DFO 2013b)

The concept of comparing or correlating the results of detailed environmental flow studies with desktop methods is a generally accepted practice in the instream flow community. Given there are a multitude of desktop methods available, and given the long history in Alberta of making environmental flow recommendations that have both a percent of flow reduction criterion and an ecosystem baseflow criterion, valuable information would be provided if the results of the Proponent's detailed instream flow assessment were compared to the desk-top guideline that was used in Alberta up until the end of 2018 (Locke and Paul 2011), and more importantly, it would be very valuable for the detailed study results to be compared to the current Alberta Ministry of Environment and Park environmental flow desk-top guideline, the "Surface Water Allocation Directive" (Alberta Environment and Parks 2019).

Given the amount of global knowledge on environmental flows and the precedent in Alberta of making environmental flow recommendations using both a percent of flow reduction factor and an ecosystem base flow component, it is recommended that in addition to developing a percent of natural flow component, an ecosystem base flow component must be developed, and both components be used to set an environmental flow recommendation for both Blairmore and Gold Creeks. Determining the EBF can be done using the Proponent's information, the subsequent information that will be generated as discussed in Sections 2.2, 2.4 and 2.5, and any other new information that may be available subsequent to the completion of the Proponent's report. As also discussed above in Section 2.2, selecting an EBF should be carried out through discussion with the Proponent, the provincial and federal regulators, the Coalition, and any other interested party.

2.4 Overwintering Habitat

It is well known that overwintering habitat, in particular deep pool habitat in east slopes streams is naturally limiting to fish populations. Deep pools have been widely described as a critical habitat feature required by stream-dwelling fish, including westslope cutthroat trout in east slope streams in winter (Brown and Mackay 1995, DFO 2013a, The Alberta Westslope Cutthroat Recovery Team 2013, Benson 2019, Fitch 2020). It is also known that flow affects ice processes in a myriad of ways and therefore any changes to flow will alter these ice processes and therefore the availability of habitat (Brown et al. 2011). It has been stated that water withdrawal and its direct influence on reducing available habitat probably impacts stream fish populations more than any other winter alteration of streams (Cunjak 1996). Limiting habitat conditions in winter is acknowledged and discussed by the Proponent. They state, "…*suitable quality overwintering habitat in Blairmore Creek is also a potential limiting feature for WSCT*…" and "…*WSCT appear to utilize deep pool habitat associated with slower water velocities, where multiple size classes congregated in large numbers*" (See page 36 in Hatfield Consultants 2017a).

Given the recognized importance of maintaining overwintering habitat, a known biological pinch point for westslope cutthroat trout, it is recommended that more analysis be carried out to better understand the changes to habitat during the winter months. This work would build upon the use of the single average habitat metric that has been carried out by the Proponent. The first step would be to re-visit the WSCT Overwintering Habitat Suitability Criteria Curves. Recent work, which highlights the correlation between large westslope cutthroat trout abundance and pool maximum depth in winter (Benson 2019), can help inform if there is a need to update the overwintering HSC curves used by the Proponent that are based on the work done by Golder Associates in 2011 (Hatfield Consultants 2017a). The second step would be to develop a set of habitat evaluation metrics to first, evaluate the project flows in relation to the natural flows and then develop an environmental flow recommendation.

It is also well known there is uncertainty in modeling habitat in winter due to: 1) the 1D-hydraulic model does not explicitly account for ice cover, and, 2) it is a significant challenge to obtain individual life stage HSC data during winter, and in particular during ice formation, ice cover, and ice breakup periods. This is acknowledged by the Proponent. It is therefore recommended to use meso-habitat HSC curves in addition to micro-habitat HSC curves, and to apply a robust set of habitat evaluation metrics to understand impacts to habitat during the winter, and specifically during the periods of ice cover.

As with all steps in setting environmental flows, it is recommended the evaluation of the winter HSC curves and the setting of habitat evaluation metrics be carried out through discussion with the Proponent, the provincial and federal regulators, the Coalition, and any other interested party.

2.5 Mesohabitat Analysis

In addition to using life stage HSC curves to develop an environmental flow recommendation, it is recommended that meso-habitat suitability criteria curves be developed to augment the analysis. The limitations of using single life stage habitat criteria in habitat hydraulic modeling is well known and a practical means of reducing this uncertainty is to carry out similar time series analysis using meso-habitat curves. The Proponent has thoroughly described meso-habitat, e.g., step-pool, pool, riffle, etc. and this information can be used in the same way as the life stage HSC data to help determine a percent of flow reduction component and ecosystem baseflow component recommendation. The development of meso-habitat curves would draw from the extensive information provided by the Proponent and finalized through discussions with the Proponent, the provincial and federal regulators, the Coalition, and any other interested party.

3.0 Monitoring

It is a generally accepted fact that an instream flow agreement developed by the most skilled personnel using the best available science cannot guarantee a particular outcome. How flow regimes influence the overall structure of aquatic and riparian ecosystems is for the most part, largely unknown (National Research Council 2005). Monitoring programs are very valuable in addressing this uncertainty by assessing the ecological response to a new flow regime. Monitoring is a necessary step in any instream flow program.

Since the link between flow and fish is not known, most jurisdictions use a surrogate—flow versus fish habitat relationship. The flow versus fish habitat concept assumes there is a linear correlation between amount of flow and the biomass of organisms (usually fish). Most scientists would argue that this correlation may be non-linear, or even a complex relationship that includes alternative states. Therefore, even if it is possible to determine changes in slope, or inflection points on flow versus fish habitat curves, it may not show potential thresholds in the relationship between the sustainability of fish populations and the amount of habitat they require (Locke et al. 2008)

The Proponent has clearly acknowledged the limitations of environmental flow assessments and recommends monitoring be conducted. It is agreed that these uncertainties should be addressed through a robust monitoring program.

4.0 Summary

Understanding how aquatic ecosystems function, let alone how modeling the various components will respond to natural or anthropogenic inputs, and then managing them for intended outcomes necessarily incurs relatively high degrees of uncertainty. The Proponent's Instream Flow Assessment report (Hatfield Consultants 2017a) is essential to understand the ecological systems of Blairmore and Gold Creeks and to manage uncertainty in context of flows and fish habitat. The level of effort conducted for this study adequately addresses much of the inherent uncertainty in the field of Environmental Flows. On top of the recognized uncertainty, it must also be acknowledged there are still unknowns about westslope cutthroat trout in the Blairmore and Gold Creek watersheds. It is therefore essential to set fully protective environmental flow recommendations. This report has presented a strategy to use the existing flow and habitat data provided by the Proponent, and recommendations for using additional habitat information to carry out further analysis for developing a percent of flow reduction criterion, and to develop an ecosystem baseflow criterion to make an environmental flow recommendation for Blairmore and Gold Creeks.

The physical flow habitat modeling recommendations outlined in this report are one of the riverine components that must be addressed. Since rivers are described more completely when all riverine components (hydrology, geomorphology, biology, water quality, and connectivity) are addressed, these components, and their interactions with each other, ultimately determine the character of rivers and all must be considered in the management of riverine ecosystems and evaluating environmental flows. Water quality and connectivity must also be considered when making a flow recommendation.

Key to making any environmental flow recommendation, is the inclusion of all interested parties who will be affected by the recommendation, or have a direct interest in the recommendation. Public involvement and support are critical elements of environmental flow studies. The public has a vested interest in natural resources management because they are the ones for whom natural resources are held in trust. As a result, the public has a legitimate right and responsibility to be involved in the decision-making process.

It is recommended that all discussions on the path forward for developing a fully protective environmental flow regime for Blairmore and Gold Creeks include the Proponent, the provincial and federal regulators, the Coalition, and any other interested party.

5.0 Closure

The environmental flow recommendations presented in this report were prepared for the exclusive use of the Coalition of the Alberta Wilderness Association and the Grassy Mountain Group. Any use which a third party makes of this report or any reliance on, or decisions to be based on this report, are the responsibility of such third parties. 547426 Alberta Corp. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

6.0 References

Alberta Environment and Parks. 2019. Surface Water Allocation Directive. Edmonton, AB. ISBN 978-1-4601-4333-9. 26 pp.

Alberta Environment and Parks. 2020. Westslope Cutthroat Trout - Crowsnest River Genetic Mapping. HUC 8: 04010102. Prepared by Alberta Environment and Parks, South Region, June, 2020.

Benson, J. 2019. Ecology of Westslope Cutthroat Trout (*Oncorhynchus clarki lewisi*) Populations in Three Small Rocky Mountain Headwater Streams. Master of Science Thesis. Department of Biological Sciences, University of Lethbridge, Lethbridge, Alberta. 174 pp.

Brown, R., Hubert, W. and S. Daly. 2011. A Primer on Winter, Ice, and Fish: What Fisheries Biologists Should Know about Winter Ice Processes and Stream-Dwelling Fish, Fisheries, 36:1, 8-26.

Costello, A. 2006. Status of the Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) in Alberta. Prepared for: Alberta Sustainable Resource Development and Alberta Conservation Association. Alberta Wildlife Status Report No. 61. Publication No. T/113. ISBN: 0-7785-4811-2. 34 pp.

Cunjak, R. 1996. Winter habitat of selected stream fishes and potential impacts from land-use activity. Can. J. Fish. Aquat. Sci. 53(Suppl. 1): 267–282.

DFO. 2013a. Recovery Strategy for the Alberta populations of Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) in Canada [Proposed]. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. iv + 28 pp + Appendices

DFO. 2013b. Framework for Assessing the Ecological Flow Requirements to Support Fisheries in Canada. Fisheries and Oceans Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2013/017.

Fitch, L. 2020. Grassy Mountain Coal Mine Review, with particular reference to possible impacts on “Threatened” Westslope cutthroat trout. Prepared for: The Coalition of the Alberta Wilderness Association and the Grassy Mountain Group. 37 pp.

Government of Canada. 2002. Species at Risk Act. S.C. 2002, c. 29. Current to August 28, 2019. 106 pp.

Government of Canada. 2012. Canadian Environmental Assessment Act. S.C. 2012, c. 19, s. 52. Current to March 28, 2016. 70 pp.

Government of Canada. 2020. Species at Risk Public Registry, accessed August 2020. https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html Date of Listing for westslope cutthroat trout: March 7, 2013.

Hatfield Consultants. 2017a. Appendix A3 – Instream Flow Assessment: Grassy Mountain Coal Project. Prepared for Benga Mining Ltd. 105 pp + Appendices.

Hatfield Consultants. 2017b. Appendix A4 – Grassy Mountain Coal Project: Preliminary Habitat Offsetting Plan. Prepared for Benga Mining Ltd. 38 pp.

Locke, A. and A. Paul. 2011. A Desk-top Method for Establishing Environmental Flows in Alberta Rivers and Streams. Alberta Environment, Edmonton, AB. ISBN: 978-0-7785-9978-4. 94 pp.

Locke, A., C. Stalnaker, S. Zellmer, K. Williams, H. Beecher, T. Richards, C. Robertson, A. Wald, A. Paul and T. Annear. 2008. Integrated Approaches to Riverine Resource Management: Case Studies, Science, Law, People, and Policy. Instream Flow Council, Cheyenne, WY. 430 pp.

National Research Council. 2005. The Science of Instream Flows: A Review of the Texas Instream Flow Program. Committee on Review of Methods for Establishing Instream Flows for Texas Rivers, National Research Council. National Academy Press, Washington DC. 162 pp.

Province of Alberta. 2014. Environmental Protection and Enhancement Act. Revised Statutes of Alberta 2000 Chapter E-12. 158 pp.

Richter, B., Davis, M., Apse, C., and C. Konrad. 2012. A presumptive standard for environmental flow protection. River Research and Applications 28: 1312-1321.

The Alberta Westslope Cutthroat Recovery Team. 2013. Alberta Westslope Cutthroat Trout Recovery Plan: 2012-2017. Alberta Environment and Sustainable Resource Development, Alberta Species at Risk Recovery Plan No. 28. Edmonton, AB. 77 pp.

SNC-Lavalin. 2016. Grassy Mountain Coal Project Fluvial Geomorphology Effects Assessment. Prepared for Hatfield Consultants. December 2016. 98 pp.

SRK Consulting. 2016. Grassy Mountain Surface Hydrology Baseline and Effects Assessment. Prepared for Benga Mining Ltd. 85 pp.

Allan Locke
<personal information removed>

EMPLOYMENT

President, Locke and Associates, 2013 to Present

Provide:

- A complete range of aquatic habitat assessment services related to the construction, inspection, reclamation, or monitoring of roads, pipelines, and well sites.
- Aquatic environment expertise for optimal pipeline routing.
- Expertise to develop local water management plans to assist obtaining water for Temporary Diversion Licenses (TDLs) and Term Licenses.
- Services that will help to ensure compliance with the requirements of both federal and provincial aquatic environmental protection measures as part of an environmental assessment or the development of an Aquatic Environment Protection Plan.
- Environment flow expertise to governments, industry and NGOs.

Provincial Environment Flows Specialist, Government of Alberta, 1998 to 2013

As the Provincial Environmental Flows Specialist, responsible to lead, develop and implement the provincial Environmental Flows program. Duties include:

- Develop and set policy options and scientific standards for the Environmental Flows Program.
- Provide leadership and specialized knowledge to align and coordinate the Environmental Flows Program with the Fish and Wildlife Division mandate, Water Management Planning and the Land Use Framework.
- Develop unique and cost effective Environmental Flow tools to protect fish and wildlife resources, e.g., province-wide guidelines and classification assessment methods.
- Develop and implement site-specific Environmental Flow studies in basin wide water management planning initiatives.
- Develop Fisheries Management Objectives in context of carrying out Environmental Flow assessments.
- Provide leadership in applying Structured Decision Making processes to represent the Fish and Wildlife Division's interests in economic versus environmental values trade-off analysis in multi-stakeholder negotiations.
- Liaise with stakeholder groups (e.g., the Alberta Water Council, Watershed Planning and Advisory Councils), the general public, industry and other provincial and federal jurisdictions on Environmental Flow matters.
- Carry out research and practical application programs in collaboration with Universities, Alberta Innovates – Energy and Environment Solutions – Water Resources, NSERC (HydroNet) and the federal government.
- Represent the Fish and Wildlife Division on the Instream Flow Council.

In addition to Environmental Flow responsibilities,

- Represent the Fish and Wildlife Management Division on the Federal / Provincial Fish Passage Technical Review Committee.

Fisheries Habitat Protection Biologist, Government of Alberta, 1981 to 1998

- Design and implement the Instream Flow Needs (IFN) program for the Province of Alberta.
- Chair the Alberta Fishways Working Group.
- Develop a series of Fisheries Habitat Protection Guidelines for the Province of Alberta.
- Assess the need for the creation of new, or modification of existing, referral systems.
- Co-ordinate Service assessment and establish conditions of approval for land use activities including: a) the exploration, development and reclamation of mineral resources (oil and gas industry, coal, oilsands, and sand and gravel), b) linear disturbances, c) water resource projects (dams, irrigation headworks), and d) timber harvesting.

- Provide expertise to regional staff in reviewing specific applications that are beyond their expertise or have provincial ramifications.
- Review Environmental Impact Assessments for development proposals.
- Be the Service representative on, intra- and inter-departmental and inter-governmental committees as required.
- Be the Service representative in setting provincial water quality objectives for the protection of fish and freshwater aquatic life.
- Develop and co-ordinate the Habitat Prosecution Training Course for Fish and Wildlife Service enforcement and biological staff.
- Pursuant to the habitat and pollution control sections of the Fisheries Act, set up regional Special Environmental Investigation Units to conduct environmental investigations and prosecutions.
- Prepare and administer budgets for the Aquatic Habitat Protection programs.

Conservation Authority Biologist, South Lake Simcoe Conservation Authority, 1981

- Design and implement environmental studies.
- Review official Plans of Development.
- Carry out environmental assessments for projects that are undertaken by the Authority.
- Provide technical advice to other staff members and the public.
- Carry out liaison with federal, provincial, and private agencies.

Conservation Authority Project Biologist, South Lake Simcoe Conservation Authority, 1979 to 1981

- Carry out resource inventory studies within the watershed.
- Hire and supervise staff to carry out stream surveys and cold-water assessments.
- Carry out environmental assessments, co-ordinate and supervise cold-water stream rehabilitation projects for brook trout.
- Carry out liaison with federal, provincial, and private agencies.
- Set terms of reference for environmental studies that are to be undertaken by private consultants on behalf of the Authority.
- Provide biological expertise to the Planning Department.
- Act as assistant to the Senior Biologist.

Policy Assessment Biologist, Government of Ontario, 1978 to 1979

- Carry out the administration of the boating restriction regulations for the Province.
- Co-ordinate Provincial involvement in the Federal Marina Policy Assistance Program and other small craft harbour developments.

Fisheries Biologist, Government of Ontario, 1977

- Research the biological, physical and chemical data of the lakes in the Bruce Peninsula.
- Co-author a book with F.P. Maher and Dr. H. H. Harvey (University of Toronto) for general public use entitled "The Lakes of the Bruce Peninsula".

Wildlife Biologist, North Grey Conservation Authority, 1975 to 1976

- Gather data on waterfowl production in the Rankin Wildlife Management Area.
- Maintain a bird and herptile inventory checklist for the Rankin Wildlife Management Area.
- Implement a live trapping program for small mammals using approved wildlife management techniques.
- Collect data on the spring migration of all species of waterfowl in the Rankin Wildlife Management Area.

PROFESSIONAL ORGANIZATIONS

Instream Flow Council (President 2004 – 2006)
Professional Biologist, P.Biol., Alberta Society of Professional Biologists
Registered Professional Biologist, R.P.Bio., British Columbia College of Applied Biology

EDUCATION

Hon. B.Sc., Zoology, University of Guelph, 1976

OTHER EDUCATION

- "Great Plains Fisheries Workshop" - Lethbridge, AB, February 1982.
- "Fisheries Act Workshop" - AFWD, Edmonton, AB, June 1983.
- "IFIM Field Techniques for Stream Habitat Assessment Course" - USFWS/CSU, Columbia, MO, July 1983.
- "Instream Flow Needs Workshop" - C. Howard/BC Env., Victoria, BC, March 1984.
- "Canadian Water Resources Association Conference" - CWRA, Vancouver, BC, May 1984.
- "National Conference on the Enforcement of Environmental Law" - Edmonton, AB, May 1984.
- "Consulting Skills Course" - ENR, Edmonton, AB, June 1984.
- "Water Safety and Small Vessels Course" - AFWD, Hinton, AB, June 1984.
- "IFIM Computer Based Physical Habitat Simulation System Course" - USFWS/CSU, Ft. Collins, CO, July 1984.
- "Applied Aquatic Workshop" - U of A/ENR, Edmonton, AB, February 1985.
- "Small Hydro Fisheries Conference" - AFS, Denver, CO, May 1985.
- "IFIM Stream Habitat Analysis as Applied to Water Management Course" - USFWS/CSU, Portland, OR, July 1985.
- "International Regulated Stream Symposium" - Edmonton, AB, August 1985.
- "IFIM SI Curve Development Workshop" - USFWS/CSU, Ft. Collins, CO, July 1986.
- "Firearms Course (Rifle, pistol, and shotgun)" - AFWD, Hinton, AB, July 1986.
- "Forestry/Wildlife Mitigation Workshop" - ENR, Hinton, AB, September 1986.
- "IFIM Advanced Hydraulics Course" - USFWS/CSU, Ft. Collins, CO, July 1988.
- "Sediment Issues Workshop" - Env. Can., Calgary, AB, September 1988.
- "Fish Hatchery Management Course" - AFWD, Calgary, AB, November 1988.
- "Dredging: Environmental Considerations Workshop" - Env. Can., Edmonton, AB, March 1989.
- "Rivers: Flowing to the Future Symposium" - Calgary, AB, May 1989.
- "Geophysical Activities on Lakes" - CPA/FLW, Rocky Mountain House, AB, May 1989.
- "Pulp and Paper: Environmental Concerns Conference" - Edmonton, AB, July 1989.
- "Dissolved Oxygen Objectives for Fish Workshop" - AE, Edmonton, AB, December 1989.
- "Water Conservation Workshop" - Edmonton, AB, March 1990.
- "IFIM Microcomputer Based Physical Habitat Simulation System Course" - USFWS/CSU, Logan, UT, July 1990.

- "Fish and Wildlife Guardian Course" - AFWD, Edmonton, AB, May 1991.

- "Water Quality Criteria for Fish Workshop" - AFWD, Calgary, AB, June 1991.

- "Alberta Irrigation Projects Association Conference" - Lethbridge, AB, November 1991.

- "Red Deer River Water Quality Workshop" - AE, Calgary, AB, December 1991.

- "Instream Flow Needs Workshop" - AFWD/AE, Edmonton, AB, April 1992.

- "Canadian Water Resources Conference - Is BC's Water for Sale?" -CWRA, Vancouver, BC, May 1992.

- "Alberta Water Resources Commission IFN Workshop" - Drumheller, AB, October 1992.

- "Water Quality Modelling Workshop" - AFWD, Edmonton, AB, January 1993.

- "Northern Rivers Basin Study - Water Quality Modelling Workshop" - Saskatoon, SK, March 1993.

- "NR561 - Habitat Evaluation Procedures Course" - USFWS, Hinton, AB, April 1993.

- "Canadian Water Resources Association Annual Conference" - CWRA, Banff, AB, June 1993.

- "Cows and Fish: Range Management Workshop" - AFWD, Blairmore, AB, August 1993.

- "Powerful Presentations Workshop" - AEP, Edmonton, AB, September 1993.

- "IFIM Workshop" - DFO, Winnipeg, MB, February 1994.

- "Videography Remote Sensing Workshop" - AEP, Calgary, AB, March 1994.

- "Partners: South Saskatchewan River Basin Workshop" - Saskatoon, SK, March 1994.

- "Bull Trout Conference" - BTTF/AFS, Calgary, AB, May 1994.

- "Pipeline Stream Crossing Workshop" - CAPP/DFO, Banff, AB, November 1994.

- "2-D Hydraulic Modelling Workshop" - DFO/U of A, Edmonton, AB, March 1995.

- "GPS Course" - Lethbridge Community College, Lethbridge, AB, May 1995.

- Alberta Irrigation Projects Association Annual Meeting" – Lethbridge, AB, November 1995.

- "Ecohydraulics 2000 – 2nd Int. Sym. on Habitat Hydraulics" – IAHR, Quebec City, PQ, – June 1996.

- "Advanced Fisheries Management Course" – FMD/LCC, Lethbridge, AB, June 1996.

- "2-D Hydraulic Modelling Workshop" - DFO/U of A, Edmonton, AB, January 1997.

- "Great Plains Fishery Workers Association Annual Meeting" – Bozeman, MT, February 1997.

- "Klamath River Basin IFN Methodology Assessment Workshop" - Redmond, WA, April 1997

- "2-D Hydraulic Modelling Workshop" - DFO/U of A, Cochrane, AB, February 1998.

- "Instream Flow Council Biennial Meeting" – IFC - Denver, CO, March 1998.

- "Bull Trout Management Workshop" – University of Calgary / AENV, Calgary, AB, April 1998.

- "Prairie Fish Habitat Management Workshop" – DFO/AB/SK/MN/ON, Hecla Island, MB, June 1998.

- “Hydropeaking Workshop” – AENV/TAU – Calgary, AB, June 1998.
- “Kananaskis River – Hydropeaking Workshop” – AENV/DFO/TAU/WSMG - Cochrane, AB, January 1999.
- “IFN Classification Workshop” – AENV/R2 Resource Consultants – Calgary, AB, March 1999.
- “Hydropower IFN Workshop” – BCMELP/DFO/BC Hydro – Vancouver, BC, June 1999.
- “3rd International Symposium on Ecohydraulics” – IAHR – Salt Lake City, UT, July 1999.
- “2D Hydraulic Modelling Workshop” – AENV/DFO/BC/SK/MN/ON – Edmonton, AB, March 2000.
- “Instream Flow Council Biennial Meeting” – IFC – Higgins Lake, MI, May 2000.
- “Habitat Suitability Criteria Workshop” – Bellingham, WA, October 2000.
- “Instream Flow Workshop” – DFO/Provinces – Burlington, ON, November 2000.
- “Habitat Suitability Criteria Workshop” – ASRD/DFO – Cochrane, AN, July 2001.
- “River 2-D Workshop” – USGS/UoA/ASRD – Ft. Collins, CO, October 2001.
- “Ice Safety Course” – ASRD – Pigeon Lake, AB, January 2002.
- “River 2-D Workshop” – USGS/IFC/ASRD – Shepherdstown, WV, March 2002.
- “Stream Crossing Workshop” – DFO/CAPP – Banff, AB, March 2002.
- “Instream Flow Council Biennial Meeting” – Crossnore, NC, May 2002.
- “River 2-D Workshop” – USGS/Oregon/IFC/ASRD – Portland, OR, July 2002.
- “River Ice Processes Workshop” – CEMA – Calgary, AB, December 2003.
- “Instream Flow Council Biennial Meeting” – Blue Mountain Lake, NY, June 2004.
- “Habitat Suitability Criteria Workshop” – CEMA – Edmonton, AB, December 2004.
- "Alberta's Environment Conference" - AENV - Edmonton, AB, April 2005.
- "Biology of Hawaiian Streams and Estuaries" - Hawaii DAR - Hilo, HI, April 2005.
- "Athabasca River IFN Workshop" - CEMA - Ft. McMurray, AB, May 2005.
- "South Saskatchewan River Basin Workshop" - AENV - Calgary, AB, May 2005.
- "Athabasca River HSC Workshop" - CEMA - Ft. McMurray, AB, September 2005.
- "Instream Flow Council HSC Workshop" - IFC - Cheyenne, WY, November 2005.
- "Instream Flow Needs Meso-Habitat Metric Determination Workshop" - CEMA - Ft. McMurray, AB, December 2005.
- "International Instream Flow Program Initiative Meeting" - IFC - Wickenburg, AZ, March 2006.
- "Prairie Provinces Board IFN Workshop" - PPWB - Calgary, AB, March 2006.
- "Instream Flow Council Biennial Meeting" - IFC - Parksville, BC, April 2006.
- "River 2D Modelling Course" - ASRD/UoA/USGS - Edmonton, AB, December 2006.

- "Fisheries Index Workshop" - ASRD - Nisku, AB, March 2007.
- "Athabasca River Canadian Science Advisory Secretariat Workshop" - CSAS/DFO - Winnipeg, MB, March 2007.
- "Athabasca River Monitoring Program Workshop" - CEMA - Calgary, AB, March 2007.
- "National DFO IFN Workshop" - DFO - Montreal, PQ, June 2007.
- "Resource Conflict Course" - ASRD - Hinton, AB, September 2007.
- "International Instream Flow Program Initiative Workshop" - IFC - Denver, CO, October 2007.
- "DFO Instream Flow Needs Workshop" - DFO - Calgary, AB, October 2007.
- "Athabasca River Research Needs Workshop" - DFO - Calgary, AB, October 2007.
- "National Sciences and Engineering Research Council of Canada Workshop" - NSERC - Ottawa, ON, November 2007.
- "River 2D Modelling Course" - OMNR/ASRD/USGS - Timmons, ON, March 2008.
- "Athabasca River Watershed Planning and Advisory Council Workshop" - AENV - Sherwood Park, AB, April 2008.
- "Flow 2008 Conference" – Instream Flow Council - San Antonio, TX, October 2008.
- "Water Allocation Transfer System Workshop" - AWRI/AWC - Calgary, AB, March 2009.
- "Athabasca River HSC Workshop" - ASRD/CEMA - Calgary, AB, April 2009.
- "Federal Parliamentary Committee Hearing on Water and the Oil Sands" - Federal Parliamentary Committee - Calgary, AB, May 2009.
- "Athabasca River Canadian Science Advisory Secretariat Workshop" - CSAS/DFO - Calgary, AB, June 2010.
- "Bow River Project Workshop" – Alberta WaterSMART – Calgary, AB, August 2010.
- "Bow River Project OASIS Modelling Workshop" – Alberta WaterSMART – Calgary, AB, September 2010.
- "Environmental Law Seminar" – University of Calgary – Calgary, AB, September 2010.
- "Bow River Project Environmental Assessment Modelling Workshop" – Alberta WaterSMART – Calgary, AB, October 2010.
- "Canadian Science-Policy Framework to Protect and Restore Environmental Flows Workshop" – WWF Canada – Ottawa, ON, November 2010.
- "Milk River Habitat Suitability Criteria Workshop" – MRWCC – Lethbridge, AB December 2010.
- "Development of a Water Exchange Research Workshop" – Alberta Innovates – Calgary, AB, February 2011.
- "Alberta Peace River Morphological and Habitat Changes Due to Regulation Workshop" – AENV, Edmonton, AB, March 2011.
- "FLOW 2011 Conference" - Instream Flow Council – Nashville, TN, May 2011.
- "Bow River Basin Science Seminar" – BRBC – Calgary, AB, May 2011.
- "Environmental Flows and BC's Proposed Water Sustainability Act Workshop" - WWF-Canada/ BC Ministry of Environment and the Ministry of Forests, Lands and Natural Resource Operations - Vancouver, BC, November 2011.

- "Canadian Science Advisory Secretariat Instream Flow Needs National Workshop" – CSAS/DFO – Montreal, QC, March 2012.

- "FLOW 2015 Conference" – Instream Flow Council – Portland, OR, April 2015.

- "Environmental Flows and Healthy Watersheds: Towards Protection in Canada and BC" – POLIS Webinar – October 2015.

OTHER SKILLS OR EXPERIENCE:

- Member of the Quality Assurance / Quality Control IFN Methods Sub-Committee of the Instream Flow Council.

- Knowledge and practical experience with 1) Environmental Flow methods including the Instream Flow Incremental Methodology, 2) Habitat Evaluation Procedures, and 3) Water Quality Modelling.

- Extensive experience with microcomputers, commercial software and Environmental Flow related software including the PHABSIM and WINHABSIM models and the River 2D hydrodynamic model.

- Working knowledge of hydrological principles and hydraulic models.

- Technical referee for the Journal "Rivers".

- Guest lecturer for the course: Civil Engineering 502 - Impact Assessment for Engineers at the University of Alberta

- Served as President of the Instream Flow Council (2004-2006).

- Assistant instructor for River 2D Hydrodynamic Modelling courses.

- Co-author of the book "Instream Flows for Riverine Resource Stewardship - Revised Edition" published by the Instream Flow Council.

- Project co-ordinator and lead author for the book "Integrated Approaches to Riverine Resource Stewardship - Case Studies, Science, Law, People, and Policy" published by the Instream Flow Council.

- International peer reviewer of instream flow needs studies.

REPORTS

Hughes, G., and A.G.H. Locke. 1975. Waterfowl Production in the Rankin Resources Management Unit. North Grey and Sauble Valley Conservation Authority. Owen Sound, Ontario. 55pp.

Hughes, G., and A.G.H. Locke. 1976. Waterfowl Production in the Rankin Resources Management Unit. North Grey and Sauble Valley Conservation Authority. Owen Sound, Ontario. 78pp.

Harvey, H.H., A.G.H. Locke, and F.P. Maher. 1978. The Lakes of the Bruce Peninsula. Fisheries Branch, Division of Fish and Wildlife, Ministry of Natural Resources. Toronto, Ontario.

Locke, A.G.H. 1979. Waterfowl Production Study on the Beaverton River and Uxbridge Brook, Regional Municipality of Durham, Ontario. South Lake Simcoe Conservation Authority. Newmarket, Ontario. 71pp.

Locke, A.G.H. 1980. Wetlands - Recommendations and Policies: Report in response to "Wetlands in Southern Ontario: Conservation Authority Actions and Attitudes". South Lake Simcoe Conservation Authority. Newmarket, Ontario. 14pp.

Locke, A.G.H. 1980. Environmental Impact of Highway De-Icing Salts. South Lake Simcoe Conservation Authority. Newmarket, Ontario. 30pp.

Locke, A.G.H. 1980. Coldwater Stream Assessment of Vivian Creek. South Lake Simcoe Conservation Authority. Newmarket, Ontario. 26pp.

Locke, A.G.H. 1981. Erosion and Water Management Study - Uxbridge Township. South Lake Simcoe Conservation Authority. Newmarket, Ontario. 73pp.

Locke, A.G.H., and D. Rimmer. 1984. Lovett River Fisheries and Fisheries Habitat Assessment. Alberta Energy and Natural Resources. Edmonton, Alberta. 42pp.

Fisher, G.L., A.G.H. Locke, and B.C. Northey. 1985. Stream Crossing Guidelines for Industry. Alberta Energy and Natural Resources. ENR Technical Report Number: T/80. Edmonton, Alberta. 52pp.

Locke, A.G.H. 1985. Administration and use of the Habitat-Related Sections of the Federal Fisheries Act in Alberta: Workshop Proceedings. Alberta Energy and Natural Resources. Edmonton, Alberta. 134pp.

Locke, A.G.H. 1986. IFIM - Microhabitat Criteria Development: Data Pooling Considerations. IN: Proceedings of a Workshop on the Development and Evaluation of Habitat Suitability Criteria. K. Bovee and J.R. Zuboy, Eds. U.S. Fish and Wildlife Service. Biological Rep. 88(11). pp. 31-54.

Locke, A.G.H., and D. Snider. 1987. Stream Crossing Guidelines for Alberta Transportation Projects. Alberta Forestry, Lands, and Wildlife, Alberta Transportation. Edmonton, Alberta. 22pp.

Locke, A.G.H. 1987. Microhabitat Utilization and Preference Curve Development for Rainbow Trout Fry in four creeks in southwestern Alberta. Alberta Forestry, Lands, and Wildlife. Pub. No.: T/143. Edmonton, Alberta. 52pp.

Locke, A.G.H. 1987. Highwood River - Instream Flow Needs for Fish: The Position of the Fish and Wildlife Division. Alberta Forestry, Lands, and Wildlife. Edmonton, Alberta. 25pp.

Locke, A.G.H. 1988. Oldman River Dam - Operational Planning Phase II: Minimum Flow Values for Fish and Modelling Run Evaluations. Alberta Forestry, Lands, and Wildlife. Edmonton, Alberta. 13pp.

Locke, A.G.H. 1988. Sheep River Instream Flow Needs Study. Alberta Forestry, Lands, and Wildlife. Pub. No.: T/162. Edmonton, Alberta. 143pp.

Locke, A.G.H. 1989. The Sampling of Water, Soils, and Collection of Biological Samples to Analyze Suspected Pollutants. Alberta Forestry, Lands, and Wildlife. Edmonton, Alberta. 26pp.

Locke, A.G.H. 1989. Sediment Issues - Concerns of the Fish and Wildlife Division. IN: Proceedings of the Alberta Sediment Issues Workshop: September 27-28, 1988, Calgary, Alberta. T.R. Yuzyk and N.F.R. Chapin, eds. Environment Canada. Calgary, Alberta. pp. 98-105.

Locke, A.G.H. 1989. Instream Flow Requirements for Fish in the Highwood River. Alberta Forestry, Lands, and Wildlife. Pub. No.: T/211. Edmonton, Alberta. 100pp.

Locke, A.G.H. 1991. Minimum Instream Flow Values for Fish and Proposed Water Balance Modelling Evaluation Criteria for the Peace River in Alberta. Alberta Fish and Wildlife Division. Edmonton, Alberta. 27pp.

Katopodis, K., A.G.H. Locke, and D. Snider. 1992. Fish Passage Culvert Guidelines. Alberta Forestry, Lands, and, Wildlife, Alberta Transportation, and Department of Fisheries and Oceans. Edmonton, Alberta.

Locke, A.G.H. 1994. The Highwood River: Instream Flow Needs for Fish and Flow Scenario Evaluations. Alberta Fish and Wildlife Services. Pub. No.: T/280. ISBN: 0-7732-0920-4. Edmonton, Alberta. 108pp.

Locke, A.G.H. 1996. Recommending Variable Flow Values for Fish. IN: Proceedings of the Ecohydraulics 2000 – 2nd International Symposium on Habitat Hydraulics June 1996, Quebec City, Quebec. Leclerc M., Capra H., Valentin S., Boudreault A. and Y. Cote, eds. Institut National de la Recherche Scientifique. Quebec, 1996. pp. 559-570.

Waddle, T., Ghanem, A., Steffler, P., Katopodis, C. and A.G.H. Locke. 1996. Comparison of One and Two-Dimensional Hydrodynamic Models for a Small Habitat Stream. Addendum to IN: Proceedings of the Ecohydraulics 2000 – 2nd International Symposium on Habitat Hydraulics June 1996, Quebec City, Quebec. Leclerc M., Capra H., Valentin S., Boudreault A. and Y. Cote, eds. Institut National de la Recherche Scientifique. Quebec, 1996.

Locke, A.G.H. 2000. Instream Flow Needs in Alberta – The Good, the Bad, and the Ugly. IN: Proceedings of the 1998 Prairie Fish Habitat Management Workshop. – Can. MS. Rep. Fish. Aquatic. Sci. 2522: ix +155p. Chang-Kue, K.T.J., ed.

Waddle, T.J., P. Steffler, A. Ghanem, C. Katopodis, and A. Locke. 2000. Comparison of one and two-dimensional open channel flow models for a small habitat stream. Rivers 7(3): 205-220.

Clipperton, G.K., R.F. Courtney, T.S. Hardin, A.G.H. Locke, and G.L. Walder. 2002. Highwood River instream flow needs technical working group final report. Alberta Transportation, Edmonton.

Annear, T.C., I. Chisholm, H. Beecher, A. Locke, and 12 other authors. 2002. Instream flows for riverine resource stewardship. Published by the Instream Flow Council, Cheyenne, WY. 411pp.

Clipperton, G.K., C.W. Koning, A.G.H. Locke, J.M. Mahoney, and B. Quazi. 2003. Instream Flow Needs Determinations for the South Saskatchewan River Basin, Alberta, Canada. Alberta Environment and Alberta Sustainable Resource Development, Pub No. T/719, Calgary, Alberta. 271pp. + App.

Annear, T.C., I. Chisholm, H. Beecher, A. Locke, and 12 other authors. 2004. Instream flows for riverine resource stewardship, Revised Edition. Published by the Instream Flow Council, Cheyenne, WY. 268pp.

Locke, A. 2007. A Template for Conducting Ecosystem-Based Instream Flow Needs Studies. IN: Proceedings of the Symposium on the Biology of Hawaiian Streams and Estuaries - April 2005, Hilo, Hawaii. Evenhuis, N.L. and J.M. Fitzsimons, eds. Bishop Museum Bulletin in Cultural and Environmental Studies 3, Bishop Museum Press, Honolulu, 2007. 334pp.

Cichra, C.E., C.N. Dahm, A. Locke, D.T. Shaw and M. Stewart. 2007. A Review of "Proposed Minimum Flows and Levels for the Upper Segment of the Hillsborough River, from Crystal Springs to Morris Bridge, and Crystal Springs". Prepared for the Ecological Evaluation Section, Resource Conservation and Development Department, Southwest Florida Water Management District. 37pp.

Cichra, C.E., C.N. Dahm and A. Locke. 2007. A Review of "Proposed Minimum Flows and Levels for the Upper Segment of the Braden River, from Linger Lodge to Lorraine Road". Prepared for the Ecological Evaluation Section, Resource Conservation and Development Department, Southwest Florida Water Management District. 25pp.

Locke, A., C. Stalnaker, S. Zellmer, K. Williams, H. Beecher, T. Richards, C. Robertson, A. Wald, A. Paul and T. Annear. 2008. Integrated Approaches to Riverine Resource Management: Case Studies, Science, Law, People, and Policy. Instream Flow Council, Cheyenne, WY. 430pp.

Paul, A. and A. Locke. 2009. Evaluation Criteria for Flow Alterations in the Lower Athabasca River – Abundance and Diversity of Mesohabitat. Prepared for the Instream Flow Needs Technical Task Group of the Surface Water Working Group, CEMA.

Paul, A. and A. Locke. 2009. Evaluation Criteria for Flow Alterations in the Lower Athabasca River – Fish Habitat. Prepared for the Instream Flow Needs Technical Task Group of the Surface Water Working Group, CEMA.

Ghamry, H., J. Shatford and A. Locke. 2009. Evaluation Criteria for Connectivity of Distributaries in the Lower Athabasca River (Fletcher Channel) – Segment 1. Prepared for the Instream Flow Needs Technical Task Group of the Surface Water Working Group, CEMA.

Ghamry, H., J. Shatford and A. Locke. 2009. Evaluation Criteria for Connectivity of Perched Basins in the Lower Athabasca River– Segment 1. Prepared for the Instream Flow Needs Technical Task Group of the Surface Water Working Group, CEMA.

Locke, A. and A. Paul. 2011. A Desk-top Method for Establishing Environmental Flows in Alberta Rivers and Streams. Alberta Environment and Alberta Sustainable Resource Development. 94 pp.

Locke, A. 2013. Don River Crossing – Drilling Waste Disposal Recommendations. Prepared for Enbridge Inc. by CCI Inc.

Locke, A. 2013. Environmental Protection Plan for the Proposed Direct Energy Marketing Ltd. Bridge Replacement on Waiparous Creek. Prepared for Direct Energy Marketing Ltd. by CCI Inc.

Locke, A. 2013. GIS Hydrology Ground Truthing for the Proposed Suncor Energy Inc. Well Site Pad #122. Prepared for Suncor Energy Inc. by CCI Inc.

Locke, A. 2013. Redwater River Crossing Project Fisheries Assessment. Prepared for Arc Resources Ltd. By CCI Inc.

Locke, A. 2013. Sheep River Crossing Project Environmental Protection Plan. Prepared for Compton Petroleum Corp. by CCI Inc.

Locke, A. 2014. Environmental Assessment of the Centrica Energy Emergency Flood Protection Works at their Water Well Facility (9 Of 18-40-7-W5). Prepared for Centrica Energy by CCI Inc.

Locke, A. 2014. Watercourse Crossing Environmental Protection Plan for an Unnamed Creek for the Proposed Direct Energy Marketing Ltd. Bridge Replacement Project NW-22-50-15-W5. Prepared for Direct Energy Marketing Ltd. by CCI Inc.

Locke, A. 2014. Watercourse Crossing Environmental Protection Plan for an Unnamed Creek for the Proposed Pembina Pipeline Corp. Pipeline Watercourse Crossing Project in 16-64-13-W5. Prepared for Pembina Pipeline Corp. by CCI Inc.

Locke, A. 2014. Watercourse Crossing Environmental Protection Plan for an Unnamed Creek for the Proposed Pembina Pipeline Corp. Pipeline Watercourse Crossing Project in NW-15-62-3-W6. Prepared for Pembina Pipeline Corp. by CCI Inc.

Locke, A. 2014. Watercourse Crossing Environmental Protection Plan for an Unnamed Creek for the Proposed Pembina Pipeline Corp. Pipeline Watercourse Crossing Project in SW-6-64-23-W5. Prepared for Pembina Pipeline Corp. by CCI Inc.

Locke, A. 2014. Watercourse Crossing Environmental Protection Plan for Paddy Creek for the Proposed Pembina Pipeline Corp. Pipeline Watercourse Crossing Project in NE 16-48-10-W5. Prepared for Pembina Pipeline Corp. by CCI Inc.

Locke, A. 2014. Watercourse Crossing Environmental Protection Plan for Loblaw Creek and 10 Unnamed Creeks for the Proposed Direct Energy Marketing Ltd. Pipeline Right of Way from 5-13-28-7-W5 to 13-6-28-6-W5 Project. Prepared for Direct Energy Marketing Ltd. by CCI Inc.

Locke, A. 2014. Watercourse Crossing Environmental Protection Plan for Marsh Head Creek for the Proposed Pembina Pipeline Corp. Pipeline from 9-7-60-18-W5 to 4-8-60-18-W5 Project. Prepared for Pembina Pipeline Corp. by CCI Inc.

Locke, A. 2014. Watercourse Crossing Environmental Protection Plan for the Cutbank River and Three Unnamed Creeks for the Proposed Paramount Resources Ltd. Pipeline Watercourse Crossing Project from 15-10-65-5-W6 to 10-35-65-5-W6. Prepared for Paramount Resources Ltd. by CCI Inc.

Locke, A. 2014. Watercourse Crossing Environmental Protection Plan for Three Unnamed Watercourses for the Proposed Direct Energy Marketing Ltd. Pipeline Right of Way from 2-23-28-7-W5 to 16-14-28-7-W5 Project. Prepared for Direct Energy Marketing Ltd. By CCI Inc.

Locke, A. 2014. Watershed Assessment and Runoff Calculations for a 1:25 Year Return Period Storm Event: Centrica Energy Well Site and Access Road. Prepared for Centrica Energy by CCI Inc.

Harwood, A., I. Girard, S. Johnson, A. Locke, and T. Hatfield. 2014. Environmental Flow Needs, Approaches, Successes and Challenges - Summary Report. Draft V1. Consultant's report prepared for the Canadian Council of Ministers of the Environment by Ecofish Research Ltd.

Locke, A. 2015. Watercourse Crossing Environmental Protection Plan for Three Unnamed Creeks for the Proposed Direct Energy Marketing Ltd. Pipeline from SW 24-51-15-W5M to SE 33-51-14-W5M Project. Prepared for Direct Energy Marketing Ltd. by CCI Inc.

Locke, A. 2015. Watercourse Crossing Environmental Protection Plan for Six Unnamed Creeks for the Proposed Direct Energy Marketing Ltd. Pipeline From 10-19-46-18-W5 to 5-36-46-19-W5 Project. Prepared for Direct Energy Marketing Ltd. by CCI Inc.

Locke, A. 2015. Watercourse Crossing Environmental Protection Plan for a Proposed Pipeline Watercourse Crossing Project in 03-042-12-W5M. Prepared for Direct Energy Marketing Ltd. by CCI Inc.

Locke, A. 2015. Watercourse Crossing Environmental Protection Plan for Two Unnamed Creeks for the Proposed Direct Energy Marketing Ltd. Pad Site and Road Project in NW-2-47-19-W5. Prepared for Direct Energy Marketing Ltd. by CCI Inc.

Locke, A. 2015. PME Inc. West Terminal Crude System Pipeline Project 17 Street Slip Bore Crossing NW5-53-23 W4 Water Management Plan. Prepared for PME Inc. by CCI Inc.

Locke, A. 2015. Stoney Nakoda Nations Pre-Water Needs Assessment. Prepared for Stoney Nakoda Nations by CCI Inc.

Locke, A. and A. Molina. 2015. Watercourse Crossing Environmental Protection Plan for an Unnamed Creek for the Proposed Direct Energy Marketing Ltd. Pipeline from 1-23-51-15-W5 to 8-20-51-15-W5 Project. Prepared for Direct Energy Marketing Ltd. by CCI Inc.

Locke, A. and A. Molina. 2015. Watercourse Crossing Environmental Protection Plan for Drywood Creek for the Two Proposed Twin Butte Energy Ltd. Pipeline Watercourse Crossing Replacement Projects in 5-14-4-29-W4. Prepared for Twin Butte Energy Ltd. by CCI Inc.

Locke, A. and A. Molina. 2015. Watercourse Crossing Environmental Protection Plan for Marsh Head Creek for the Proposed Pembina Pipeline Corp. Watercourse Crossing Pipeline Replacement Project in 8-60-19-W5. Prepared for Pembina Pipeline Corp. by CCI Inc.

Locke, A. and A. Molina. 2015. Watercourse Crossing Environmental Protection Plan for the Edson River, Little Sundance Creek and Two Unnamed Creeks for the Proposed Pembina Pipeline Corp. Treestone Pipeline Watercourse Crossing Replacement Projects in NE 22-57-19-W5, SE 15-54-19-W5, SW 2-55-19-W5 and SE 29-60-19-W5. Prepared for Pembina Pipeline Corp. by CCI Inc.

Locke, A. and A. Molina. 2015. Watercourse Crossing Environmental Protection Plan for the Belly River for the proposed Belly River NPS 12 Pipeline Replacement Project in SE 12-03-28-W4M. Prepared for Plains Midstream Canada ULC by CCI Inc.

Locke, A. and A. Molina. 2015. Watercourse Crossing Environmental Protection Plan for the Waterton River for the proposed Plains Midstream Canada Pipeline Watercourse Crossing Replacement Project in 6-33-3-28-W4. Prepared for Plains Midstream Canada ULC by CCI Inc.

Locke, A. and A. Molina. 2015. Watercourse Crossing Environmental Protection Plan for Willow Creek and an Unnamed Tributary to Rice Creek for the Proposed NOVA Chemicals Corp. Pipeline Watercourse Crossing Replacement Project in 6-26-14-2-W5. Prepared for NOVA Chemicals Corp. by CCI Inc.

Molina, A. and A. Locke. 2015. Centrica Energy Ltd. Watercourse Crossing Environmental Protection Plan PL RoW 05-32 to 02-23-028-07-W5M. Prepared for Centrica Energy Ltd. by CCI Inc.

Molina, A. and A. Locke. 2015. Jupiter Resources Ltd. Aquatic Habitat Assessment Pipeline RoW 1-28 to 10-29-061-06-W6M. Prepared for Jupiter Resources Ltd. by CCI Inc.

Locke. A. 2015. Devon Energy Corporation Waterbody Environmental Protection Plan for the Kirby Lake Proposed Resistivity Survey. Prepared for Devon Energy Corp. by CCI Inc.

Molina, A. and A. Locke. 2015. Harvest Operations Corp. Watercourse Crossings Environmental Protection Plan Pipeline 4-32 to 11-33-064-06-W6M. Prepared for Harvest Operations Corp. by CCI Inc.

Molina, A. and A. Locke. 2015. Crew Energy Inc. Aquatic Habitat Assessment Pine River HDD Crossing. Prepared for Crew Energy Inc. by CCI Inc.

Molina, A. and A. Locke. 2015. ATCO Gas. Watercourse Crossings Environmental Protection Plan. Fish Creek HDD Crossing. Prepared for ATCO Gas by CCI Inc.

Molina, A. and A. Locke. 2015. Plains Midstream Canada ULC. Environmental Protection Measures for Pipeline Removal Gull Lake For the Plains Midstream Canada Gull Lake Pipeline Replacement Project in 2-26 to 10-26-013-19-W3M. Prepared for Plains Midstream Canada ULC by CCI Inc.

Molina, A. and A. Locke. 2015. Direct Energy Ltd. Watercourse Crossing Environmental Protection Plan PL RoW 05-32 to 02-23-028-07-W5M. Prepared for Direct Energy Ltd. by CCI Inc.

Locke, A. 2016. Professional Peer Review of “Instream Flow Study of the Middle Trinity River Draft Study Design”. Prepared for Middle Trinity River Basin Stakeholder Group, Texas Instream Flow Program and Trinity River Authority. 8p.

Locke, A. 2016. Professional Peer Review of “Instream Flow Study of the Lower Guadalupe River Draft Study Design”. Prepared for Lower Guadalupe River Basin Stakeholder Group, Texas Instream Flow Program and Guadalupe - Blanco River Authority. 7p.

Molina, A. and A. Locke. 2016. TransCanada Pipelines Limited. North Montney Mainline Project – Aitken Creek Section RFI No. 10124763 Water Quality Monitoring and Fish Salvage. Prepared for TransCanada Pipelines Limited by CCI Inc.

Molina, A. and A. Locke. 2016. Imperial Oil Ltd. Burrard Inlet Pipeline Removal Project 2225A IOCO Road, Port Moody, BC. Burrard Inlet Fisheries Assessment and Water Quality Monitoring Plan. Prepared for Imperial Oil Ltd. by CCI Inc.

Molina, A. and A. Locke. 2016. Plains Midstream Canada ULC. Watercourse Crossing Environmental Protection Plan Raven River HDD Crossing. Prepared for Plains Midstream Canada ULC by CCI Inc.

Molina, A. and A. Locke. 2016. Plains Midstream Canada ULC. Watercourse Crossing Environmental Protection Plan Modeste Creek HDD Crossing. Prepared for Plains Midstream Canada ULC by CCI Inc.

Molina, A. and A. Locke. 2016. Outlier Resources Ltd. Watercourse Crossing Environmental Protection Plan Pass Creek Bridge Replacement Project. Prepared for Outlier Resources Ltd. by CCI Inc.

Molina, A. and A. Locke. 2016. Plains Midstream Canada ULC. Watercourse Crossing Environmental Protection Plan Belly River and an Unnamed Tributary of the Belly River For the proposed Belly River NPS 12 Pipeline Replacement Project in SE 12-03-28-W4M. Prepared for Plains Midstream Canada ULC by CCI Inc.

Molina, A. and A. Locke. 2016. Plains Midstream Canada. Watercourse Crossing Environmental Protection Plan Waterton River and Unnamed Small Permanent Creek, Pipeline Watercourse Crossing Replacement Project in 6-33-3-28-W4. Prepared for Plains Midstream Canada by CCI Inc.

Molina, A. and A. Locke. 2016. Plains Midstream Canada. Watercourse Crossing Environmental Protection Plan Little Red Deer River HDD Crossing. Prepared for Plains Midstream Canada by CCI Inc.

Locke, A. 2016. Aquatic Assessment of the Duncan Brown Pond. Prepared for Jano’s Custom Homes.

Locke, A. 2017. Canadian Forest Products Ltd. Watercourse Crossing Environmental Protection Plan Highwood River Temporary Bridge Project. Prepared for Canadian Forest Products Ltd.

Locke, A. 2017. Plains Midstream Canada. Watercourse Crossing Environmental Protection Plan - Swift Current Creek HDD Crossing. Prepared for Plains Midstream Canada.

Harwood, A., S. Johnson, I. Girard, S. Richard, J. Wick, A. Locke, G. Wendling, and T. Hatfield 2017. Guidance on Assessing and Reporting Cumulative Impacts of Water Withdrawal on Environmental Flow Needs. Draft V1. Consultant's report prepared for the Canadian Council of Ministers of the Environment by Ecofish Research Ltd., GW Solutions Inc. and Locke and Associates.

Harwood, A., Johnson, S., Richter, B., Locke, A., Yu, X. and Tickner, D. 2017. Listen to the river: Lessons from a global review of environmental flow success stories, WWF-UK, Woking, UK.

Locke, A. 2017. Professional Peer Review of the Instream Flow Study of the Lower San Antonio River and Lower Cibolo Creek. Prepared for Texas State University.

Locke, A. 2017. Professional Peer Review of the Instream Flow Study of the Middle and Lower Brazos River. Prepared for Texas State University.

Locke, A. 2018. Artis Exploration Ltd. Water Sources Assessment: Hummock Lake and Four Unnamed Water Bodies. Prepared for Artis Exploration Ltd.

Locke, A. 2018. Canadian Forest Products Ltd. Watercourse Crossing Environmental Protection Plan 2018-19 Highwood River Temporary Bridge Project. Prepared for Canadian Forest Products Ltd.

Locke, A. 2018. Hell's Half Acre Petroleum Corporation. Watercourse Crossing Environmental Protection Plan - Prairie Creek HDD Crossing. Prepared for Hell's Half Acre Petroleum Corporation.

Locke, A. 2018. Outlier Resources Ltd. Watercourse Crossing Environmental Protection Plan – Unnamed Creek Bridge Project. Prepared for Outlier Resources Ltd.

Locke, A. 2018. Whitefish Lake First Nation - Whitefish Lake Arterial Road Watercourse Crossing Environmental Protection Plan. Prepared for Whitefish Lake First Nation.

Harwood A.J, Tickner D, Richter B.D, Locke A, Johnson S and Yu X. 2018. Critical Factors for Water Policy to Enable Effective Environmental Flow Implementation. Front. Environ. Sci. 6:37.

Locke, A. 2018. Artis Exploration Ltd. Portable Pump Station and Term Licence Environmental Protection Plan. Prepared for Artis Exploration Ltd.

Locke, A. 2018. TERVITA Corp. Watercourse Crossing Environmental Protection Plan - Parker Creek and Two Unnamed Creeks. Prepared for Tervita Corp.

Locke, A. and M. Schmunk. 2019. Artis Exploration Ltd. Portable Pump Station and Term Licence Environmental Protection Plan. Prepared for Artis Exploration Ltd.

Locke, A. 2019. Artis Exploration Ltd. Watercourse Crossing Environmental Protection Plan Pipeline and Permanent Road Project (30-32-23-W4). Prepared for Artis Exploration Ltd.

Locke, A. 2019. Fishing Lake Metis Settlement. Watercourse Crossing Environmental Protection Plan Culvert Replacement Project (SW5-57-2-W4 & NW31-57-1-W4). Prepared for the Fishing Lake Metis Settlement.

Locke, A. 2019. Inter Pipeline Ltd. Watercourse Crossing Environmental Protection Plan CEP Water Pipeline Project. Prepared for Inter Pipeline Ltd.

Locke, A. 2019. Professional Peer Review of the Instream Flow Study of the Middle and Lower Brazos River – June 2018. Prepared for Texas State University.

Locke, A. 2019. Professional Peer Review of the Instream Flow Study of the Lower San Antonio River and Lower Cibolo Creek – December 2017. Prepared for Texas State University.

Locke, A. and T. Annear. 2020. Supplemental Peer Review of the Texas Water Development Board: Statewide Synthesis of Environmental Flow Studies - Middle and Lower Brazos River, Lower Guadalupe River, Lower Sabine River, Lower San Antonio River and Lower Cibola Creek, Middle Trinity River, and Nueces Delta. Prepared for Texas State University.

Updated July 6, 2020

Grassy Mountain Coal Mine Review, with particular reference to possible impacts on "Threatened" Westslope cutthroat trout

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On Behalf of the Coalition of the Alberta Wilderness Association and the Grassy Mountain Group

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Executive Summary:

The proposal details an open-pit, mountain-top coal strip mine, on top of a legacy coal mine on Grassy Mountain, north of Blairmore, Alberta. Watersheds on either side of Grassy Mountain will be impacted by this development. Gold Creek contains the last, major concentration of pure-strain Westslope cutthroat trout in the Crowsnest River watershed. Blairmore Creek has potential for recovery efforts to meet requirements for Westslope cutthroat trout, a federally and provincially listed "Threatened" species at risk. Westslope cutthroat trout have declined precipitously throughout their range in the Oldman and Bow watersheds, for a variety of reasons, most notably the impact of cumulative effects.

The proposed mine will negatively impact the existing Westslope cutthroat trout population of Gold Creek and the potential of Blairmore Creek for recovery efforts. Monitoring proposed by the proponent is not rigorous, robust or sensitive enough to detect changes and impacts in a timely manner for correction. Mitigation/compensation actions proposed are untested, unproven, unsuitable, theoretical and overly optimistic to ensure Westslope cutthroat trout populations persist and are allowed to recover.

The Westslope cutthroat trout population is currently vulnerable to existing land uses, which are beyond the range of natural variation these native trout evolved with and adapted to—the mine proposal puts the population at even greater risk.

The potential for an irreversible loss of a pure-strain population of Westslope cutthroat trout, locally adapted to Gold Creek is of such significance that this must become a dominant consideration in evaluating the advisability of the coal mine project.

Life history and status of Westslope cutthroat trout:

The life history of Westslope cutthroat trout includes spawning in the spring (May-June) based on water temperature. Adult females excavate depressions in smaller gravel substrate, into which fertilized eggs are deposited. The depression, termed a "redd", is then covered with gravel as a new depression is excavated upstream. Eggs incubate in the gravel substrate and hatch approximately six to seven weeks after spawning, again dependent on water temperature. The young fish, with yolk sac still visible, may remain in the gravel of the redd for an additional week before emergence. At emergence the fry are from 2.5 to 4.0cm in length. By early fall (September) the fry have grown to 6.0 to 8.0cm.

The preferred habitat of fry at this point in their life history includes pools and other micro-habitats of relativity slow moving water, where the energy expenditure of swimming against the current is minimized. Fry have limited swimming ability and minimal reserves of energy to constantly negotiate higher velocity water in the main current of a stream. Pools, with low, or areas of no current velocity, coupled with overhead cover in the form of large woody material and overhanging riparian vegetation, plus large, instream substrates of cobbles and boulders provide excellent rearing and hiding cover (Rosenfeld et al 2000; Rosenfeld and Boss 2001).

By late summer/early fall, streams that have reduced current velocities and run clear, create optimal rearing conditions for young cutthroat trout.

Older age classes of cutthroat trout utilize more of the stream environment for resting, feeding, movement and hiding cover. Pools are still favored habitat and deeper ones, where depth is sufficient to allow over-winter survival (generally > 1.0m), are essential for the long-term persistence of the species. There is consistent use of low velocity habitat at the micro-habitat and channel unit scale for both juvenile and adult trout.

Micro-habitats for trout include small areas of little or no current velocity behind and beneath cobbles, small boulders, roots and root wads and undercut streambanks. Channel habitats are the areas of larger scale that include pools, large boulders, bedrock outcrops, log jams and instream woody material that also have low current velocities.

Benson (2019) studied Westslope cutthroat populations in Gold, Blairmore creeks (streams affected by proposed mining) and Daisy Creek (located on the north boundary of proposed mining operations). In summary, he concluded that: "Well connected, deep pools with suitable cover provided the best WCT [Westslope cutthroat trout] habitat during summer low flows. During winter, small WCT (< 20 cm) concealed and large WCT (> 20 cm) used pools for winter refuge. Summer habitat metrics (depth, area, geomorphology) in addition to seasonal changes in water temperature were drivers of large WCT presence-absence in pools during winter. Large WCT winter abundance in pools was further driven by water velocity, ice cover, and connectivity."

Generally, cutthroat trout have a high fidelity to specific stream sections and do not undertake extensive migratory movements, sometimes undergoing all of their life cycle within a few hundred meters of the site of spawning and overwintering pools (Young 1996). No movement studies have been undertaken by the proponent to identify the extent to which Westslope cutthroat trout (or other trout species) have seasonal movement patterns in either Gold or Blairmore creeks and between tributaries of these streams and the main stream.

A variety of land uses in the Eastern Slopes (and within the Oldman watershed) have profoundly changed the physical environment of native fish (Weaver 2013; Fitch 2015). The cumulative effect of human activities is now beyond the range of natural variation under which these species evolved. As an example, the amount of erosion-generated sediment from human activity now exceeds the natural range of variability by several orders of magnitude (Southern Foothills Study 2015).

The Alberta Chapter of The Wildlife Society commissioned a cumulative effects study of the Oldman and Bow watersheds to consider past, present and future land uses (ALCES, 2020). The results of this exercise indicate cumulative effects present substantial risk to Bull trout and Westslope cutthroat trout, now, in the

Southern East Slopes, including the Crowsnest River watershed. The cumulative effects exercise confirms that the linear footprint (i.e. roads/trails) and the spatial footprint (i.e. logging, mining, oil and gas extraction) require reduction and restoration, if threatened trout species are to be maintained.

Mayhood (2009), in assessing threats and limiting factors to cutthroat trout in Alberta, observed that these headwater tributaries are subject to a variety of negative land uses, the most notable being road/trail development and use.

As a consequence of population declines and loss of populations in several watersheds, Westslope cutthroat trout were listed as "Threatened" by Alberta in 2009 and in 2013 by the Government of Canada.

Headwater streams (and their tributaries) like Gold Creek are disproportionately important since they hold the last, remnant, genetically pure populations of Westslope cutthroat trout. Gold Creek is the last major tributary of the Crowsnest River that still contains pure-strain Westslope cutthroat trout (Alberta Environment and Parks, 2020a).

The recovery strategy for Westslope cutthroat trout has, as a primary objective: "To protect and maintain the existing ≥0.99[%] pure populations at self-sustaining levels and re-establish additional pure populations at self-sustaining levels, within the species original distribution in Alberta" (Fisheries and Oceans Canada 2014). Populations with less genetic purity (more introgression) as is the case with trout in Blairmore Creek, still rate as important since these form the basis of recovery efforts to improve purity through a number of strategies and expand the population, which is an integral part of species at risk recovery efforts (Alberta Westslope Cutthroat Recovery Team, 2013).

Precipitation, runoff and water quality:

A cautionary note to modelled responses to proposed land use impacts is provided in Beaulac and Reckhow (1982):

> "As watersheds shift from natural, undisturbed conditions to increasing levels of human disturbance, the ecological mechanisms controlling nutrient [and sediment] flux become more complicated and less

understood. Therefore the ability to accurately quantify or predict interactions between land use and aquatic conditions or responses becomes less precise and more uncertain."

Modelling work by the proponent to indicate the impacts on stream flow from mine operations asserts that changes will remain within the range of natural variability, at least as indicated from existing hydrometric records. Changes in runoff coefficients, under the ideal conditions advanced by the proponent, may not affect overall runoff volumes but will influence seasonality and rate of delivery to receiving streams. This has implications for continued survival of trout populations.

Surface mining results in higher streamflow and storm generated runoff (Sullivan, 1976; Collier, et al, 1970; Touysinhthiphonexay and Gardner, 1984), primarily because of compaction of mine spoils. Bare soils (overburden) have lower hydraulic resistance than soils with dense sod cover and produce double the overland flow and 10 times more sediment than spoils covered by topsoil alone (U.S. Forest Service, 1980c).

Waters (1995) concluded "Strip mining for coal generates the most erodible spoils" and is the largest single contributor of surface-mined spoils. Glancy (1973) found annual sediment yields of 218-2,670 tonnes/km^2 from mined areas; undisturbed areas yielded only 21-326 tonnes/km^2. Musser (1963) found that sediment yields from forested areas increased 1000 times as a result of strip mining.

Part of this sediment export is from roads. Unpaved roads are a major sediment source, increasing landslide erosion rates 10-300 times and sediment production rates an order of magnitude or more (Donahue, 2013). Unpaved logging roads, equivalent to mine roads, under heavy use (more than four trucks/day) generated 500 tonnes of sediment/road km/year, had a sediment production figure of 500,000 kg/ha and delivered 70,000 kg/ha of sediment/road (Cederholm, et al, 1980).

Plans to redirect overland flow with ditches beneath spoil piles into natural drainages are unclear on how water quality from such facilities will be dealt with. Like roads, these drainage ditches will collect runoff, redirect it, speed flow, increase erosion and result in the delivery of more water, laden with sediment, faster, to receiving streams. Because roads and ditches increase peak flows, all linear drainage features for mine operations and existing and new roads need to be assessed cumulatively, before it is asserted these will have no “significant hydrologic effect.” Linear disturbances (roads, trials, pipelines, drainage ditches) as measured as km/km^2 can be used as an indication of the potential impacts on fish and wildlife populations, and should have been considered for this initiative. A spatial footprint analysis would have helped to define runoff coefficients, but was not undertaken.

It is unclear how the proponent plans to follow the linear thresholds set out in the Livingstone-Porcupine Hills Land Footprint Management Plan (Alberta Environment and Parks, 2018), since mine roads are likely to be a major, chronic contributor to sediment delivery to streams.

Donahue (2013) provides a literature-derived review of watershed export coefficients, to assist in determining the impacts from a variety of land uses. There is no evidence this resource was used by the proponent to assess impacts from mining operations.

Although surface mining and timber harvest are not equal, both introduce watershed scale changes and information from logging impacts adds to the information base of probable impacts. Donahue (2013) reports that sediment exports from a logged watershed can increase by 150% for subsequent years and sustain sediment export up to 15 years following harvest (50% above pre-disturbance levels). The proponent asserts that logging will not affect hydrologic conditions. This needs to be re-examined in light of research available on the effects of timber harvest.

A meta-analysis of four snowmelt watersheds with moderate timber harvest levels (30-40%) demonstrated how logging increases the magnitude and frequency of all flood events, including the largest ones (Green, 2013). These effects increase, with increasing return intervals. This included 3-fold increases in the number and duration of peak flows. The increased frequency of floods included those capable of mobilizing bedload and altering the form of gravel bed streams. Flood regime changes were linked to increases in basin-average snow melt rates, amplified by aspect, elevation range, slope and amount of alpine area.

Surface mining, on a similar scale to logging might well produce similar results and significantly impact receiving streams and Westslope cutthroat populations.

The analysis to determine precipitation extremes, useful for settling pond design and assessing water quality issues in Gold and Blairmore creeks was based on four discrete time periods. None of these time periods included 2013, the year of upslope conditions, persistent heavy rainfall, significant flooding and extreme erosion rates in southern Alberta. It would have been useful to run the scenarios with actual data from 2013 (and/or extreme events of 1975, 1995, 2005) to understand whether the design criteria are reasonable for such an extreme event (s) and whether water quality issues from mine workings is possible and probable under such conditions.

In the analysis of extreme flow events and maximum probable floods the probability of multiple extreme rain storm events, close together and possibly coupled with rain on snow events does not seem to have been taken into account. This would influence the efficacy of sediment ponds and the impact of these flow events, coupled with substantial erosion from mine workings, on water quality in receiving streams.

The risk of failure of one, or multiple sediment controls and containment features, even if modelling suggests this is remote, needs to be assessed. This should have been done for all seasons and the implications for receiving waters and trout populations discussed.

It is unclear how sediment accumulation in sediment ponds would impact storage capacity, the ability to accommodate all flood flows and the ability of these ponds to reduce sediment outflow into receiving streams. It is also unclear on how sediment ponds are to be managed to deal with sediment accumulation, attenuation and eventual water release, including timing and monitoring to assure water quality parameters are met.

It is also unclear what the risk of mine spoil slumping, on steep slopes, and the probability of catastrophic mine spoil failure would have on sediment pond efficacy and the impact on downstream water quality. The following are examples of systems failures despite use of engineering standards to design and build containment structures:

In the early 1970's a spoil dump failure and landslide on Coleman Collieries Tent Mountain coal strip mine completely covered the downstream portion of East Crowsnest Creek. The company was charged under the Federal Fisheries Act and found guilty of negatively impacting trout habitat. Mitigation included the construction of a sediment pond, to deal with continued erosion from the spoil pile (Duane Radford, former Regional Fisheries Biologist, pers. comm. 2018).

I conducted a physical habitat and biological survey of East Crowsnest Creek in 1976, part of an overall inventory of the Crowsnest watershed (Fitch, 1977). At that time the sediment pond had completely filled with eroded material from the mine workings and was a flow-through system, without any capacity to slow, accumulate or mitigate sediment from the spoil pile. It is unclear how long after the spoil pile failure occurred that the sediment pond was constructed, but it could not have been in operation for more than two to three years. Ostensibly, the design of the pond was based on contemporary, or best engineering principles.

As part of stream inventories in the Crowsnest River watershed, monthly water samples were collected from Crowsnest Creek (two locations), East Crowsnest Creek and Ptolemy creeks between April and October, 1976 (Fitch, 1978). Crowsnest Creek was affected by the haul road from the active Tent Mountain strip mine and East Crowsnest Creek, a tributary stream, was impacted by mine overburden disposal into that watershed. Ptolemy Creek, another tributary, had no mine-related disturbance.

Crowsnest Creek and East Crowsnest Creek, both affected by mine operations had elevated turbidity and Total Dissolved Solids levels, compared to Ptolemy Creek, unaffected by mining operations (Table 1). Physical habitat measurements found the mean percentage of sand/silt as a substrate type was substantially elevated in both Crowsnest and East Crowsnest creeks, compared to Ptolemy Creek with no mine-related disturbances.

Table 1. Comparative water chemistry and substrate type between mine-affected and unaffected streams- Crowsnest Creek watershed

Stream/sampling station	Turbidity (JTU)	Total Dissolved Solids (mg/l)	Mean % sand/silt
Crowsnest Creek #1	4±2	275±41	17
Crowsnest Creek #2	18±36	203±54	
East Crowsnest Creek	2.9±4	265±19	17
Ptolemy Creek	1±0.6	160±38	<1

Coal strip mines in the Coal Branch to Grande Cache have had similar sediment pond failures, the latest being the Obed Coal mine pond failure of 2013 that discharged massive amounts of sediment into Apetowun Creek, a tributary of Plante Creek, itself a tributary of the Athabasca River, and affected a long reach of the Athabasca River as well (Carl Hunt, retired Fisheries Biologist, pers. comm. 2018, and Agreed Statement of Facts-Provincial Court of Alberta-Between Her Majesty the Queen and Prairie Mines and Royalty ULC).

The owner of the mine, Prairie Mines and Royalty was ordered, in a subsequent provincial judgement, to fund a "dam safety research project" related to coal mine water storage. The dam safety research being conducted by the University of Alberta as a result of the creative sentencing is ongoing and will conclude September, 2021 (G. Neilson, Alberta Energy Regulator, pers. comm. 2020). The authors of the research proposal (Wilson and Beier, 2017) point out:

> -there has been minimal consideration of the long-term behavior of dams for coal and oil sands mines;
>
> -few tailings dams have been fully reclaimed and little is understood about the aging process, or failure modes they are subject to over time; and,
>
> -little is known about their performance long-term with respect to erosion and/or extreme storm events.

In a period from 1982 to 1993 five coal strip mines were monitored in the Coal Branch on a regular basis: Coal Valley at Robb on the Lovett River; Cardinal River Coal at Cadomin on the Macleod River; Greg River Resources at Cadomin on the Macleod River; Smoky River Coal at Grande Cache on the Smoky and Muskeg rivers; and Obed Mountain Coal in the Athabasca River watershed (Richard Quinlan, retired Fish and Wildlife Habitat Protection Biologist, pers. comm. 2020). In that time period there were a minimum of 22 serious incidences of sediment release, 12 of which were forwarded for charges under the Federal Fisheries Act (one case went forward as a prosecution). These resulted from settling ponds insufficient to contain sediment-laden runoff resulting from heavy rainfall events as well as chronic levels of erosion from coal haul roads.

In the case of Cardinal River Coal, heavy rainfall around September 1, 1983, caused a settling pond to fail, the collapse of a mine pit and a haul road failure resulting in the inundation of Mary Gregg Creek, a stream containing Athabasca rainbow trout (now designated as “Endangered”), with sediment. Sediment from those sources filled the channel of the stream to the bank full level and into the riparian zone (1.0 - 1.5 meters deep) for approximately 400 hundred meters downstream. The impact on the Athabasca rainbow trout population was a long-term population decline affecting not just the section of stream inundated with sediment, but downstream as well (Carl Hunt, retired Fisheries Biologist, pers. comm. 2020).

In the case of Smoky River Coal, the topography of the mine site, on very steep slopes, resulting in chronic erosion problems with every rainfall event. These coal mines in mountainous terrain were noted to have had slope stability issues, insufficient space to build settling ponds capable of containing runoff and inadequate planning for heavy and catastrophic runoff events, all leading to chronic erosion and sediment delivery to receiving streams.

A cumulative effects analysis of the Elk Valley, BC, just west of the proposed Grassy Mountain mine site concluded “mining disturbance likely contributes the most intense hazard” to aquatic ecosystems (Elk Valley Cumulative Effects Management Framework, 2018). Cope (2016) noted three major habitat concerns for native trout populations in the Upper Fording River, BC, as a consequence of coal mining activity: water quality, loss of tributary habitats and stream channel degradation. Teck Resources (2019) provided information on the impact of their coal mining operations on native Westslope cutthroat populations in the Upper Fording River, in proximity to several coal mines. Adult Westslope cutthroat populations had declined 93% (76.3 fish/km to 8.6 fish/km) and fry and juvenile trout populations had declined 74% (13.38 fish/100m^2 to 3.9 fish/100m^2), compared with 2017 population estimates.

The Independent Expert Engineering Investigation and Review Panel (2015), in an analysis of the Mount Polley mine tailings pond failure, undertook a review of failures in BC tailings dams. They found a historic failure frequency of 1.7X 10^{-3}/ dam year. The risk of a tailings pond dam failure was estimated at two failures in ten years and six failures in 30 years. Their blunt summary of the risk of tailings pond dam failures was: “It is axiomatic that nothing in engineering or in life, can be assured with 100% certainty.”

The assertions of the proponent that water quality issues from mining operations will not impact downstream reaches containing Westslope cutthroat trout seem to be based on best-case scenarios that assume everything works as planned, designed, constructed and maintained. There seems to be no consideration of the reality of human error, negligence, design flaws, unanticipated issues (especially weather events), engineering constraints, construction problems, maintenance failures and ineffective monitoring that fails to discern problems in a timely way.

Even more uncertain is the impact of mining operations on ground water flows. Power, et al (1999) indicate that changes to ground water flow, especially less flow back into a receiving stream means more ice formation (frazil and anchor ice). Brown and MacKay (1995) link higher winter stream temperatures with less development of ice formation, summarizing that groundwater influenced stream reaches provide thermal refuges for overwinter survival of trout.

For the unanswered questions, adaptive management seems to be the fall-back position. This assumes there are options available that are tested, timely, effective and the proponent is able (and willing) to take on additional economic burdens to affect these additional mitigative solutions.

What is more likely is periodic, chronic, catastrophic and cumulative sediment additions to receiving streams, as is the experience from other Alberta mountain coal mines (and from mines in BC). The following is a review of the issues that could be faced and the possible impacts on Westslope cutthroat trout.

Habitat and Water Quality issues:

The persistence of native fish species like Westslope cutthroat trout requires several habitat parameters to be met. Spawning substrates of suitable gravels free of sediment are required. Appropriate stream flow and ground water recharge, especially during the stage when eggs are incubating in the substrate is essential. Low velocity, micro-habitats to minimize energy expenditure are necessary for rearing habitat for juvenile fish. Overwintering pools of substantial depth allow fish to successfully survive winter conditions of reduced stream flow, ice cover and physical blockages to movement. As well as overwintering pools, winter flows need to be sufficient to allow all age classes of trout to successfully find appropriate habitats. These are "critical" habitats necessary for the survival or recovery of a listed species.

Water temperatures cannot exceed, for lengthy periods, the upper thermal thresholds for the species. Water temperatures are moderated by ground water capture during spring melt and subsequent rainfall events. Water stored as shallow ground water eventually reaches the stream, is cooler than stream water and reduces stream temperatures in summer. In winter, groundwater temperatures are higher than stream temperatures, moderating ice formation and facilitating overwinter survival. Overhanging riparian vegetation shades the stream surface from direct sunlight and moderates summer stream temperatures.

Riparian vegetation is also a source of terrestrial food items and tends to "glue" stream bank materials together, maintains cross sectional profiles of narrower, deeper stream channels and makes the system more resilient to erosion and mobilization of sediment. Riparian areas (the near-shore band of vegetation) also constitute critical habitat for trout species.

Sediment or "fines" is categorized as sand, silt or clay of an organic or inorganic origin. Turbidity is the optical property of water which results from suspended and dissolved minerals in water. Measurements of turbidity estimate the amount of sediment in a sample of water and are usually described as Nephelometric Turbidity Units (NTU). Suspended sediment is the amount of mineral or organic particles transported in the water column and is described as milligrams/liter (mg/l). Deposited sediment refers to those intermediate particles that settle out of the water column on the stream bed under conditions of slower water velocity (Canadian Council of Ministers of the Environment 2002).

Sediment, the product of both natural erosion and human sources, is a major limiting factor to native fish populations. Suttle et al (2004) showed increasing amounts of sediment decreased growth and survival of juvenile trout. The authors concluded that there is no threshold below which sediment levels are harmless to trout, but that any reduction provides benefits.

Much (2010) summarized the effects of sediment on trout. Sediment can be lethal, leading to direct mortality. It can have sublethal effects which are characterized as reductions in feeding and growth rates, decreases in habitat quality, reduced resistance to diseases, respiratory impairment and physiological stress. The result can be delayed mortality and population decline over time. Sediment can result in behavioral shifts, a change in activity patterns, altered types of activity or a change in habitats used. These behavioral shifts may also lead to delayed mortality and population decline over time.

Removal of riparian vegetation (i.e. trees and shrubs) decreases overhead cover, important to moderate water temperatures within the tolerance limits of trout. Overhanging and adjacent riparian vegetation is also an important contributor to trout food, in the form of terrestrial insects. The root mass of riparian vegetation, especially of trees and shrubs, acts to bind substrate materials together making stream banks more resistant to erosion and creating overhanging banks, beneath which trout find useful and essential habitat (Fitch et al 2001; Fitch and Ambrose 2003). Stream banks lacking riparian vegetation are more susceptible to erosion and are less resilient, in terms of natural recovery from flood events.

Caskenette, Durhack and Enders (2020) provide guidance on critical habitat that is relevant for Westslope cutthroat trout. The authors, based on extensive reviews, provide an inclusive definition of critical habitat. The authors point out, "Performance of the riparian zone is often dependent on the state and use of the upland areas. Although the science advice in this document pertains to Critical Habitat associated with the riparian zone, it is important to note that identifying riparian Critical Habitat will not mitigate threats to upland areas. Some upland areas may also be disproportionately important in maintaining attributes of aquatic Critical Habitat features, and therefore warrant protection."

Also, “riparian habitat should be considered as Critical Habitat if impaired riparian performance affects aquatic habitat quality or water quality in a way that negatively impacts the survival or recovery of a species at risk.” Wider riparian zones should be acknowledged as critical habitat when they are necessary to maintain those aquatic features identified as critical habitat, and are necessary to maintain water flow and quality upstream of critical habitats.

Lastly, the authors’ review of Westslope cutthroat trout habitat concludes that, “this suggests the width of the meander belt should be considered as Critical Habitat. Due to its mountainous habitat, for Westslope Cutthroat Trout, slope in the remaining floodplain will determine the extent of the riparian features to be considered Critical Habitat, with sediment and vegetation playing lesser roles. Where slope is greater than 8%, the entire floodplain to the upland ledge will need to be protected to control erosion. Features that hold water and allow for infiltration (e.g., dense vegetation, wetlands) within the groundwater recharge area should be considered Critical Habitat to maintain areas of upwelling. In addition, riparian features adjacent to upstream habitat of aquatic Critical Habitat may be considered Critical Habitat to protect water quality, level, and flow. Finally, riparian habitat adjacent to migration and movement corridors connecting aquatic Critical Habitat may need protection to ensure water quality and flow.”

This analysis of what constitutes “critical habitat” for Westslope cutthroat trout indicates the essential features required for trout population survival, maintenance and recovery exist at a watershed scale, not simply near-stream (within 30 meters) and instream attributes.

The effects of sediment on the aquatic environment:

The effects of deposited sediment on the physical habitat of trout include: the infilling of interstitial spaces between substrates of gravels, cobbles and larger materials, which reduces and/or eliminates the spaces essential for aquatic invertebrates (trout food) and for juvenile trout to rear and to find overwinter cover; the cementing of larger substrate together which creates problems for spawning fish, eggs incubating when flows through the gravels are blocked and inability of fry to emerge; and, reductions in water depth in pools, including loss of pools and instream cover, which decreases the physical space available for juvenile and adult fish for critical rearing times and for successful overwinter conditions (Waters 1995). Sediment accumulating on the surface of substrate materials has been shown to have a smothering effect on trout eggs and young fish as well as aquatic invertebrates.

The infilling of the interstitial spaces between larger substrate materials precludes use by aquatic invertebrates, the primary source of food for trout (Hynes 1970; Lemly 1982). This is especially so for species of mayflies (*Ephemeroptera)* and stoneflies (*Plecoptera)* which show declines in other streams in the Oldman River watershed as sediment generated from a variety of land uses increases and coats cobble and gravel substrate materials.

Limestone and shale-dominated bedrock in the Canadian Rockies create water chemistry conditions that promote streambed calcite accumulation. This natural phenomenon is intensified downstream of surface coal mines in the region due to extreme supersaturation of CO_2 and calcite passing through rock spoil (Ford and Pedley, 1996). This results in concretion (embeddedness) of stream channels and substrate. Lemly (2019) noted the potential for a major problem of calcite deposition, as a result of coal cleaning from the proposed project. Calcite, he notes, "coats the stream bottom and, in effect, turns it into cement that is uninhabitable to invertebrates that form the basis of the aquatic food chain and also eliminates the loose gravels necessary for successful fish spawning."

Excess sediment, beyond the range of natural variation, results in increased embeddedness of cobbles and gravels, filling in the interstitial spaces. The problem of embeddedness has been investigated by Bjornn, et al (1974) and McClelland and Brusven (1980) as well as being reviewed by Chapman and McLeod (1987). An embedded substrate, "cemented" together with sediment particles can prevent trout from spawning, make spawning actions, such as the excavation of "redds" or depressions into which eggs are deposited extremely difficult and interferes with the movement of water through the substrate, essential for maintaining an oxygen flow to the incubating eggs and removing metabolic by-products.

Kuchapski (2013) found impaired aquatic invertebrate communities that related to influences from surface coal mining. Aquatic insect communities, generally reflective of healthy aquatic ecosystems declined in abundance, richness and diversity as a consequence of multiple stressors (physical and chemical) resulting from mining operations.

An embedded substrate is also resistant to movement and scour by regular flood flows, increasing bank erosion as a consequence. This would mean that even if stream flows under normal flood events and extreme ones do not increase under the influence of mine operations, increased stream bank erosion may well be a consequence.

In an undisturbed-disturbed watershed pair, Hawthorn (2014) found the disturbed watershed (Smith Creek- a South Racehorse Creek tributary) had over 2.5 times the amount of entrained (embedded) sediment compared to an undisturbed watershed (Star Creek- a Crowsnest River tributary). To a degree the watersheds of Gold and Blairmore creeks are already impacted by legacy mine workings and other land uses. The thresholds for embeddedness in these streams may already have been exceeded, without additional sediment from proposed mine operations.

Observations from other coal mining areas in the province indicate this is an issue for trout and aquatic invertebrate populations, originating from crushed mine overburden (Carl Hunt, retired Fisheries Biologist, pers. comm. 2018). The risk of increased sediment loading, especially from calcite-rich mine spoil leading to higher degrees of embeddedness is not dealt with in any of the predictions and assumptions provided by the mine proponent. Without a robust review and risk assessment, based on case studies and research from other coal mining areas in Alberta and adjacent jurisdictions, this is a significant gap in understanding the implications of mine operations on trout and aquatic invertebrates.

Cederholm et al (1980) noted a rapid decrease in survival to emergence for trout for each 1.0% increase in sediment amounts over natural background levels. The authors found survival of trout eggs is inversely correlated with percentage sediment, when the percentage of sediment exceeds natural background levels by 10%.

Weaver and Fraley (1991) showed there is a strong relationship between sediment in the trout egg incubation environment and ultimate fry emergence success. They noted, for Westslope cutthroat trout, that sediment from road/ trail building and use reduced trout embryo survival to emergence and negatively impacted rearing, once trout have emerged.

A study on the effects of sediment addition to streams containing trout and salmon showed substantial decrease in fish densities (Klamt 1976). Sediment additions to pools decreased pool volumes affecting available habitat and fish densities decreased. Similar results were found for riffle habitat. Sediment filled interstitial spaces, increased the degree of embeddedness, forcing trout and salmon into less optimal habitats. In channels with natural background levels of sediment few territorial interactions were observed between fish. Trout and salmon densities decreased over winter with higher sediment loads; this was attributed to sediment decreasing optimal cover conditions (blanketing large substrate) and decreasing the ability of juvenile fish to burrow into substrate materials.

Severity of sediment effects on trout:

Several researchers have compiled information on the effects of sediment on adult and juvenile fish and determined, from a dose response (concentration of suspended sediment, and the duration of exposure), the scale of severity. For example, Newcombe and Jensen (1996) and Newcombe (2003) provide an ascending scale of severity from a nil response, through behavioral impacts (i.e. alarm, abandonment of cover and avoidance) to sublethal impacts (i.e. reduction in feeding rates/success, minor to major physiological stress and habitat degradation) to lethal impacts (i.e. reduced fish density and mortality).

Using information from a variety of sources Newcombe (2003) and Birtwell et al (2008) assembled criteria for aquatic resource protection for the Pacific and Yukon Region of Fisheries and Oceans Canada. Risk of significant impairment to fish and their habitat was categorized with suspended sediment concentrations (mg/l) and turbidity levels (NTU). Generally, the risk to trout populations and their habitats is minimized when suspended sediment concentrations are below 100mg/l and turbidity levels less than 25 NTU, especially if the levels do not persist for more than a few hours. Risks to adult fish are less than those to juvenile fish and levels below 100mg/l and 25 NTU can still provide levels of impairment to young fish. However, lower suspended sediment concentrations for extended periods produce many of the same effects as high suspended sediment concentrations for brief periods.

Suttle et al (2004) showed increasing amounts of sediment decreased growth and survival of juvenile trout. The authors concluded that there is no threshold below which sediment levels are harmless to trout, but that any reduction provides benefits.

There is no evidence for the proponent's assertion that historic, or legacy coal mining has had no adverse impact on trout habitat. Since there are no pre-disturbance fish population estimates there is no benchmark from which to measure impacts and assess older coal mining activity. However, to suggest erosion of sediment from un-reclaimed overburden piles from the legacy Grassy Mountain strip mine and from un-reclaimed haul and exploration roads, plus partial infilling of some of the tributary valleys as well as coal fines from earlier underground mines have had no impact on the aquatic environment and trout populations is untenable.

Physiological impacts to trout from mining operations:

Trout have sense receptors including inner ears. There is no need for external ears since the density of water is similar to the body density of trout and sound passes easily to an inner ear. Trout also have a lateral line system which is a complex sensory mechanism that detects movement, slight pressure changes and changes in water quality, like increasingly turbid water from sediment addition (Frost and Brown 1967). The nature of movement of sound in water is that sound travels about five times faster and farther than in air (Behnke 2002). Trout would react to the stimuli produced by loud noise, wave action and sediment plumes, especially juvenile fish which would have had no exposure to the type of disturbance created by blasting to remove overburden.

Trout displaced from their habitats by noise, disruption and sediment are disadvantaged in finding alternative refuges, because these may already be occupied by other trout. Miller (1958) showed that competition between stocked and resident trout caused high mortality of stocked trout when these fish were attempting to adjust to a stream environment with suitable micro-habitats already occupied by resident trout.

Mortality of stocked trout was due to exhaustion, the inability to find suitable cover to avoid swimming constantly in the current. The analysis of superimposing stocked trout, even ones relocated from other stream sections, on a resident population essentially duplicates the effect on trout displaced by human activity into areas of sub-optimal habitat, or into habitats already occupied by other trout. It is the biological equivalent of "musical chairs" where, when the displacement occurs, some trout cannot find a suitable place to occupy.

Trout are territorial animals, a result of resource partitioning to divide up food resources and the most suitable aquatic habitats to exploit those resources. Trout displaced into occupied habitats are subject to aggressive, defensive behavior on the part of existing fish (Mills 1971). This increases energy expenditure, especially for juvenile trout which have the least ability to expend energy by swimming in areas of higher current velocity and where micro-habitats are denied them by occupying, resident trout. Displaced trout would also be forced to move into sub-optimal stream sections where suitable niches of low water velocity are unavailable.

Miller and Miller (1962) found five to 15 minutes of experimental exercise (substantially duplicating the aggressive, territorial behavioral response between resident and stocked trout) elevated blood lactic acid content two to five times over resting levels. The trout in the experiment were 1.5 years old and of a larger size (with greater energy reserves) than juvenile cutthroat trout would be in either Gold or Blairmore creeks. The net effect is exhaustion and death for displaced trout fry attempting to find suitable micro-habitats or pools with little or no current velocity.

Wysocki et al (2006) found anthropogenic noise that was characterized by amplitude and frequency fluctuations constituted a potential stressor to fish. The authors measured the effect of noise on adrenal activity through increased cortisol secretion. Cortisol is released in response to stress. Cortisol has detrimental effects on growth, sexual maturation and reproduction, immunological function and survival in fish. The authors concluded noise can alter the behavior of fish and have a long term or indirect consequence on the behavior, fitness and ecology of fish species.

Graham and Cooke (2008) studied the effect of noise on the cardiac physiology of a freshwater fish species subject to variable noise levels, including from motorboats. Increased cardiac output indicates an elevation in metabolic requirements and is a sensitive measure of a fish's response to stimuli. The level of change in cardiac response in the experiment was greatest with the combustion engine treatment from a motorboat and the length of time for cardiovascular variables to recover was also with the motorboat treatment. The authors showed that fish experience sublethal physiological disturbances in response to noise and the greatest disturbance was from motorboat activity. The study exposed fish to abrupt noise followed by silence, similar to what trout in Gold and Blairmore creeks will experience with periodic traffic and blasting. This will elicit a flight response, with elevated cardiac output, which will be repeated multiple times over the course of daily mine operations. The authors (Graham and Cooke 2008) concluded if cardiac output remains elevated for extended periods this would conflict with other metabolic processes (i.e. growth, digestion, movement) and fish could succumb to metabolic-rate-dependent mortality.

Stress is cumulative. Sigismondi and Weber (1988) found that fish subjected to two or more stresses had less tendency to respond to a stimulus and required longer recovery times than fish stressed only once. In the experiment, stressed fish took longer to reach cover, with the greatest delay in response occurring immediately after the stress. When stress reduces the ability to seek cover, this decreases a fish's chances to survive. Trout in the Gold and Blairmore watersheds will be subject to multiple, repeated stresses as a consequence of mine operations.

Exposure to suspended solids (sediment/turbidity) is an environmental stressor that elicits a physiological response. Redding et al (1987) found exposure of yearling trout and salmon to suspended sediment increased cortisol levels, an indicator of stress. The authors indicated trout and salmon underwent sublethal physiological stress that reduced performance capacity related to obtaining food and resisting disease. The effect of relatively low turbidity levels or suspended sediment amounts ranges from stressing fish, altering behavioral patterns, to mortality (Lloyd 1987). Sediment plumes from fugitive releases, unanticipated sediment pond releases, and as a consequence of extreme flow events coupled with high erosion will cause stress (suspended feeding, displacement, exhaustion) to trout in the Gold and Blairmore watersheds.

Stress in fish results in extra energy costs and demands. Stressed fish have less energy available for necessary activities, such as swimming stamina and this would be particularly true for juvenile trout in the Gold and Blairmore watersheds. Recovery from stress can take variable periods of time and, when exposed to multiple stresses (or repeat stresses), require longer recovery periods (Sigismondi and Weber, 1988; Barton, et al, 1986). This comes at the expense of body maintenance and growth, especially for juvenile trout (Frost and Brown 1969). Diverting energy to deal with stress reduces fitness of individuals and this has severe implications for survival.

There is no evidence the proponent has considered the additive impact of physiological stress to trout from mining operations.

Review of mitigation strategies and efficacy of mitigation/compensation plans:

One of primary goals of mitigation is to compensate for trout and habitat losses with a goal of no net loss of existing populations and a net gain through recovery actions to ensure Westslope cutthroat trout populations continue to persist into the future, with assurances of resilience to natural and anthropogenic disturbance.

Harper and Quigley (2005) reviewed progress and made several observations and conclusions about mitigation effectiveness. They found uncertainty on fish-habitat linkages with the consequence being that the goal of no net loss was largely not being met. Only 14% of proponents complied with mitigation plans, there was inadequate record keeping, a lack of standardized approaches to measure mitigation effectiveness and a general lack of monitoring, or monitoring that was of too short an interval to effectively demonstrate trends towards meeting no net loss goals. It brings into question whether effective mitigation and compensation strategies are being employed to deal with impacts on fish and their habitats. This should form a cautionary note to any review of proposed mitigation strategies.

The design of mitigation strategies is best accomplished with a full appreciation of cumulative habitat changes and risks to the Westslope cutthroat trout population. The mitigation strategy proposed by the proponent only deals with some of the estimated and predicted changes, not a true cumulative loss matrix. The strategy does not seem to deal with legacy mine workings, motorized recreational use, linear features, angling, residential development, logging (past and future), petroleum development, grazing and wildfire as contributors to cumulative effects.

Unmentioned, in the proponent's assessment of cumulative impacts is the historic loss of Bull trout from the lower section of Gold Creek, and from Blairmore Creek. One native salmonid species has already been extirpated from the upper Crowsnest watershed, a cumulative function of coal mining, dams, urban development, road and railway construction (Fitch, 2012). Additionally, there is no mention of the threat of Whirling disease, already found in the Crowsnest River watershed (Alberta Environment and Parks, 2020b) and the implications to Westslope cutthroat trout persistence in Gold Creek.

If the metric is to maintain habitat conditions within 10% of the range of natural variation, then a cumulative effects assessment needs to consider all these other perturbations to determine if a critical threshold is being approached, without the addition of the new mine operation, and if a threshold has already been exceeded.

Pattenden, et al (1998) summarized the results of five years (1991-1996) of research on instream habitat structures in southwestern Alberta, and provided information on the efficacy of these stream habitat improvement devices. The short-term performance of 351 instream structures, in place between two and seven years and subject to less than a 1:6 flood flow was investigated. Under those conditions, 63% of the structures were found to have maintained their physical stability, or had minor flaws. Sixty one percent of the structures provided the design and desired deep-water refuge fish habitat.

This information was re-analyzed to determine relationships between structure performance and fluvial and hydraulic characteristics using information in Fitch, et al (1994). This investigation concluded that structures tended to perform better in stable channels with low rates of bedload transport.

Following a sizeable flood in June 1995 (≥100-year return period) a subset of the original structures was re-evaluated (R. L. and L. and Miles, 1996). Eighty one percent of the sampled structures had been severely damaged or destroyed due to processes of general and local scour, sediment deposition and/or channel shifting. Of the structures that were still intact, only 31% provided the desired deep-water habitat of the original design.

The results indicated that many instream habitat structures built in southwestern Alberta were subsequently degraded by small flood events, and most did not survive a sizeable flood. In several cases, normal bed load movement simply filled in the deep-water habitat. Streams with higher gradients and subject to flashier flow regimes due to proximity to mountain slopes had the highest structure failure rates.

Instream habitat structures provided short-term benefits, but even with appropriate design and location require regular maintenance and rebuilding to be effective under conditions of minor flood events. It is unlikely that the proponent's claim such structures will be "self-sustaining", not requiring any scheduled maintenance, has credence.

A conclusion of the research indicated instream habitat structures, such as those proposed by the proponent for creating overwinter habitat, tend to be ephemeral and do not provide useful trout habitat over the long-term. The value for long-term mitigation purposes (over the active life of a coal mine and beyond) is questionable.

There are physical limits to the amount of instream habitat a river or stream is capable of maintaining, throughout a variety of fluvial processes. While deep water habitat (i.e. overwintering pools) is viewed as a limiting factor to stream-dwelling trout and hence an increase in this habitat type is regarded as a way to bolster trout populations, there are limitations. In an alluvial system, pools occur with a size and frequency that is dependent on the meander wave-length, which in turn is a property of the hydraulic regime (Bray, 1982). These relationships cannot be changed and attempts to manipulate this relationship, for example by attempting to increase the number of wintering pools, have a high probability of failure.

As a fundamental step in stream habitat enhancement planning candidate reaches for habitat enhancement need to be evaluated for channel stability and classified, by stream type, to assess the suitability of proposed fish habitat structures for various channel types. Rosgen (1996) provides a stream reach classification system as well as a way to evaluate the suitability of habitat enhancement structures. There is no evidence the proponent has undertaken this fundamental step in mitigation/compensation planning.

While some research indicates that, in some circumstances, instream habitat enhancement can increase fish production (Ward and Slaney, 1981; Ward, 1993) there is increasing evidence that structural measures alone do not necessarily improve fish production. Monitoring of trout population responses to instream habitat structures to mitigate habitat losses from the Oldman River Dam have not demonstrated significant, increased trout production (O'Neil and Pattenden, 1994).

Riley and Fausch (1995) documented an increase in fish numbers and biomass in enhanced sections of six northern Colorado streams. However, the authors suggested that the success was related more to the movement of fish into structures from adjacent areas, rather than an increase in fish production (i.e. growth or survival). Gowan and Fausch (1996) found when pool habitat was artificially added to streams, abundance and biomass of large trout increased, but, again, immigration from other stream segments was the primary reason for the increase. Cunjak (1996) pointed out that stream habitat enhancements can have deleterious effects on salmonid populations if water conditions are not considered. Simply increasing the number of chairs (wintering pools) increases the movement between chairs but does not increase the number of players (trout) or necessarily create the opportunity for enhanced trout populations.

It is assumed, by the mine proponent, that overwintering pools are the primary limiting factor for the Westslope cutthroat populations in the Gold and Blairmore watersheds. This is an over-simplification of the complex inter-relationships between the physical environment and the biological organisms that inhabit that environment. Without a solid understanding of all of the biological limiting factors, or a sound basis for predicting the outcomes of proposed habitat manipulation, the mitigation program may well produce no significant, positive impact on trout populations, let alone equitable compensation for habitat losses.

Benson (2019) inventoried 253 pools on Gold Creek (as well as similar inventories on Blairmore Creek). Of the 253 pools identified, 47 were sampled and 33 were found to contain overwintering Westslope cutthroat trout. There is no evidence the proponent has used this information to determine how many of the 253 pools on Gold Creek would constitute overwinter habitat and thus establish if such habitats limit the population of Westslope cutthroat trout. Hatfield (2018) identified six wintering pools in 2016; surveys in 2017 and 2018 added 18 additional wintering pools. This indicates the difficulty of concluding, from limited investigation, the actual number of wintering pools in Gold Creek and the degree to which this habitat feature limits the trout population.

The establishment of additional riparian habitat, through vegetation replanting, as compensation for mine-related habitat losses is, at best, a theoretical gain. The experience of riparian restoration to compensate for riparian vegetation losses incurred by construction and operation of the Oldman River dam showed the problematic nature of this technique. There was very poor plant reestablishment success and only a small fraction of the losses in riparian habitat were compensated for, despite massive planting efforts, with multiple plant species, and maintenance for several years following initial work. Restoring riparian vegetation, especially on sites compromised by present and previous land use activities, with existing invasive plant establishment, compacted soils, poor soil development, unstable stream banks and a lack of shallow ground water is a herculean task, fraught with failure.

The lack of movement studies for Westslope cutthroat trout, for spawning and overwintering purposes, makes it difficult to assess the implications and risks of settling pond locations on trout populations, especially in headwater reaches of Gold Creek. Benson (2019) noted the prevalence of gravels suitable for trout spawning were greater in headwater sections of Gold Creek. The location of one of the settling ponds upstream of noted trout spawning sites provides substantial risk to the Westslope cutthroat population. The lack of trout movement studies also makes it difficult to assess the efficacy and utility of tributary stream enhancement, part of the proposed compensation program.

The mitigation strategy to eliminate threats from non-native species needs more explanation to discern how Westslope cutthroat populations would benefit. A more fulsome review of the Quirk Creek, Alberta example is necessary to understand if non-native brook trout were effectively, permanently suppressed with removal techniques and if the effect was positive for Westslope cutthroat trout in either the short or long term. At the present time there is not an unequivocal answer to this restoration technique and it is unlikely to be a viable mitigation option.

Alberta Environment and Park’s Cumulative Effects Assessment methodology, better known as the “Joe” Model, would have been a useful tool to apply to mitigation strategies for Westslope cutthroat trout. If dose response curves had been generated for all of the known limiting factors to the trout populations in Gold and Blairmore creeks, then the proponent would have been able to test assumptions to determine priorities, or best options, for mitigation/compensation. This was not undertaken by the proponent.

There is no reference to the likely time step between habitat losses from mine operations and the onset of effective, compensatory mitigation. If declines in trout populations are the trigger for mitigation, or compensatory actions, this assumes the trout population benchmarks are robust enough to signal changes, the changes are outside of natural population level fluctuations and the cause of the declines are easily and quickly discerned so effective actions can be taken.

Determining a metric for population levels in Gold Creek is hampered by limited population estimates. Hatfield (2018) found 0.04 to 1.69 trout/m^2 in snorkeling surveys, 0.24 to 13.13 trout/m^2 in mark/recapture surveys, while Benson (2019) found 0.17 trout/m^2 in 2016 and 0.15 trout/m^2 in 2017. This wide variation in population estimates indicates the difficulty of setting a population threshold as a trigger for mitigation actions, especially when the natural range of variation in trout populations is unknown.

Mortality of trout as a consequence of stress and impacts from mining operations is highly probable, although it is often very difficult to find moribund or dead fish without a concerted search effort, especially if mortality is delayed. The thing about fish mortality is it is not completely predictable and does not happen according to some recipe. All the fish usually don't die at once; instead they disappear as a consequence of reduced fitness, lack of spawning success, reduced habitat and an inability to survive winter conditions.

Unfortunately, population declines are rarely dramatic, unless there is a catastrophic event like a settling pond failure, and by the time this, and lesser perturbations are discerned, it may be too late to take effective, corrective actions. The impact of a catastrophic event has not been anticipated by the proponent, nor has there been consideration of a contingency program to deal with trout population and habitat losses.

The likelihood of mitigation success is based on several assumptions, most of which are unaccounted for by the proponent:

-all cumulative effects, from proposed mining operations, legacy mining and other land uses (past, present and future) have been factored into mitigation planning.

-mining operations will not impact Westslope cutthroat trout populations through changes to water quality, sediment loading, instream flows or ground water.

-mine operations, coupled with other land uses, may affect water temperature regimes in Gold and Blairmore creeks and this has been incorporated into mitigation planning.

-habitats created or improved represent ones that form critical, limiting factors and that these habitats are not already present in either Gold or Blairmore creeks.

-Gold and Blairmore creeks are not at population carrying capacity and habitat enhancements will increase abundance and biomass.

-stream productivity (benthic and terrestrial insect production) will not be a limiting factor beyond a certain trout population size.

-habitats created or improved will persist over long periods of time to permanently benefit Westslope cutthroat trout populations.

-habitat created or improved will not disproportionately increase non-native trout species (i.e. brook trout, rainbow trout or rainbow/cutthroat trout hybrids) to the detriment of native, pure-strain Westslope cutthroat trout.

-changes in ground water and instream flows do not negate any habitat enhancements.

-the cumulative effects of the mine operation, including other land uses, and any unforeseen impacts (e.g. climate change, increased frequency and intensity of floods, wildfire, settling pond failures, landslides from spoil piles) will not negate habitat and population gains.

-that there is an accurate, multi-year estimate of Westslope cutthroat populations, including the range of natural population fluctuation, within Gold Creek, that forms a benchmark, against which effects of mining operations and the efficacy of any mitigation/compensation can be measured.

-Westslope cutthroat trout abundance, distribution and biomass increase and not because of a shift in population usage of created habitats.

-non-native trout removal is a realistic, long term mitigation option.

-salvage of Westslope cutthroat trout from tributary streams and some stream sections will enhance other populations and not result in competitive overlap for habitat, to the detriment of existing trout populations.

-monitoring is timely and effective in providing a realistic review of the trends in populations and in any impacts of mining operations.

-there are no legacy issues (e.g. settling pond performance, land slides from mine spoil, revegetation failure) with the proposed mine that will persist beyond the active life of the mine.

Summary:

The only reliable way to test the proponent's assumptions about water quality in receiving streams being a "low-probability" event and sedimentation a "negligible" issue is to review the monitoring results from other, similar facilities.

Models are as good as the assumptions that created them and the data used to make the assumptions. However, models are imprecise and can be improved with more and better data. A model points out a direction, a course of action, but it isn't necessarily a prescription with 100% certainty.

There is much reliance on modelling to predict impacts and the outcomes of mitigation strategies. Modelled results are only as good as the data used for input and need to be verified to provide a sense of reality. Case studies (actual monitored results of impact effects and mitigation undertaken) would provide more certainty and aid in decision making.

Modelling is a surrogate for reality, providing assumptions that can be tested. The assumptions made by the proponent need to be tested through a synoptic review of other surface coal mines in Alberta and adjacent jurisdictions. In particular: what is the experience from monitoring sediment generation and the efficacy of controls and containment; what were the actual impacts on stream flow; and, what was the efficacy of mitigative solutions? There is no evidence that the proponent has undertaken this test of modelled results.

It would seem prudent to have undertaken this review rather than engage in a "doomsday" experiment, using only modelled results where there is a risk the proof becomes irrelevant because the subject is already destroyed.

There is a tendency for the proponent to avoid answers to some impacts by deferral to some other, unstated, subsequent plan, action, design or concept. It is virtually impossible then, to realistically determine outcomes and consequences of some mine operations and their cumulative impact on Westslope cutthroat trout and their habitats.

The risk to water quality, to the aquatic environment and to Westslope cutthroat trout populations from the proposed Grassy Mountain coal mine is understated, despite evidence from other coal strip mines in Alberta and adjacent ones in BC that show the risks to trout populations can't be successfully mitigated.

Westslope cutthroat trout are subject to a recovery strategy to ensure the population, now “threatened”, does not decline to “endangered”. Because pure-strain populations are now restricted to just a few streams, every stream containing these should be subject to a high level of protection, like Gold Creek. Streams with near-pure populations, like Blairmore Creek, provide the best opportunity for efforts to expand the population, to meet federal and provincial terms of the recovery strategy.

Compensatory mitigation actions by the proponent are poorly thought out, lack rigor, especially in defining population metrics, fail in identifying cumulative effects and will not successfully minimize the impacts of an operating coal mine.

There is enough uncertainty and potential risk to the viability of Westslope cutthroat trout populations in Gold Creek and to population recovery efforts in Blairmore Creek with the proposed mine that approval has a high probability of significantly impacting the small and currently vulnerable threatened Westslope cutthroat trout population and its habitat. A compromise decision, to allow mining, but with conditions of mitigation and/or compensation, given the considerable uncertainties in both, presents substantial risk to the persistence of the last significant Westslope cutthroat population in the Crowsnest River watershed and to recovery efforts for the species.

References:

Alberta Environment and Parks. 2018. Livingstone-Porcupine Hills Land Footprint Management Plan. Government of Alberta. ISBN. No. 978-1-4601-3965-3.

Alberta Environment and Parks. 2020a. Westslope cutthroat trout- Crowsnest River genetic mapping; HUC 8: 04010102. Prepared by Alberta Environment and Parks, South Region, June, 2020.

Alberta Environment and Parks. 2020b. Whirling disease decontamination risk zone: upper Oldman River- Crowsnest Pass. Map prepared by Government of Alberta, August, 2020.

Alberta Westslope Cutthroat Recovery Team. 2013. Alberta Westslope cutthroat trout recovery plan: 2012-2017. Alberta Environment and Sustainable

Resource Development. Alberta Species at Risk Recovery Plan No. 28. Edmonton, Alberta.

ALCES, 2020. Cumulative Effects of Land Uses and Conservation Priorities in Alberta's Southern East Slopes Watersheds. Undertaken for the Alberta Chapter of The Wildlife Society, Edmonton, March, 2020.

Barton, B.A., C.B. Schreck and L.A. Sigismondi. 1986. Multiple acute disturbances evoke cumulative physiological stress responses in juvenile Chinook salmon. Transactions of the American Fisheries Society 115: 245-251.

Beaulac, M. N. and K. H. Reckhow. 1982. An examination of land use—nutrient export relationships. Water Resources Bulletin 18:6, 1013-1024.

Behnke, R.J. 2002. Trout and Salmon of North America. Chanticleer Press, New York.

Benson, J. W. 2019. Ecology of Westslope cutthroat trout (*Oncorhychus clarki lewisi*) populations in three small Rocky Mountain headwater streams. MSc thesis, Department of Biological Sciences, University of Lethbridge, Lethbridge, Alberta: 174p.

Birtwell, I. K., M. Farrell and A. Jonsson. 2008. The validity of including turbidity criteria for aquatic resource protection in Land Development Guidelines. (Pacific and Yukon Region). Canadian Manuscript Report of Fisheries and Aquatic Science 2852: xiii + 72 p.

Bonneau, J.L., and D.L. Scarnecchia. 1998. Seasonal and diel changes in habitat use by juvenile bull trout (*Salvelinus confluentus)* and cutthroat trout (*Oncorhynchus clarki)* in a mountain stream. Canadian Journal of Zoology 76: 783-790.

Bjornn, T.C. and seven coauthors. 1974. Sediment in streams and its effect on aquatic life. University of Idaho, Water Resources Research Institute, Research Technical Completion Report. Project B-025-IDA, Moscow.

Bray, D.I. 1982. Regime equations for gravel-bed rivers. In: Gravel Bed Rivers. Edited by R.D. Hey, J.C. Bothurst and C.R.Thorne. John Wiley and Sons Ltd. Pp. 517-541

Brown, R., and W. Mackay. 1995. Fall and winter movements of and habitat use by cutthroat trout in the Ram River, Alberta. Transactions of the American Fisheries Society 124:873–885.

Canadian Council of Ministers of the Environment. 2002. Canadian water quality guidelines for the protection of aquatic life: Total particulate matter. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg, Manitoba.

Caskenette, A.L., T.C. Durhack and E.C. Enders, 2020. Review of information to guide the identification of Critical Habitat in the riparian zone for listed freshwater fishes and mussels. DFO Can. Sci. Advis. Sec. Res. Doc. 2020.

Cederholm, C.J., L. M. Reid and E.O. Salo. 1980. Cumulative effects of logging road sediment on salmonid populations in the Clearwater River, Jefferson County, Washington. Contribution 543 to: Salmon-Spawning Gravel conference, Seattle, Washington.

Chapman, D.W. and K.P. McLeod. 1987. Development of criteria for fine sediment in the Northern Rockies ecosystem. U.S. Environmental Protection Agency, EPA report 910/9-87-162, Washington, D.C.

Collier, C.R., R.J. Pickering and J.J. Musser, editors. 1970. Influences of strip mining on the hydrologic environment of parts of Beaver Creek basin, Kentucky, 1955-56. U.S. Geological Survey Professional paper 427-C.

Cope, S. 2016. Upper Fording River Westslope cutthroat trout population assessment and telemetry project. Final Report: August, 2015 to November, 2015. Report prepared for Teck Coal Ltd, Sparwood, BC.

Cunjak, R. A. 1996. Winter habitat of selected stream fishes and potential impacts from land-use activity. Canadian Journal of Fisheries and Aquatic Sciences 53:267–282.

Donahue, W. F. 2013. Determining appropriate nutrient and sediment loading coefficients for modelling effects of change in land uses and land cover in Alberta watersheds. Water Matters Society of Alberta.

Elk Valley Cumulative Effects Management Framework. 2018. Aquatic Ecosystems Cumulative Effects Assessment report- Elk Valley, Kootenay Boundary Region, Government of BC.

Ford, T.D. and H.M. Pedley. 1996. A review of tufa and travertine deposits of the world. Earth-Science Review 41:117-175.

Fisheries and Oceans Canada. 2014. Recovery strategy for the Alberta populations of Westslope cutthroat trout (*Oncorhynchus clarki lewisi)* in Canada. Species at Risk Recovery Strategy Series, Fisheries and Oceans Canada, Ottawa.

Fitch, L. 1977. East Crowsnest Creek: Stream Survey Inventory. AB F&W Division. MS.   12 p.

Fitch, L. 1978. A Report on Biological Inventories of 11 Streams in the Crowsnest Drainage District of Alberta. AB F&W Division. MS. 92 p.

Fitch, L., M. Miles, J.O'Neil, R. Pattenden and G. Van der Vinne. 1994. Defining the variables that influence succes of habitat structures in southwestern Alberta; a work in progress. In: Proceedings of 9th International Trout Stream Improvement workshop Sept. 6-9, 1994. Calgary, Alberta. Trout Unlimited Canada.

Fitch, L., B.W. Adams and G.Hale. 2001. Riparian health assessment for streams and small rivers- Field Workbook. Alberta Riparian Habitat Management Society, Lethbridge, Alberta.

Fitch, L. and N. Ambrose. 2003. Riparian Areas: A user's guide to health. Alberta Riparian Habitat Management Society, Lethbridge, Alberta.

Fitch, L. 2012. An Elegy for the Crowsnest Bull Trout. Wildlands Advocate: Vol. 20 Number 3. Pp 14-17.

Fitch, L. 2015. Oldman watershed bull trout and cutthroat trout: Stream reaches/watersheds of concern. Unpublished report.

Frost, W.E. and M.E. Brown. 1967. The Trout. NMN Collins, St. James Place, London.

Glancy, P.A. 1973. A reconnaissance of streamflow and fluvial sediment transport, Incline Village area, Lake Tahoe, Nevada. Nevada Division of Water Resources, Water Resources Information series, Second progress report, 1971, Carson City.

Gowan, C. and K. D. Fausch. 1996. Long-term demographic responses of trout populations to habitat manipulation in six Colorado streams. Ecological Applications 6: 931-946.

Graham, A.L. and S.J. Cooke. 2008. The effects of noise disturbance from various recreational boating activities common to inland waters on the cardiac physiology of a freshwater fish, the largemouth bass (*Micropterus salmoides).* Aquatic Conservation: Marine and Freshwater Ecosystems. 18: 1315-1324.

Green, K.C. 2013. Forests, floods and channel processes: illuminating links between forest harvesting, the flood regime and channel responses in snowmelt headwater streams. PhD thesis, University of British Columbia.

Harper, D.J. and J.T. Quigley. 2005. No net loss of fish habitat: a review and analysis of habitat compensation in Canada. Environmental Management Vol.36, No.3: 343-355.

Hatfield Consultants. 2018, Grassy Mountain Coal Project: Detailed Fisheries Offsetting Plan. Prepared for Benga Mining Ltd. Appendix B-1.

Hawthorn, K. 2014. The role of fine sediment in phosphorus dynamics and stream productivity in Rocky Mountain headwater streams: Possible long-term effects of extensive logging. MSc thesis, University of Alberta, Department of Renewable Resources, Edmonton, Alberta.

Hynes, H.B.N. 1970. The ecology of running waters. University of Toronto Press, Toronto, Ontario.

Independent Expert Engineering Investigation and Review Panel. 2015. Report on Mount Polley Tailings Storage Facility Breach. Appendix I: BC tailings dam failure frequency and porfolio risk. Victoria, BC.

Klamt, R. R. 1976. The effects of coarse granitic sediment on the distribution and abundance of salmonids in the central Idaho batholith. MSc thesis, University of Idaho. Moscow, Idaho.

Kuchapski, K.A. 2013. Effects of selenium and other surface coal mine influences on fish and invertebrates in Canadian Rockies streams. MSc thesis, University of Lethbridge, Lethbridge, Alberta.

Lemly, A.D. 1982. Modification of benthic insect communities in polluted streams: combined effects of sedimentation and nutrient enrichment. Hydrobiologia 87: 229-245.

Lemly, A. D. 2019. Environmental hazard assessment of Benga Mining's proposed Grassy Mountain Coal project. Environmental Science and Policy 96 (2019): 105-113.

Lloyd, D.S. 1987. Turbidity as a water quality standard for salmonid habitats in Alaska. North American Journal of Fisheries Management 7: 34-45.

Mayhood, D.W. 2009. Contributions to a recovery plan for westslope cutthroat trout (*Oncorhynchus clarkii lewisi)* in Alberta: Threats and limiting factors. FWR Technical Report No. 2009/05-2: Prepared for Alberta Fish and Wildlife Division, Cochrane, Alberta.

McClelland, W.T. and M.A. Brusven. 1980. Effects of sedimentation on the behavior and distribution of riffle insects in a laboratory stream. Aquatic Insects 2: 161-169.

Miller, R.B. 1958. The role of competition in the mortality of hatchery trout. J. Fish. Res. Bd. Canada 15 (3).

Miller, R.B. and F. Miller. 1962. Diet, glycogen reserves and resistance to fatigue in hatchery rainbow trout: Part II. J. Fish. Res. Bd. Canada 19 (3).

Mills, D. 1971. Salmon and Trout: A resource, its ecology, conservation and management. Oliver and Boyd, Edinburgh.

Much, J. 2010. Biological effects of sediment on bull trout and their habitat- Guidance for evaluating effects. U.S. Fish and Wildlife Service, Washington Fish and Wildlife Office, Lacey, Washington.

Musser, J.J. 1963. Description of the physical environment and of strip-mining operations in parts of Beaver Creek Basin, Kentucky. U.S. Geological Survey. Professional Paper 427-A, Washington, D.C.

Newcombe, C.P. and J.O.T. Jensen. 1996. Channel suspended sediment and fisheries: A synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management 16 (4): 693-727.

Newcombe, C. P. 2003. Impact assessment model for clear water fishes exposed to excessively cloudy water. Journal of the American Water Resources Association 39 (3): 529-544.

O'Neil, J. and R. Pattenden. 1994. Making sense of the numbers-evaluating the response of fish populations to habitat structures in southwestern Alberta (1987-1993). In: Proceedings of 9th International Trout Stream Improvement workshop Sept. 6-9, 1994. Calgary, Alberta. Trout Unlimited Canada.

Pattenden, R., M. Miles, L. Fitch, G. Hartman, and R. Kellerhals. 1998. Can instream structures effectively restore fisheries habitat? Pages 1-11 in M.K. Brewin and D.M. Monita, tech. editors. Forest-fish conference: land management practices affecting aquatic ecosystems. Proc. Forest-Fish Conference, May1-4, 1996. Nat. Resources Canada, Canadian Forest Service Centre Information Report NOR-X-356

Power, G., R. S. Brown, and J. G. Imhof. 1999. Groundwater and fish—insights from northern North America. Hydrological Processes 13:401–422.

Redding, J.M., C.B. Schreck and F.H. Everest. 1987. Physiological effects on Coho salmon and steelhead of exposure to suspended solids. Transactions of the American Fisheries Society 116: 737-744.

R. L. and L. Environmental Services Ltd. and M. Miles and Associates Ltd. 1996. Post-flood status of instream habitat structures in southwestern Alberta. Report prepared for Alberta Environmental Protection, Southern Region, Lethbridge, Alberta.

Rosenfeld, J., M. Porter and E. Parkinson. 2000. Habitat factors affecting the abundance and distribution of juvenile cutthroat trout (*Oncorhynchus* *clarki)* and Coho salmon (*Oncorhynchus kisutch).* Canadian Journal of Fisheries and Aquatic Science 57: 766-774.

Rosenfeld, J.S. and S. Boss. 2001. Fitness consequences of habitat use for juvenile cutthroat trout: energetic costs and benefits in pools and riffles. Canadian Journal of Fisheries and Aquatic Sciences 58: 585-593.

Rosgen, D. 1996. Applied River Morphology, Second Edition. Wildland Hydrology, Pagosa Springs, Colorado.

Riley, S.C. and K.D. Fausch. 1995. Trout population response to habitat enhancement in six northern Colorado streams. Canadian Journal of Fisheries and Aquatic Sciences 52:34-53.

Southern Foothills Study. 2015. A future worth protecting: Beneficial management practices and the southern Alberta foothills. Report of the Southern Foothills Study, East Slopes, Phase 3. Southern Alberta Land Trust Society, High River, Alberta.

Sigismondi, L. A. and L.J. Weber 1988. Changes in avoidance response time of juvenile Chinook salmon exposed to multiple acute handling stresses. Transactions of the American Fisheries Society 117: 196-201.

Sullivan, G.D. 1967. Current research trends in mined-land conservation and utilization. Mining Engineering 19(3):63-67.

Suttle, K.B., M.E. Power, J.M. Levine and C. McNeely. 2004. How fine sediment in riverbeds impairs growth and survival of juvenile salmonids. Ecological Applications 14 (4): 969-974.

Teck Resources. 2019. Presentation to Elk Valley Fish and Fish Habitat Committee meeting, October 31, 2019.

Touysinhthiphonexay, K.C.N. and T.W. Gardner, 1984. Threshold response of small streams to surface coal mining, bituminous coal fields, central Pennsylvania. Earth Surface Processes and Landforms 9:43-58.

U.S. Forest Service. 1980c. User guide to hydrology: mining and reclamation in the West. U.S. Forest Service General Technical Report INT-74.

Ward, B.R. and Slaney, P.A. 1981. Further evaluations of structures for improvement of salmonid rearing habitat in coastal streams of British Columbia. In: Proceedings-Propagation, Enhancement and Rehabilitation pf Anadromous Salmonid Populations and Habitat Symposium, Oct. 15-17, 1981, Arcata, California. Pp 99-108.

Ward, B.R. 1993. Habitat manipulations for the rearing of fish in British Columbia. In: Le developpement du Saumon atlantique au Quebec. Edited by: G. Shooner et S. Asselin. Colloque Internationale de la Federation Quebecoise pour le Sauman Atlantique, Quebec City Quebec. Collection Salmo sala No. 1.

Waters, T.F. 1995. Sediment in Streams: Sources, biological effects and control. American Fisheries Society Monograph 7, American Fisheries Society, Bethesda, Maryland.

Weaver, J.L. 2013. Protecting and Connecting Headwater Havens: Vital landscapes for vulnerable fish and wildlife, Southern Canadian Rockies of Canada. Wildlife Conservation Society Canada Conservation Report no. 7, WCS Canada, Toronto, Ontario.

Weaver, T. and J. Fraley. 1991. Fisheries habitat and fish populations. Flathead Basin Forest Practices, Water Quality and Fisheries Cooperative Program, Flathead Basin Commission, Kalispell, Montana.

Wilson, G. N. and N. Beier. 2017. Proposal for dam safety research, University of Alberta. Submission to Alberta Energy Regulator, June 1, 2107.

Wysocki, L.E., J.P. Dittami and F. Ladich. 2006. Ship noise and cortisol secretion in European freshwater fishes. Biological Conservation 128:501-508.

Young, M.K. 1996. Summer movements and habitat use by Colorado cutthroat trout (*Oncorhynchus clarki pleuriticus)* in small, montane streams. Canadian Journal of Fisheries and Aquatic Science 53: 1403-1408.

Lorne A. Fitch Curriculum Vitae

<personal information removed>

HOME ADDRESS

ACADEMIC BACKGROUND

- Graduate from the University of Calgary (1974):
  Bachelor of Science; major in Zoology; minor in Physical Geography

PROFESSIONAL REGISTRATION

- Certified Professional Biologist – Alberta Society of Professional Biologists - #176

PROFESSIONAL ACTIVITIES/MEMBERSHIPS/ASSOCIATIONS

- Great Plains Fishery Workers Association – President (1990), Secretary Treasurer (1982)
- Alberta Society of Professional Biologists- Director (1983-84)
- The Wildlife Society (Alberta Chapter) – Director (1992-93)
- American Fisheries Society
- Alberta Native Plants Council
- Society for Range Management
- Riparian Wetland Research Program, University of Montana
- Oldman Watershed Council- Director at large (2006-2009)
- Oldman Watershed Council- Headwaters Action Team member
- Water Matters- Founding Director
- Nature Conservancy of Canada- Alberta Board member (2006-2014)
- Nature Conservancy of Canada- Alberta Conservation Advisory Committee member
- Trout Unlimited- National Resource Advisory Committee member
- Crown of the Continent Conservation Initiative- Board member
- Alberta Society of Professional Biologists- Discipline Committee member
- National Riparian Stewardship Working Group-Alberta member
- Alberta Chapter, The Wildlife Society- Conservation Affairs Committee
- Alberta Endangered Species Conservation Committee member
- Alberta Fisheries Management Advisory Committee member

AWARDS

- Honorary Life Membership – Great Plains Fishery Workers Association (1992)
- Recognition of Achievement Award – Alberta Fish and Wildlife Division (1992)
- Alberta Emerald Award – Antelope Creek Ranch-Research and Innovation

category (1996)
- Alberta Emerald Award – Barry Adams and Lorne Fitch-Corporate or Institutional Leadership category (1997)
- President's Special Award (1998)- Society for Range Management
- Alberta Order of the Bighorn Award – Bow Habitat Station Core Committee (1998)
- Growing Alberta – Green Team Award; Knowledge Builder category (1999)
- Premier's Award of Excellence – Fish in Schools (FINS) program (2000)
- Recognition of Achievement Award- Alberta Sustainable Resource Development (2003)
- Wildlife Administrator Award- The Wildlife Society (2003)
- Canadian Environment Gold Award- Cows and Fish- Environmental Learning category (2003)
- Alberta Emerald Award- Cows and Fish- Education category (2005)
- Special Achievement Award- Western Association of Fish and Wildlife Agencies (2005)
- Peggy Thompson Publication Award (2009)- Alberta Society of Professional Biologists
- William Rowan Distinguished Service Award (2012)- Alberta Chapter, The Wildlife Society
- Wildlife Outreach Award (2014)- Alberta Chapter, The Wildlife Society
- Wildlife Publication Award (2017)- Alberta Chapter, The Wildlife Society

ADDITIONAL TRAINING

Habitat Evaluation Procedures; Instream Flow Needs assessment procedures; Remote sensing; Collection and preservation of environmental evidence; Cumulative effects analysis; Wildlife Resource inventory and assessment; Environmental mitigation; Riparian health evaluation methodology; Conflict Resolution

PROFESSIONAL EXPERIENCE

1971 to 1973 Alberta Fish and Wildlife Division, Red Deer

- **Biological Assistant** – Fisheries investigations of rivers, streams, alpine lakes in support of fisheries management and aquatic habitat protection. Carried out field component of northern pike reproduction research project in a saline lake. Assisted with range evaluations of grazing allotments. Assisted with Canada goose research project. Operated field check stations for deer hunters.

1974 to 1975 Alberta Fish and Wildlife Division, Red Deer

- **Fisheries Biologist** – East Slope trout stream investigations; detailed physical, chemical and biological surveys of streams in support of management objectives. Carried out lake surveys to assess stocking potential, investigated pollution/habitat complaints and assessed impacts of land use activities on fish and fish habitat.

1976 to 1980 Alberta Fish and Wildlife Division, Lethbridge

- **Fisheries Biologist** – East Slope trout stream investigations; physical habitat inventories, fish population estimates, water chemistry assessment, management assessments and stream habitat protection recommendations. Review, research and assessment of the effects of land and water use activities on fish populations and the aquatic environment. Carried out research activities on lake ecosystems and fish population interactions. Investigated and collected evidence in pollution/habitat infractions.

1980 Lethbridge Community College, Lethbridge

- **Instructor** – Taught laboratory component of Fisheries Resource Management course.

1981 to 1993 Alberta Fish and Wildlife Division, Lethbridge

- **Section Head, Regional Habitat Management** – Responsible for the regional delivery of fish and wildlife habitat protection, habitat development and habitat planning programs.

1993 to 1996 Alberta Fish and Wildlife Services, Lethbridge

- **Biologist, Regional Programs, Fisheries Management Division** – Responsible for the regional delivery and coordination of fisheries and wildlife habitat programs, evaluation of habitat projects, habitat related research activities and ecosystem management planning.

1996 to 1999 Natural Resources Service, Fisheries Management Division, Lethbridge

- **Section Head, Regional Fisheries Management** – Responsibilities for fisheries inventory, management/regulation, sport/commercial fisheries allocation, research, habitat enhancement, habitat protection and watershed planning.

1999 to 2006 Fish and Wildlife Division, Resource Coordination and Planning Branch, Edmonton

- **Provincial Riparian Specialist** – Manage a provincial riparian program. Direct extension programs, develop extension materials and work with a multidisciplinary group to research facets of biodiversity, water quality, forage production and ecological functions related to riparian condition. Provide training and training materials for riparian health assessment. Develop, implement and evaluate community- based riparian programs in rural and urban municipalities.

2006 to 2017 Alberta Riparian Habitat Management Society (Cows and Fish Program), Lethbridge

- **Provincial Riparian Specialist** – Provide provincial level support through development of extension materials, presentations, program evaluation and training. Provide direction to riparian health inventory element, research components (biodiversity, forage and livestock behaviour), riparian restoration projects and extension initiatives. Interaction with federal, provincial and local governments, on delivery of Water for Life, Land Use Framework, and Species at Risk elements. Liaison with conservation community and livestock industry on biodiversity conservation.

1996 to Present

- **Riparian Consultant** – Consult to provincial/federal agencies, conservation groups, rural/urban municipalities and agricultural groups on riparian issues, management, research, implementation and evaluation.

2004 to 2018

- **Adjunct Professor, Faculty of Environmental Design, University of Calgary-** Guest lecturer, seminar leader, member of Master's Degree project committees.

PROFESSIONAL RESPONSIBILITES

Undertook and directed habitat and fisheries inventories of Eastern Slope trout streams (Waterton, St. Mary, Belly, Castle, Crowsnest, Oldman, Red Deer and North Saskatchewan drainages), prairie and parkland rivers (Red Deer, Oldman, Bow, South Saskatchewan rivers), alpine lakes, prairie and parkland lakes/potholes and irrigation reservoirs. Collected and analysed data on:

-physical habitat parameters
-benthic invertebrate populations
-water quality
-fish species composition
-fish population estimates
-angler use
-fish movement, migration, distribution
-fish health
-fish ecology
-fish kill investigations
-fish collection for heavy metals, pesticides
-instream flow needs for fish population maintenance
-impact of land use practices on fish and fish habitat

-fish stocking

Initiated or directed the assessment of resource utilization plans, land use practices, impact assessments and land and water use referrals to ensure compatibility with the production and maintenance of fish and wildlife resources. This included impacts from the following land use categories:

-agriculture (cultivation, grazing)
-energy development (petroleum exploration, development)
-forestry/timber harvest
-mining (coal, gravel)
-urban development
-linear disturbances (roads, trails, power/pipelines)
-recreation (motorized and non-motorized)
-rural residential subdivisions
-water management (water abstraction for irrigation, domestic, industrial uses)

Participated, as the Alberta Fish and Wildlife Division representative, on river basin plans and on large water management planning, construction and mitigation projects:

-Oldman River basin study
-Brocket dam site study – Oldman River
-Little Bow basin study
-Little Bow reservoir EIA
-Willow Creek basin study
-Pine Coulee EIA
-Milk River basin study
-South Saskatchewan River basin study
-Southern tributaries IFN (instream flow need) study (Belly, Waterton, St. Mary rivers)

Designed terms of reference for impact assessments related to fish, wildlife and habitat for the following water management projects:

-Keho Lake Reservoir upgrading – LNID
-Badger Lake Reservoir – BRID
-Stafford Lake Reservoir – SMRID
-Forty Mile Coulee Reservoir – SMRID
-Crawling Valley Reservoir – EID
-Little Bow Reservoir
-Pine Coulee Reservoir

Led teams to assess land use impacts, effects on fish and wildlife populations and the need for mitigation, as compensation for habitat losses. Quantified the amount of habitat development required to mitigate losses. Negotiated and directed mitigation efforts including evaluation components:

-Undertook research to define the impacts of channelization on the physical, chemical and biological features of Racehorse Creek.
-Designed and undertook a study to assess the current status of bull trout in the Oldman River watershed. Determined inflection points for declines in populations on a sub-watershed level, reasons for population declines and significance of population declines in aid of provincial bull trout management planning.

Participated in and led planning teams for the Oldman River Dam mitigation program which included:

-Development, in team setting, of inventory programs for impact assessment; designed terms of reference.
-Co-chaired the development of strategic plans for mitigation including direction to consultants, negotiation over mitigation definitions, interactions with public advisory groups and coordination within the Fish and Wildlife Division.
-Participated in the development of action plans for mitigation including direction to consultants and professional advice to the proponent.
-Directed fisheries and wildlife mitigation efforts through technical advisory committees.
-Reviewed and provided critical input on technical reports from inventory, implementation and evaluation components.
-Participated in the development of evaluation programs to measure impacts of mitigation and act as the Division's representative on an interdepartmental monitoring committee.
-Designed evaluation criteria to measure efficacy of mitigation programs.

Initiated a mitigation program for stream habitat with industry, other government agencies, municipalities and landowners and directed the following components:

-Inventories of stream bank disturbance to quantify problems.
-An awareness program through presentations, to inform and educate land use proponents.
-Implementation of demonstration projects to test methods and show construction methodology.
-Negotiation to ensure stream habitat mitigation became part of project planning and implementation.
-Designed and implemented evaluation and monitoring programs to measure efficacy of mitigation techniques.

Act as an expert witness in prosecutions related to aquatic habitat and fisheries management:

R. v. Lefthand, ABPC, 2001, qualified as an expert in "fish, fish habitat and fisheries management in Alberta, including the Eastern Slopes Region of Alberta."

R. v. SouthWest Concrete, 2001, qualified as an expert in fish, fish habitat, aquatic invertebrates and the impacts of sediment on aquatic invertebrates and fish, including southern Alberta.

R. v. Eagle Child, ABPC, 2003, qualified as an expert in "fish, fish habitat and fisheries management in Alberta, including the Eastern Slopes Region of Alberta."

R. v. Goodstriker, ABPC, 2009, qualified as an expert in "fish, fish habitat, and fisheries management in Alberta, including southern Alberta and the St. Mary River watershed in southern Alberta."

Provided expert testimony on the effects of development projects on fish and wildlife populations and their habitats in provincial hearings:

-Vacation Alberta Westcastle Four Season Resort EIA hearing- 1993
-Petro-Canada Sullivan Field Development Project EIA hearing- 2008

Initiated a riparian habitat management project. Developed a partnership between Alberta Cattle Commission, Trout Unlimited, Canadian Cattleman's Association, Alberta Agriculture, Alberta Environmental Protection, and Department of Fisheries and Oceans. In a team setting, arranged for demonstration sites, with changes in grazing management practices. Designed monitoring components for aquatic habitat, wildlife habitat and wildlife responses. Provide an extension effort on compatible grazing management to achieve riparian system health. Manage a provincial, non-government program known as "Cows & Fish" (Alberta Riparian Habitat Management Society).

Directed the delivery of a regional habitat development program for both fisheries and wildlife which included the following projects:

-Moose habitat renovation using both mechanical clearing techniques and fire.
-Elk habitat enhancement projects.
-Wetland creation for ungulates, birds and fur bearers.
-Trout stream restoration and enhancement.
-Landowner Habitat Program – maintenance of habitat on private lands.
-Development of landscape management plans to provide multi-use benefits to land users and wildlife.
-Projects to enhance habitat for non-game species and the development of Watchable Wildlife project sites.

Provided regular guest lectures at University of Alberta, University of Calgary, University of Lethbridge, Northern Alberta Institute of Technology and Lethbridge College on topics related to fish and wildlife management, riparian/stream ecosystems, riparian extension programs, community involvement in landscape management and evaluation/monitoring of community-based conservation actions. Instructed the fish and wildlife ecology portion of the Alberta Sustainable Resource Development, Public Lands Division- “Stockman’s Course”. Assisted in the development of the “Rancher’s Range Management Course” and provide the biodiversity portion and riparian health instruction.

Developed and deliver workshops on communication skills, interaction and engagement techniques with resource users and landowners and coaching in the delivery of difficult, contentious messages.

Participated on the Alberta Westslope Cutthroat Trout Recovery Team as a professional advisor for an environmental coalition. Provided input, review and strategic advice on the preparation and delivery of the Alberta Westslope Cutthroat Trout Recovery Plan 2012-2017.

Participate on the Alberta Bull Trout Provincial Advisory Committee, providing input and review for the preparation of a provincial recovery strategy for the species (2015 to present).

Assess and provide independent reviews of land use impacts on aquatic resources, including “threatened” species (i.e. westslope cutthroat trout, bull trout) in the southwestern portion of the Eastern Slopes.

Undertake voluntary tracking/inventory of bull trout spawning in selected streams in the Oldman watershed- Racehorse Creek, South Racehorse Creek, Hidden Creek, Dutch Creek, Oldman River (2011 to present).

FISHERIES, AQUATIC HABITAT, RIPARIAN and ECOLOGICAL related REPORTS, PUBLICATIONS AND ARTICLES

Kraft, M.E. and L. Fitch. 1973. Survey of the Fish Population and Habitat in Shunda Creek, 1972. Alberta Fish and Wildlife Division. MS. 47 p.

Fitch, L. 1975. Habitat Surveys of Scalp, Bighorn, Eagle, Wildhorse, Yara, McCue, Wigwam, Unnamed, Sheep and Dogrib Creeks, 1972-1973. Fisheries Survey Report #21. AB F&W Division. 68 p.

Fitch, L. 1975. Beaver Creek Land Use and Water Quality Evaluation. AB F&W Division. MS. 49 p.

Fitch, L. 1977. Allison Creek: Stream Survey Inventory. AB F&W Division. MS. 13 p.

Fitch, L. 1977. Rainy Ridge Lake: Lake Survey Inventory. AB F&W Division.MS. 17 p.

Fitch, L. 1977. Blairmore Creek: Stream Survey Inventory. AB F&W Division.MS.14 p.

Fitch, L. 1977. Survey of the Fish Population and Habitat in Fallentimber Creek, 1973-1974. Fisheries Survey Report #23. AB F&W Division. 39 p.

Fitch, L. 1977. Crowsnest Creek: Stream Survey Inventory. AB F&W Division. MS. 16 p.

Fitch, L. 1977. Lys Lake: Lake Survey Inventory. AB F&W Division. MS. 16 p.

Fitch, L. 1977. East Crowsnest Creek: Stream Survey Inventory. AB F&W Division. MS. 12 p.

Fitch, L. 1977. Gold Creek: Stream Survey Inventory. AB F&W Division. MS. 15 p.

Fitch, L. 1977. Trout Stocking in Streams: A Review. Fisheries Management Report #24. AB F&W Division. 24 p.

Fitch, L. 1977. McGillivray Creek: Stream Survey Inventory. AB F&W Division. MS. 13 p.

Fitch, L. 1977. Ptolemy Creek: Stream Survey Inventory. AB F&W Division. MS. 14 p.

Fitch, L. 1977. Magrath Children's Pond: Lake Survey Inventory. AB F&W Division. MS. 13 p.

Fitch, L. 1977. Rock Creek: Stream Survey Inventory. AB F&W Division. MS. 13 p.

Fitch, L. 1977. Grizzly Lake: Lake Survey Inventory. AB F&W Division. MS. 16 p.

Fitch, L. 1977. Todd Creek: Stream Survey Inventory. AB F&W Division. MS. 18 p.

Fitch, L. 1977. Prairie Bluff Lake: Lake Survey Inventory. AB F&W Division.MS. 14 p.

Fitch, L. 1977. York Creek: Stream Survey Inventory. AB F&W Division. MS. 15 p.

Fitch, L. 1977. South Scarpe Lake: Lake Survey Inventory. AB F&W Division.MS.17 p.

Fitch, L. 1978. Crowsnest River: Stream Survey Inventory. AB F&W Division.MS.27 p.

Fitch, L. 1978. A Report on Biological Inventories of 11 Streams in the Crowsnest Drainage District of Alberta. AB F&W Division. MS. 92 p.

Fitch, L. 1978. A Limnological Survey of Crowsnest Lake. AB F&W Division.MS. 47 p.

Fitch, L. 1978. A Report on the Biological Inventory of Pincher Creek. AB F&W Division. MS. 37 p.

Fitch, L. 1978. Lee Creek: Stream Survey Inventory. AB F&W Division. MS. 22p.

Fitch, L. 1978. Chain Lakes Reservoir Sucker Removal Program: Evaluation Project. AB F&W Division. MS. 13 p.

Fitch, L. 1978. An Inventory of Aquatic Habitat Protection Requirements in the Lethbridge Region. AB F&W Division. MS. 11 p.

Fitch, L. 1979. A Creel Survey program for Cypress Hills Provincial Park. AB F&W Division. MS. 15 p.

Fitch, L. 1979. Cottonwood Creek: Stream Survey Inventory. AB F&W Division. MS. 13 p.

Fitch, L. 1979. Observations on Trout Spawning in Window Mountain Lake, Alberta. AB F&W Division. MS. 18 p.

Fitch, L. 1979. Beavermines Creek: Stream Survey Inventory. AB F&W Division. MS. 13 p.

Fitch, L. 1979. Unnamed South Lake (Three Lakes Ridge): Lake Survey Inventory. AB F&W Division. MS. 13 p.

Fitch, L. 1979. Font Creek: Stream Survey Inventory. AB F&W Division. MS. 11 p.

Fitch, L. 1979. Castle River: Stream Survey Inventory. AB F&W Division. MS. 22 p.

Fitch, L. 1979. Unnamed Lake (Gravenstafel Ridge): Lake Survey Inventory. AB F&W Division. MS. 12 p.

Fitch, L. 1979. Gladstone Creek: Stream Survey Inventory. AB F&W Division. MS. 10 p.

Fitch, L. 1979. Grizzly Creek: Stream Survey Inventory. AB F&W Division. MS. 11 p.

Fitch, L. 1979. Unnamed North Lake (Three Lakes Ridge): Lake Survey Inventory. AB F&W Division. MS. 12 p.

Fitch, L. 1979. Jutland Brook: Stream Survey Inventory. AB F&W Division. MS. 11 p.

Fitch, L. 1979. Mill Creek: Stream Survey Inventory. AB F&W Division. MS. 14 p.

Fitch, L. 1979. The Life History of the Golden Trout (*Salmo aquabonita*) in Rainy Ridge Lake, Alberta, with Particular Reference to Observations on Spawning. AB F&W Division. MS. 24 p.

Fitch, L. 1979. Dungarvan Creek: Stream Survey Inventory. AB F&W Division. MS. 18 p.

Fitch, L. 1979. Scarpe Creek: Stream Survey Inventory. AB F&W Division. MS. 11 p.

Fitch, L. 1979. Screwdriver Creek: Stream Survey Inventory. AB F&W Division. MS. 10 p.

Fitch, L. 1979. A Report on the Biological Inventory of Lee Creek, AB F&W Division. MS. 40 p.

Fitch, L. 1979. South Castle River: Stream Survey Inventory. AB F&W Division. MS. 17 p.

Fitch, L. 1979. The Present and Potential Sustained Yield of Rough Fish from Lakes and Reservoirs in the Lethbridge Region. AB F&W Division. MS. 12 p.

Fitch, L. 1979. West Castle River: Stream Survey Inventory. AB F&W Division. MS. 16 p.

Fitch, L. 1979. Whitney Creek: Stream Survey Inventory. AB F&W Division. MS. 10 p.

Fitch, L. 1980. A Limnological Study of Tyrrell Lake. AB F&W Division. MS. 85 p.

Fitch, L. 1980. Window Mountain Lake: Lake Survey Inventory. AB F&W Division. MS. 21 p.

Fitch, L. 1980. Carbondale River: Stream Survey Inventory. AB F&W Division. MS. 20 p.

Fitch, L. 1980. Drywood Creek: Stream Survey Inventory. AB F&W Division. MS.18 p.

Fitch, L. 1980. Age, Growth and Food Habits of Northern Pike (*Esox lucius*) and Yellow Perch (*Perca flavescius*) in Elkwater Lake, Alberta. AB F&W Division. MS. 45 p.

Fitch, L. 1980. Gardiner Creek: Stream Survey Inventory. AB F&W Division. MS. 13 p.

Fitch, L. 1980. Goat Creek: Stream Survey Inventory. AB F&W Division. MS. 12 p.

Fitch, L. 1980. North Drywood Creek: Stream Survey Inventory. AB F&W Division. MS. 17 p.

Fitch, L. 1980. South Drywood Creek: Stream Survey Inventory. AB F&W Division. MS. 15 p.

Fitch, L. 1980. Spionkop Creek: Stream Survey Inventory. AB F&W Division. MS.13 p.

Fitch, L. 1980. Ruby Lake: Lake Survey Inventory. AB F&W Division. MS. 13 p.

Fitch, L. 1980. Lost Creek: Stream Survey Inventory. AB F&W Division. MS. 13 p.

Fitch, L. 1980. The Effects of Channelization on Fish and Fish Habitat in Racehorse Creek, Alberta. AB F&W Division. MS. 47 p.

Fitch, L. 1980. Lynx Creek: Stream Survey Inventory. AB F&W Division. MS. 16 p.

Fitch, L. 1980. Unnamed Lake (Mt. Coulthard): Lake Survey Inventory. AB F&W Division. MS. 13 p.

Fitch, L. 1980. Island Creek: Stream Survey Inventory. AB F&W Division. MS. 11 p.

Fitch, L. 1980. North Lost Creek: Stream Survey Inventory. AB F&W Division. MS. 12 p.

Fitch, L. 1980. Yarrow Creek: Stream Survey Inventory. AB F&W Division. MS. 18 p.

Fitch, L. 1980. A Survey of the Fish Population and Habitat in Prairie Creek, 1974-1975. Fisheries Survey Report #27. AB F&W Division. 53 p.

Fitch, L. 1980. South Lost Creek: Stream Survey Inventory. AB F&W Division. MS. 13 p.

Fitch, L. 1980. Phillipps Lake: Lake Survey Inventory. AB F&W Division. MS. 22 p.

Fitch, L. 1981. A Creel Survey of Three Lakes in Cypress Hills Provincial Park, Elkwater Lake, Reesor Lake and Spruce Coulee Reservoir. AB F&W Division. MS. 35 p.

Fitch, L. 1981. West Scarpe Lake: Lake Survey Inventory. AB F&W Division. MS.12 p.

Fitch, L. 1981. A Summary of Biological Surveys on Crowsnest Lake, 1979-1981. AB F&W Division. MS. 21 p.

Fitch, L. 1981. A Study of the Limnology and Fisheries of Tyrrell Lake. In: Proceedings of Great Plains Fishery Workers Association, 30th Annual Workshop, Cody, Wyoming, Feb. 9-11, 1981.

Fitch, L. 1981. McCarty Lake: Lake Survey Inventory. AB F&W Division. MS. 16 p.

Fitch, L. 1983. Instream Devices for Habitat Mitigation – The Alberta Experience. In:

Proceedings of Great Plains Fishery Workers Association, 32nd Annual Workshop, Minot, North Dakota, Feb. 21-23, 1983.

Fitch, L. 1984. Proposal for the Integration of Irrigation System Rehabilitation with the Fish and Wildlife Resource. AB F&W Division. MS. 44 p.

Fitch, L. 1984. Southern Region Habitat Concerns: Estimates and Predictions. AB F&W Division. MS. 31 p.

Fitch, L. 1985. Habitat Protection and Mitigation for Streams in Southern Alberta. In: Proceedings of Great Plains Fishery Workers Association, 34th Annual Workshop, Rapid City, South Dakota, Feb. 4-6, 1985.

Fitch, L. 1985. Fisheries Management Techniques: Physical Stream Improvement, pp 100 – 108 In: Symposium on Fish and Wildlife Management – Alberta: Current Practice – Future Strategies, Edmonton, Alberta, April 16, 17, 1985.

Fitch, L. 1986. Irrigation and the Fish and Wildlife Resource. Report to the Renewable Resources Study Group – Environment Council of Alberta, Edmonton.

Fitch, L. 1989. Habitat Retention and Special Irrigation Projects. In: Wetlands, Wildlife and Agriculture, CWRA/SWCS Conference, Edmonton, Alberta, Feb. 15-17. 1989.

Fitch, L. 1989. Dollars for Wildlife: A Review of Habitat Incentives for Irrigation Districts, p.2. The Water Hauler. Spring, 1989.

Fitch, L. 1989. Fishery Management and Riparian Wildlife Habitats in Southern Alberta. pp 117-121. In: Flowing to the Future, Proceedings of the Alberta Rivers Conference, May 11-13, 1989.

Fitch, L. 1990. Environmental Consequences of River Damming: Impacts on Fish. In: Ecological Consequences of River Damming. University of Lethbridge Seminar Course, 1990.

Busch, M., L. Fitch, N. Fraser, B. Glasgow, B. Peters, B. Rippin and B. Stubbs. 1990. Report of the strategic planning task force on the Fish and Wildlife Division's Conservation goal, objectives and activities. Alberta Forestry, Lands and Wildlife, Edmonton. 11 p.

Fitch, L. 1991. The Oldman Dam: A Case Study in Habitat Mitigation. pp 151-159 In: Western Proceedings - 71st Annual Conference of Western Association of Fish and Wildlife Agencies, Edmonton, Alberta, June 24-26, 1991.

Bjorge, R., L. Fitch, G. Hamilton, J. Kneteman and H. Wollis. 1993. Ecosystem Management: A Discussion. MS. 11 p.

Fitch, L., and J. O'Neil. 1994. Performance Audit of Instream Habitat Structures in Southwestern Alberta. In: Proceedings of Great Plains Fishery Workers Association, 43rd Annual Workshop, Deadwood, South Dakota. Feb 2-4, 1994.

Fitch, L., B. W. Adams, P. Strankman, C. Mills and G. Szabo. 1994. Alberta's Riparian Habitat Project: Moving from Conflict to Cooperation, Trout Canada. Fall 1994. 3p.

Fitch, L., M. Miles, J. O'Neil, R. Pattenden and G. Van Der Vinne. 1994. Defining the variables that influence success of habitat structures in southwestern Alberta. Proceedings of 9th International Trout Habitat Improvement Workshop, Sep. 6-9. 1994. Trout Unlimited Canada, Calgary.

Adams, B. W. and L. Fitch. 1995. Caring for the Green Zone: Riparian Areas and Grazing Management – First Edition. Alberta Riparian Habitat Management partnership. Lethbridge, Alberta. 39 p.

Fredenberg, W., T. Weaver, L. Fitch and T. Clayton. 1996. Bull Trout status report for the International Headwaters of the Oldman River Drainage: St. Mary's, Belly and Waterton Rivers. United States Department of the Interior, Fish & Wildlife Service, Kalispell, Montana. 34 p.

Fitch, L. and B. W. Adams. 1996. Cows & Fish: Caring for Riparian Areas. Wildlands Advocate, Vol. 4 #2 p 4-5.

Thomas, J. E., R. Sandham, E. C. Pienkowski, G. Chree, D. Groth, L. Chew, T. Clayton and L. Fitch. 1997. Genetic Variation in Populations of Bull Trout (*Salvelinus confluentus*) from Glacier National Park. United States National Park Service, West Glacier, Montana.

Groft, D., R. Sandham, D. Gonci, C. Prozniak, J. Thomas, L. Chew, T. Clayton and L. Fitch. 1997. Genetic variation among Alberta Bull Trout (*Salvelinus confluentus*) populations. University of Lethbridge report for Alberta Fisheries Management Enhancement Program. 82 p.

Fitch, L. 1997. Bull Trout in southwestern Alberta: Notes on Historical and Current Distribution. Pages 147-160 in Mackay, W. C., K. Brewin and M. Monita, editors. Friends of the Bull Trout conference proceedings Bull Trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary.

Fitch, L. and G. Hale. 1997. Alberta Riparian Habitat Management Program: A Provincial Strategy. Alberta Environment, Natural Resources Service, Lethbridge, Alberta. 16 p.

Pattenden, R., M. Miles, L. Fitch, G. Hartman and R. Kellerhals. 1998. Can Instream Structures Efficiently Restore Fisheries Habitat? Pages 1-11 in Brewin, K. and D. Monita, editors. Proceedings of the Forest Fish Conference. May, 1996.

Canadian Forest Service Information Report NOR-X-356.

Fitch, L. and B. W. Adams. 1998. Can Cows and Fish Co-exist? Can. J. Plant Science 78: 191-198.

Adams, B. W. and L. Fitch. 1998. Caring for the Green Zone: Riparian Areas and Grazing Management – Second Edition. Alberta Riparian Habitat Management Partnership. Lethbridge, Alberta. 40p.

Fitch, L., B. W. Adams and G. Hale. 1998. Down by the Riverside: Taking Care of Cows and Fish. Alberta Game Warden Vol. 10 #2 p 13-16.

Fitch, L. 1998. Riparian Issue Analysis- Alberta. Prepared for Agriculture Canada (PFRA) National Soil and Water Conservation Program. 8 p.

Fitch, L, and B. W. Adams. 1998. Prairie Biodiversity Conservation – the Ranching Connection. Proceedings of the Fifth Prairie Conservation and Endangered Species Conference, Saskatoon, Saskatchewan. Prov. Museum of Alberta Natural History Occasional Paper #24.

Adams, B. W., and L. Fitch. 1999. Module 10, Riparian Areas and Grazing Management. Range Management Module by Distant Learning, Lethbridge Community College. 28p.

Hurley, T. A., E. J. Saunders and L. Fitch. 1999. Effects of Cattle Grazing on Bird Communities in Cottonwood Forests along the Oldman River, Alberta. Proceedings of the Fifth Prairie Conservation and Endangered Species Conference, Saskatoon, Saskatchewan. Prov. Museum of Alberta Natural History Occasional Paper #24.

Fitch, L. 2000. Rangelands: Home to Ranchers and Wildlife. Proceedings of the Western Range Science Seminar, Lethbridge, Alberta. Jan. 23-25, 2000.

Fitch, L. 2000. A Template for Conservation in Agricultural Alberta: the Cows and Fish Process. Proceedings of the Caring for our Land and Water: Stewardship and Conservation in Canada. Guelph, Ontario. June 3-6, 2000.

Fitch, L. 2001. Restoration Choices: Thinking Like a Fish, Like a Stream, or Like a Watershed. Proceedings of 2001 Interior Forest Site Rehabilitation Workshop, Kamloops, BC. April 10-11, 2001.

Fitch, L., B. W. Adams and G. Hale. 2001. Riparian Health Assessment for Streams and Small Rivers – Field Workbook. Cows and Fish program, Lethbridge, Alberta. 90p.

Fitch, L. 2001. Water Management and Aquatic Systems: A Review. Proceedings of

Meridian Dam Forum, Medicine Hat, Alberta. Sept. 29, 2001.

Fitch, L. 2002. The Cows and Fish “Experiment”. Pages 186, 187 in Draper, D., Our Environment: A Canadian Perspective, Second Edition. Nelson Thompson Learning.

Fitch, L. 2002. Stewardship- The Elements of a Complex Relationship. Proceedings of Department of Fisheries and Oceans, Prairie Area, Habitat Management workshop, March 25- 28, 2002, Banff, Alberta. 8p.

Fitch, L., B. W. Adams and M. Alexander. 2003. The Value and Functions of Woody Plants in Range and Riparian Ecosystems. Proceedings of the Workshop on Integrated Brush Management, Saskatoon, Saskatchewan, Feb. 18, 19, 2003.

Fitch, L. and N. Ambrose. 2003. Riparian Areas: A User’s Guide to Health. Cows and Fish program, Lethbridge, Alberta. 46p.

Fitch, L., B. W. Adams and K. O’Shaughnessy. 2003. Caring for the Green Zone: Riparian Areas and Grazing Management- Third Edition. Cows and Fish program, Lethbridge, Alberta. 47p.

Fitch, L. 2004. Stewards- Changing the World. Proceedings of Volunteers in Motion II Conference, March 13, 2004, Red Deer, Alberta. 8p.

Fitch, L. 2006. “Who Me? Part of a Watershed?” Don’t Flush Yet! Trout Unlimited Canada Currents: Vol.12, No. 3, Summer, 2006, p 6-8.

Fitch, L. 2006. What’s a Wetland Worth? Alberta Conservation Association Croaks and Trills newsletter. Vol. 11, Issue 2. 2p.

Fitch, L. 2006. Alberta’s Riparian Areas- A Diagnosis and a Prescription. Proceedings of Alberta Chapter of the Wildlife Society Annual Conference, March 10-12, 2006, Lethbridge, Alberta.

Fitch, L. 2007. What’s in the “Stew” of Stewardship? Pages 1-3 in Awareness to Action: A Showcase of Environmental Stewardship in Alberta. Alberta Stewardship Network, Edmonton. 65p.

Fitch, L. 2007. Challenging Our Thinking- Will we get the future we planned for or the one we didn’t? Wildlands Advocate, Vol.14, Number 2. 4p.

Fitch, L. 2007. Protecting Shorelines and Streambanks- Naturally! Cows and Fish Fact Sheet. 4p.

Fitch, L. 2008. Cows and Fish Program-A Pathway to Watershed Stewardship. Pages 452-454 in D. Meredith and D. Radford, writers and editors. Conservation Pride and Passion- The Alberta Fish and Game Association 1908-2008. Alberta Fish and Game Association, Edmonton. 560p.

Fitch, L. 2008. Mitigation- Cosmetics or Compensation? Wildlands Advocate, Vol.16, Number 3. 6p.

Fitch, L. 2008. From Jasper to Jackfish- Thoughts for the Future of the Athabasca Watershed. Proceedings of Athabasca WPAC workshop, April 15, 16, 2008. www.gov.ab.ca/env/. 11p.

Fitch, L. 2008. Alberta Cows and Fish Program- Changing the World One Community at a Time. Proceedings of Great Plains Riparian Forest Summit, September 9- 10, 2008, Sioux Falls, South Dakota.

Fitch, L. 2008. Petro-Canada Sullivan Field Development Project- EIA Review. Prepared for Big Loop Interveners Group/ Carscallen and Leitch Barristers and Solicitors, Calgary. 10p.

Bradley, C., C. Wallis and L. Fitch. 2008. Paramount Pipeline within Rumsey Natural Area- Review of Environmental Assessment. Prepared for Alberta Native Plant Council and Alberta Wilderness Association. 16p.

Wonnacott, R., L. Fitch and L. Kinnear. 2009. Stepping Back from the Water: Protecting Ecological Functions of Riparian Areas in Alberta. AMEC Earth and Environmental and Alberta Riparian Habitat Management Society (Cows and Fish). Prepared for Alberta Environment. Edmonton, Ab. 33p.

Fitch, L. 2009. An Albertan's Perspective of the Future of Stewardship in Canada. Pages 5-7 in: "A Review of Stewardship Programs and Activities in Canada's Provinces and Territories", prepared by the Centre for Environmental Stewardship and Conservation for Alberta Environment. Edmonton, Ab.

Cleator, H., J. Earle, L. Fitch, S. Humphries, M. Koops, K. Martin, D. Mayhood, S. Petry, C. Pacas, J. Stelfox and D. Wig. 2009. Information Relevant to a Recovery Potential Assessment of Pure Native Westslope Cutthroat Trout, Alberta Population. Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, Research Document 2009/036.

Fitch, L. and J. T. Weaver. 2009. A Pond of Gold- Storing Water Naturally. Wildlife Conservation Society Canada and Cows and Fish Fact Sheet. Lethbridge, Alberta 4p.

Fitch, L. 2010. The Oldman Watershed-An Introduction to Our Home. In: Oldman River State of the Watershed Report-Summary 2010. Oldman Watershed Council, Lethbridge, Ab. 5p.

Fitch, L. 2011. Noah and the Fish: A Lesson for our Time. Nature Alberta Vol. 40, Number 4. 2p

Fitch, L. 2011. A Cutthroat We Should Respect. Wildlands Advocate Vol.19, Number 2. 4p

Fitch, L. 2011. Do Nothing- For Wildlife. Nature Alberta Vol. 41, Number 1. pp 28-31.

Alberta Westslope Cutthroat Trout Recovery Team. 2011. Alberta Westslope Cutthroat Trout Recovery Plan 2012-2017. Alberta Sustainable Resource Development, Fish and Wildlife Division, Alberta Species at Risk Plan, Edmonton, Ab. 78p.

Fitch, L. 2011. Connecting with Frogs: A Kind of Fairy Tale of Stewardship on the Balog Ranch. In: Amphibians on My Land, Alberta Conservation Association brochure, Edmonton, Ab. p. 6-9.

Fitch, L. 2011. Rust Never Sleeps. Nature Alberta, Vol. 41, Number 2. pp 24-31.

Fitch, L. 2011. Why Care About a Cutthroat? Castle Wilderness News, Vol. 21, Number 3.

Fitch, L. 2012. Riparian Areas Help to Mitigate Flood Impacts. Farming for Tomorrow magazine, Alberta Agriculture. Spring 2012.

Fitch, L. 2012. Challenging Our Thinking. Nature Alberta, Vol. 41, Number 4, pp40-44.

Fitch, L. 2012. An Elegy for the Crowsnest Bull Trout. Wildlands Advocate Vol. 20 Number 3. Pp 14-17

Fitch, L. 2012. A Letter to the Future. Nature Alberta Vol. 42, Number 1. Pp. 42-44.

Fitch, L. 2013. The Might Peace Watershed- 54ºN to 60ºN. Mighty Peace Watershed Alliance AGM, March 22, 2013, Peace River, Alberta.

Fitch, L. 2013. Eating Tomorrow. Nature Alberta Vol. 43, Number 1. Pp 9-10.

Fitch, L. and K. Spicer-Rawe. 2013. A River Starts in My Backyard: Prairie-fed Rivers. Nature Alberta, Vol. 43, No. 3

Fitch, L. 2013. A Legacy of Logging: The Shame of Hidden Creek. Wildlands Advocate, Vol. 21, No. 3

Fitch, L. 2014. Flood- The Other “F” Word? Nature Alberta, Vol. 44, Number 2. Pp 24-28.

Fitch, L. 2014. Bats in Your Hair and Other Wildlife Myths and Misperceptions. Nature

Alberta, Vol. 44, No. 3

Fitch, L. 2014. You Can't Put a Price on a Wetland. CPAWS Green Notes Newsletter. Summer, 2014. Pp 6-7.

Fitch, L. 2014. An Overview of Beaver Management for Agricultural Producers. Cows and Fish fact sheet. Lethbridge, Alberta 8p.

Fitch, L. 2014. Who Speaks for Endangered Species? The Alberta Wildlifer Vol. 25, Number 3. Pp 2-3.

Fitch, L. 2015. Oldman Watershed Bull Trout and Cutthroat Trout- Stream Reaches/Watersheds of Concern. Unpublished report.

Fitch, L. 2015. Two Fish, One Fish, No Fish: Alberta's Fish Crisis. Wildlands Advocate, Vol. 23, No. 5

Fitch, L. 2015. Wheel Spinning: A Productive Path to Protect Native Trout? Wildlands Advocate, Vol. 23, No. 6.

Fitch, L. 2015. In the Bedrooms of the Bull Trout. Nature Alberta, Vol. 45, No. 1.

Fitch, L. 2015. Tracks and Spoor. Nature Alberta, Vol. 45, No. 3.

Fitch, L. 2016. Hearts and Minds- Developing a Prairie Story. In: Kjoss, V. (Ed). Proceedings of the 11th Prairie Conservation and Endangered Species Conference, Feb. 2016, Saskatoon Saskatchewan. Saskatchewan Prairie Conservation Action Plan.

Fitch, L. 2016. Beavers: An Ally or an Inconvenient Species? Crown of the Continent and the Greater Yellowstone magazine. University of Montana, Missoula, Montana.

Fitch, L. 2016. Caring for the Green Zone: Beaver- Our Watershed Partner. Lethbridge, Alberta: Cows and Fish- Alberta Riparian Habitat Management Society. 43p.

Fitch, L. 2016. Myths About Off Highway Vehicle Use. Wildlands Advocate, Vol. 24, No. 4.

Fitch, L. 2016. Of Lizards, Oil and Velcro. Nature Alberta. Vol. 46, No. 1.

Fitch, L. 2017. Developing a Prairie Story. Nature Alberta, Vol. 47, No. 1.

Fitch, L. 2017. Fisheries Management: Complex, Complicated and Poorly Comprehended. Don Meredith Outdoors, donmeredith@wordpress.com.

Fitch, L. 2017. Hare-Footed Locoweed. Nature Alberta, Vol. 47, No. 2.

Fitch, L. 2017. The Inequity of “Balance”. Nature Alberta, Vol. 47, no. 3.

Fitch, L. 2018. Putting a Landscape to “Work”. Nature Alberta, Vol. 48, No. 1.

Fitch, L. 2018. Once, There Were Trout. Nature Alberta, Vol. 48, No. 2.

Fitch, L. 2019. A “Modest Proposal” for Alberta’s Caribou? Nature Alberta, Vol. 49, no.1, 2.

Fitch, L. 2019. Braking for the Planet- Learning the Limits. Nature Alberta, Vol.48, No. 4.

Fitch, L. 2019. Enlightenment-The Dying Age? Nature Alberta, Vol.48, No. 3.

Fitch, L. 2019. Public Land: Alberta’s Best Idea. Alberta Outdoorsmen, June, 2019.

Fitch, L. 2020. Counsel to Resource Professionals. ASPB BIOS, Vol.35, No. 1.

Fitch, L. 2020. Eating Tomorrow. ASPB BIOS. Vol.35, No. 2.

Fitch, L. 2020. A Trout is a Trout is a Trout, Isn’t it? ASPB BIOS, Vol 35, No. 3.

Fitch, L. 2020. Restructuring Eden- Shifting the Benchmarks. Nature Alberta, Summer, 2020.

Submission from Dr. John R. Post, Professor, University of Calgary

Following is my submission to the **Grassy Mountain Coal Project Environmental Assessment** for consideration at the hearing scheduled for October 2020.

This submission focusses on four issues, which in aggregate, bring into serious doubt the proponent's assertion that the proposed development will not negatively impact the viability of Threatened Westslope Cutthroat Trout (WSCT) in Alberta. Instead, the proposed development has a high likelihood of severely compromising the distributional and population viability objectives as laid out in the 'Westslope Cutthroat Trout: Recovery Strategy and Action Plan" (Fisheries and Oceans Canada 2019). In this submission, I assess issues of population viability of genetically unique WSCT, critical habitat loss, cumulative effects and the proposed mitigation and offsetting plan.

Current Viability of Westslope Cutthroat Trout in Alberta – Westslope Cutthroat Trout are a unique genetic stock of Cutthroat Trout that were assessed as Threatened by COSEWIC and subsequently listed under the *Species at Risk Act*. This listing triggers a series of legislated prohibitions and the Grassy Mountain Coal Project involves activities that are currently prohibited under this legislation. How serious are the proposed activities to the distributional and population objectives of this *SARA* listed species? In addressing this question there are several key points to consider. Over the previous several decades the distribution of WSCT in Alberta has been reduced by ~95%, resulting in few residual stream populations remaining in Alberta, outside of National Parks. Of these remnants, the Gold Creek population is one of the largest (6th out of 36). This population is therefore an important component of the long-term viability of the remaining 5% of this Threatened species in Alberta. Yet the long-term persistence of relatively small, locally adapted, remnant populations is not guaranteed; Mahood and Taylor (2011) suggest that a population the size of that in Gold Creek has only a 73% probability of long-term persistence (over 40 generations). The most recent status assessment estimates that mining within the southern East Slopes will cause a 31-70% percent decline in abundance of WSCT over the next 3 generations, within the footprint of the current operations (COSEWIC 2016). These estimates of long- and short-term population viability and decline rates are determined for current WSCT population sizes, and current levels of mining activity. The prognosis for viable WSCT will certainly worsen if the footprint of mining development in the East Slopes of Alberta is enlarged.

Habitat Losses Due to the Proposed Development – the project involves a permanent loss of WSCT Critical Habitat[1], both instream and riparian. In addition to this planned habitat destruction, the submission ignores the downstream impairment to habitat quality due to upstream Critical Habitat destruction. Therefore, the actual losses of functional habitat are understated in the proposal. Instream flow analyses also identify functional habitat loss: many

[1] Critical Habitat is defined under the *Species at Risk Act* - the habitat that is necessary for the survival or recovery of listed extirpated, endangered, or threatened species, and that is identified as Critical Habitat in a recovery strategy or action plan.

estimates are presented, but in the aggregate, there appears to be on average and 11%, or 20% worst case scenario, losses (Addendum 6 page 123). The report also under-represents actual Critical Habitat as the earlier DFO assessment considered only genetically pure WSCT, and ignored near-pure WSCT habitat. Once this oversight is fixed by DFO, the significance of the WSCT in Gold and Blairmore Creeks to the Alberta wide distributional and population viability objectives increases. So, the conclusion is that substantial losses of Critical Habitat for Threatened WSCT are expected from the proposed mine development. It should be noted that the current level of Critical Habitat of WSCT in Alberta is insufficient to ensure recovery (Recovery Action Plan 2019).

Cumulative Impacts of the Proposed Development – the proponent considers only cumulative impacts across a series of existing mining developments in the East Slopes and argues that since they do not overlap spatially, that there are no cumulative impacts. These arguments are fundamentally flawed for two reasons. First, *SARA* prohibitions are range wide and habitat losses at any individual location reduces the viability of WSCT for the species within Alberta. And second, and more crucial to this development proposal, the proponent ignores cumulative effects of multiple local impacts, and uncertainty in these impacts. For example, reported "minor" changes to flows, sediment, temperature, riparian structures, and contaminants, when overlain by predicted climate change (increased spring flooding, late summer droughts, summer temperature increases), will certainly have a negative cumulative impact on WSCT population viability. The analyses presented by the proponent therefore seriously under-represents the true cumulative impact of development on the long-term viability of WSCT within their proposed footprint. Analyses of cumulative effects of threats must incorporate all threats, model their synergies, and incorporate uncertainties to be credible – this EIA does none of this.

Mitigation Measures and Offsetting – Substantial aquatic and riparian habitat, key components of designated Critical Habitat, will be permanently eliminated causing loss of habitat for spawning, incubation, adult holding, juvenile rearing, and overwintering. Mitigation and offsetting proposals include constructing over-wintering pools, connecting reaches that may be seasonally disconnected, flow augmentation when feasible, and eliminating Brook Trout. The proponent argues that they can achieve a 9:1 offsetting of eliminated Critical Habitat. But the materials provided to the Environmental Assessment offer no evidence that these techniques will be successful! Critical questions to the proponent about the effectiveness of offsetting approaches were not addressed in follow-ups. For example: are overwintering pools or seasonal fragmentation or naturally low seasonal flows limiting the viability of WSCT in Gold and Blairmore Creeks? If not, these techniques will have no offsetting impact. Without such evidence, the proponent can not demonstrate that they can offset or mitigate the elimination of WSCT Critical Habitat. They argue that WSCT and their habitat will be monitored and that they will develop an "Aquatics Resource Management Plan" and "Aquatic Effects Monitoring Plan". But monitoring and paper plans do not replace Critical Habitat, and likely will do nothing other than document the further erosion of viability of WSCT in the East Slopes. Without clear evidence of an ability to offset the destruction of Critical Habitat, the project fails to ensure the distributional and population objectives for this listed species.

Conclusions

Westslope Cutthroat Trout of the East Slopes of southern Alberta are a *SARA* Listed Threatened species that has undergone substantial range contraction due to anthropogenic threats. Of the approximately 274 abundant stream populations that occurred historically in Alberta, only 50 small remnant pure populations remain (many of these populations contain less that 100 individuals). Province wide abundance has been estimated to be less that 5,000 mature WSCT. Unless current threats are effectively ameliorated, the species will become Endangered or Extirpated (COSEWIC 2016). This mining development proposal will further destroy Critical Habitat for the species. Although offsetting is proposed, there is no evidence that it will be effective in supporting the short or long-term persistence of the species. The proponent is committed to a substantial monitoring plan, but without evidence to the contrary, it will likely be useful only as documentation of a further reduction in the viability of one of the largest of the remaining locally adapted populations of WSCT in Alberta. This habitat destruction will likely result in, what was at one time the most widely distributed native trout in Alberta, WSCT becoming Endangered if these incremental losses of Critical Habitat are allowed to continue.

References

Mahood DW and EB Taylor. 2011. Contr5ibutions to a recovery plan for Westslope cutthroat Trout (*Oncorhynchus clarkia lewisi*) in Alberta: distribution, population size and trends. Freshwater Research Limited Technical Report No. 2011/06-1.

COSEWIC. 2016. Assessment and Status Report on the Westslope Cutthroat Trout *Oncorhynchus clarkia lewisi*.

Fisheries and Oceans Canada. 2019. Westslope Cutthroat Trout: recovery strategy and action plan, 2019.

CURRICULUM VITAE

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BIRTH DATE AND PLACE: November 1955, Toronto, Ontario, Canada

CITIZENSHIP: Canadian

ACADEMIC QUALIFICATIONS

1987 Ph.D. Zoology - York University, Toronto, Ontario
Dissertation: Size-Dependent Processes in Yellow Perch Recruitment

1984 M.Sc. Zoology - York University, Toronto, Ontario
Thesis: Planktivorous Fish and the Structure of Pelagic Plankton Communities
Graduated "With Distinction"

1980 B.Sc. Biology - University of Toronto, Toronto, Ontario

EMPLOYMENT

2003-present Professor, Biological Sciences, University of Calgary

1999-2003 Associate Professor, Biological Sciences, University of Calgary

1997-1998 Associate Professor, and NSERC University Research Fellow, Biological Sciences, University of Calgary

1991-1997 Assistant Professor, and NSERC University Research Fellow, Biological Sciences, University of Calgary

1989-1991 Assistant Professor, and NSERC University Research Fellow, Zoology, University of British Columbia

1987-1989 Post-Doctoral Fellow, Center for Limnology and Department of Zoology, University of Wisconsin-Madison

ACADEMIC AWARDS AND APPOINTMENTS

Current

2009-2021	Member, Committee on the Status of Endangered Wildlife in Canada, COSEWIC
2009-2021	Co-Chair, Freshwater Fishes Species Specialist Committee of COSEWIC
2006-present	Professor, Biogeosciences Institute of the Canadain Rockies and Foothills

Past

2014-2018	Associate Editor, Proceedings of the Royal Society B
2015-2018	Chair, Ecology and Evolutionary Biology, Department of Biological Sciences, University of Calgary
2015-2017	Chair, International Science Advisory Board for the 8th World Recreational Fishing Conference in Victoria, British Columbia, Canada - July 2017
2014	Noteworthy Publication in *Fisheries* – Hutchings and Post (2013)
2014	Community Engagement Award – Faculty of Science, University of Calgary
2014	Best Paper of the Year Award, American Fisheries Society, *North American Journal of Fisheries Management*
2014-2016	Board of Directors – Canadian Conference for Fisheries Research (CCFFR)
2012-13	Senior Fellow, Leibniz Institute of Freshwater Ecology and Inland Fisheries (IGB), Berlin Germany
2012	NSERC Discovery Grant Appeals Advisor
2010-2011	Co-Chair, NSERC Evolution and Ecology Evaluation Group 1503
2010-2014	Member, Peter Larkin Award Committee of the Canadian Aquatic Resources Section of the American Fisheries Society
2008-2010	Member, NSERC Evolution and Ecology Evaluation Group 1503
2008-2009	President – Canadian Conference for Fisheries and Aquatic Science
2007-2016	Associate Editor, Canadian Journal of Fisheries and Aquatic Sciences
2006-2008	Chair, Ecology and Evolutionary Biology, Department of Biological Sciences, University of Calgary
2006	Best Paper of the Year Award, American Fisheries Society, *North American Journal of Fisheries Management*
2005	Visiting Professor, University of Umea, Sweden
2004	Best Paper of the Year Award, American Fisheries Society, *North American Journal of Fisheries Management*
2003-2010	Associate, Canadian Rivers Institute, University of New Brunswick
2001	Alberta Emerald Award Nomination
2000	Faculty of Science Research Fellowship, University of Calgary
1999-2004	Chair, Division of Ecology, Department of Biological Sciences, University of Calgary
1990	Best Paper of the Year Award, American Fisheries Society, *Transactions of the American Fisheries Society*
1989-1998	NSERC University Research Fellowship
1987-1989	NSERC Post-Doctoral Fellowship

1987-1989	Gyer Post-Doctoral Fellowship, Department of Zoology and Centre for Limnology, University of Wisconsin
1986-1987	Province of Ontario Postgraduate Scholarship
1984-1986	NSERC Postgraduate Scholarship

RESEARCH GRANT SUPPORT HELD

Year	Title/Agency/Collaborators	Value $
2020-21	Conservation of wild stocks of rainbow trout – Freshwater Fisherries Society Techincal Committees Fund (with Theressa Godin and Dr. Brett van Poorten)	30,000
2019-20	Assessing the Effectiveness of Alberta's Walleye Regulations to Sustain High Quality Fishing Opportunities – Alberta Conservation Association	14,100
2019-21	East Slopes Fisheries Analyses – Alberta Environment and Parks.	15,000
2019-20	Value of information to make management decisions – Freshwater Fisherries Society Techincal Committees Fund (with Dr. Brett van Poorten and Vicki Lewis)	35,000
2018-22	Rising to the challenge: recovering native salmonids in the Alberta east slopes in the face of multiple stressors – Alberta East Slopes Fish Habitat and Native Fish Recovery Research Fund (PI with collaborators Dr. Andrew Paul and Jessica Reilly)	499,572
2018-19	Wild stocks of ranbow trout in British Columbia. British Columbia Forests, Lands and Natural Resources Operations.	25,000
2016-20	From genes to ecosystems: an eco-evolutionary assessment of alternative harvesting approaches and consequences for fisheries productivity – NSERC Strategic Programs Grant (with Drs. Dylan Fraser, Sean Rogers and Allison Derry)	579,840
2016-20	Sustaining freshwater recreational fisheries in a changing environment – Genome Canada and Genome British Columbia (with Dr. Particia Schulte and 12 others)	4,386,000
2016-18	Science for the Sustainable Management of Canada's Recreational Fishery – Freshwater Fisheries Society of British Columbia	75,000
2015-16	Life history variation and sustainable harvest of Nunavut Arctic Char – Fisheries and Oceans Canada (with PhD student Chris Cahill)	9,750
2015-17	Life history variation and sustainable harvest of Lake Trout – BC Large Lakes Committee, BC Forestry Lands and Natural Resources Operations and BC Freshwater Fisheries Society (with PhD student Kyle Wilson)	44,000
2014-15	The numerical response of anglers to fishing quality in British Columbia's lake trout fisheries – Mitacs-Accelerate Graduate Research Internship Program (with PhD student Kyle Wilson)	45,000
2013-18	Population dynamics in fishes: recruitment processes, environmental variation, adaptation and harvest – NSERC Discovery Grant	165,000

2012-17	Enhancing Angling Opportunities, Participation Rates and License Sales in the BC Small Lakes Rainbow Trout Fishery. BC Habitat Conservation Trust Fund (PI with Dr. Paul Askey, Cory Williamson, Steve Maricle and Adrian Clarke)	375,000
2010-15	Science for the Sustainable Management of Canada's Recreational Fishery – NSERC Collaborative Research and Development Grant with the Freshwater Fisheries Society of British Columbia (PI with Drs. Wolfgang Haider and Murdock McAllister)	1,236,300
2010	Vehicle for Field Research – NSERC Research Tools and Instruments (PI with Dr. Sean Rogers)	38,000
2010-11	Angler Effort Response to Stocking Density Manipulations – BC Small Lakes Management and Conservation Inititive (with MSc Student Hillary Ward)	25,000
2009-10	An Investigatrion of Factors Influencing Angling Effort – BC Habitat Conservation Trust Fund (with MSc Student Hillary Ward)	30,000
2008-13	Rivers for Life: Advancing Instream Flow Assessment Tools and Policy – Alberta Ingenuity Water Research Institute (PI with 9 others)	1,623,000
2008-09	Stream Productivity and the Use of Bioenergetics Models for Instream Flow Needs Analysis – Alberta Environment (with MSc Student Jacson Laliberte)	20,000
2008-09	Temperature Thresholds for Fish Communities – British Columbia Ministry of Environment, Ecosystems Branch (with MSc student Ellen Lea)	4,950
2008-10	Genotype X Environment Interactions in Growth, Survival and Energy Allocation in Rainbow Trout – Freshwater Fisheries Society of British Columbia (with MSc Student Ellen Lea)	24,500
2008-09	Instream Flow Needs for Fish in Jumpingpound Creek – Trout Unlimited Coldwater Conservation Fund (with MSc Student Jacson Laliberte)	6,750
2007-12	Recruitment Dynamics in Fishes: Population Consequences of Trait-Mediated Tradeoffs and Harvest – NSERC Discovery Grant	181,000
2006-09	Flowing To the Future: Influence of Climate Change on Hydrology and Ecology of Rivers from Alberta's Rocky Mountains – Alberta Ingenuity Water Research Centre (with Dr. Stu Rood and 4 others – Total Funding $415,600)	89,000
2004-06	Adapting Regional Management of Lake Trout Fisheries to Climate Change – Climate Change Impacts and Adaptation Program – Canada National Research Council (with Drs. Brian Shuter, Ken Minns, Paul Blanchfield and Shusen Wang)	165,000
2004-06	Predictive Approaches to Instream Flow Needs: Linking Biological and Physical Processes Across Spatial and Temporal Scales – Alberta Ingenuity Water Research Centre (PI with Drs. Ed McCauley and Lee Jackson)	87,320
2003-06	The South Saskatchewan Recreational Fishery: Adapting to Climatic Variation – Canadian Climate Action Fund, Natural Resources Canada (PI with Dr. Ted Horbulyk)	75,000
2003-04	The Magnitude and Significance of Fish Loss at the Calgary Bow River Headworks Canal to the Lower Bow River Fishery – Alberta Environment	125,000

2002-07	Sustainable Harvest of Wild Stocks in Low Productivity Monoculture Lakes – British Columbia Environment and BC Freshwater Fisheries Society	101,500
2002-03	Benchmarks of Pre-Industrial Contaminants in Arctic Food Webs – Fisheries Joint Management Committee (PI with Dr. Lee Jackson and Charles Arnold)	15,000
2002-03	Metal Bioaccumulation in Pre-Industrial Marine, Freshwater and Terrestrial Food Webs – University of Calgary Research Grants (PI with Drs. Lee Jackson, Annie Katzenberg and Bernhard Maier)	10,000
2002-06	Recruitment Dynamics in Fishes – NSERC Discovery Grant	160,000
2002-04	Lower Kananaskis Lake Bull Trout – Alberta Challenge Grants in Biodiversity (with Graduate Student Fiona Johnston)	11,500
2002-04	The Demography of an Unexploited Rainbow Trout Population in Cabin Lake, Jasper National Park – Alberta Challenge Grants in Biodiversity (with Graduate Student Brett van Poorten)	14,800
2001-05	Water Quality and Quantity in the South Saskatchewan River Basin – Canadian Water Network NSERC National Center of Excellence (with Drs. Lee Jackson and Ed McCauley)	558,000
2001-02	Literature Review of the Loss of Sport Fishes in Irrigation Canals and Experimental Design – Alberta Environment	26,800
1999-02	Recruitment Dynamics in Fishes – NSERC Research Grant	79,002
1999	Field Vehicle – NSERC Equipment Grant (PI with Drs. Lee Jackson and Ed McCauley)	32,930
1998-99	Recruitment Dynamics in Fishes – NSERC Research Grant	25,180
1997	Population Dynamics of Fluvial Bull Trout in the Highwood River – Alberta Conservation Association	17,174
1996	Spatial Distribution of Bull Trout in Kananaskis Country – Alberta Challenge Grants in Biodiversity (with graduate student Andrew Paul)	16,330
1995-00	Population Dynamics of Bull Trout in Smith Dorrien Creek and Lower Kananaskis Lake – Alberta Conservation Association, Alberta Fish and Wildlife Trust Fund and TransAlta Utilities	379,464
1995-99	A Quantitative Assessment of the Recovery of Bull Trout Populations in Alberta and Models of Sustainable Yield – Alberta Conservation Association and Alberta Fish and Wildlife Trust Fund	288,208
1995	Electrofishing Effects on Fish: Consequences at the Individual and Population Levels – Alberta Fish and Wildlife Trust Fund	9,692
1995-01	Strategic Management Plan for Canada’s Recreational Fisheries – NSERC Strategic Grant (with Dr. Carl Walters and Eric Parkinson)	502,000
1995	Angling During Reproduction in Stream Salmonids – Alberta Fish and Wildlife Trust Fund	4,950

1994-98	Recruitment Dynamics in Fishes – NSERC Research Grant	72,000
1992	Startup Grant – University of Calgary Research Grants	10,000
1991-04	Recruitment Dynamics in Fishes – NSERC Research Grant	93,000
1991-92	Use of GIS to Determine the Relationships Between Salmon Production, Habitat and Land Use – Department of Fisheries and Oceans Fisheries Subvention	12,000
1991	Equipment Grant – University of Calgary	30,000
1989-91	Recruitment Dynamics in Fishes – NSERC Research Grant	93,000
1989	Equipment Grant – University of British Columbia	20,000
1987	Mercury Bioaccumulation in Juvenile Yellow Perch – Ontario Ministry of the Environment (with Dr. D.J. McQueen)	29,000

REFEREED JOURNAL PUBLICATIONS

Yates MC, D Glaser, JR Post, M Cristescu, DJ Fraser and AM Derry. *in press*. The relationship between eDNA particle concentration and organism abundance in nature is strengthened by allometric scaling. Molecular Ecology.

Sinnatamby N, B Mayer, MK Kruk, SB Rood, A Farineau and JR Post. 2020. Considering multiple anthropogenic threats in the context of natural variability: Ecological processes in a regulated riverine ecosystem. Ecohydrology.

Dauwalter DC, A Duchi, J Epifanio, A Gandolfi, R Gresswell, F Juanes, J Kershner, J Lobon-Cervia,P McGinnity, A Meraner, P Mikheev, K Morita, C Muhlfeld, K Pinter, J R Post, G Unfer, LA Vollestad, J Williams. 2020. A Call for Global Action to Conserve Native Trout in the 21st Century and Beyond. Ecology of Freshwater Fish.

Sinnatamby N, A Cantin and JR Post. 2019. Threats to at-risk salmonids of the Canadian Rocky Mountain region. Ecology of Freshwater Fish.

Wilson K, A Foos, O Barker, A Farineau, J De Gisi and JR Post J. 2020. Social–ecological feedbacks drive spatial exploitation in a northern freshwater fishery: a halo of depletion. Journal of Applied Ecology.

Arlinghaus R, JK Abbott, EP Fenichel, SR Carpenter, LM Hunt, J Alós, T Klefoth, SJ Cooke, R Hilborn, OP Jensen, MJ Wilberg, JR Post and MJ Manfredo. 2019. Governing the recreational dimension of global fisheries. Proceedings of the National Academy of Sciences 116:5209-5213.

Wilson K, J de Gisi, C Cahill, O Barker and JR Post. 2019. Life History variation along environmental and harvest clines of a northern freshwater fish: plasticity and adaptation. Journal of Animal Ecology 88:717-733.

Brownscombe JW, K Hyder, W Potts, K Wilson, KL Pope, AJ Danylchuk, SJ Cooke, A Clarke, R Arlinghaus and JR Post. 2018. The future of recreational fisheries: advances in science, monitoring, management, and practice. Fisheries Research 21:247-255.

Carruthers TR, K Dabrowska, W Haider, E Parkinson, DA Varkey, H Ward, MK McAllister, T Godin, B Van Poorten, P Askey, KL Wilson, LM Hunt, A Clarke, E Newton, C Walters and JR Post. 2019. Landscape scale social and ecological outcomes of dynamic angler and fish behaviours: processes, data, and patterns. Canadian Journal of Fisheries and Aquatic Sciences 76:970-988.

Cahill CL, S Mogensen, KL Wilson, A Cantin, RN Sinnatamby, P Christensen, JR Reilly, L Winkle, A Farineau and JR Post. 2018. Multiple challenges confront a high-effort inland recreational fishery in decline. Canadian Journal of Fisheries and Aquatic Sciences 75:1357-1368.

Cantin A and JR Post. 2018. Habitat availability and ontogenetic shifts alter bottlenecks in size-structured fish populations. Ecology 99:1644-1659.

Sinnatamby RN, MC Pinto, FD Johnston, AJ Paul , CJ Mushens, JD Stelfox, H Ward and JR Post. 2018. Temporal patterns of reproductive migrations in adfluvial bull trout: an assessment of sex, spawning experience, population density, and environmental factors. Canadian Journal of Fisheries and Aquatic Sciences 75:2172-2183.

Biro PA, T Garland Jr., C Beckmann, B Ujvari, F Thomas, and J R Post. 2018. Metabolic scope as a proximate constraint on behaviour: effects on ‘personality’, plasticity, and predictability. American Naturalist 192:142-154.

Ward, H.G.M.. J.R. Post, N.P. Lester, P.J. Askey and T. Godin. 2017. Empirical evidence of plasticity in life history characteristics across climatic and fish density gradients. Canadian Journal of Fisheries and Aquatic Sciences 74:464-474.

Arlinghaus, R., J. Alos, B. Beardmore, K. Daedlow, M. Dorow, M. Fujitani, D. Huhn, W. Haider, L. M. Hunt, B. M. Johnson, F. Johnston, T. S. Matsumura, C. Monk, T. Pagel, J. R. Post, C. Riepe, H. Ward, and C. Wolter. 2017. Understanding and managing freshwater recreational fisheries as complex adaptive social-ecological systems. Reviews in Fisheries Science and Aquaculture 25:1-41.

Mee, JA, G Robins and JR Post. 2016. Patterns of fish species assemblage replicated across three parallel rivers suggest biotic zonation in response to a longitudinal temperature gradient. Ecology of Freshwater Fish 2016:1-18.

Laliberte, J, JR Post, JS Rosenfeld and JA Mee. 2016. Modelling temperature, body size, prey density, and stream gradient impacts on longitudinal patterns of potential fish production. River Research and Applications 32:2045-2055.

Mee, JA, JR Post, H Ward, KL Wilson, E Newton and A Cantin. 2016. Interaction of ecological and angler processes: experimental stocking in an open access, spatially structured fishery. Ecological Applications 26:1693-1707.

Ward H.G.M., M.S. Allen, E. Camp, N. Cole, L.M. Hunt, B. Matthias, J.R. Post, K. Wilson and R. Arlinghaus. 2016. Understanding and managing social-ecological feedbacks in spatially-structured recreational fisheries: the overlooked behavioral dimension. Fisheries 41:524-535.

Wilson KL, A Cantin, H.G. M. Ward, E. R. Newton, J.A. Mee, D. Varkey, E.A. Parkinson, and J.R. Post. 2016. Supply-demand equilibria and the size-number tradeoff in spatially structured recreational fisheries. Ecological Applications 26:1086-1097.

Lea, E, J Mee, JR Post, S Rogers and S Mogensen. 2015. Rainbow trout in seasonal environments: local adaptation and phenotypic plasticity across a gradient in winter duration. Ecology and Evolution 5:4778-4794.

Mogensen S., J.R. Post and M.G. Sullivan. 2014. Vulnerability to harvest by anglers differs across climate, productivity and diversity clines. Canadian Journal of Fisheries and Aquatic Sciences 71:416-426.

Lapointe, N., S. Cooke, J. Imhof, D. Boisclair, J. Casselman, R.A Curry, O. Langer, R. McLaughlin, K. Minns, J.R. Post, M. Power, J. Rasmussen, J. Reynolds, J. Richardson, W. Tonn. 2014. Principles for ensuring healthy and productive freshwater ecosystems that support sustainable fisheries. Environmental Reviews 22:1-25.

Laliberte, J., J.R. Post, J.S. Rosenfeld. 2014. Hydraulic geometry and longitudinal patterns of habitat quantity and quality for rainbow trout (*Oncorhynchus mykiss*). Rivers Research and Applications 30:593-601.

Pinto, M.C., J.R. Post, A.J. Paul, F.D. Johnston, C.J. Mushens and J.D. Stelfox. 2013. Lateral and longitudinal displacement of stream rearing juvenile bull trout in response to upstream migration of spawning adults. Transactions of the American Fisheries Society 142:1590-1601.

Hutchings, J. and J.R. Post. 2013. Gutting Canada's Fisheries Act: No fishery, no fish habitat protection. Fisheries 38:497-501.

Ward, H.G.M., P.J. Askey and J.R. Post. 2013. A mechanistic understanding of hyperstability in catch per unit effort and density-dependent catchability in a multistock recreational fishery. Canadian Journal of Fisheries and Aquatic Sciences 70:1542-1550.

Askey P.J., E.A. Parkinson, J.R. Post. 2013. Linking fish and fisher dynamics to assess stocking strategies for hatchery-dependent, open access recreational fisheries. North American Journal of Fisheries Management. 33:557-568. *[Best Paper of the Year Award]*

Ward, H.G.M., M.S. Quinn and J.R. Post. 2013. Angler characteristics and management implications in a large multi-stock spatially structured recreational fishery. North American Journal of Fisheries Management. 33:576-584.

Post, J.R. 2013. Resilient recreational fisheries or prone to collapse? A decade of research on the science and management of recreational fisheries. Fisheries Management and Ecology 20:99-110.

Ward, H.G.M., P.J. Askey, J.R. Post, D. Varkey and M. McAllister. 2012. Basin characteristics and temperature improve abundance estimates from standard index netting of small lakes. Fisheries Research 131-133:52-59.

Post, J.R. and E.A. Parkinson. 2012. Temporal and spatial patterns of angler effort across lake districts and policy options to sustain recreational fisheries. Canadian Journal of Fisheries and Aquatic Sciences 69:321-329.

Mogensen S. and J.R. Post. 2011. Energy allocation strategy modifies growth-survival tradeoffs in juvenile fish across ecological and environmental gradients. Oecologia 168:923-933.

Johnston, F.D., R. Arlinghaus, J. Stelfoxd and J.R. Post. 2011. Decline in angler use despite increased catch rates: anglers' response to the implementation of a total catch-and-release regulation. Fisheries Research 110:189-197.

Rosenfeld J.S., K. Campbell, E.S. Leung, J. Bernhardt, and J.R. Post. 2011. Habitat effects on depth and velocity frequency distributions: implications for modelling hydraulic variation and fish habitat suitability in streams. Geomorphology 130:127-135.

Johnston, F.D. and J.R. Post. 2009. Density-dependent life history compensation of an iteroparous salmonid. Ecological Applications 19:449-467.

Romanuk, T.N., B.E. Beisner, A.Hayward, L.J. Jackson, J.R. Post and E. McCauley. 2009. Processes governing riverine fish species richness are scale-independent. Community Ecology 10:17-24.

Granek, E.F., E.M.P. Madin, M.A. Brown, W. Figueira, D.S. Cameron, Z. Hogan, G. Kristianson, P. de Villiers, J. E. Williams, J.R. Post, S. Zahn and R. Arlinghaus. 2008. Engaging recreational fishers in management and conservation: global case studies. Conservation Biology 22:1125-1134.

Post, J.R., L. Persson, E.A. Parkinson and T. van Kooten. 2008. Angler numerical response across landscapes and the collapse of freshwater fisheries. Ecological Applications 18:1038-1049.

Biro, P.A. and J.R. Post. 2008. Fishery-induced evolution: rapid depletion of genotypes with fast growth and bold personality traits. Proceedings of the National Academy of Science. 105:2919-2922.

Rosenfeld, J.S., J.R. Post, G. Robins and T. Hatfield. 2007. Hydraulic geometry as a physical template for the River Continuum: application to optimal flows and longitudinal trends in Salmonid habitat. Canadian Journal of Fisheries and Aquatic Sciences 64:755-767.

Biro, P.A., J.R. Post and D.J. Booth. 2007. Climate induced mortality of fish populations is mediated by behaviour in whole-lake experiments. Proceedings of the National Academy of Science 104:9715-9719.

Askey, P.J., L.K. Hogberg, J.R. Post, L.J. Jackson, T. Rhodes and M.S. Thompson. 2007. Spatial patterns in fish biomass and relative trophic level abundance in a waste water enriched river. Ecology of Freshwater Fish 16:343-353.

Biro, P.A., M.V. Abrahams and J.R. Post. 2007. Direct manipulation of behaviour reveals a mechanism for variation in growth and mortality among prey populations. Animal Behaviour 73:891-896.

Johnston, F.D., J.R. Post, C.J. Mushens, J.D. Stelfox, A.J. Paul and B. Lajeunesse. 2007. The demography of recovery of an overexploited bull trout, *Salvelinus confluentus*, population. Canadian Journal of Fisheries and Aquatic Sciences 64:113-126.

Askey, P.J., J.R. Post, E.A. Parkinson, E. Rivot, A.J. Paul and P.A. Biro. 2007. Estimation of gillnet efficiency and selectivity across multiple sampling units: A hierarchical Bayesian analysis using mark-recapture data. Fisheries Research 83:162-174.

Beckmann, C., P.A. Biro and J.R. Post. 2006. Asymetric impact of piscivorous birds on size-structured fish populations. Canadian Journal of Zoology 84:1584-1593.

Askey, P.J., S.A. Richards, J.R. Post and E.A. Parkinson. 2006. Linking angling quality and learning under catch and release regulations: why are the fish not biting? North American Journal of Fisheries Management 26:1020-1029.

Post, J.R., van Poorten, B.T., Rhodes, T., Askey, P. and Paul, A.J. 2006. Fish entrainment into irrigation canals: an analytical approach and application to the Bow River, Alberta, Canada. North American Journal of Fisheries Management 26:875-887.

Biro, P.A., M.V. Abrahams and J.R. Post and E.A. Parkinson. 2006. Behavioral tradeoffs between growth and mortality help explain evolution of sub-maximal growth rates. Journal of Animal Ecology 75:1165-1171.

Anderson, K., A.J. Paul, E. McCauley, L. Jackson, J.R. Post and R. Nisbet. 2006. Ecological dynamics and the management of instream flow needs in rivers and streams. Frontiers in Ecology and the Environment 6:309-318.

Mackenzie-Grieve, J.L. and J.R. Post. 2006. Thermal habitat use by lake trout (*Salvelinus namaycush*) in two contrasting Yukon lakes. Transactions of the American Fisheries Society 135:727-738.

Mackenzie-Grieve, J.L. and J.R. Post. 2006. Projected impacts of climate warming on production of lake trout (*Salvelinus namaycush*) in southern Yukon lakes. Canadian Journal of Fisheries and Aquatic Sciences 63:788-797.

Romanuk, T.N., L.J. Jackson, J.R. Post, E. McCauley and N.D. Martenez. 2006. The structure of food webs along river networks. Ecography 29:3-10.

Biro, P.A., J.R. Post and M.V. Abrahams. 2005. Ontogeny of energy allocation reveals selective pressure promoting risk-taking behaviour in young fish cohorts. Proceedings of the Royal Society London B 272:1443-1448.

van Poorten, B.T. and J.R. Post. 2005. Seasonal fishery dynamics on a previously unexploited rainbow trout population with contrasts to established fisheries. North American Journal of Fisheries Management 25:329-345. [*Awarded 2005 Mercer Patriarche Best Paper of the Year*]

Biro, P.A., M.V. Abrahams, J.R. Post and E.A. Parkinson. 2004. Predators select against high growth rates and risk-taking behaviour in domestic trout populations. Proceedings of the Royal Society London B 271:2233-2237.

Biro, P.A., A.E. Morton, J.R. Post and E.A. Parkinson. 2004. Overwinter lipid depletion and mortality of age-0 rainbow trout (*Oncorhynchus mykiss*). Canadian Journal of Fisheries and Aquatic Sciences 61:1513-1519.

Parkinson, E.A., J.R. Post and S.P. Cox. 2004. Linking the dynamics of harvest effort to recruitment dynamics in a multi-stock, spatially-structured fishery. Canadian Journal of Fisheries and Aquatic Sciences 61:1658-1670.

Biro, P.A., J.R. Post and E.A. Parkinson. 2003. From individuals to populations: prey fish risk-taking mediates mortality in whole-system experiments. Ecology 84:2419-2431.

Biro, P.A., J.R. Post and E.A. Parkinson. 2003. Density-dependent activity reduces growth and survival of prey fish in whole-lake experiments. Journal of Animal Ecology 72:546-555.

Cox S.P., Walters, C.J. and Post, J.R. 2003. A model-based evaluation of active management of recreational fishing effort. *North American Journal of Fisheries Management* 23:1294–1302.

Post, J.R., C.J. Mushens, A.J. Paul and M. Sullivan. 2003. Assessment of alternative management strategies for sustaining recreational fisheries: model development and application to bull trout, *Salvelinus confluentus*. North American Journal of Fisheries Management 23:22-34. [*Awarded Best Paper of the Year*]

Biro, P.A., J.R. Post and E.A. Parkinson. 2003. Population consequences of a predator-induced habitat shift by trout in whole-lake experiments. Ecology 84:691-700.

Paul, A.J., J.R. Post and J.D. Stelfox. 2003. Can anglers influence the distribution of native and non-native salmonids in streams from the Canadian Rocky Mountains? North American Journal of Fisheries Management 23:109-119.

Post, J.R., M. Sullivan, S. Cox, N.P. Lester, C.J. Walters, E.A. Parkinson, A.J. Paul, L. Jackson, B.J. Shuter. 2002. Canada's recreational fisheries: the invisible collapse? Fisheries 27:6-17.

Post, J.R. and E.A. Parkinson. 2001. Energy allocation strategy in age-0 fish: allometry and survival. Ecology 82:1040-1051.

Paul, A.J. and J.R. Post. 2001. Spatial distribution of native and non-native salmonids in streams from the Canadian Rocky Mountains. Transactions of the American Fisheries Society 130:417-430.

Paul, A.J., J.R. Post, G.L. Sterling, C. Hunt. 2000. Density-dependent inter-cohort interactions and recruitment dynamics: models and a bull trout time series. Canadian Journal of Fisheries and Aquatic Sciences 57:1220-1231.

Benoit, H.B. and J.R. Post. 2000. Recruitment dynamics and size structure in experimental populations of the mosquitofish, *Gambusia affinis*. Copea 100:216-221.

Landry, F., J.R. Post and E.A. Parkinson. 1999. Spatial ontogeny of lentic rainbow trout: whole lake manipulations of population size-structure. Canadian Journal of Fisheries and Aquatic Sciences 56:1916-1928.

Post, J.R., E.A. Parkinson and N.T. Johnston. 1999. Density-dependent processes in structured fish populations: interaction strengths in whole lake experiments. Ecological Monographs 69:155-175.

Post, J.R., E.A. Parkinson and N.T. Johnston. 1998. Spatial and temporal variation in risk to piscivory of age-0 rainbow trout: patterns and population level consequences. Transactions of the American Fisheries Society 127:932-942.

Ainslie, B.J., J.R. Post and A.J. Paul. 1998. Effects of pulsed and continuous DC Electrofishing on juvenile rainbow trout. North American Journal of Fisheries Management 18:905-918.

Benoit, H.B. E. McCauley and J.R. Post. 1998. Testing the demographic consequences of cannibalism in *Tribolium confusum*. Ecology 79:2839-2851.

Benoit, H.B. and J.R. Post, E.A. Parkinson and N.T. Johnston. 1998. Colinization by lentic macrionvertebrates: evaluating colinization processes using artificial substrates and appraising applicibility for the technique. Canadian Journal of Fisheries and Aquatic Sciences 55:2425-2435.

Briggs, C.T. and J.R. Post. 1997. Field metabolic rates of rainbow trout (*Oncorhynchus mykiss*) estimated using electromyogram telemetry. Journal of Fish Biology 51:807-823.

Post, J.R., M.R.S. Johannes and D.J. McQueen. 1997. Evidence of density-dependent cohort-splitting in age-0 yellow perch, *Perca flavescens*: potential behavioural mechanisms and population level consequences. Canadian Journal of Fisheries and Aquatic Sciences 54:867-875.

Briggs, C.T. and J.R. Post. 1997. In situ activity metabolism of rainbow trout (*Oncorhynchus mykiss*): estimates obtained from telemetry of axial muscle electromyograms. Canadian Journal of Fisheries and Aquatic Sciences 54:859-866.

Post, J.R. and J.A. Lee. 1996. Metabolic ontogeny of teleost fishes. Canadian Journal of Fisheries and Aquatic Sciences 53:910-923.

Post, J.R., R. Vandenbos and D.J. McQueen. 1996. Uptake rates of food-chain and waterborne mercury by fish: field measurements, a mechanistic model, and an assessment of uncertainties. Canadian Journal of Fisheries and Aquatic Sciences 53:395-407.

Post, J.R., L.G. Rudstam and D.M. Schael. 1995. Temporal and spatial distribution of pelagic young-of-the-year fishes in a diverse freshwater community. Transactions of the American Fisheries Society 124:84-93.

Post, J.R. and D.J. McQueen. 1994. Variability in first year growth of yellow perch (*Perca flavescens*): predictions from a simple model, observations and an experiment. Canadian Journal of Fisheries and Aquatic Sciences 51:2501-2512.

Walters, C.J. and J.R. Post. 1993. Density dependent growth and competitive asymmetries in size-structured fish populations: a theoretical model and recommendations for field experiments. Transactions of the American Fisheries Society 122:34-45. [*Nominated Best Paper of the Year*]

McQueen, D.J., E.L. Mills, J.F. Forney, M.R.S. Johannes and J.R. Post. 1992. Trophic level relationships in pelagic food webs: comparisons derived from long-term data sets for Oneida Lake, New York (USA) and Lake St. George, Ontario (Canada). Canadian Journal of Fisheries and Aquatic Sciences 49:1588-1596.

Schael, D.M., L.G. Rudstam and J.R. Post. 1991. Gape limitation and prey selection in larval yellow perch (*Perca flavescens*), freshwater drum (*Aplodinotus grunniens*) and black crappie (*Pomoxis nigromaculatus*). Canadian Journal of Fisheries and Aquatic Sciences 48:1919-1925.

Post, J.R. 1990. Metabolic allometry of larval and juvenile yellow perch (*Perca flavescens*): in situ estimates and bioenergetic models. Canadian Journal of Fisheries and Aquatic Sciences 47:554-560.

Shuter, B.J. and J.R. Post. 1990. Climate, population viability and the zoogeography of temperate fishes. Transactions of the American Fisheries Society 119:314-336. [*Nominated Best Paper of the Year*]

Post, J.R. and D.O. Evans. 1989. Size-dependent overwinter mortality of young-of-the-year yellow perch (*Perca flavescens*): laboratory, in situ enclosure and field experiments. Canadian Journal of Fisheries and Aquatic Sciences 46:1958-1968.

Johannes, M.R.S., D.J. McQueen, T.J. Stewart and J.R. Post. 1989. Determinants of population abundance in golden shiners (*Notomigonus crysoleucas*): correlations with food and predators. Canadian Journal of Fisheries and Aquatic Sciences 46:810-817.

McQueen, D.J., M.R.S. Johannes, J.R. Post and D.R.S. Lean. 1989. Bottom-up and top-down impacts on freshwater pelagic community structure. Ecological Monographs 59:289-309.

Post, J.R. and D.J. McQueen. 1988. Ontogenetic changes in the distribution of larval and juvenile yellow perch (*Perca flavescens*): a response to prey or predators?. Canadian Journal of Fisheries and Aquatic Sciences 45:1820-1826.

McQueen, D.J. and J.R. Post. 1988. Cascading trophic interactions: uncoupling at the zooplankton-phytoplankton link. Hydrobiologia 159:277-296.

Post, J.R. and D.J. McQueen. 1987. The impact of planktivorous fish on the structure of a plankton community. Freshwater Biology 17:79-89.

Post, J.R. and A.B. Prankevicius. 1987. Size-selective mortality in young-of-the-year yellow perch (*Perca flavescens*): evidence from otolith microstructure. Canadian Journal of Fisheries and Aquatic Sciences 44:1840-1847.

McQueen, D.J., J.R. Post and E.L. Mills. 1986. Trophic relationships in freshwater pelagic ecosystems. Canadian Journal of Fisheries and Aquatic Sciences 43:1571-1581.

Post, J.R. and D. Cucin. 1984. Changes in the benthic community of a small precambrian lake following the introduction of yellow perch, *Perca flavescens*. Canadian Journal of Fisheries and Aquatic Sciences 41:1496-1501.

LETTERS, NOTES AND COMMUNICATIONS IN REFEREED JOURNALS

Post, J.R. and D.O. Evans. 1989. Experimental evidence of size-dependent predation mortality in juvenile yellow perch. Canadian Journal of Zoology 67:521-523.

McQueen, D.J. and J.R. Post. 1987. Reply to Pierre Pepin. Canadian Journal of Fisheries and Aquatic Sciences 44:1096-1098.

PAPERS IN REFEREED CONFERENCE PROCEEDINGS

Mackenzie-Grieve, J. and J.R. Post. 2008. Projected impacts of climate warming on lake trout production in the north. In K.H. Mills, M. Dyck and L.A. Harwood. Proceerings of the Second Lake Trout Symposium, Yellowknife, Northwest Territories. Canadian Technical Report of Fisheries and Aquatic Sciences 2778:170-173.

Paul, A., C. Pacas, M. Sullivan, N. Lester, and J.R. Post. 2008. Using population-level risk and uncertainty as a basis for lake trout management in Banff National Park. In K.H. Mills, M. Dyck and L.A. Harwood. Proceerings of the Second Lake Trout Symposium, Yellowknife, Northwest Territories. Canadian Technical Report of Fisheries and Aquatic Sciences 2778:133-136.

Post, J.R. 2004. Life history variation and sustainable harvest with regulations in lake trout, *Salvelinus namaycush*, populations. Pages 134-137. In McKee L. and S. Thompson. Symposium on the Ecology, Habitat and Management of Lake Trout in North America. Yukon Department of the Environment, Whitehorse, Yukon, Canada.

Thera, T.M., A.J. Paul, P.J. Hvenegaard and J.R. Post. 2001. Identification of research priorities for a fluvial bull trout (*Salvelinus confluentus*) population using a quantitative life-cycle model in a simulation modelling framework. Pages 105-107. In Brewin M.K., A.J. Paul and M. Monita, editors. Bull Trout II Conference Proceedings. Trout Unlimited, Calgary, Alberta.

Post J.R., C.J. Mushens and A.J. Paul. 2001. Sustainable exploitation of bull trout: biology, management and models. Page 215. In Brewin M.K., A.J. Paul and M. Monita, editors. Bull Trout II Conference Proceedings. Trout Unlimited, Calgary, Alberta.

Paul. A.J., G.L. Stirling, C. Hunt and J.R. Post. 2001. The implications of a prolonged youth: Ecological and management consequences of intercohort interactions among juvenile bull trout. In Brewin M.K., A.J. Paul and M. Monita, editors. Bull Trout II Conference Proceedings. Trout Unlimited, Calgary, Alberta.

Mushens, C.J., J.R. Post, J.D. Stelfox and A.J. Paul. 2001. Dynamics of an adfluvial bull trout population following the implimentation of catch-and-release only regulations. In Brewin M.K., A.J. Paul and M. Monita, editors. Bull Trout II Conference Proceedings. Trout Unlimited, Calgary, Alberta.

McQueen, D.J., M.R.S. Johannes, J.R. Post, T.J.Stewart and D.R.S. Lean. 1990. Biomanipulation and community structure at Lake St. George, Ontario, Canada. Verh. Internat. Verien. Limnol. 24:335-338.

McQueen, D.J. and J.R. Post. 1988. Limnocorral studies of cascading trophic interactions. Verh. Internat. Verein. Limnol. 23:739-747.

McQueen, D.J. and J.R. Post. 1986. Enclosure experiments: the effects of planktivorous fish. In: Lake and Reservoir Management: Vol II. Proceedings of the Fifth International Symposium on Applied Lake and Watershed Management. Lake Geneva, Wisconsin. pp. 313-318.

McQueen, D.J. and J.R. Post. 1985. Effects of planktivorous fish on zooplankton, phytoplankton and water chemistry. In: Lake and Reservoir Management: Practical Applications. Proceedings of the Fourth Annual Conference and International Symposium, North American Lake Management Society. McAfee, New Jersey 1984. pp. 35-42.

<u>REFEREED BOOK CHAPTERS</u>

Rudstam, L.G., J.R. Post and J.L. Forney. 2016. Functional response and prey population dynamics: analysis of interactions between walleye and young-of-year yellow perch in Oneida Lake. *In* L. Rudstam, E. Mills, R. Jackson and D. Stewart. Oneida Lake: Long-Term Dynamics of a Managed Ecosystem and its Fisheries. American Fisheries Society, Bethesda, Maryland.

Post J.R., N. Mandrak and M. Burridge. 2016. Canadian freshwater fish, fisheries and their management south of 60°N Latitude. *in* J. Craig (ed). Freshwater Fisheries Ecology. Blackwell Science, UK.

Post, J.R., M. Sullivan, S. Cox, N.P. Lester, C.J. Walters, E.A. Parkinson, A.J. Paul, L. Jackson, B.J. Shuter. Reprint. Canada's recreational fisheries: the invisible collapse? Fisheries 27:6-17. in GG Saas and MS Allen. Foundations in Fisheries Science. American Fisheries Society. 801p.

Arlinghaus R. J.R. Post, L.M. Hunt and M. Allen. 2014. Not fish not meat – some guidance on how to study fisheries from an interdisciplinary persppective. *in* W. Taylor, N. Leonard and A. Lynch (eds.) Future of fisheries: perspectives for the next generation of professionals. American Fisheries Society. Bethesda MD.

Post, J.R. and L.G. Rudstam. 1992. Interactive dynamics of walleye and perch populations. *In* J.F. Kitchell (ed.) Food Web Research and its Application to Lake Management: A Case Study of Lake Mendota, Wisconsin. Springer-Verlag.

Rudstam, L.G., Y. Allen, B.M. Johnson, C. Luecke, J.R. Post and M.J. Vanni. 1992. Food web structure of Lake Mendota. *In* J.F. Kitchell (ed.) Food Web Research and its Application to Lake Management: A Case Study of Lake Mendota, Wisconsin. Springer-Verlag.

Post, J.R., L.G. Rudstam, D.M. Schael and C. Luecke. 1992. Pelagic planktivory by larval fishes in Lake Mendota. *In* J.F. Kitchell (ed.) Food Web Research and its Application to Lake Management: A Case Study of Lake Mendota, Wisconsin. Springer-Verlag.

Carpenter, S.R., B.M. Johnson, C. Luecke, C.J. Madenjian, K. McTigue, J.R. Post, L.G. Rudstam and M. Vanni. 1992. Modelling the Lake Mendota Ecosystem: Synthesis and evaluation of progress. *In* J.F. Kitchell (ed.)

Food Web Research and its Application to Lake Management: A Case Study of Lake Mendota, Wisconsin. Springer-Verlag.

OTHER REFEREED CONTRIBUTIONS (incomplete list of COSEWIC reports)

Note on COSEWIC Reports: My involvement over a 2-year period for each report includes advertising for and selecting a contract writer, managing 2 review periods of 5-8 jurisdictional reviews each, preparing instructions for the contract author, presenting the report to COSEWIC, and revising the report following the COSEWIC Species Assessment Meeting review. The final report that is submitted to the Minister of Environment and Climate Change, and to the Canadian public, is authored by COSEWIC.

COSEWIC 2017. COSEWIC status appraisal summary on Shortnose Cisco *Coregonus reighardi*. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 18 pp.

COSEWIC 2016. COSEWIC status report on Westslope Cutthroat Trout *Oncorhynchus clarki lewisi*. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xv + 102 pp.

COSEWIC 2016. COSEWIC status report on Speckled Dace *Rhinichthys osculus*. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 58 pp.

COSEWIC 2016. COSEWIC status report on Northern Sunfish *Lepomis peltastes*. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xii + 47 pp.

COSEWIC 2016. COSEWIC status report on the River Darter *Percina shumardi*. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xxi + 54 pp.

COSEWIC 2015. COSEWIC status appraisal summary on River Redhorse *Moxostoma carinatum*. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 16 pp.

COSEWIC 2015. COSEWIC assessment and update status report on the black redhorse *Moxostoma duquesnei* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 22 pp.

COSEWIC 2015. COSEWIC assessment and update status report on the warmouth *Lepomis gulosus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 45 pp.

COSEWIC. 2014. COSEWIC assessment and status report on the Banded Killifish *Fundulus diaphanus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 22 pp.

COSEWIC. 2014. COSEWIC assessment and status report on the Copper Redhorse *Moxostoma hubbsi* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xiii + 80 pp.

COSEWIC. 2014. COSEWIC assessment and status report on the Rainbow Trout *Oncorhynchus mykiss* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 60 pp.

COSEWIC. 2014. COSEWIC status appraisal summary on the Spotted Sucker *Minytrema melanops* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 18 pp.

COSEWIC. 2013. COSEWIC assessment and status report on the Pugnose Shiner *Notropis anogenus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 32 pp.

COSEWIC. 2013. COSEWIC assessment and status report on the Bridle Shiner *Notropis bifrenatus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 30 pp.

Post, J.R. and F.D. Johnston. 2002. The status of bull trout (*Salvelinus confluentus*) in Alberta. Alberta Environment, Fisheries and Wildlife Management Division, and Alberta Conservation Association, Wildlife Status Report No. 39, Edmonton, AB. 44 pp.

NON-REFEREED PROCEEDINGS AND TECHNICAL REPORTS

Sinnatamby, N. J.R. Post, B. Mayer, S. Rood, A. Farineau and V. Fau. 2018. Ecological dynamics and instream flow needs: a program and assessment of the challenges for the SSRB. Alberta Inginuity. 33p.

Cantin, A., A. Farineau and J.R. Post. 2018. Distribution of rainbow trout across western Canada: Identification of wild populations in contrasting climatic conditions. Genome BC. 41p.

Burn, D., G. Dixon, M. Dube, J. Flotemersch, W. Franzin, J. Gibson, K. Munkittrick, J.R. Post, S. Watmough (authors alphabetical). 2011. Regional Aquatics Monitoring Program (RAMP) Scientific Review. Alberta Innovates Technology Futures. 160p.

Mackenzie-Grieve, J., J.R. Post, C. Arnold, A. Katzenberg, B. Mayer and L. Jackson. 2005. Pre-Industrial Food Webs and Benchmark Metal Concentrations in the Mackenzie River Delta of the Western Canadian Arctic. Prepared for the Fisheries Joint Management Committee. Yellowknife, NWT. 28 pages.

van Poorten, B. and J.R. Post. 2004 Magnitude and temporal variability of entrainment at the Carseland-Bow river Headworks Canal. Prepared for Alberta Environment. 81 pages.

Post, J.R. 2004. State of Canada's Freshwater Fisheries. Pages 111-119 In P. Gallaugher and L. Wood (ed.) The World Summit on Salmon Proceedings. Continuing Studeis in Science, Simon Fraser University, Burnaby, BC.

Mushens, C., F.D. Johnston, and J.R. Post. 2003. Population dynamics of the Lower Kananaskis Lake bull trout: 1995-2000 Final Report. University of Calgary, Calgary, AB. Prepared for Alberta Conservation Association and TransAlta Utilities. 71 pp. + app.

Earle, S. N. and J.R. Post. 2001. Fish loss in water diversions: a literature review. Alberta Environment Report April 2001. Calgary, Alberta.

Post, J.R. and A.J. Paul. 2000. A quantitative assessment of the recovery of bull trout populations in Alberta and development of models of sustainable yield. Alberta Conservation Association Report.

Mushens, C.J. and J.R. Post. 2000. Population dynamics of the Lower Kananaskis Lake bull trout: 1998 progress report. Alberta Conservation Association Report.

Mushens, C.J. and J.R. Post. 1999. Population dynamics of the Lower Kananaskis Lake bull trout: 1998 progress report. Alberta Conservation Association Report.

Mushens, C.J. and J.R. Post. 1998. Population dynamics of the Lower Kananaskis Lake bull trout: 1997 progress report. Alberta Fisheries Habitat Development Fund Report.

Mushens, C.J. and J.R. Post. 1997. Population dynamics of the Lower Kananaskis Lake bull trout: 1996 progress report. Alberta Fisheries Habitat Development Fund Report.

Paul, A.J. and J.R. Post. 1997. A quantitative assessment of the recovery of the bull trout populations in Alberta and development of models of sustainable yield: the second year of investigation (1996). Alberta Fisheries Management Enhancement Report.

Mushens, C.J. and J.R. Post. 1996. Population dynamics of the Lower Kananaskis Lake bull trout. Alberta Fisheries Habitat Development Report.

Paul, A.J. and J.R. Post. 1996. A quantitative assessment of the recovery of the bull trout populations in Alberta and development of models of sustainable yield. Alberta Fisheries Management Enhancement Report.

Ainslie, B. and J.R. Post. 1996. Pulsed and continuous DC electroshocking: effects at the individual and population levels. Alberta Fisheries Management Enhancement Report.

Parkinson, E., J.R. Post and T. Johnston. 1995. Using growth and survival data to optimize management strategies on small lakes. Province of British Columbia Fisheries Management Report.

Ainslie, B. and J.R. Post. 1995. Effects of catch and release angling on the reproductive success of stream spawning salmonids: a literature review. Alberta Fisheries Management Enhancement Report.

Walters, C.J., J. DeGisi, J.R. Post and J. Sawada. 1991. Kootenay Lake fertilization response model: results from an Adaptive Environmental Assessment Workshop November 1990-February 1991. A report prepared for the British Columbia Fish and Wildlife Branch and British Columbia Hydro.

Post, J.R. 1988. Modelling growth/consumption dynamics of young fish. In: Bioenergetics Booter Vol 1:52-54. University of Wisconsin Sea Grant Institute and the UW-Madison Center for Limnology.

PUBLICATIONS BY GRADUATE STUDENTS AND POST-DOCTORAL FELLOWS WORKING IN MY LABORATORY

Dabrowska K., W. Haider and L. Hunt. 2014. Examining the impacts of fisheries resources and quality on licence sales. Journal of Outdoor Recreation and Tourism 5-6:58-67.

van Poorten B.T., T.R. Carruthers, H.G.M. Ward and D. Varkey. 2015. Imputing recreational angling effort from time-lapse cameras using a hierarchical Bayesian model. Fisheries Research 172:265-273.

Van Poorten B.T., C.J. Walters and H.G.M. Ward. Predicting changes in the catchability coefficient through effort sorting as less skilled fisheres exit the fishery during stock declines. Fisheries Research 183:379-384.

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MANUSCRIPTS IN REVIEW

Cahill CL, Anderson SC, Paul AJ, MacPherson L, Sullivan MG, van Poorten B, Walters CJ and Post JR. *in review*. A Spatial-temporal approach to modeling somatic growth across inland recreational fisheries landscapes. Canadian Journal of Fisheries and Aquatic Sciences.

Mee JA, Farineau, A, Wilson, K, and Post JR. *in review*. Modelling the effects of climate change on water temperature and fish distributions in the foothills of the Canadian Rocky Mountains. Canadian Journal of Fisheries and Aquatic Sciences.

Taylor EB, Mandrak, NE, JR Post and JD Reynolds*.* i*n review.* Conservation of Canadian freshwater fishes: current status and research needs. *in* Cooke SJ (ed) Fish and Fisheries of Canada.

van Poorten B, MG Sullivan, T Godin, JR Post, EA Parkinson and D Close. i*n review.* Status and management of freshwater resources in western Canada (Alberta and British Columbia). *in* Cooke SJ (ed) Fish and Fisheries of Canada.

Pope KL, CJ Chizinski, AJ Lynch and JR Post. i*n review.* Creel surveys. *In* Analysis and Interpretation of Freshwater Fisheries Data. 2nd Edition. American Fisheries Society.

Biro P, JR Post, C Beckmann. i*n review*. Autumn lipid reserves, overwinter lipid depletion, and high winter mortality of rainbow trout in experimental lakes. Oecologia.

THESES

Post JR. 1987. Size-dependent processes in yellow perch recruitment. Ph.D. Thesis, York University, Toronto. 262 p.

Post JR. 1984. Planktivorous fish and the structure of pelagic plankton communities. M.Sc. Thesis, York University, Toronto. 128 p.

Post JR. 1980. Changes in the benthic community of a small precambrian lake following the introduction of yellow perch, *Perca flavescens*. B.Sc. Thesis, University of Toronto, Toronto.

INVITED SEMINARS AND PRESENTATIONS

An assessment of alternate regulations to maintain quality lake trout fisheries. Parks Canada Workshop: Developing a framework of standard analyses for lake trout stock assessment in western Canada. Banff, June 2019.

Use of Threats to At-Risk Salmonids of the Canadian Rocky Mountain Region. Symposium on the Population Ecology of Stream Salmonids V. Granada, Spain, May 2019.

A Primer on the Assessment of Species-at-risk in Canada. Environmental Law Panel Discussion. University of Calgary, April 2019.

Landscape Scale Dynamics of Fish, Fishers and Policy: Experiments, Data and Models of BC's Recreational Fisheries. Natural Resources and the Environment, University of Northern British Columbia, January 2019.

Landscape Scale Interactions Among Fishers, Fish and Policy: Experiments, Data and Models in the BC Rainbow Trout fishery. British Columbia Annual Fisheries Meeting, Kelowna, January 2018.

Landscape Scale Dynamics of Fishers, Fish and Policy: Models of Canadian Recreational Fisheries. World Recreational Fishing Conference, Victoria, British Columbia, July 2017.

Landscape Scale Dynamics of Fishers, Fish and Policy: Experiments in Canadian Recreational Fisheries. World Recreational Fishing Conference, Victoria, British Columbia, July 2017.

Landscape Scale Dynamics of Fish, Fishers and Policy: Experiments, Data and Models of Recreational Fisheries. British Columbia annual fisheries Meeting, Kelowna, January 2016.

Landscape Scale Dynamics of Fish, Fishers and Policy: Experiments, Data and Models of Recreational Fisheries. Ecology and Evolution, University of Toronto. July 2015.

Landscape Scale Dynamics of Fishers, Fish and Policy: Experiments, Data and Models of Canadian Recreational Fisheries. EIFAAC International Symposium on Recreational Fisheries, Lillehammer, Norway. June 2015.

Landscape Scale Dynamics of Fishers, Fish and Policy: Experiments, Data and Models of Canadian Recreational Fisheries. Global Conference on Inland Fisheries, FAO-UN. Rome, Italy. January 2015

Optimizing stocking rates in spatially structured recreational fisheries. Keynote a the Annual Meeting of the Fisheries Society of the British Isles, Hull, UK. July 2014.

Recruitment as an emergent property of ecological and evolutionary processes. Ecology and Evolutionary Biology Research Seminar. University of Calgary. March 2014.

Recreational Fisheries: Resilient Fisheries (or Prone to Collapse?). Departmental Seminar, Leibniz Institute of Freshwater Ecology and Fisheries. Berlin, Germany. October 2012.

Population Consequences of Behavioural and Physiological Tradeoffs in Young Fish in a Seasonal Environment. IGB Colloquium, Leibniz Institute of Freshwater Ecology and Fisheries. Berlin, Germany. November 2012.

Science for the Sustainable Management of Canada's Recreational Fisheries. British Columbia Fisheries Program Annual Meeting. Kelowna, BC. January 2012.

Science for the Sustainable Management of Canada's Recreational Fisheries. British Columbia Small Lakes Management Meeting. Vancouver, BC. November 2011.

Effectiveness of regulations to sustain sport fisheries across landscapes. Annual Meeting of the American Fisheries Society, Seattle, WA. September 2011.

Recreational fisheries: resilient fisheries or prone to collapse? Keynote Presentation at the World Recreational Fishing Conference. Berlin, Germany. August 2011.

A landscape scale adaptive management experiment in recreational fisheries. Annual Meeting of the Freshwater Fisheries Society of British Columbia. February 2011.

Growth, survival and recruitment of juvenile fish across environmental gradients: behaviour and energy allocation strategies. Concordia University. January 2010.

Fish production and angler effort dynamics within lakes and across landscapes. Freshwater Fisheries Society of British Columbia. Vancouver, BC. September 2008.

Sustainable freshwater fisheries in a changing world: experiments, models and management. University of British Columbia Okanagan. Kelowna, BC. February 2008.

Temperature dependent growth and survival of juvenile fishes and implications to climate change. Swedish Initiative on Climate Change and Freshwater Ecology Workshop. Kronlund, Sweden. November 2007.

Landscape scale processes that lead to the collapse of freshwater fisheries. Leibniz Institute of Freshwater Ecology and Fisheries. Berlin, Germany. October 2007.

Recruitment processes in size-structured populations. Leibniz Institute of Freshwater Ecology and Fisheries. Berlin, Germany. October 2007.

Numerical responses over landscapes: anglers as predators and the collapse of freshwater fisheries. Ecology and Evolutionary Biology Seminar Series, University of Calgary. January 2007.

Sustainable harvest rates of Lake Minnewanka lake trout. Aquatic Ecosystem Advisory Group, Banff National Park. January 2007.

How do anglers respond to quality and how can regulations optimize catch and effort? British Columbia Annual Small Lakes Meeting. Kelowna. November 2006.

Data and models of fisheries ecology. Pacific Institute for the Mathematical Sciences. Mathematical Ecology Workshop. Kananaskis Field Stations. October 2006.

Canada's recreational fisheries: the invisible collapse? Symposium on the Role of Fishers in Conservation and Management: Lessons from Freshwater Systems for Marine Practioners. Society for Conservation Biology. San Jose, California. June 2006.

The invisible collapse of recreational fisheries: patterns, processes and prognosis. Bevan Series in Sustainable Fisheries, School of Aquatic and Fishery Science, University of Washington. January 2006.

Size-Dependent Competitive Interactions in Lake Fishes: Does Behaviour Matter? Department of Ecology and Environmental Science, Umea University, Umea, Sweden. October 2005.

Angler Dynamics and Sustainable Fisheries. Department of Aquaculture, Swedish Agricultural University (SLU), Umea, Sweden. September 2005.

Determining Instream Flow Needs for Fishes of the South Saskatchewan River Basin. Teleconference Presentatiuon to Alberta Environment, Alberta Sustainble Resource Development and Canada Department of Fisheries and Oceans. February 2005.

Challenges for the Management of Freshwater Recreational Fisheries. Cornel University, Ithaca, NY. March 2004.

Population Dynamics of Freshwater Fish. Cornell Biological Field Station, Bridgeport, NY. March 2004.

State of Canada's Freshwater Fisheries. World Salmon Summit. Wosk Centre for Dialogue, Simon Fraser University, Vancouver. June 2003.

Canada's Recreational Fisheries: The Invisible Collapse. Great Lakes Fisheries Commission. Thunder Bay, Ontario. June 2003.

Why Do We Continue to Collapse Fisheries? Canadian Council of Deans of Science. Kananaskis, Alberta. May 2003.

Multiple Stressors and the Invisible Collapse of Recreational Fisheries. Joint Symposium at the Canadian Conference for Fisheries Research and Society for Canadian Limnologists, Ottawa, January. 2003.

Mechanisms of Collapse in Recreational Fisheries. Umea University, Umea, Sweden. October 2002.

Modelling Population and Fishery Processes to Assess Alternate Policy Options. Umea University, Umea, Sweden. October 2002.

Challenges to Fishery Management: Life History Variation and Angler Behaviour. Umea University, Umea, Sweden. October 2002.

Collapse of Canada's Recreational Fisheries. National Strategic Task Force for Freshwater Fisheries, Canadian Centre of Inland Waters, Burlington, Ontario. March 2002.

The mechanisms of collapse of fisheries. Department of Biological Sciences, University of Calgary. February 2001.

The invisible collapse of Canada's recreational fisheries. Department of Biological Sciences, University of Alberta. February 2000.

Density-dependent processes in size-structured fish populations: allometry and experiments. Department of Biology, University of Windsor. October 1999.

Assessing Research and Management Objectives for Lower Kananaskis Lake Bull Trout. Alberta Bull Trout Workshop, University of Calgary. June 1999.

The Philosophy of Modelling Resource Systems. Alberta Bull Trout Workshop, University of Calgary. March 1999.

Density-dependent processes in size-structured fish populations: allometry and experiments. Ecology and Systematics Colloquim, Cornell University. October 1998.

Biology, management and models: a little bit about bull. Seminar Series, Cornell University Field Station, Oneida Lake, NY. July 1998.

The bull trout program in Alberta: science and management. The Status of Alberta Bull Trout Workshop, University of Calgary, AB. April 1998.

Fisheries biology and management models. The Status of Alberta Bull Trout Workshop, University of Calgary, AB. April 1998.

Yellow perch population dynamics: models and data. Hypothesis Testing Approaches to Understanding Perch Dynamics Workshop, Cornell University. April 1997.

Density-dependent processes in rainbow trout populations. Science and Management of Trout Populations Workshop, Kamloops, B.C. April 1997.

Density-dependent processes in size-structured fish populations: interaction strengths in whole lake experiments. Department of Zoology Seminar Series, Erindale College, University of Toronto. December 1996.

Density-dependent Processes in Size-structured Fish Populations. Division of Ecology, Biological Sciences, University of Calgary, December 1996.

Models of sustainable harvest of bull trout. Alberta Fish and Wildlife Meeting, Calgary, October 1995.

Data needs for development of models of sustainable harvest of bull trout. Alberta Fish and Wildlife Meeting, Calgary, April 1995.

Dynamics of interacting size-structured predator and prey populations. Canadian Conference for Fisheries Research, Ottawa, January, 1995.

Metabolic ontogeny of teleost fishes. American Fisheries Society Annual Meeting, Halifax, Nova Scotia, August 1994.

Managing fish populations using regulations and stocking. Western Walleye Council Meeting, Edmonton, Alberta, March 1994.

Animal energetics: can ecologists and physiologists learn from one another? Division of Zoology Seminar, University of Calgary, Calgary, Alberta, March 1994.

Novel approaches to and applications of studies of fish bioenergetics. Introductory Talk in Theme Session, Canadian Conference for Fisheries Research, Saskatoon, Saskatchewan, January 1994.

Fish recruitment dynamics: experiments and models. Department of Natural Resources, Cornell University, March 1993.

Predatory and competitive interactions between walleye and perch populations. Cornell Biological Field Station, March 1993.

Fish recruitment dynamics: experiments and models. Department of Zoology, University of Alberta, November 1992.

Recruitment variability in fish populations and impacts of climate warming. Meanook Biological Station, University of Alberta, August 1992.

Fish recruitment dynamics: what can we learn from models? Groupe de Researche Interuniversitaire en Limnologie et en Environment Aquatique, Universite du Quebec a Trois-Rivieres, April 1992.

Kootenay Lake fertilization experiment: results and recommendations from an adaptive environmental assessment workshop. Ecology Division Seminar Series, Biological Sciences, University of Calgary, November 1991.

Kootenay Lake fertilization response model. Fisheries and Aquatic Science Seminar Series, Department of Zoology, University of British Columbia, Vancouver, B.C., February 1991.

Climate, recruitment variability, population viability and zoogeography of temperate fishes. Biological Sciences, University of Calgary, November 1990.

Trophic ontogeny in fishes and impacts on invertebrate communities. Lake Mendota Symposium, University of Wisconsin, WI. July 1990.

Climate, recruitment variability, population viability and zoogeography of temperate fishes. West Vancouver Laboratory, Department of Fisheries and Oceans, Vancouver, B.C. March 1990.

Predator-prey dynamics in lakes: zooplankton, planktivores and piscivores. Fisheries and Aquatic Science Seminar Series, Department of Zoology, University of British Columbia, Vancouver, B.C., January 1990.

Metabolic allometry in fishes: do larvae and adults follow the same rules? A Critical Review of Bioenergetics Models Symposium, American Fisheries Society Annual Meeting, Anchorage, Alaska, September 1989.

Mechanisms of size-dependent mortality in young fish. Department of Zoology, University of Manitoba, Winnipeg, Manitoba, March 1989.

Bioenergetics modelling of fish populations and implications for the management of salmonids in the Great Lakes. Ontario Ministry of Natural Resources, Maple, Ontario, October 1988.

Mechanisms of size-dependent mortality in young fish. Department of Biology, Queens University, Kingston, Ontario, September 1988.

Climatic warming and effects on geographic distribution and recruitment variability in fish. Climate Effects Symposium, American Fisheries Society Annual Meeting, Toronto, Ontario, September 1988.

Mechanisms of size-dependent mortality in young fish. Department of Zoology, University of Wisconsin, Madison WI, March 1988.

Validation of a growth model for young-of-the-year yellow perch and its application to studies of recruitment processes. Bioenergetics Modelling Symposium, American Fisheries Society Annual Meeting, Winston-Salem, NC, September 1987.

Size-dependent recruitment in yellow perch. Ontario Ministry of Natural Resources, Toronto, Ontario, April 1987.

The importance of size to survival of young fish. Center for Limnology, University of Wisconsin, Madison WI, March 1987.

CONFERENCE PRESENTATIONS

Landscape Scale Dynamics of Fish, Fishers and Policy: Experiments, Data and Models of Recreational Fisheries. Canadian Conference for Fisheries Research. Edmonton. January 2018.

At-Risk Status of Athabasca River Rainbow Trout With Lots of Poor Resolution Catch Data. International Conference for Conservation Biology. Montpellier, France. August 2015.

Vulnerability to harvest by anglers differs across climate, productivity and diversity clines: or why are northern fisheries more vulnerable to overharvest? Annual Meeting of the American Fisheries Society, Quebec, QC. August 2014.

Recruitment as an emergent property of juvenile ecology and life history evolution. Canadian Conference for Fisheries Research. Yellowknife. January 2014.

The dynamic balance between compensation and depensation in fisheries harvest. Canadain Society for Evolution and Ecology. May 2011.

Dyanmics at Low Density: Thresholds for Sustainable Harvest and Conservation. Canadian Conference for Fisheries Research. Halifax. January 2008.

Landscape Scale Processes that Lead to the Collapse of Freshwater Fisheries. Society of Conservation Biology. Port Elizabeth, South Africa. July 2007.

Angler Numerical Responses Across Landscapes, Policy Options and the Collapse of Freshwater Fisheries. Canadian Conference for Fisheries Research. Montreal. January 2007.

Challenges in Sustaining Recreational Fisheries. World Fisheries Congress, Vancouver, BC. May 2004

Life History Variation and Sustainable Harvest with Regulations in Lake Trout, *Salvelinus namaycush*, Populations. Canadian Conference for Fisheries Research, Saint Johns, Nfld. January 2004.

Recruitment Dynamics in Yellow Perch: Phenomenological Description and Mechanistic Understanding. Canadian Conference for Fisheries Research, Vancouver, ON. January 2002.

Using models and data to assess alternate management strategies for sustaining recreational fisheries. Canadian Conference for Fisheries Research, Toronto, ON. January 2001.

Mechanisms of collapse of recreational fisheries. Canadian Conference for Fisheries Research, Fredericton, NB. January 2000.

Sustainable exploitation of bull trout: biology, management and models. Ecology and Management of Northwest Salmonids, Canmore, Alberta, November 1999.

Energy allocation strategy in young fish: the allometry of lipid storage. Canadian Conference for Fisheries Research, Edmonton, Alberta, January 1999.

Density-dependent processes in size-structured fish populations. Canadian Conference for Fisheries Research, Ottawa, Ontario, January 1997.

Dynamics of interacting size-structured prey and predator populations. Canadian Conference for Fisheries Research, Ottawa, Ontario, January 1995.

Spatial and temporal patterns in vulnerability of small fish to piscivory. Canadian Conference for Fisheries Research, Peterborough, Ontario, January 1993.

Mechanisms of size-dependent mortality in young-of-the-year yellow perch. Midwest Ecology and Evolution Conference, Kellogg Biological Station, MI, April 1988.

Size-dependent overwinter mortality of young-of-the-year yellow perch. Canadian Conference for Fisheries Research, Ottawa, Ontario, January 1988.

Field test of cascading trophic interactions and biomanipulation theory. Midwest Fish and Wildlife Conference, Milwaukee, WI, December 1987.

Evidence of overwinter mortality in young-of-the-year yellow perch. Ontario Ecology and Ethology Colloquium, Ottawa, Ontario, May 1987.

Trophic relationships in freshwater pelagic ecosystems. Annual Meeting of the American Society of Limnology and Oceanography, Kingston, RI, June 1986.

REFEREEING FOR JOURNALS AND GRANTING AGENCIES

JOURNALS

- Nature Sustainability
- American Naturalist
- Canadian Journal of Fisheries and Aquatic Science
- Canadian Journal of Zoology
- Ecology
- Ecoscience
- Journal of Great Lakes Research
- Limnology and Oceanography
- Oikos
- Ecology of Freshwater Fish
- Proceedings of the National Academy of Science
- Global Change Biology
- Fish and Fisheries
- Fishereis Management and Ecology
- Environmental Biology of Fish
- Fish Ecology
- Functional Ecology
- Journal of Animal Ecology
- Journal of Fish Biology
- North American Journal of Fisheries Management
- Oecologia
- Transactions of the American Fisheries Society
- Ecological Applications
- Oecologia
- Proceedings of the Royal Society B
- The Proceedings of the Nova Scotia Institute of Science
- Mathematical Biosciences

GRANTING AGENCIES

- NSERC Collaborative Research and Development Program
- NSERC Discovery Grants Program
- Alberta Biodiversity Grants Program
- Great Lakes Fisheries Commission

- NSERC Strategic Grants Program
- Portugese Science Foundation
- NSERC Canada Research Chairs Program
- Hudson River Foundation
- U.S. National Science Foundation

PROFESSIONAL SKILLS DEVELOPMENT

The Confident Facilitator: Essential Skills & Tools for Guiding Groups / Effective Meetings. May 7-8, 2015

The Skillful Facilitator**:** Strategies for Meeting Dynamics & Group Dysfunction. June 5, 2015

TEACHING

NOTE: A complete description of teaching duties and philosophy is presented in my Teaching Dossier. Included here is a listing of teaching contributions to the undergraduate and graduate programs at University of Calgary and elsewhere.

UNDERGRADUATE & GRADUATE COURSES TAUGHT

2019-20	Lecturer	Population Ecolgy	18 lec, 5 labs
	Lecturer	Quantitative Biology	18 lec, 5 labs
	Course Coordinator	Fish Ecology	36 lec, 12 tut
2018-19	Lecturer	Population Ecolgy	18 lec, 5 labs
	Lecturer	Quantitative Biology	18 lec, 5 labs
2017-18	Course Coordinator	Population Ecolgy	18 lec, 5 labs
	Course Coordinator	Quantitative Biology	18 lec, 5 labs
	Course Coordinator	Fish Ecology	36 lec, 12 tut
2016-17	Lecturer	Population Ecolgy	18 lec, 5 labs
	Lecturer	Conservation Biology	18 lec, 4 tutorials
	Course Coordinator	Aquatic Ecology	
2015-16	Course Coordinator	Quantitative Biology	18 lec, 5 labs
	Course Coordinator	Population Ecolgy	18 lec, 5 labs
	Course Coordinator	Fish Ecology	36 lec, 12 tut
	Course Coordinator	Undergrad-Independent Studies	6 Students - Term
	Course Coordinator	Graduate-Independent Studies	2 Students - Term
	Co-Course Coordinator	Graduate-Models & Statistics	2 Students - Term
	Lecturer	Biology for Non-Majors	4 lec
2014-15	Lecutrer	Field Ecology	Field course (⅓)
	Course Coordinator	Quantitative Biology	18 lec, 5 labs
	Course Coordinator	Population Ecolgy	18 lec, 5 labs
	Course Coordinator	Conservation Biology	14 lec, 4 tutorials
	Course Coordinator	Undergrad-Independent Studies	1 Term
	Course Coordinator	Graduate-Independent Studies	1 Term
2013-14	Lecutrer	Field Ecology	Field course (⅓)
	Lecturer	Quantitative Biology	18 lec, 5 labs
	Course Coordinator	Population Ecolgy	18 lec, 5 labs
	Course Coordinator	Ecological Applications	6 workshops
	Course Coordinator	Undergraduate-Independent Studies	1 Term
	Course Coordinator	Graduate-Independent Studies	1 Term
2012-13	Sabbatical Leave		

2011-12	Course Coordinator	Fish Ecology	36 lec, 12 tut
	Course Coordinator	Conservation Biology	18 lec, 5 tut
2010-11	Course Coordinator	Field Ecology	Field course (⅓)
	Lecturer	Quantitative Biology	12 lec, 3 labs
	Course Coordinator	Conservation Biology	18 lec, 5 tut
	Lecturer	Ecological Applications	6 workshops
2009-10	Course Coordinator	Field Ecology	Field course (⅓)
	Course Coordinator	Ecology and Evolution	12 lec
	Course Coordinator	Conservation Biology	18 lec, 5 tut
2008-09	Lecutrer	Field Ecology	Field course (⅓)
	Course Coordinator	Fish Ecology	36 lec, 12 tut
	Course Coordinator	Conservation Biology	18 lec, 5 tut
2007-08	Lecturer	Ecology and Evolution	12 lec
	Lecturer	Aquatic Ecosystems	12 lec
	Course Coordinator	Conservation Biology	15 lec, 4 tut
	Lecutrer	Field Ecology	Field course (⅓)
2006-07	Course Coordinator	Fish Ecology	36 lec, 12 tut
	Course Coordinator	Conservation Biology	12 lec, 3 tut
	Lecutrer	Field Ecology	Field course (⅓)
2005-06	Sabbatical		
2004-05	Course Coordinator	Fish Ecology	36 lec, 24 tut
	Lecturer	Conservation Biology	9 lec, 2 tut
2003-04	Lecturer	Aquatic Ecology	18 lec
	Lecturer	Conservation Biology	9 lec, 2 tut
2002-03	Lecturer	Field Biology	4 days
	Lecturer	Aquatic Ecology	12 lec
	Course Coordinator	Fish Ecology	36 lec, 24 tut
	Course Coordinator	Graduate Ecology	12 tut
2001-02	Lecturer	Aquatic Ecology	12 lec
	Lecturer	Ecology and Evolution	14 lec
	Course Coordinator	Ecological Applications	18 lec + tut
	Course Coordinator	Quantitative Fisheries (Grad)	
2000-01	Lecturer	Aquatic Ecology	12 lec
	Lecturer	Quantitative Ecology II	12 lec, 3 labs
	Lecturer	Ecology and Evolution	14 lec
	Course Coordinator	Fish Ecology	36 lec, 24 tut
1999-00	Course Coordinator	Aquatic Ecology	12 lec, 3 labs

	Lecturer	Quantitative Ecology II	12 lec, 3 labs
1998-99	Sabbatical Leave		
1997-98	Course Coordinator	Quantitative Ecology II	12 lec, 3 labs
	Lecturer	Ecology of Individuals	6 lec, 2 labs
	Lecturer	Aquatic Ecology	12 lec, 4 labs
1996-97	Course Coordinator	Quantitative Ecology II	12 lec, 3 labs
	Lecturer	Ecology of Individuals	6 lec, 2 labs
	Lecturer	Aquatic Ecology	12 lec, 4 labs
	Course Coordinator	Fish Ecology	36 lec, 24 tut
	Course Coordinator	Independent Studies	2 Students
1995-96	Course Coordinator	Quantitative Ecology II	24 lec, 6 labs
	Course Coordinator	Intro Ecology and Evolution	18 lec
	Lecturer	Quantitative Ecology I	12 lec, 3 labs
	Course Coordinator	Independent Studies	2 Students
1994-95	Course Coordinator	Fish Ecology	36 lec, 24 tut
	Lecturer	Intro Ecology	7 lec
	Lecturer	Quantitative Ecology I	12 lec, 3 labs
	Lecturer	Quantitative Ecology II	12 lec, 3 labs
	Course Coordinator	Independent Studies	2 Students
1993-94	Lecturer	Intro Ecology	6 lec
	Lecturer	Quantitative Ecology I	12 lec, 3 labs
	Lecturer	Quantitative Ecology II	12 lec, 3 labs
	Course Coordinator	Independent Studies	2 Students
1992-93	Course Coordinator	Fish Ecology	36 lec
	Course Coordinator	Independent Studies	4 Students
1991-92	Course Coordinator	Fish Ecology	36 lec
	Course Coordinator	Independent Studies	2 Students
1990-91	Lecturer	Fish Biology (UBC)	8 lec
1989-90	Course Coordinator	Limnology (UBC)	24 lec, 10 labs

GRADUATE STUDENTS SUPERVISED

Dylan Glaser, M.Sc. 2017-

Christopher Cahill, Ph.D. 2014-

Stephanie Mogensen, Ph.D. 2014-

Ariane Cantin, Ph.D. 2012-2018.
Habitat Structures Rainbow Trout Population Dynamics Across Spatial Scales.
Current Position: Post-doctoral Researcher at University of Calgary, Calgary, AB.

Kyle Wilson, Ph.D. 2013-2018.
Consequences of Spatial Exploitation in Complex Adaptive Social-Ecological Systems: Managing for Sustainable Freshwater Fisheries.
Current Position: Post-doctoral Researcher at Simon Fraser University, Burnaby, BC.

Hillary Ward, Ph.D. 2009-2014
Understanding Dynamic Interactions Between Angler Behaviour and Fish Populations in Spatially Structured Recreational Fisheries.
Current Position: Fisheries Stock Assessment Biologist, BC Forestry, Lands and Natural Resources Operations, Penticton, BC.

Ellen Lea, M.Sc. 2007-2011
Environmental and genotypic influences on body size and survival of juvenile rainbow trout in seasonal ecosystems.
Current Position: Fisheries Management Biologist, Fisheries and Oceans Canada, Inuvik, NT.

Jacson Laliberte, M.Sc. 2007-2012
Physical and Bioenergetic Approaches for Modeling Instream Habitat Quality of Drift-feeding Fish
Current Position: Fish Biologist, WorleyParsons Consultants, Calgary, AB.

Geneva Robins, M.Sc., 2004-2009
Impacts of Climate Change on the Fishes of the South Saskatchewan River Basin.
Current Position: Risk Assessor, Meridian Environmental Inc, Calgary, AB.

Paul Askey, Ph.D., 2002-2007
Towards optimal management of spatially structured recreational fisheries: linking ecology and angler dynamics in British Columbia rainbow trout (*Oncorhynchus mykiss*).
Current Position: Senior Scientsit, Freshwater Fisheries Society of BC, Summerland BC.

Fiona Johnston, M.Sc., 2001-2005
Demographic and life-history responses of an over-exploited bull trout (*Salvelinus confluentus*) population to zero harvest regulations.
Fiona's thesis was nominated for the Governor General's Gold Medal Award.
Current Position: PhD candidate, IGB, Berlin, Germany.

Jody Mackenzie-Grieve, M.Sc., 2001-2004
Climate warming and northern lake trout, *Salvelinus namycush*: energetics, production and conservation under climate change.
Current Position: Fisheries Biologist, Fisheries and Oceans Canada, Whitehorse, YT.

Trevor Rhodes, M.Sc., 2000-2005
The immediate and short-term impacts of catch-and-release angling on migrating and pre-spawning condition rainbow trout (*Oncorhynchus mykiss*) in the Bow River, Alberta.
Current Position: Head of Fisheries Section, Golder Consulting, Calgary, AB.

Cindy Rejwan, Ph.D., 1997-2006
Investigating the extent and nature of among-population differences in age-structure and life history characteristics in 37 wild rainbow trout (Oncorhynchus mykiss) populations. [did not defend successfully]

Brett van Poorten, M.Sc., 2000-2003
The impacts of angling on rainbow trout life history and demography.
Current Position: Senior Fisheries Biologist, BC Ministry of Environment, Vancouver, BC.

Craig Mushens, M.Sc., 1999-2003
Migration, diel movement and habitat use of juvenile bull trout (*Salvelinus confluentus*).
Current Position: Senior Fisheries Biologist, WorleyParsons Consultants, Calgary, AB.

Peter Biro, Ph.D., 1997-2003
Population consequences of behaviourally-mediated tradeoffs between growth and mortality in age-0 rainbow trout (*Oncorhynchus mykiss*) cohorts.
Current Position: Associate Professor, Deakin University, Geelong, Australia.

Andrew Paul, Ph.D., 1995-2000
Recruitment dynamics in bull trout (*Salvelinus confluentus*):linking theory and data to species management.
Anderew won the John Kendal Award for the Best Ph.D. Thesis in the Faculty of Science at University of Calgary in 2000 and the T.W.M. Cameron Award from the Canadian Society of Zoology for the Best Ph.D. Thesis in Zoology in Canada in 2000.
Current Position: Senior Fisheries Biologist, Alberta Environment and Sustainable Resource Development, Cochrane, AB.

Francois Landry, M.Sc., 1993-1997
Direct and indirect effects of interference competition in size-structured rainbow trout (*Oncorhynchus mykiss*) populations.
Current Position: Head Fisheries Biology, Rescan Consulting, North Vancouver, BC.

Chris Briggs, M.Sc., 1992-1995
The metabolic costs of activity of free-swimming, adult rainbow trout (O*ncorhynchus mykiss*) estimated by electromyogram telemetry.
Current Position: Fisheries Biologist, Consulting, Calgary, AB.

Joseph DeGisi, M.Sc.,1990-1994 (co-supervised with C.J. Walters, UBC)
Density-dependent recruitment responses in manipulated brook trout (*Salvelinus fontinalis*) populations of the Sierra Nevada Mountains, California.
Current Position: Fisheries Biologist, BC Ministry of Forests, Lands and Natural Resources Operations, Smithers, BC.

EXTERNAL EXAMINER ON PH.D. DISSERTATIONS

2016	Justin Hanisch	University of Alberta
2015	Jordan Pleet	University of Toronto
2011	James Smith	University of New South Wales
2009	Steven Spencer	Renewable Resources, University of Alberta
2000	Kyle Young	Faculty of Forestry, University of British Columbia
1995	Haakon Hop	Biological Sciences, University of Alberta

GRADUATE SUPERVISORY, CANDIDACY & EXAMINATION COMMITTEES

Ross Connor	MSc	Population Ecology	2019-
Richard Kwafo	MSc	Behavioural Ecology	2018-
Annie He	MSc	Plant Ecology	2018
Analisa Lazaro-Cote	PhD	Physiology	2018-
Rachel Tessier	MSc	Statistical Ecology	2016-2019
Cassiano Porto	MSc	Hydrology and Forest Ecology	2015-2016
Jessica Hopson	MSc	Community Ecology	2015-2017
Tyler Jessen	PhD	Veterinary Medicine	2015
Emma Carroll	MSc	Landscape Genetics	2014-2017
Shantel Koenig	PhD	Landscape Ecology	2014
Scott Seamone	MSc-PhD	Physiological Ecology	2013-
Moujan Tuloui	MSc	Landscape Ecology	2013-2016
Jinyan Ding	PhD	Ecosystem Ecology	2013-2017

Brian Meagher	MSc	Fish Evolution	2013-withdrew
Patrick Jablkowski	MSc	Ecosystem Ecology	2013-2016
Erick Elgin	MSc	Food Webs	2012-2015
June Chao	MSc	Hydrogeology	2011
Jobran Chebib	MSc	Harvest Induced Evolution	2010-2013
Cory Kremer	MSc	Fish Evolution	2010-2013
Dawn Byars	Ph.D.	Fish Physiology	2010-withdrew
Cecilia Chung	M.Sc.	Aquatic Toxicology	2009-2013
Stephen Hausch	Ph.D.	Evolutionary Ecology	2009-2015
Hilary Young	Ph.D.	Behavioural Ecology	2008
Angela Aivaz	M.Sc.	Behavioural Ecology	2008-2010
Heather Sutton	M.Sc.	Stream Ecology	2008-withdrew
Sarah Davies	M.Sc.	Zoology	2007-2009
Reneeta Mamdani	M.Sc.	Mathematics	2007
Jeff Gruver	Ph.D.	Physiological Ecology	2004-?
Marc Macias Fauria	M.Sc.	Fires in the Boreal Forest	2003-05
Craig Sheridan	M.Sc.	Remote Sensing	2002-05
Cori Lausen	Ph.D.	Conservation Biology	2001-07
Patrick Druckenmiller	Ph.D.	Paleontology	2000-06
Lydia Hollis	Ph.D.	Physiological Ecology	1999-04
Robyn Irvine	Ph.D.	Aqatic Ecology	1998-04
Marianne Meding	M.Sc.	Aquatic Ecology	1998-00
Brian Parker	Ph.D.	Aquatic Ecology	1998-05
Michael Ryan	Ph.D.	Functional Morphology	1997-03
Christine Brown	MEDes	Aquatic Ecology	1997-99
Michael Newel	M.Sc.	Respiratory Physiology	1996-99
Michael Sullivan	Ph.D. (UofA)	Fisheries Biology	1996-03
David Gummer	M.Sc.	Behavioural Ecology	1995-97
Simon Bridge	M.Sc.	Landscape Ecology	1995-97
Garland Jonker	M.Sc.	Aquatic Ecology	1995-98
Tammy Rosner	M.Sc.	Theoretical Ecology	1995-99
Janice James	M.Sc.	Physiological Ecology	1994-97
Susan Watson	Ph.D.	Limnology	1994-99
Ian Hamilton	M.Sc.	Behavioural Ecology	1994-96
Caedmon Nash	M.Sc.	Meteorology	1993-95
Dan Wicklum	M.Sc.	Toxicology	1993-94
Greg Townsend	M.Sc.	Population Ecology	1992-94

Jenny Earl	M.Sc.	Population Ecology	1992-95
Derek Zelmer	M.Sc.	Parisitology	1992-94
Beatrix Beisner	M.Sc.	Community Ecology	1992-94
Kim Dibble	M.Sc.	Theoretical Ecology	1991-93
Michael Strilchuk	M.Sc.	Respiratory Physiology	1991-95
Marilyn Merkle	M.Sc.	Physiological Ecology	1991-93
Heidi Hardisty	M.Sc.	Limnology	1991-93
Heather Brook	M.Sc.	Physiological Ecology	1991-94
Therese Cochlin	MEDes	Environmental Design	1991-94
Beata Biernacka	M.Sc.	Evolutionary Biology	1991-94
Todd Hatfield	Ph.D. (UBC)	Evolutionary Biology	1989-91
Joel Sawada	M.Sc. (UBC)	Fisheries Biology	1989-91
Dana Atagi	M.Sc. (UBC)	Fisheries Biology	1989-91
Jeff Burrows	M.Sc. (UBC)	Fisheries Biology	1989-91
Darcie Quamie	M.Sc. (UBC)	Fisheries Biology	1989-91
Regina Schiffer	M.Sc. (UBC)	Fisheries Biology	1989-91
Dean Watts	M.Sc. (UBC)	Environmental Science	1989-92
Chantell Ouimet	Ph.D. (UBC)	Limnology	1989-91

UNDERGRADUATE INDEPENDENT STUDIES (THESES) SUPERVISED

2017-18	Exeter, UK		Quantitative Fisheries
2015-16	ECOL 507	Gary Thai	Quantitative Fisheries
2015-16	ECOL 507	Morgan Cotroneo	Quantitative Fisheries
2015-16	ECOL 507	Troy Machovec	Quantitative Fisheries
2015-16	ECOL 507	Hilary Goble	Quantitative Fisheries
2015-16	ECOL507	Hima Marisinghe	Quantitative Fisheries
2015-16	Ecol 507	Vicki Kisch	Quantitative Fisheries
2014-15	ECOL 507	Nicole Dionne	Arctic Fisheries
2013-14	ECOL 507	Eric Newton	Fisheries Ecology
2011-12	ECOL 507	Suzanne Havard	Fish Ecology
2010-11	ECOL 528	Beth Wilson	Molecular Ecology
2008-09	ECOL 528	Andrew Harbicht	Fisheries Ecology
2007-08	ECOL 530	Stephanie Mogensen	Physiological Ecology
2003-04	ECOL 507	Chris Dormer	Fisheries Ecology
2001-02	ECOL 528	Cameron MacKenzie	Community Ecology
2000-01	ECOL 528	Ashley Morton	Physiological Ecology

1996-97	ECOL 530	Jim Porter	Behavioural Ecology
1996-97	ECOL 528	Marriane Medding	Fisheries Ecology
1995-96	ECOL 530	Barbara Ainslie	Fisheries Ecology
1995-96	ECOL 530	Hugues Benoit	Theoretical Ecology
1994-95	ZOOL 528	Mary Ilkiw	Behavioural Ecology
1993-94	ECOL 528	Craig Mushens	Behavioural Ecology
1993-94	ECOL 528	Laura Remple	Behavioural Ecology
1992-93	ECOL 528	Scott Reid	Behavioural Ecology
1992-93	ECOL 528	Julie Lee	Physiological Ecology
1992-93	ECOL 528	Scott Rolseth	Behavioural Ecology
1992-93	ECOL 507	Robin Weaver	Behavioural Ecology
1991-92	ECOL 528	Mark Hammond	Physiological Ecology
1991-92	ECOL 528	Allison Steves	Population Ecology
1991-92	ECOL 507	Julie Lee	Physiological Ecology

SERVICE, OUTREACH AND MEDIA

DEPARTMENT

2019-20	Member, Ecology Program Committee
	Member, Safety Improvement Team
2018-19	Member, Ecology Program Committee
	Member, Safety Improvement Team
2017-18	Member, Ecology Program Committee
	Member, Safety Improvement Team
2016-17	Chair, Ecology and Evolutionary Biology
	Member, Ecology Program Committee
	Member, Safety Improvement Team
2015-16	Chair, Ecology and Evolutionary Biology
	Member, Ecology Program Committee
	Member, Safety Improvement Team
2014-15	Chair, Ecology and Evolutionary Biology
	Member, Ecology Program Committee
	Chair, EEB Retreat Committee
	Member, Safety Improvement Team
	Presenter – Tips for Successful Scholarship Applications Workshop
2013-14	Member, Ecology Program Committee
	Member, Safety Improvement Team
2012-13	Sabbatical Leave
2011-12	Member, Graduate Policy and Admissions Committee
	Member, Ecology Program Committee
2010-11	Member, Graduate Policy and Admissions Committee
2007-08	Chair, Ecology and Evolutionary Biology Research Cluster
	Member, Collections and Facilities Committee
2006-07	Chair, Ecology and Evolutionary Biology Research Cluster
	Member, Collections and Facilities Committee
2005-06	Sabbatical Leave
2004-05	Member, Ecology Search Committee
	Coordinator, Ecology Cooperative Education Program
	Coordinator, Ecology and Evolution Seminar Series
2003-04	Chair, Division of Ecology
	Member, Ecology Search Committee
	Coordinator, Ecology Cooperative Education Program

2002-03	Chair, Division of Ecology
	Member, Ecology Search Committee
	Coordinator, Ecology Cooperative Education Program
	Member, Biology Curriculum Committee
2001-02	Chair, Division of Ecology
	Member, Ecology Search Committee
	Coordinator, Ecology Cooperative Education Program
	Member, Biology Curriculum Committee
2000-01	Chair, Division of Ecology
	Coordinator, Ecology Cooperative Education Program
1999-00	Chair, Division of Ecology
	Curriculum Redesign Fellow, Ecology Program
1998-99	Sabbatical Leave
1997-98	Member, Selection Committee - Population Ecologist
	Member, Selection Committee - Community Ecologist
	Undergraduate Councilor, Ecology Division
	Member, Biological Sciences Curriculum Committee
1996-97	Member, Selection Committee - Population Ecologist
	Member, Selection Committee - Community Ecologist
	Undergraduate Councilor, Ecology Division,
	Member, Biological Sciences Curriculum Committee
1995-96	Member, Ecology Undergraduate Core Course Review Committee
	Member, Biological Sciences Safety Committee
	Ecology Division Representative, Science Library Committee
	Undergraduate Councilor, Ecology Division
	Membe, Biological Sciences Curriculum Committee
1994-95	Member, Ecology Undergraduate Core Course Review Committee
	Member, Biological Sciences Safety Committee
	Ecology Division Representative, Science Library Committee
	Undergraduate Councilor, Ecology Division
1993-94	Member, Ecology Undergraduate Core Course Review Committee
	Member, Biological Sciences Safety Committee
	Ecology Division Representative, Science Library Committee
	Undergraduate Councilor, Ecology Division
1992-93	Chair, Ecology Open House Committee
	Member, Biological Sciences Safety Committee
1991-92	Member, Post-Doctoral Fellowship Committee

1990-91	Chair, Fisheries and Aquatic Science Seminar Committee - UBC
1989-90	Chair, Fisheries and Aquatic Science Seminar Committee - UBC

FACULTY

2019-20	CRC TierI Search Committee in Geomicrobiology
2019-20	Faculty Tenure and Promotion Committee
2005-06	Sabbatical Leave
2004-05	Member, Search Committee for Watershed Hydrologist
	Member, Search Committee for Actuarial Scientist
2003-04	Member, Search Committee for Watershed Hydrologist
2002-03	Member, Environmental Science Program Steering Committee
2001-02	Member, Faculty of Science Research Committee CRC Nominations
	Member, Environmental Science Program Steering Committee
2000-01	Representative, EVDS Faculty Council
	Member, Environmental Science Program Steering Committee
1999-00	Member, Environmental Science Program Steering Committee
	Member, Science Education Committee
1998-99	Sabbatical Leave
1997-98	Member, Environmental Science Program Steering Committee
1996-97	Member, Environmental Science Program Steering Committee
1995-96	Member, Environmental Science Program Steering Committee

UNIVERSITY

2014-15	Member, Faculty of Graduate Studies Scholarship Committee
2013-14	Member, Faculty of Graduate Studies Scholarship Committee
2010-11	Member, Northern Studies Training Program, Arctic Institute of North America
2009-10	Member, Northern Studies Training Program, Arctic Institute of North America
2008-09	Member, Northern Studies Training Program, Arctic Institute of North America
2007-08	Member, Northern Studies Training Program, Arctic Institute of North America
2006-07	Member, Northern Studies Training Program, Arctic Institute of North America
2005-06	Sabbatical Leave
2004-05	Member, Northern Studies Training Program, Arctic Institute of North America
2003-04	Member, Northern Studies Training Program, Arctic Institute of North America
	Invitee, VPR Life Science Research Initiative
	Invitee, Provost’s Committee to establish “Culture of Calgary” Curriculum
2002-03	GFC, Selection Committee Member for Dean of EVDS

	Member, Northern Studies Training Program, Arctic Institute of North America
2001-02	Member, Northern Studies Training Program, Arctic Institute of North America
	Member, Search Committee in Satelite Oceanography
1998-99	Sabbatical Leave
1997-98	UofC Rep., Alberta Challenge Grants in Biodiversity Grant Selection Committee
	UofC Rep., Crown of the Continent Research Steering Committee
1996-97	UofC Rep., Alberta Challenge Grants in Biodiversity Grant Selection Committee
	UofC Rep., Crown of the Continent Research Steering Committee
1995-96	UofC Rep., Alberta Challenge Grants in Biodiversity Grant Selection Committee
	UofC Rep., Crown of the Continent Research Steering Committee
1994-95	UofC Rep., Alberta Challenge Grants in Biodiversity Grant Selection Committee
	UofC Rep., Crown of the Continent Research Steering Committee

PROFESSIONAL/COMMUNITY/PUBLIC SECTOR ORGANIZATIONS

2018-19	Member, Committee on the Status of Endangered Wildlife in Canada
	Co-Chair, Freshwater Fishes Specialist Committee of COSEWIC
2017-18	Associate Editor, Proceedings of the Royal Society B
	Member, Committee on the Status of Endangered Wildlife in Canada
	Co-Chair, Freshwater Fishes Specialist Committee of COSEWIC
	Chair, International Advisory Board for the 8th World Recreational Fishing Conference in Victoria, British Columbia, Canada - July 2017
2016-17	Associate Editor, Canadian Journal of Fisheires and Aquatic Sciences
	Associate Editor, Proceedings of the Royal Society B
	Member, Committee on the Status of Endangered Wildlife in Canada
	Co-Chair, Freshwater Fishes Specialist Committee of COSEWIC
	Chair, International Advisory Board for the 8th World Recreational Fishing Conference in Victoria, British Columbia, Canada - July 2017
2015-16	Associate Editor, Canadian Journal of Fisheires and Aquatic Sciences
	Associate Editor, Proceedings of the Royal Society B
	Member, Committee on the Status of Endangered Wildlife in Canada
	Co-Chair, Freshwater Fishes Specialist Committee of COSEWIC
	Chair, International Advisory Board for the 8th World Recreational Fishing Conference in Victoria, British Columbia, Canada - July 2017
2014-15	Member of the Board of Directors of the Canadian Conference for Fisheries Research
	Member, Committee on the Status of Endangered Wildlife in Canada
	Co-Chair, Freshwater Fishes Specialist Committee of COSEWIC
	Member of the Board of Directors of the Canadian Conference for Fisheries Research
2013-14	Associate Editor, Canadian Journal of Fisheires and Aquatic Sciences

	Member, Committee on the Status of Endangered Wildlife in Canada
	Co-Chair, Freshwater Fishes Specialist Committee of COSEWIC
	Member of the Board of Directors of the Canadian Conference for Fisheries Research
	Member, Peter Larkin Award Committee of the Canadian aquatic Resources Section of the American Fisheries Society
2012-13	Associate Editor, Canadian Journal of Fisheires and Aquatic Sciences
	Member, Committee on the Status of Endangered Wildlife in Canada
	Co-Chair, Freshwater Fishes Specialist Committee of COSEWIC
	Member, Species Bundling Working Group COSEWIC
	Member, COSEWIC Chair Selection Committee
	Chair, Species Specialist Co-Chair Selection Committee
	Appeals Advisor, NSERC
	Member, Peter Larkin Award Committee of the Canadian aquatic Resources Section of the American Fisheries Society
2011-12	Associate Editor, Canadian Journal of Fisheires and Aquatic Sciences
	Member, Committee on the Status of Endangered Wildlife in Canada
	Co-Chair, Freshwater Fishes Specialist Committee of COSEWIC
	Member, Search Committee for COSEWIC Chair
	Chair, Search Committee for Non-Government Science Member of COSEWIC
	Member, Strategic Planning Working Group COSEWIC
	Member, Peter Larkin Award Committee of the Canadian aquatic Resources section of the American Fisheries Society
2010-11	Associate Editor, Canadian Journal of Fisheires and Aquatic Sciences
	Member, Committee on the Status of Endangered Wildlife in Canada
	Co-Chair, Freshwater Fishes Specialist Committee of COSEWIC
	Co-Chair, NSERC Evolution and Ecology Evaluation Group
	Associate, Canadian Rivers Institute, University of New Brunswick, Frederiction, NB
	Reviewer, Alberta Oilsands Regional Aquatic Monitoring Program
	Member, Peter Larkin Award Committee of the Canadian aquatic Resources section of the American Fisheries Society
2009-10	Member, Committee on the Status of Endangered Wildlife in Canada
	Co-Chair, Freshwater Fishes Specialist Committee of COSEWIC
	Panel Member, Portugeuse Science Foundation
	Member, NSERC Evolution and Ecology Evaluation Group
	Associate Editor, Canadian Journal of Fisheires and Aquatic Sciences
	Member, Parks Canada Aquatic Ecosystem Advisory Group
	Associate, Canadian Rivers Institute, University of New Brunswick, Frederiction, NB
2008-09	Member, NSERC Grant Selection Committee 18
	Associate Editor, Canadian Journal of Fisheires and Aquatic Sciences

	Member, Parks Canada Aquatic Ecosystem Advisory Group
	Associate, Canadian Rivers Institute, University of New Brunswick, Frederiction, NB
2007-08	Member, Parks Canada Aquatic Ecosystem Advisory Group
	Associate, Canadian Rivers Institute, University of New Brunswick, Frederiction, NB
2006-07	Member, Parks Canada Aquatic Ecosystem Advisory Group
	Associate, Canadian Rivers Institute, University of New Brunswick, Frederiction, NB
2005-06	Sabbatical Leave
	Local Organizer Chair, Canadian Conference for Fisheries Research and Society for Canadian Society of Limnologists Conference
	Member, Parks Canada Aquatic Ecosystem Advisory Group
	Associate, Canadian Rivers Institute, University of New Brunswick, Frederiction, NB
2004-05	Member, Endangered Species Conservation Committee advising the Provincial Minister of Sustainable Resource Development
	Associate, Canadian Rivers Institute, University of New Brunswick, Frederiction, NB
	Member, Parks Canada Aquatic Ecosystem Advisory Group
2003-04	Member, Endangered Species Conservation Committee advising the Provincial Minister of Sustainable Resource Development
	Associate, Canadian Rivers Institute, University of New Brunswick, Frederiction, NB
2002-03	Member, Endangered Species Conservation Committee advising the Provincial Minister of Sustainable Resource Development
2001-02	Member, Endangered Species Conservation Committee advising the Provincial Minister of Environmental Protection
2000-01	Member, Endangered Species Conservation Committee advising the Provincial Minister of Environmental Protection
1999-00	Nominations Chair, Canadian Conference for Fisheries Research
	Member, Endangered Species Conservation Committee advising the Provincial Minister of Environmental Protection
1998-99	Member, Endangered Species Conservation Committee advising the Provincial Minister of Environmental Protection
1997-98	Member, Endangered Species Conservation Committee advising the Provincial Minister of Environmental Protection
	Membe, Workshop Organizing Committee for Alberta Fish and Wildlife Bull Trout Management Task Force
1996-97	Scientific Advisor and Editorial Board Member, Parks Canada Publication ‘Research Links’
	Member, Workshop Organizing Committee for Alberta Fish and Wildlife Bull Trout Management Task Force
	Member, Organizing Committee for ‘Science and Management of Protected Areas Conference’ in Banff in May 1997
	Member, Organizing Committee preparing a bid to host the Year 2000 Annual Meeting of the American Fisheries Society

1995-96	Scientific Advisor and Editorial Board Member, Parks Canada Publication 'Research Links'
	Member, Workshop Organizing Committee for Alberta Fish and Wildlife Bull Trout Management Task Force
1994-95	Scientific Advisor and Editorial Board Member, Parks Canada Publication 'Research Links'
	Member, Workshop Organizing Committee for Alberta Fish and Wildlife Bull Trout Management Task Force

Add bunch of media contacts dealing with Threatened and Endangered AB fishes

Also add in the interactons with Chris on UToday

MEDIA PRESENTATIONS – Journals and Magazines

Add the two Alberta Outdoorsman articles in 2020

MacLean's March 2014. Something Fishy. Article.

Fisheries. February 2014. AFS Presidents Commentary. Editorial.

International Innovation. February 2014. Fishy Population Dynamics. Article.

Outdoor Canada. February 2014. Fish Fail. Editorial.

West Coast Environmental Law 2013. Gutting Canada's fisheries law- what the changes mean for fish.

U Magazine. Fall 2011. Fishing for sustainable solutions. Leanne Yohemas.

Science. June 2007. Fish fatalities while feeding. Editors Choice feature by G. Chin and J. Yeston.

Nature. June 2007. Fish fry. Nature Reports Climate Change feature by H. Leifert.

Canadian Business, November 2002. Gone fishin' and Canada's neglected, multi-billion sportfishing industry might not come back. Feature article by Andrew Nikiforuk.

Alberta Outdoorsman, November 2002. Fishing Lines, something fishy? Editorial column by Duane Radford.

Outdoor Canada, Summer 2002. Political neglect. Pollution. Invasive species. Overfishing. Can our sportfish survive the next 30 years? That depends on you. Feature article by Gord Pyzer.

Outdoor Canada, May 2002. A new study released in January has concluded that anglers are putting some fisheries at risk. University of Calgary Ecology Professor John Post who spearheaded the study explains why. Dialogue Feature.

MEDIA PRESENTATIONS - Newspapers

Put in the two articles from the Bow river work…

The Fitzhugh Newspaper, Jasper. May 06, 2015. Alberta Bull trout threatened, could be listed as species at risk.

Truro Chronicle Herald. November 2013. Fisheries protection laws gutless.

Calgary Herald. November 7, 2013. Scientists say fish habitat no longer protected under federal act. Colette Derworiz.

Saltspring News. November 2013. Harper gov't gut federal Fisheries Act to reduce burden on oil and gas corporations. Gutting Fisheries Act a 'politically motivated abrogation" say fish biologists.

Ottawa Citizen. November 1, 2013. Scientists say new fisheries law "guts" protection for habitat. Tom Spears.

Washington Times. November 13, 2013. New law eliminates habitat protection for most fish species in Canada. Laura Sesana.

Spectator Tribune. November 26, 2013. Fish species lose protection as changes to Fisheries Act take effect.

Whitehorse Star. November 2013. The Federal Government has gutted the Fisheries Act.

Edmonton Journal. November 25, 2006. Sport fishermen may be on hook for fish lost to industrial development. Article by Hanneke Brooymans.

News North, Yellowknife. March 11, 2002. Fishery collapses a southern problem. Article by Mike W. Bryant.

Wollwich Observer, Elmira. February 26, 2002. Article by Eric Martinson.

Edmonton Journal. February 15, 2002. Anglers not lured to fished-out lakes. Editorial.

Regina Leader-Post. February 14, 2002. Sport fishing in Saskatchewan in healthy state. Article by Adrienne Bangsund.

Red Deer Advocate. February 14, 2002. Preserving our fisheries an urgent priority. Editorial.

Thunder Bay Chronicle. February 13, 2002. Fishery collapsing rapidly, scientists warn. Article.

St. John's Telegraph. February 13, 2002. Sport fishery collapsing rapidly. Front page article.

Edmonton Journal. February 13, 2002. Fish stocks recovering – provincial official. Article by Ed Struzik, Edmonton.

The Fishing News Wire. February 13, 2002. Canadian fish stocks collapsing. Article by Mark Lamb.

Ottawa Citizen, February 12, 2002. Sport fishing near collapse study warns. Article.

Victoria Times Colonist, February 12, 2002. Canadian sport fisheries at risk from efficient anglers. Article.

Calgary Herald, February 12, 2002. Scientists fear failure of sport fishery. Front page article by Ed Struzik.

Edmonton Journal. February 12, 2002. Alberta's fish stocks take dive. Article by Ed Struzik, Edmonton.

Vancouver Sun. February 12, 2002. Sport fishery headed to collapse. Article.

National Post, February 12, 2002. Canadian fishing stocks collapsing. Article

Edmonton Journal. February 11, 2002. Scientists fear failure of Alberta's fisheries. Article by Ed Struzik, Edmonton.

Pike Masters. February 10, 2002. Can we ruin wilderness pike fishing? Article by Tim Mead, North Carolina.

<u>MEDIA INTERVIEWS AND PRESENTATIONS - Radio/Television</u>

CBC Radio. July 7, 2015. Interview.

CBC Radio. December 12, 2014. Interview with Neville Crabbe.

As It Happens, CBC Radio. October 30, 2013. Interview with Carol Off.

CBC Radio, Calgary Eye Opener, August 2010. Interview

CBC Radio, Calgary Eye Opener. June 14, 2002. Interview

CBC Radio, Calgary. Wild rose Country. June 14, 2002. Interview

Global TV June 14, 2002. Interview

CBC TV. June 14, 2002. Interview

A Channel. The Big Breakfast. February 22, 2002. Two interviews.

CTV National. February 21, 2002. Interview with Mark Stevenson

QR77 Radio. Calgary. February 15, 2002. Interview

CKNU Radio Vancouver, The World Today. February 15, 2002. Interview

CBC Radio, Thunder Bay. February 14, 2002. Interview

CBC TV. Country Canada. February 14, 2002. Interview

CBC Radio, St. Johns. February 13, 2002. Interview

CBC Radio, Vancouver. February 13, 2002. Interview

CBC Radio, Calgary. February 13, 2002. Interview

CBC Radio, Regina. February 13, 2002. Interview

CBC French Radio, Vancouver. February 12, 2002. Interview

CBC Radio National. As It Happens. February 12, 2002. Interview.

CBC Radio, Edmonton. February 12, 2002. Interview

CBC Radio, Vancouver. February 12, 2002. Interview.

CBC Newsworld. February 12, 2002. Interview.

CBC Radio, Ottawa, February 12, 2002. Interview.

Earthwatch Radio Wisconsin, January 2002. Three interviews with Richard Hoops, Producer, for distribution to 110 US and Canadian radio stations.

CBC Radio, Edmonton. September 1997. Whirling Disease in Alberta Salmonids. Interview with Paul Smiley,

CFCN TV, Calgary. August 1997. Alberta Sport Fisheries. Interview with Paul Bzeta,

CBC Radio, Homestretch, Calgary. August 1996. Alberta Bull Trout. Interview.

<u>MEDIA PRESENTATIONS – World Wide Web</u>

InsideScienceNews.org. June 15,2015. Sport fishing opens evolutionary can of worms. Interview and article with writer Devin Powell.

CBC News. December 13, 2014. Atlantic Sturgeon may be listed as threatened species.

Science Daily. January 31, 2014. Nine steps to save waterways, fisheries identified by researchers.

Canadian Science Publishing. February 20, 2014. It is not just about the fish…

Science Daily. November 2013. Changes to fisheries legislation have removed habitat protection of most fish species in Canada.

The Tyee. November 2013. Experts protest ‘gutting’ of Fisheries Act. Crawford Kilian.

The News. November 2013. When a river isn’t really a river at all.

U Today University of Calgary. November 7, 2013. Study: Changes to fisheries legislation have removed habitat protection for most species in Canada. Mark Lowey.

The Fish Site. November 2013. Fisheries legislation changes leave many fish without habitat protection.

The Telegram.com. November 2013. Oil pipeline not worth the risk.

Summit County Citizens Voice. November 2013. Study: Canadian politicians have ‘Eviscerated” habitat protection for freshwater fish.

Science Newsline Nature. November 2013. Changes to fisheries legislation have removed habitat protection of most fish species in Canada.

Watershed Moments: thoughts from the hydrosphere. November 2013. Say hello to Canada's new Fisheries Act.

Salish Sea News and Weather. November 2013. Changes to fisheries legislation have removed habitat protection for most fish species in Canada.

Osprey Steelhead News. November 2014. Article in American Fisheries Society Magazine rips Canadian Federal Government for changes to Fisheries Act.

Physics.org. November 2013. Changes to fisheries legislation have removed habitat protection for most fish species in Canada.

Quirks and Quarks Blog. November 2013. Changes to fisheries legislation have removed habitat protection for most fish species in Canada.

Oceans Society. November 2013. Revisions of Canada's Fisheries Act alerts biologists.

Northwest Coast Energy News. November 2013. New fisheries regulations further gut habitat protection in Canada study says.

Nature News. November 25, 2013. Changes to Canada's fisheries law alarm biologists. Anne Casselman.

Fishery Nation. November 2013. Scientists say new fisheries law "guts" protection for habitat.

Envnewsbits.worldpress.com. November 2013. Changes to fisheries legislation has removed habitat protection for most fish species in Canada, new study says.

ConservationBytes. November 2013. Medieval Canada threatens global biodiversity.

Colorado News. November 2013. Study: Canadian politicians have 'eviscerated' habitat protection for freshwater fish.

CBC Nova Scotia. November 2013. DFO at risk from budget cuts, change: internal review.

Canadian Angling. November 2013. Fish habitat protection removed by Canadian Federal Government.

Blacklock's Reporter, Ottawa. 12 November 2013. Cabinet "gutted" Fisheries Act, say Canadian scientists.

Beaty Biodiversity Museum. November 2013. The new Federal Fisheries Act and its effects.

Atlantic Fisherman. December 2013. Scientists raise alarm against Harper government changes to Fisheries Act.

Atlantic Salmon Federation. November 2013. Fisheries Act Changes remove habitat protection.

The Tyee. October 31, 2013. Gutting of Fisheries Act a 'politically motivated abrogation': biologists. Andrew Nikiforuk.

TIDEPOOL.org. June 13, 2003. Salmon summit adds to knowledge but not hope. Fish's difficulties grow clearer while solutions remain elusive. Article by Seth Zuckerman.

CBC.ca. June 14, 2002. Biologist says Cardinal's actions endangering species. Article.

NNSL.com March 11, 2002. Yellowknife. Troubled waters. Article by Mike W. Bryant.

CTVNews.com. February 26, 2002. sport fisheries in danger of collapse: study.

CBC.ca. February 12, 2002. New study says sport fishery near collapse.

CBC.ca. February 12, 2002. Canadian sport fishing stocks collapsing.

CBC.ca. February 12, 2002. Canadian sport fishing stocks collapsing.

Environmental Considerations for the
Benga Mining Limited
Grassy Mountain Coal Project
CEAA Reference No. 80101
Crowsnest Pass Area, Alberta

Submission of

CLIFF WALLIS P. BIOL.

Prepared for Ifeoma Okoye and Richard Secord, Ackroyd LLP
On Behalf of the
Coalition of the Alberta Wilderness Association and the Grassy Mountain Group

September 2020

Cottonwood Consultants Ltd.
615 Deercroft Way SE
Calgary, AB T2J 5V4
<contact information removed>

EXECUTIVE SUMMARY

Benga Mining Ltd.'s Grassy Mountain Coal Project will be located in the Rocky Mountain Natural Region near Crowsnest Pass, Alberta.

Although coal is mentioned in other portions of the South Saskatchewan Regional Plan, it is not specifically cited in the vision of the SSRP. Species at risk recovery and headwaters protection are emphasised. The vision has a clear focus on sustainability and conservation as well as for non-renewable resource production centred on oil and natural gas.

The key terrestrial biodiversity issues are:

- Environmentally Significant Areas (gives context to the overall importance of the site)
- Intact Native Grasslands (guidance from the South Saskatchewan Regional Plan)
- "Species at Risk" and other species of management concern, with particular emphasis on federally listed endangered Whitebark Pine (guidance from the Governments of Alberta and Canada as well as Canada's Species at Risk Act and associated guidance documents)

From a biodiversity perspective:

- Much of the Grassy Mountain Coal Project boundary is located in one or more Environmentally Significant Areas.
- "Species at Risk", e.g. endangered Whitebark Pine, are present in significant quantities in the soil salvage area boundary and will be directly harmed by the project.
- The failure to identify the full extent of distribution of endangered "Species at Risk" like Whitebark Pine raises issues related to the adequacy of the field work and the resulting environmental assessment.
- Cumulative effects are not being addressed adequately due to incomplete data and other proposed coal mining projects in the immediate vicinity that are not considered.
- In contravention of guidance in the South Saskatchewan Regional Plan (SSRP) to maintain intact native grasslands on public land, portions of the project footprint (soil salvage area) occur on public land inside areas mapped as intact native grasslands in the SSRP.

When species are considered individually, it is easy to fall into the trap of ignoring the collection of environmentally significant features of the Grassy Mountain project area. There are multiple species at risk facing numerous threats, including disease, loss of habitat and climate change effects. In my professional opinion, an area of environmental significance that supports multiple species at risk is not a place to approve the destruction of tens of thousands of individuals (in the case of whitebark pine) or supporting habitat which could take decades, if not longer, to recover even where there are known techniques to restore such habitats. For some habitats and species, like rough fescue grassland and whitebark pine, the techniques are unproven and, for rough fescue grassland, attempts at restoration have been met with multiple failures.

Given the difficulties of reclaiming certain vegetation types in any reasonable time frame, e.g. rough fescue grassland and whitebark pine, and the acknowledgement by Benga that "after reclamation" native species richness is expected to be lower, it is improper to characterize the residual effects as "not significant". Regardless of extent, anywhere that Benga has identified effects that are of high magnitude and that are extended or long-term in duration, those should be classified as significant at some level.

This approach of arriving at "not significant" effects is also not supported by the evidence given the continued declining populations of many species. If each project takes the view that there is no significance to the effects that it has on habitats and species, the declines of species and the loss of valuable, sometimes irreplaceable habitats, will continue.

Developing a coal mine that would eliminate tens of thousands of individual whitebark pine trees would seem to be at odds with the range-wide whitebark pine recovery strategy (strategy 3--conserving genetic diversity) which has guidance to protect known high value trees that are both cone-bearing and blister rust resistant.

It is difficult to reconcile the development of the Grassy Mountain coal project with conservation objectives for Little Brown Myotis when significant use has been recorded in parts of the project area. The project would effectively remove a variety of productive habitats for Little Brown Myotis for decades or longer. Alone, this may not be sufficient reason to deny the project but it adds weight to other valued components of this project that emphasize the project area's environmental significance.

The lack of attention to the ecological effects of drawdown from pit dewatering on adjacent wetland areas, riparian areas, and spring-dependent plant communities is a potentially significant omission.

Most important for regulators to consider is Benga's unproven restoration many decades from mine closure as well as the almost total destruction of potentially critical habitat for a currently healthy population of endangered whitebark pine and intact foothills fescue grassland.

When considered in the context of regulatory guidance, there are compelling reasons to deny this project given its direct impact on tens of thousands of endangered Whitebark Pine trees within potential critical habitat as well as intact foothills fescue grasslands. My professional recommendation is that the project not be approved in its current configuration.

1. INTRODUCTION

Cottonwood Consultants Ltd. was retained by Ackroyd LLP, on behalf of the Coalition of the Alberta Wilderness Association and the Grassy Mountain Group

I was charged with providing an evaluation of the impacts of the Grassy Mountain Project on biodiversity, primarily terrestrial, with a particular focus on Environmentally Significant Areas and Species at Risk, as well as habitats and other species of conservation concern. While all documentation was reviewed, the key documents which I examined are listed in Appendix 1 of this report.

I am personally familiar with the lands in question through field work in the region since the late 1970s including a project on the Montane Natural Region (Wallis 1980), rare plant work (Wallis et al. 1986), and Environmentally Significant Areas for the Municipality of Crowsnest Pass and Government of Alberta (Sweetgrass 1988), as well as the neighboring M.D. of Pincher Creek (Cottonwood 1987). Most recently, I conducted one field visit in August 2020 to the northern portion of the project area.

I acknowledge that I have been engaged to be an independent witness to give opinion evidence on issues within my area of expertise and acknowledge that as such I have a duty to provide evidence that is fair, objective and non-partisan.

2. PROTECTION AND PLANNING CONTEXT

2.1 Natural Regions Framework

Alberta has adopted the natural regions' landscape classification system to describe environmental diversity and provide the scientific framework for the protected areas network (Alberta Parks 2020; Natural Regions Committee. 2006). Each natural region contains a mix of similar vegetation, geology, soils, and landscape features. Alberta recognizes six natural regions including the Rocky Mountain that are again subdivided into 21 natural subregions, including the Montane and Subalpine in which lands affected by the proposed project are located.

The importance of the Rocky Mountain Natural Region is emphasized by Timoney (1998):

> *"The Rockies are a meeting place and a migratory corridor for life forms. Vegetation types and plant and animal species typical of the arctic extend southward in the Rockies at higher elevations. Likewise, species and communities from the Great Plains, the southern Cordillera, and the intermountain west all extend in one degree or another into the Rockies, finding a home within the great diversity of topography, climates, and landforms. The unbroken spine of the continent is a major northwest/southeast highland migration corridor extending from Alaska to Mexico."*

With respect to the Rocky Mountain Natural Region, Timoney (1998) notes:

> *"Pressure from the logging, oil and gas, mining, agricultural, tourism, housing, and commercial development industries continues in the Rocky Mountain Natural Region. Old growth forests are disappearing and with them all the life forms and processes they support; seismic cutlines, well-drilling, logging, and other industrial activities continue to fragment the landscape into ever smaller, isolated pieces. Outside the national parks, there is little time left to protect large, relatively undisturbed pieces of the Rocky Mountains that might serve as a functional, linked network."*

With respect to the Montane Natural Subregion, Timoney notes:

> *"A review of special features, disturbances, and significance for protection, heritage appreciation, recreation, and tourism of the Alberta montane subregion has been conducted by Natural Resources Service (1995). A salient feature of that review is the high degree of reduced habitat effectiveness due to the preponderance of human activities in montane valleys."*

Alberta Environmental Protection (1995) describes the Montane and why it is ecologically important:

> *"Montane landscapes are of restricted distribution in Alberta, found primarily along major river valleys in the Front Ranges from Grande Cache to Waterton. They are recognized as having high biological diversity and ecological values but are also among the most affected landscapes in the province."*
>
> *. . .*
>
> *"The montane occupies a relatively small portion of Alberta, covering about 5897 km^2, or less than 1 percent of the province's land area (Alberta Government, GIS digital data), but it is disproportionately important for biodiversity conservation. Several rare plant species and*

rare/uncommon plant associations occur in the montane. Montane landscapes apparently rival the best areas in North America for songbird diversity."

"These landscapes function as centres of ecological diversity and productivity within the region. They also provide important seasonal migration corridors for large carnivores, ungulates and songbirds as well as critical reproductive and overwintering habitat for a variety of species."

"Thus it is imperative that the ecological integrity of montane landscapes remains intact. Consequently, the "wholeness" of these landscapes, with all their elements and processes, must be maintained and not severely modified through inappropriate or incompatible development or other land uses."

Alberta Environmental Protection (1995) notes how the Montane has been impacted by human activities:

"Most of the montane valleys in Alberta have been significantly affected by developments. These developments include major highway and railway corridors, major hydroelectric developments, town sites and mining operations. One estimate is that more than 70 percent of Albert's montane has been heavily affected by highways, golf courses, towns, and tourist resorts (CPAWS 1995). This impact has dramatically decreased natural montane landscapes and the amount of land available for wildlife."

"Extensive areas of montane in southwestern Alberta, in the Kananaskis Country fringe, in the Ghost River/Wildcat Hills area and south of Pincher Creek in the Waterton area have been profoundly altered by roads, pipelines, wellsite, cutlines and gas processing plants. In some areas, grasslands have been converted to tame pasture and cropland. Forests on both private and public lands have been logged. Livestock grazing occurs on much of the montane. Even within national parks which are generally considered "protected" lands, recent analysis shows that the integrity of their montane areas has been seriously eroded."

2.2 South Saskatchewan Regional Plan

The South Saskatchewan Region Regional Plan (SSRP) (Government of Alberta 2018) expresses the following vision:

> *"Southern Alberta is a diverse, healthy, vibrant and prosperous region where the natural beauty of the region is managed so that citizens feel connected to the land and its history. Albertans, industry, governments, and aboriginal peoples work together to share responsibility for stewardship of the land and resources in a way that ensures current needs are met without compromising opportunities for future generations. Aboriginal peoples, through their traditional knowledge, share their intimate understanding of the region's natural environment and ecosystems."*

> *"The South Saskatchewan Region supports a diverse and growing population. Economic diversification supports employment and contributes to a prosperous future. Agriculture is a significant renewable resource industry demonstrating environmental stewardship while pursuing growth and diversification opportunities. There are continued opportunities for oil and natural gas production and renewable energy will become increasingly significant. Forests are managed with watershed management and headwaters protection as the highest priority and healthy forests continue to contribute to the province's timber supply. The region has unique landscapes that form the basis of a popular tourism and recreation destination which continues to grow."*

> *"Air, water, land and biodiversity are sustained with healthy functioning ecosystems. The headwaters in the region supply vital regional freshwater quality. Conservation strategies help many species at risk in the South Saskatchewan Region recover, while also preserving the diversity and splendor of Alberta's natural regions with various parks and conservation areas providing Albertans with improved health and inspiration to value nature."*

Although coal is mentioned in other portions of the SSRP, it is not specifically cited in the vision of the SSRP. Species at risk recovery and headwaters protection are emphasised. The vision has a clear focus on sustainability and conservation as well as non-renewable resource production centred on oil and natural gas. The SSRP describes the importance of the region:

> *"A wide range of fish, wildlife and plant species exist in the region, including: 17 sport fish species; over 700 vascular plant species; numerous songbirds, hawks, owls, waterfowl and grouse; and mammals such as moose, deer, pronghorn, wolves, grizzly bears, cougars and lynx. The region also serves as breeding grounds and staging areas for birds during migration and overwintering periods. The South Saskatchewan Region has more than 80 per cent of the province's species at risk as listed under the federal Species at Risk Act and the provincial Wildlife Act. Factors contributing to this high proportion include human settlement, disturbance from industrial, recreational and other uses, fragmentation, environmental contaminants and the introduction of invasive species."*

> *"The range of species and diversity of ecosystems across the region reflects the biodiversity found here and means there is a broad range of ecosystem services provided. Biodiversity represents the assortment of life – including the variety of genetics and species and the habitats in which they occur – all shaped by natural processes of change and adaptation. Biodiversity and ecosystem services are not the same thing but they are interdependent. Ecosystem services are the benefits humans, communities and society as a whole receive from healthy, functioning ecosystems and the biodiversity within them. Biodiversity*

underpins the supply of ecosystem services, so changes in biodiversity will affect the type and amount of those services available to humans."

"All ecosystem services contribute to sustaining a healthy and prosperous way of life for all Albertans. Fish, wildlife, traditional medicinal plants, berries and less-developed spaces are also important for the cultural practices of First Nations peoples."

3. MAJOR TERRESTRIAL BIODIVERSITY ISSUES

Rather than do an in-depth critique of every point in the extensive hearing documentation, I have focused on a few key issues that might help in the hearing panel's work and whether to approve or deny the Grassy Mountain coal project as currently proposed.

I have undertaken this approach since most of the area is ranked as environmentally significant in several studies going back to the 1980s (Sweetgrass 1988; Timoney 1998; and Fiera 2009, 2011 and 2014). From a provincial guidance (South Saskatchewan Regional Plan-Government of Alberta 2018) and federal regulatory perspective (*Species at Risk Act*), the project will result in direct and measurable impact on intact native rough fescue grasslands and on endangered species such as whitebark pine.

Given those impacts in contravention of the spirit and intent found in the guidance and law, I recommend that the project not be approved in its current configuration. My rationale is detailed in the following sections.

If the project is approved, the mitigations proposed by Benga will help ameliorate residual or long-term effects for many terrestrial biodiversity components. However, they will not prevent immediate and lasting damage to an area of environmental significance. There will be residual or long-term effects on valued components (VCs) of conservation concern where there is clear regulatory guidance, including whitebark pine and intact rough fescue grassland.

With respect to climate change, on pdf page 190 of CIAR251, Tenth Addendum, Package 2, Vegetation and Reclamation, Benga acknowledges some issues for establishing whitebark pine and rough fescue grassland habitats but notes that climate change will also affect natural vegetation:

- *"There is a moderate reduction in level of confidence in the reestablishment of whitebark pine and rough fescue due the uncertainty in the future forest fire regime associated with climate change (as described in sections F.5.2.7 and F.5.2.8).*
- *The confidence in the revegetation techniques used for reclamation is expected to remain high. Natural recovery, seeding, fertilization, tree and shrub plantings, and transplantation should be carried out as expected.*
- *Potential impacts on vegetation that may occur as a result of future climate change, would occur with or without the Project.*

In my professional opinion, it is premature to state that the potential impacts of future climate change with or without the project would be essentially the same. I think the potential impacts on vegetation will be even more uncertain on disturbed lands than in native habitats where there is the full complement of soil mycorrhizae, soil structure, vegetation structure, and species diversity (flora and fauna) that will support greater resilience in the face of climate change than on disturbed sites.

In my professional opinion, the key terrestrial biodiversity issues are:

- Much of the Grassy Mountain Coal Project boundary is located in one or more Environmentally Significant Areas.
- In contravention of guidance in the South Saskatchewan Regional Plan (SSRP), portions of the soil salvage area occur on public land inside areas mapped as intact native grasslands in the SSRP.

- “Species at Risk”, e.g. endangered whitebark pine, are present in significant quantities in the soil salvage area boundary and will be directly harmed by the project.
- The failure to identify the full extent of distribution of endangered “Species at Risk” like whitebark pine raises issues related to the adequacy of the field work and the resulting cumulative effects assessment.
- Cumulative effects are not being addressed adequately due to incomplete data and other proposed coal mining projects in the immediate vicinity that are not considered.

3.1 Environmentally Significant Areas

Environmentally Significant Areas (ESAs) are areas that have been identified as being of ecological, hydrological, or geological importance based on representativeness, diversity, naturalness, and ecological integrity. In Alberta, ESAs include areas that meet any of the following criteria (Sweetgrass Consultants 1997):

"1. areas that provide an important linking function and permit the movement of wildlife over considerable distances, including migration corridors and migratory stopover points;
2. areas that perform a vital environmental, ecological, or hydrological function such as aquifer recharge;
3. areas that contain rare or unique geological or physiographic features;
4. areas that contain significant, rare, or endangered plant or animal species;
5. areas that are unique habitats with limited representation in the region or are a small remnant of once large habitats that have virtually disappeared;
6. areas that contain an unusual diversity of plant and/or animal communities due to a variety of geomorphological features and microclimatic effects;
7. areas that contain large and relatively undisturbed habitats and provide sheltered habitat for species that are intolerant of human disturbance;
8. areas that are excellent representatives of one or more ecosystems or landscapes that characterize a natural region;
9. areas with intrinsic appeal due to widespread community interest or the presence of highly valued features or species such as game species or sport fish; and
10. areas with lengthy histories of scientific research."

These criteria were simplified by Fiera (2009) to:

"1. Areas that contain elements of conservation concern.
2. Areas that contain rare or unique landforms.
3. Areas that contain habitat for focal species.
4. Areas that contain important wildlife habitat.
5. Riparian areas.
6. Large natural areas.
7. Sites of recognized significance."

Fiera (2009) states

> *"Environmentally Significant Areas (ESAs) are defined as areas that are vital to the long term maintenance of biological diversity, physical landscape features and/or other natural processes at multiple spatial scales. Identifying these areas using scientifically rigorous, defendable, and relevant methodology is the first step toward the successful integration of ecological values into provincial planning and management. The early recognition of ESAs is essential to help identify and prioritize areas that may be important to conserve, or that require special management consideration, thus supporting land-use planning processes. For example, areas of environmental importance are commonly used to prioritize environmental management toward areas that represent under-protected or vulnerable resources or resources that are highly unique (naturally rare) or "irreplaceable". Identifying ESAs using credible, broadly supported methods enables decision makers to rapidly progress through the planning process where informed trade-offs can be discussed, priorities set and clear policy direction achieved."*

Alberta has compiled ESA information for the entire province. ESAs may contain rare or unique biodiversity or are areas that may require special management consideration due to biodiversity conservation needs. ESAs currently have no policy context and are only intended to be an information tool to help inform land use planning and policy at local, regional, and provincial scales.

Representativeness, diversity, naturalness, and ecological integrity all play a role in delineating ESAs (Sweetgrass 1988; Fiera 2009, 2014). Fiera (2011) delineated aquatic ESAs (Figure 1).

The Government has updated ESAs for the province (Fiera 2014) but has provided it in a format that is somewhat challenging to use as it is only a quarter-section method with no named/numbered natural area boundaries, being based strictly on a numerical threshold (Figure 2). Each quarter section is ascribed a ranking based on a summation of various criteria. Fiera states: "Ultimately, professional judgment was used to determine a cutoff value of >0.189 for designating quarter sections as Environmentally Significant Areas in the province." From experience, this is a relatively arbitrary cutoff number and must be used with historical ESA information and current field studies to refine ESA boundaries. Limitations are recognized by the authors themselves:

> *"It should be recognized that there may be environmentally significant areas that have not been identified in this assessment, and these omissions may be due to a lack of inventory and data that documents their location and/or significance. Further, it's important to note that all ecosystems in Alberta, including those that fall outside of designated ESAs, should be considered in planning exercises that involve objective setting for environmental and land use criteria. This is of particular importance when considering coarse-filter biodiversity at a landscape scale. For example, habitat connectivity and locations that provide diverse habitat for a variety of species are important considerations in addition to ESAs . . . It is important to note that this project focused on identifying ESAs at the provincial scale. There are many regionally and locally significant sites that are not included in this compilation, but should be identified and considered during finer scale planning."*
>
> *. . .*
>
> *"This ESA product does not replace other indicator-specific mapping and planning tools, such as wetland inventories, caribou range maps, and species at risk recovery plans. These more detailed information sources must be consulted when planning for projects that may impact specific environmental resources, particularly when dealing with regulatory requirements. ESAs are not intended to be used in the regulatory context."*
>
> *. . .*
>
> *"the provincial wetland inventory consists of a compilation of different inventories that were produced using a variety of methods and mapping techniques. The result is an inventory with inconsistent accuracy across different regions of the province . . . As a result, any indicator that required a wetland inventory was removed. Given the environmental importance of wetlands, the inability to reliably identify wetlands in Alberta was considered a major gap in this assessment."*
>
> *. . .*
>
> *"ESAs were identified at a very coarse scale (provincial) using the quarter-section as the unit of analysis. As such, this model provides a coarse-scale assessment of environmental values in the province, and the resulting ESA map highlights general areas that contain environmentally significant elements. Finer-scale planning processes are required if the objective is to identify and delineate specific areas of environmental significance at scales finer than the quarter section (e.g., a single wetland or a tree*

stand). Further, the identification of ESAs at finer scales allows for region-specific prioritization and weighting of criteria and indicators. "

. . .

"Several of the indicators used to identify ESAs relied on species observation and occurrence records, which represents "presence only" data. The use of presence only data can be problematic because there is no reliable information about where a particular species is not found, and these types of data often exhibit strong spatial bias related to survey effort."

Nevertheless, Fiera (2014) provides insights into concentrations of significant features and is an additional tool that, with appropriate context, can be used in planning work.

To put the significance of the project area into an overall context, the entire Grassy Mountain Coal Project boundary is located in one or more ESAs.

Much of the project area has been classified as an ESA of national significance by Fiera (2009) with much of the area falling under aquatic ESAs (Fiera 2011) and portions cited as regionally significant in earlier ESAs (Sweetgrass 1988; Timoney 1998).

Fiera (2014) maps much of the area as at least provincially significant but, unlike Fiera (2009) does not differentiate to national or international significance. A smaller amount of the area maps to inferred regional significance along the eastern, northern, and southern boundaries of the project area (and the soil salvage area). I have inferred "regional significance" to the next threshold tier below the provincial or higher significance threshold of >0.189 in the scoring system. This comports reasonably well with previous field-based ESA studies (Sweetgrass 1988 and Timoney 1998). As noted in CIAR 42, Consultant Report 10, Land and Resource Use:

"A majority of the ESAs in the area were classified as an area that contributes to water quality and quantity (Criterion 4.0) and as areas with ecological integrity (Criterion 3.0). Key features of these two criteria were related to the presence of rivers and streams (4a), wetlands and lakes (4b), habitat patch size (3a), and habitat intactness and connectivity (3b) (Fiera 2014)."

Since Fiera (2009 and 2014) use quarter section boundaries and not natural boundaries, non-significant lands are often included, e.g. the old mine site, in those boundaries so more detailed field work is required to refine the actual boundary of each ESA.

The checksheets on the following pages are from Fiera (2009) for Site Number "2"; Sweetgrass (1988) for named regionally significant ESAs "Coleman" and "Gold Creek-Livingstone Range"; and from Timoney (1998) for "Middle-Upper Crowsnest River" and "Livingstone Range". Boundaries of the Sweetgrass (1988) ESAs are constrained by the Municipality of Crowsnest Pass boundary (Figure 1).

from Sweetgrass (1988):

Site Name: COLEMAN

Site Location:

- north of Coleman along north boundary of study area, between McGillivray Creek and Blairmore Creek
- Twp. 8 - Rge. 4 - W5M

Description:

- key Mule Deer and Elk habitat

Significance: Regional

- key ungulate habitats are important features of the region

Management Considerations:

- heavy grazing reduces the suitability of these habitats for a variety of native plants and animals

References:

- Fish and Wildlife key area maps

from Sweetgrass (1988):

Site Name: GOLD CREEK - LIVINGSTONE RANGE

Site Location:

- northeastern portion of study area from north of Blairmore and Frank to northwest of Burmis
- Twp. 7 and 8 - Rge. 3 and 4 - W4M

Description:

- diversity of habitats including talus slopes, ephemeral and permanent streams, subalpine meadows and woodland, and montane woodland
- concentrations of rare plants including: Utah honeysuckle (Lonicera utahensis), sticky currant (Ribes viscosissimum), Alaska bog orchid (Habenaria unalascensis) and shrubby beard-tongue (Penstemon fruticosus) on Bluff Mountain; yellow monkey-flower (Mimulus guttatus) on small creek east of Gold Creek; and sticky laurel (Ceanothus velutinous) and stands of big sagebrush (Artemisia tridentata) in Section 27 - Twp. 7 - Rge. 3 - W5M, previously unrecorded in the Crowsnest Pass
- scattered large mature Douglas fir and limber pine
- key ungulate area; a high density of Elk, Moose, and Mule Deer use was noted on the west slopes of Bluff Mountain
- habitat for Rock Wren, an uncommon bird in region
- productive trout habitat along Gold Creek
- cold water, calcium-sulfate bicarbonate (sulphur) springs in L.S. 12 - Section 36 - Twp. 7 - Rge. 4 - W5M

Significance: Regional
- apparently one of the most significant ungulate habitats in the study area
- key trout habitats are important features of the region
- only a few stands of big sagebrush are known for Alberta; the stands in the study area are smaller than other Alberta stands but represent a northern extension for this species
- sulphur springs are localized and this may be one of the best examples in Alberta

Management Considerations:
- maintenance of wildlife diversity is dependent on maintaining a variety of forest types including burned-over areas and old-growth forest
- - stream pollution from subsurface or surface sources and erosion and siltation can have significant impacts on fisheries- heavy grazing reduces the suitability of these habitats for a variety of native plants and animals

References:
- 1987 field program notes

From Timoney (1998) database:

Site No. 45: MIDDLE - UPPER CROWSNEST VALLEY

Location: Tp. 8-Rge. 4-W5

Map Sheet: 82G

Subregions: Montane

Significance: Regional

Site Description:

- includes portion of Crowsnest River between Sentinel and Savanna (with extensive riverine shrub and adjacent grassland and mature aspen, high diversity and density of breeding birds, extensive flower blooms in grasslands, and productive trout fishery).
- also includes part of Allison Creek area (with diverse habitat mosaic of grassland, deciduous and conifer woodland, ravines, and a permanent stream; some large spruce, Douglas fir, alder, and aspen; key mule deer and elk habitat; marl wetland, productive trout habitat along Allison Creek). See also polygon 44.
- also includes Coleman area key mule deer and elk habitat; and part of York Creek area (diverse, relatively undisturbed habitat; exposure of Crowsnest Formation volcanic rock, key habitat for moose, elk, and mule deer, rare plants (Lonicera utahensis, Ceanothus velutinus), and regionally uncommon bird species (e.g. LeConte's sparrow).
- includes two explosive volcanic centres (under the town of Coleman, and southeast of Coleman). The Crowsnest Formation is one of only two units of volcanic rock known from the Canadian Rockies (the other is the Siyeh Formation in Waterton/Glacier. The Crowsnest Formation is volcanic mudflow rock about 160 m thick composed mainly of fragments of trachyte. "Includes Crowsnest Natural Area (#392) with steep, high rocky ridge sloping to McGillivray Creek; aspen forest; open lodgepole - Douglas fir forest, white spruce forest, mixedwood forest, and heavy use by ungulates.
- includes Coleman Natural Area (#58) with rolling to steep slopes dominated by Douglas fir - lodgepole pine, white spruce/horsetail along creek, aspen and balsam along creek, and a scenic waterfall in a deep canyon.

References:

- Sweetgrass Consultants 1988
- Gadd 1995.

From Timoney (1998) database:

Site No. 79: LIVINGSTONE RANGE

Location: Tp. 9-Rge. 3-W5

Map Sheet: 82G

Subregions: Alpine, Subalpine

Significance: Regional

Site Description:

- includes part of Gold Creek
- high to low elevation Front Range landscape with little industrial/logging disturbance
- zone prime protection due to sensitive alpine and subalpine lands
- high landscape connectivity due to lack of disturbance
- Includes a diversity of habitats from talus slopes to ephemeral and permanent streams, subalpine meadows, productive trout habitat on Gold Creek
- Includes >/=1 rare plant occurrence and >/= 1 spotted frog occurrence

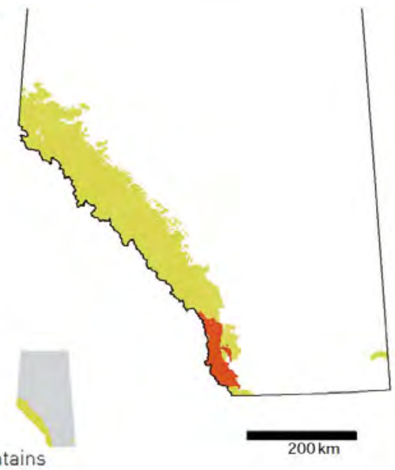
References:
- Resource Evaluation and Planning 1987
- Sweetgrass Consultants 1988
- Resource Appraisal Group 1979
- Biodiversity Observation Database
- G. Court, pers. comm. 1997
- ANHIC rare plant database, 1997

from Fiera (2009):

Rocky Mountain

CRITERION

- ☑ 1 Contains **253** element(s) of conservation concern
- ☑ 2 Contains rare or unique landforms
  - Barnaby Ridge Area patterned ground
  - Beaver Mines Area valleys, v-shaped valleys
  - Beaver Mines Area volcanic rocks
  - Coleman Area volcanic rocks
  - Crowsnest Lake Area karst springs
  - Crowsnest Mountain klippes
  - Crowsnest Pass flatirons
  - Drywood Mountain Area hanging valleys
  - Lundbreck Area hogbacks
  - Lundbreck Area river terraces, rock-cut terraces
  - Ma Butte Area volcanic rocks
  - Newman Peak Area volcanic rocks
  - Plateau Mountain Area limestone pavement
  - Thunder Mountain Area water gaps
  - Turtle Mountain Area rock falls
  - West Castle Mountain mountains, castellated mountains



- ☑ 3 Contains habitat for focal species
- ☑ 4 Contains important wildlife habitat
- ☑ 5 Contains riparian areas
  - ☑ a Contains headwater streams
  - ☑ b Contains intact riparian areas
  - ☑ c Contains riparian areas along the six major rivers
- ☑ 6 Contains large natural areas
- ☑ 7 Contains sites of recognized significance

ESA CHARACTERISTICS

Natural Region(s):	Natural Subregion(s):	River Basin(s):
Rocky	Subalpine	Oldman River
Mountain Grassland	Montane	Bow River
Parkland	Alpine	
	Foothills Fescue	
	Foothills Parkland	

Area:

398,552.0 hectares

3,985.5 km²

Density of Human Features:

Well **0.05** heads/km²

Road **0.33** km/km²

Pipeline **0.11** km/km²

ELEMENTS OF CONSERVATION CONCERN

Amphibians and Reptiles

Leopard frog

Birds

Black-headed grosbeak

Cassin's finch

Ferruginous hawk

Trumpeter swan

Insects

Acadian hairstreak

Arrowhead blue

Astarte fritillary

Blue copper

Blue copper

Bronze copper

Gillette's checkerspot

Henry's copper

Icarioides blue

Little copper

Lorquin's admiral

Moss's elfin

Oreas anglewing

Pacific forktail

Pacific fritillary

Pale swallowtail

Purple azure

Sheridan's green hairstreak

Striped meadowhawk

Sylvan hairstreak

Thicket hairstreak

Woodland skipper

Liverworts

Athalamia hyalina

Chiloscyphus pallescens

Conocephalum conicum

Diplophyllum taxifolium

Jungermannia atrovirens

Jungermannia sphaerocarpa

Lophozia ascendens

Pellia epiphylla

Pellia neesiana

Porella cordaeana

Porella platyphylla

Radula complanata

Scapania curta

Scapania cuspiduligera

Scapania subalpina

Mammals

Grizzly bear

Red-tailed chipmunk

Wandering shrew

Mosses

Alpine broom moss

Alpine curly heron's bill moss

Alpine grimmia

Alpine lemming moss

Atrichum selwynii

Aulacomnium androgynum

Brachythecium plumosum

Brachythecium reflexum

Broken-leaf moss

Bryum amblyodon

Bryum calobryoides

Bryum calophyllum

Buxbaumia piperi

Cirriphyllum cirrosum

Common extinguisher moss

Curl-leaved fork moss

Desmatodon leucostoma

Desmatodon systylius

Dichodontium olympicum

Didymodon vinealis

Donian beardless moss

Donian grimmia

Drepanocladus crassicostatus

Encalypta brevicolla

Encalypta spathulata

Fissidens limbatus

Flagon-fruited splachnum

Fontinalis antipyretica

Fontinalis neomexicana

Globe-fruited splachnum

Green shield moss

Homalothecium nevadense

Hygrohypnum styriacum

Large-fruited splachnum

Leskeella nervosa

Long-stalked beardless moss

Mnium ambiguum

Mountain forest grimmia

Myurella tenerrima

Orthotrichum pallens

Orthotrichum pumilum

Pohlia longicolla

Pseudoleskea patens

Pseudoleskea stenophylla

Pterygoneurum subsessile

Racomitrium sudeticum

Rhizomnium magnifolium

Rhizomnium nudum

Rhytidiadelphus squarrosus

Rigid screw moss

Schistidium pulvinatum

Scouleria aquatica

Seligeria campylopoda

Silky fork moss

Spreading fringe moss

Sun grimmia

Twisted-leaved grimmia

Urn moss

Urn-like pogonatum

Vascular Plants

Alpine foxtail

Alpine harebell

Alpine spleenwort

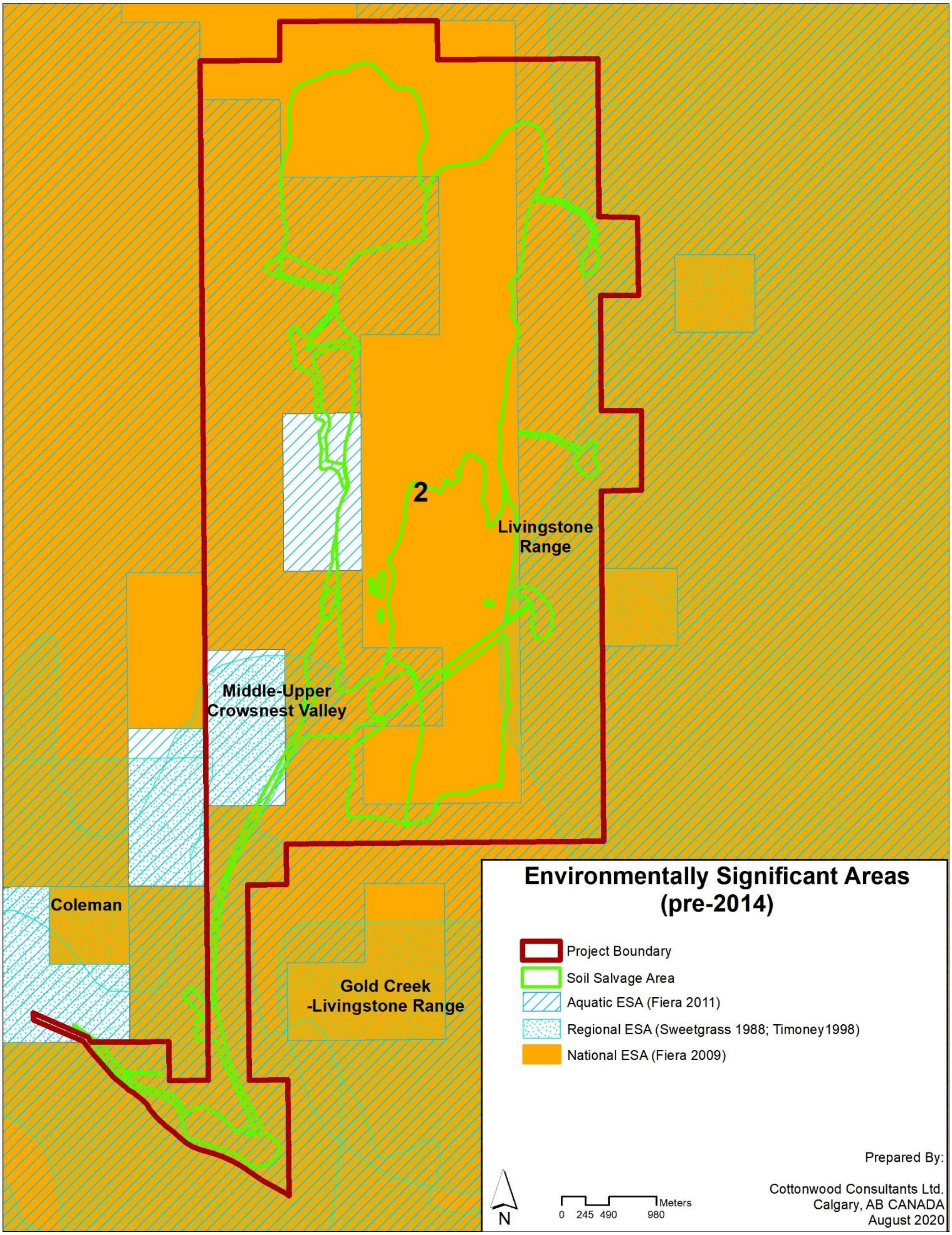


Figure 1. Environmentally Significant Areas (Sweetgrass 1988; Timoney 1998; Fiera 2009 and 2011). The Fiera studies use quarter section boundaries. Sweetgrass (1988) and Timoney (1998) use natural feature boundaries but Sweetgrass' boundaries are constrained by the Municipality of Crowsnest Pass boundary.

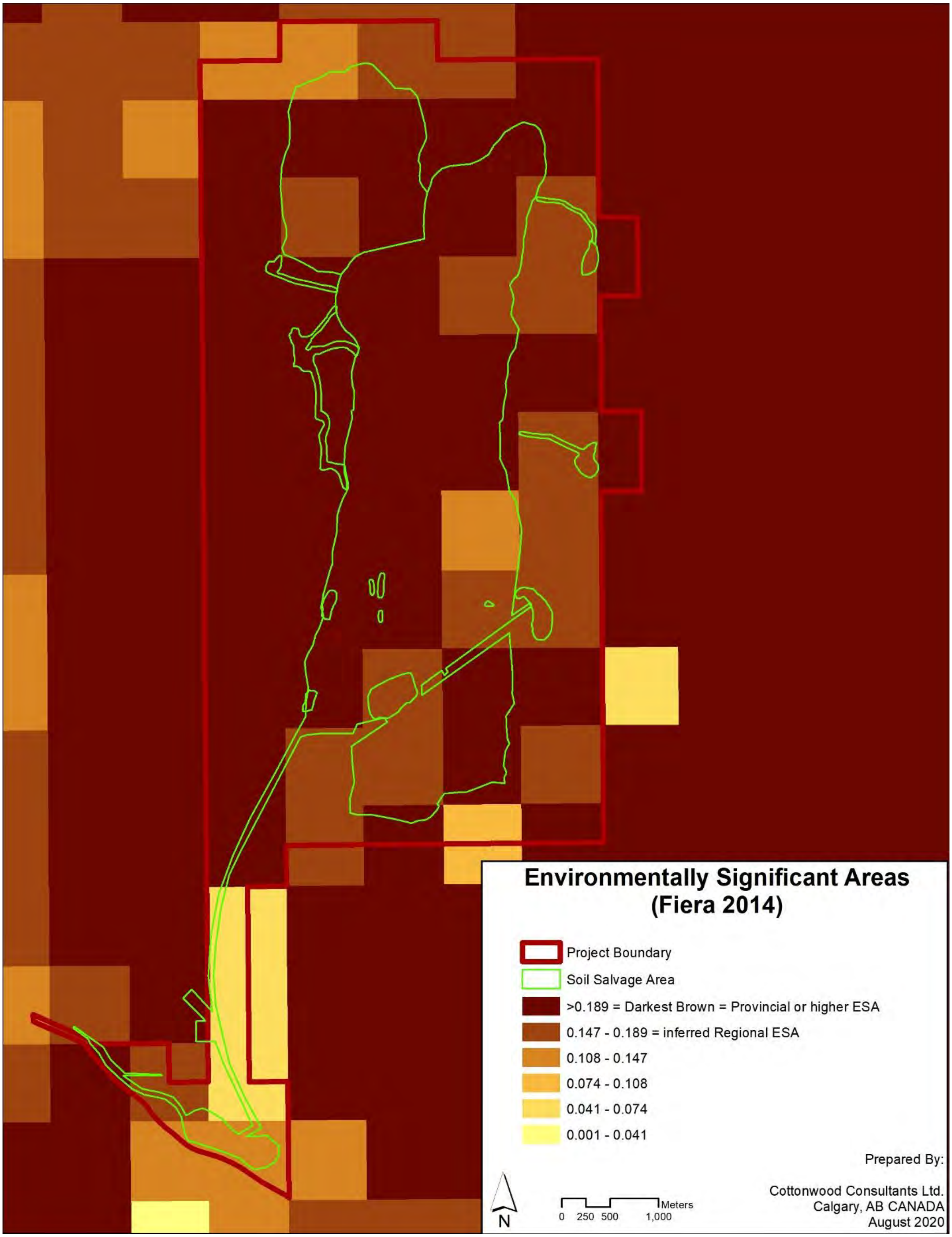


Figure 2. Environmentally Significant Areas (Fiera 2014). Quarter sections with ESA qualities of regional significance are inferred from data in the next tier below “Provincial or higher” significance.

3.2 South Saskatchewan Regional Plan -- Intact Native Grassland

The Alberta Land Stewardship Act provides direction for decision-making bodies in section 21(1):

> ***"21(1)*** *When a regional plan is made, every decision-making body affected by the regional plan must*
> *(a) review its regulatory instruments, and*
> *(b) decide what, if any, new regulatory instruments or changes to regulatory instruments are required for compliance with the regional plan."*
>
> ***"(2)*** *Every decision-making body affected by the regional plan must, within the time set in or under, or in accordance with, the regional plan,*
> *(a) make any necessary changes or implement new initiatives to comply with the regional plan, and*
> *(b) file a statutory declaration with the secretariat that the review required by this section is complete and that the decision-making body is in compliance with the regional plan."*

The South Saskatchewan Regional Plan (Government of Alberta 2018) provides guidance with respect to intact native grasslands:

> *"Implement guidelines to* ***avoid conversion and maintain intact native grasslands on public land*** *(see Appendix G - Grasslands).*
> *• Species at risk habitat – No conversion permitted as habitat needs to be sustained as part of government programs for species recovery (as required under federal and provincial legislation)."*
> *. . .*
> *"Areas with high biodiversity value such as areas important for connectivity and areas that are "intact" and would benefit from remaining in a less disturbed condition such as intact native grasslands."*

In contravention of this guidance to maintain intact native grasslands, portions of the project footprint (soil salvage area) occur on public land inside areas mapped as intact native grasslands and areas of high biodiversity in the SSRP (Figure 3).

At pdf pages 1526 and 1527 of CIAR 89, Eighth Addendum, Provincial and Federal Requests for Additional Information, regarding MSL160757, cautions related to PNT090084 and PNT090087 in the mine area are noted:

> *"THIS LOCATION MAY FALL WITHIN AN AREA OF FOOTHILLS FESCUE GRASSLAND, A VERY VALUABLE NATIVE GRASSLAND TYPE THAT IS LIMITED IN REMAINING AREA. ROUGH FESCUE GRASSLANDS ARE VERY SENSITIVE TO SURFACE DISTURBANCE AND DIFFICULT AND COSTLY TO RECLAIM. PROPONENTS MUST CONSULT INFORMATION LETTER (IL) 2010-02, FESCUE GRASSLANDS -- PRINCIPLES FOR MINIMIZING SURFACE DISTURBANCE AND MAKE EARLY CONTACT WITH ALBERTA ENVIRONMENT & SUSTAINABLE RESOURCE DEVELOPMENT STAFF FOR THE AREA IN QUESTION. THE INFORMATION LETTER ADDRESSES OBLIGATIONS AND SPECIFIC DIRECTION REGARDING ALL POTENTIAL SURFACE DISTURBANCE RELATED ACTIVITY IN FOOTHILLS ROUGH FESCUE GRASSLAND PLANT COMMUNITIES. THIS DIRECTIVE SUPPLEMENTS THE ERCB'S IL 2002-01: PRINCIPLES FOR MINIMIZING SURFACE DISTURBANCE IN NATIVE PRAIRIE AND PARKLAND AREAS. IL 2010-02 MAY BE FOUND AT:*

HTTP://WWW.SRD.ALBERTA.CA/FORMSONLINESERVICES/INFORMATIONLETTERS/LANDSINFORMATIONLETTERS/DOCUMENTS/IL2010-02-FOOTHILLSFESCUEGRASSLANDPRINCIPLESFORMINIMIZINGSURFACEDISTURBANCE-MAR23-2010.PDF IL2002-01 MAY BE FOUND AT:HTTP://WWW.ALBERTAPCF.ORG/RSU_DOCS/EUB_NATIVE_PRAIRIE.PDF"

On pdf pages 89 and 90 of CIAR 42, Consultant Report 8, Vegetation, Benga notes:

> *"The natural range plant community and species diversity were intact throughout most of the LSA. Rough fescue grass was prevalent throughout the five grassland sites assessed within the LSA, with cover at each site ranging from 20% to 40%."*
>
> *. . .*
>
> *"The total area occupied by areas with foothills rough fescue is 219.9* ha. Foothills rough fescue dominant communities (Fescue) occupy approximately 3.4 ha of the Project Footprint and compose an insignificant area of the LSA. Range community types where foothills rough fescue is a sub-dominant component (Grassland Sparse) occupies approximately 18.2 ha of the Project Footprint, and open forest grassland with whitebark pine as the canopy species (Whitebark Sparse) which have foothills rough fescue as a component of the grassland, occupies 197.3 ha of the Project Footprint."*
>
> *Table 3.3-3 shows 218.9 ha.

Reclamation of Rough Fescue Communities

On pdf pages 139, 141 and 142 of CIAR 69, the Fifth Addendum, Supplemental Information Request Responses #1, Benga notes:

> *"As stated in Section F, Section F.3.6.3.2, Benga will identify opportunities for direct placement of salvaged reclamation material. The scheduling of direct placement opportunities is limited to having recontoured lands available in proximity to reclamation material salvage areas. Direct placement practices to encourage rough fescue would be limited to dry, south-facing mid slopes in reclaimed areas where rough fescue communities have been established and there is a rough fescue seed bank in the stored topsoil piles. As indicated in Section F.3.2.4, areas where direct placement is targeted will be further supported by other seeding and maintenance techniques to ensure soil stability and vegetation establishment of the desired communities is achieved."*
>
> *"Areas devoid of rough fescue communities will be reclaimed as close as possible to the target ecosite; however, as indicated in Section F.3.2.4 direct placement of salvaged reclamation material will be prioritized, when opportunities exist, to promote foothills rough fescue and native grassland establishment. The viability of establishing rough fescue in these devoid areas will be determined based on the evaluation of reclaimed moisture conditions, topographic position, aspect and expected ecosite. Establishment measures such as seeding of rough fescue in the seed mixes in Table F.3.6.3 or planting of rough fescue plugs in these devoid areas will also be considered."*
>
> *. . .*
>
> *"The natural variability and complexity of the existing terrain within the Project will not be duplicated by creation of re-contoured landscapes. The reclaimed landscape will be more homogenous than current conditions. However, the reclaimed landscapes will contain characteristics similar to the existing upland terrain. Similar aspects and slope lengths will exist and will include ridges, benches (plateaus) separated by terraces, valleys, and steep single slope inclines. A variety of wetland complexes will also be created during the*

reclamation of the Project. It is expected that the creation of a range of terrain types, during contouring and reclamation will provide a reclaimed terrain that will tie into adjacent undisturbed lands, provide suitable landscapes for the development of a range of reclaimed soil types and functioning vegetation communities."

. . .

"After mining and reclamation of Project infrastructure there will be a permanent loss of organic landforms and the extreme slopes in the upland terrain will be reduced to a maximum slope angle of 23°."

Bradley and Neville (2010) indicate that successful restoration of rough fescue grasslands has not been documented. Revegetation success is hampered by invasive non-native species such as smooth brome, Kentucky bluegrass and timothy. They state that for industrial projects in rough fescue grasslands "avoidance is the preferred strategy." Alberta Sustainable Resource Development (2010) also recognized the values of foothills fescue grasslands and the difficulties of re-establishing them -- they also recommended avoidance as the key guidance:

"Foothills fescue grasslands contribute ecological goods and services important to the economy and public interests of Alberta. The value of retaining the ecological health and function of these grasslands is acknowledged by the ranching community, government agencies, stewardship groups and through conservation easements on freehold lands. Of increasing value to Albertans is the role foothills fescue grasslands play in maintaining surface and groundwater resources. Also there is an increasing awareness of their role in capturing and storing carbon. It is recognized that fragmentation of these remaining fescue grasslands jeopardizes their ecological health, function and operability."

. . .

"Unlike many native prairie ecosystems, natural recovery has failed to restore foothills fescue plant communities as the native plants simply cannot compete with invasive non-native species. Disturbed sites seeded with native plant cultivars have resulted in limited success in reducing non-native species invasion. Long term restoration success has yet to be demonstrated and documented on industrial sites subjected to the full range of production and operational disturbance related activities."

. . .

"While many of these guidelines have been specifically designed to reduce the footprint of the petroleum industry in native grassland, it is expected that all industrial development will adhere to the broad concepts of the guidelines and develop industry specific best management practices."

On pdf pages 108 and 110 of CIAR 69, Tenth Addendum, Package 2, Vegetation and Reclamation, Benga acknowledges that establishment of rough fescue grassland is unproven and may take a long time:

"The preferred primary mitigation strategy for native foothills rough fescue grasslands is avoidance. Vegetative disturbance within the project footprint is unavoidable, and therefore mitigation strategies will be implemented to improve the likelihood of re-establishing rangeland communities across the project throughout the life of the mine. The targeted distribution of grasslands in the reclaimed landscape is demonstrated in Table F.3.2-2 and is shown in comparison to pre-disturbance landscapes."

. . .

"Benga acknowledges that restoration of foothills rough fescue inhabited lands is relatively unproven but will rely on industry best practices and will utilize key findings from successful efforts made on other industrial disturbances in similar fescue grassland areas. A search of

available literature, such as Lancaster et al. (2016), demonstrates several successes on similar landscapes, which will be incorporated into the reclamation plan as further defined below."

. . .

"As the growth of native foothills rough fescue grasslands may require a long period of time, the majority of early stage reclamation will use a certified, weed-free native seed mix that is representative of appropriate range type communities for the reclamation of natural upland herbaceous grasslands."

While Lancaster et al. (2016) provide a good overview of issues related to the benefits of native grasslands and the difficulties of reclamation in Alberta's foothills, the "successes" described relate primarily to one site (Lewis Ranch) where the soil layer was not disturbed. There has also been limited success using plugs (Cross gravel pits) but re-establishment of rough fescue grassland on most stripped sites has not been successful.

"Relative to each unique ecological site, intact native grasslands possess a rich diversity of native grasses, forbs and shrubs that produce a characteristic plant community structure, facilitating optimal use of moisture, nutrients and available sunlight. To the extent possible, reclamation practices aim to restore the native plant community so that ecological health and function, and the related ecological services are maintained. In the Alberta Grassland Natural Region, recovery of native plant communities can be more readily achieved in drier prairie environments while mesic foothill environments are much more challenging, primarily due to the greater competitiveness of agronomic grasses and weeds in the moister growing environment. Ecological health, function and associated ecological services will be diminished when plant communities are modified by non-native species."

"Topsoil stripping was commonly used as a pre-construction practice for pipelines and wellsites prior to the 2000s. Desserud (2006) concluded recovery of rough fescue grassland was poorest on pipelines that had been fully (15 m or more width) stripped; therefore, recommended no topsoil stripping should be done."

"The pre-disturbance plant communities at all wellsites were native in character but had a significant component of invasive agronomic species including awnless brome, Kentucky bluegrass and timothy. In addition to these species, the MFC and Cross ranch sites included a minor cover of Parry's oat grass or rough fescue plus a significant component of native forbs and graminoids."

"At the Lewis ranch sites, the lower slopes of the wellsite remained unstripped. This area of intact sod was covered in geotextile and topsoil from the upper portion of the lease was placed onto the geotextile over winter. Soil was then carefully removed from the storage area and replaced on the stripped portion of the lease. Revegetation was accomplished on both areas of the lease with rough fescue plugs and over seeded to native grasses with a bunch type growth habit. Similarly, on both the Cross site and the Cross Gravel Pit sites, once stripped topsoil was replaced, revegetation was accomplished with seeding of rough fescue plugs plus over-seeding of native species with a bunch type growth habit."

. . .

"On the post-2000 wellsites some hopeful expressions of native species infilling and recruitment were evident including a very strong re-establishment of rough fescue on the Lewis wellsite where the surface topsoil had not been stripped."

"The general conclusion here is that minimum disturbance practices such as matting appears to have enhanced the re-establishment of native infilling species. Plug seeding with

associated native species from seed has produced one of the very few sites in the fescue grassland where rough fescue appears to be re-established as a dominant species in the plant community."

Minimum disturbance is not how I would describe the approaches that Benga will use at Grassy Mountain for rough fescue grassland restoration. The plug seeding successes for rough fescue were on ecosites quite different than Grassy Mountain (Cross Gravel Pit and Cochrane).

On pdf pages 73 and 74 of CIAR 251, Tenth Addendum, Package 2, Vegetation and Reclamation, Benga states:

"The construction and operation stages of the Project will result in the removal of vegetation, and a temporary reduction of native species diversity in the Project Footprint. The ecosite phases impacted by Project development have mostly moderate to high biodiversity potential. After mine closure and reclamation, native species richness is expected to be lower than the intact naturally developed vegetation, with the exception of the 185.2 ha of previously disturbed land on the Project Footprint, which will result in an improvement over pre-development conditions. Over time, species and community diversity will improve across the reclaimed Project Footprint and landscape."

Lastly, some areas mapped as a1 Limber Pine/Juniper may at least partly fall into a grassland vegetation type (pdf page 268, CIAR 42, Consultant Report 8, Vegetation). Either way it is mapped, the Limber Pine/Juniper type would be of significance due to presence of limber pine or intact grasslands.

For the reasons outlined in this section (difficulty of restoring rough fescue grassland and SSRP guidance against disturbing intact native grassland), I recommend that the Grassy Mountain coal project not be approved in its current configuration.

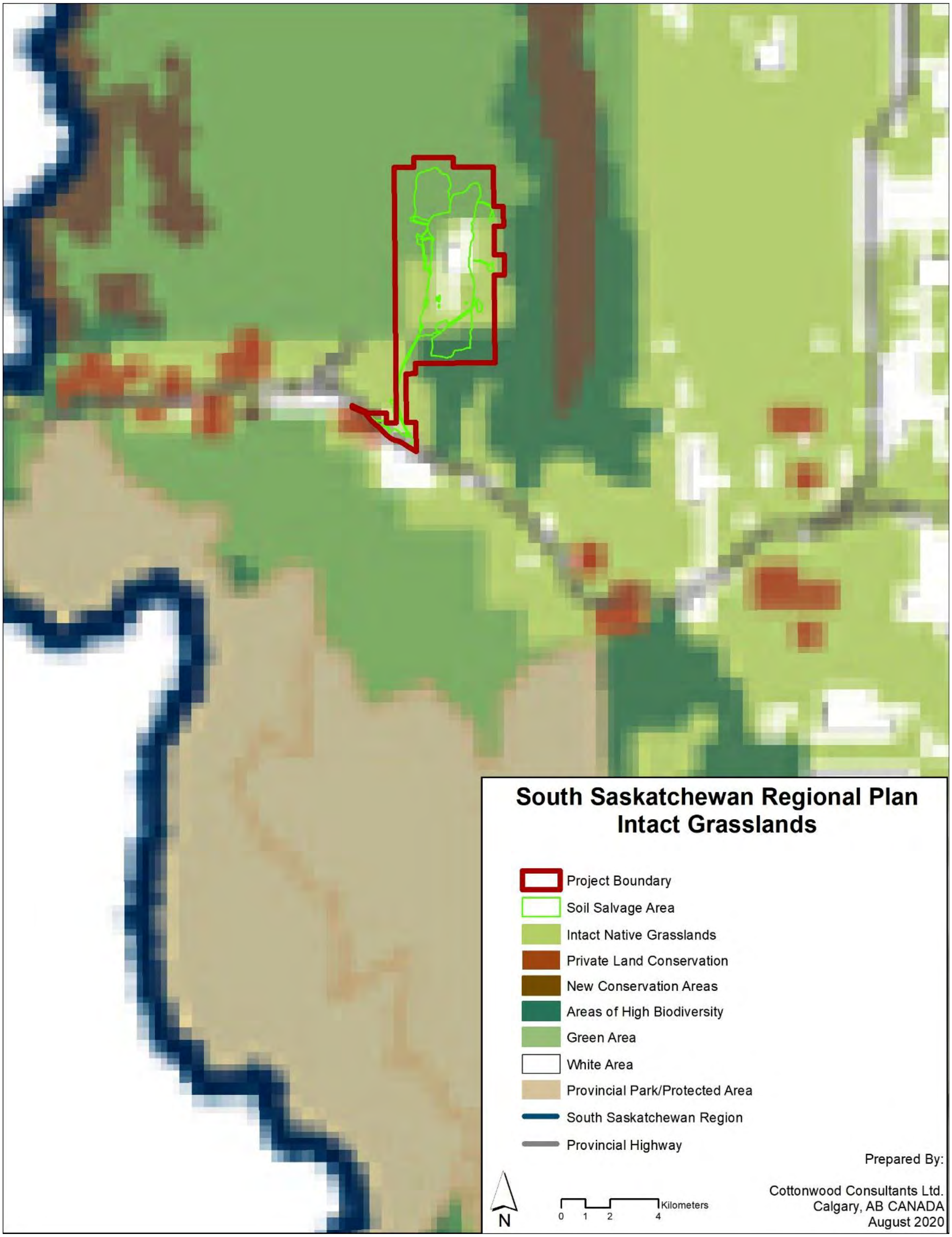


Figure 3. Intact native grasslands as identified in the South Saskatchewan Regional Plan. Some of these are on public lands inside the project boundary and soil salvage area. Note also “Area of “High Biodiversity” in southeast corner of the project lands includes intact native grasslands on public land. Base map and legend from the South Saskatchewan Plan (Government of Alberta 2018).

3.3 Species of Management Concern

With respect to other species at risk, on pdf pages 60 and 62 of CIAR 55, Attachment 2, Benga states:

> *"The wildlife species at risk associated with this Project include: olive-sided flycatcher, little brown bat, short-eared owl, and common nighthawk. Similarly, western toad (Committee on the Status of Endangered Wildlife in Canada [COSEWIC] – Special Concern for calling and non-calling populations), barn swallow (COSEWIC – Threatened), and grizzly bear (COSEWIC – Special Concern) are also included."*
> *. . .*
> *"The magnitude of potential effects of clearing resulting in the removal and/or mortality of trees is high for whitebark pine and limber pine. Effects will initially be of high magnitude with clearing of vegetation and mining operations exceeding that of large natural disturbances, including fire and insect infestations that are more selective and less homogeneous (CR #8, Section 4.2.7)."*

At pdf page 181 of CIAR 69, Fifth Addendum, Supplemental Information Request Responses #1, the potential effects on VC species are described by Benga:

> *"For potential effects on movement, mortality risk, and abundance, the magnitude of residual effects was rated low for all species assessed as VCs (including little brown myotis, olive-sided flycatcher, western toad, and grizzly bear, as well as great gray owl) (CR #9, Section 5.3.11, Table 5.3-26). Following reclamation, which aims to provide a diversity of natural wildlife habitats representative of the region, it is anticipated that the movement, mortality risk, and abundance of these species will be little changed from general baseline conditions."*

> *"The magnitude of potential effects on habitat availability for olive-sided flycatcher and little brown myotis was conservatively characterized as moderate. The rationale for this is that the reclaimed landscape is anticipated to be different from the current landscape; more different than would happen from natural disturbance such as fire. Because reclamation aims to restore the area to natural land cover representative of the area and consisting of suitable habitats for these three species, the magnitude of effects is believed to be lower than high."*

> *"The magnitude of potential effects on habitat availability for western toad and grizzly bear was characterized as low, because the reclaimed landscape is anticipated to have more wetland area and primary source habitat that currently exists for these two species, respectively. Benga considers this characterization as conservative since the actual magnitude for western toad and grizzlies may be low (less than) because of the increase of suitable habitat after reclamation."*

> *"The overall magnitude of potential effects on barn swallow, common nighthawk, and short-eared owl were characterized as low (CR #9, Section 5.4.9, Table 5.4-1), as a result of the diversity of habitats provided in the reclaimed landscape. Similarly, adverse residual effects on species such as moose, elk, lynx and marten are expected to be low, because, over the long term, the amount of effective habitat for these species in the reclaimed landscape is predicted to be greater than currently exists."*

For plants, at pdf pages 139 and 148, CIAR 42, Consultant Report 8, Vegetation, Benga states:

> *"Construction and operation of the Project would result in the removal of all rare plants observed within the Project Footprint"*
>
> *. . .*
>
> *"Of the 41 rare species (with 94 occurrences) identified in the LSA, 27 species (with 53 occurrences) were observed in the Footprint (Table 4.2-1). These species included 11 vascular plant species (32 occurrences), nine mosses and liverworts (11 occurrences) and seven lichen species (10 occurrences)."*

Within the footprint (soil salvage area), I calculated that approximately 10.7% is ranked as having high or very high rare plant community potential (Figure 4) (pdf page 275, CIAR 42, Consultant Report 8, Vegetation). On pdf page 147, CIAR 42, Consultant Report 8, Vegetation, Benga notes that the project will reduce the area of the Local Study Area with high / very high potential to support rare plant communities by 30.5% (63.4 ha) in the Montane and 61.2% (103.6 ha) in the Subalpine Natural Subregion.

Within the footprint (soil salvage area), I calculated that approximately 36.9% of the footprint (soil salvage area) is ranked as having high rare plant species potential .(Figure 5) (pdf page 274, CIAR 42, Consultant Report 8, Vegetation). On pdf page 147, CIAR 42, Consultant Report 8, Vegetation, Benga notes that the project will reduce the area of the Local Study Area with high potential to support rare plants by 15% (17.8 ha) in the Montane and 38.8% (465.2 ha) in the Subalpine Natural Subregion.

The magnitudes of the potential effects on wildlife VCs are described by Benga in CIAR 42 and 69 but the lack of inclusion of the Atrum Elan South coal project is concerning. The regional effects would be even more significant with that inclusion. The effects on those VC species may not be a deciding factor in whether this project should be approved, but they add to the weight of evidence about the importance of this area for various species of conservation concern. Habitat for these species will be further alienated from their use for an extended period of time, which in conjunction with other projects like Elan South, impoverishes the richness of the region's biodiversity. This long-term effect on some species is acknowledged by Benga on pdf page 182 of CIAR 69, Fifth Addendum, Supplemental Information Request Responses #1, which states: "*Habitat will be progressively reclaimed throughout the lifespan of the Project, making the loss of olive-sided flycatcher habitat temporary but long-term."*

See the cumulative effects section 3.4.2 of this report for further discussion on the significance of the effects on flora and fauna of management concern.

The importance of the area has been reflected over decades of work on environmentally significant areas done regionally and provincially, key wildlife and biodiversity areas, and the South Saskatchewan Regional Plan's identification of intact grasslands and high biodiversity areas.

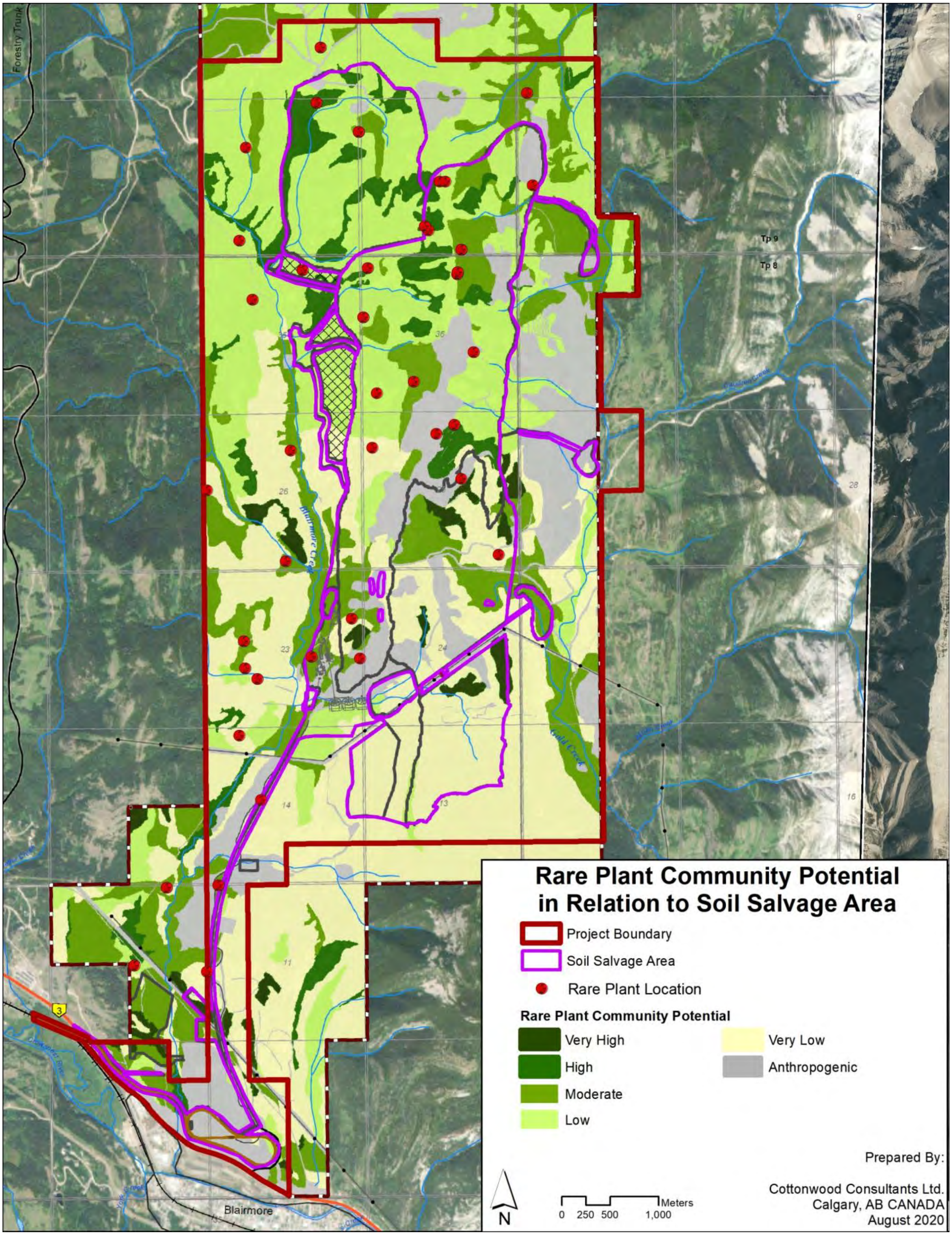


Figure 4. Within the footprint (soil salvage area), approximately 10.7% is ranked as high or very high rare plant community potential habitat (base map -- pdf page 275, CIAR 42, Consultant Report 8, Vegetation).

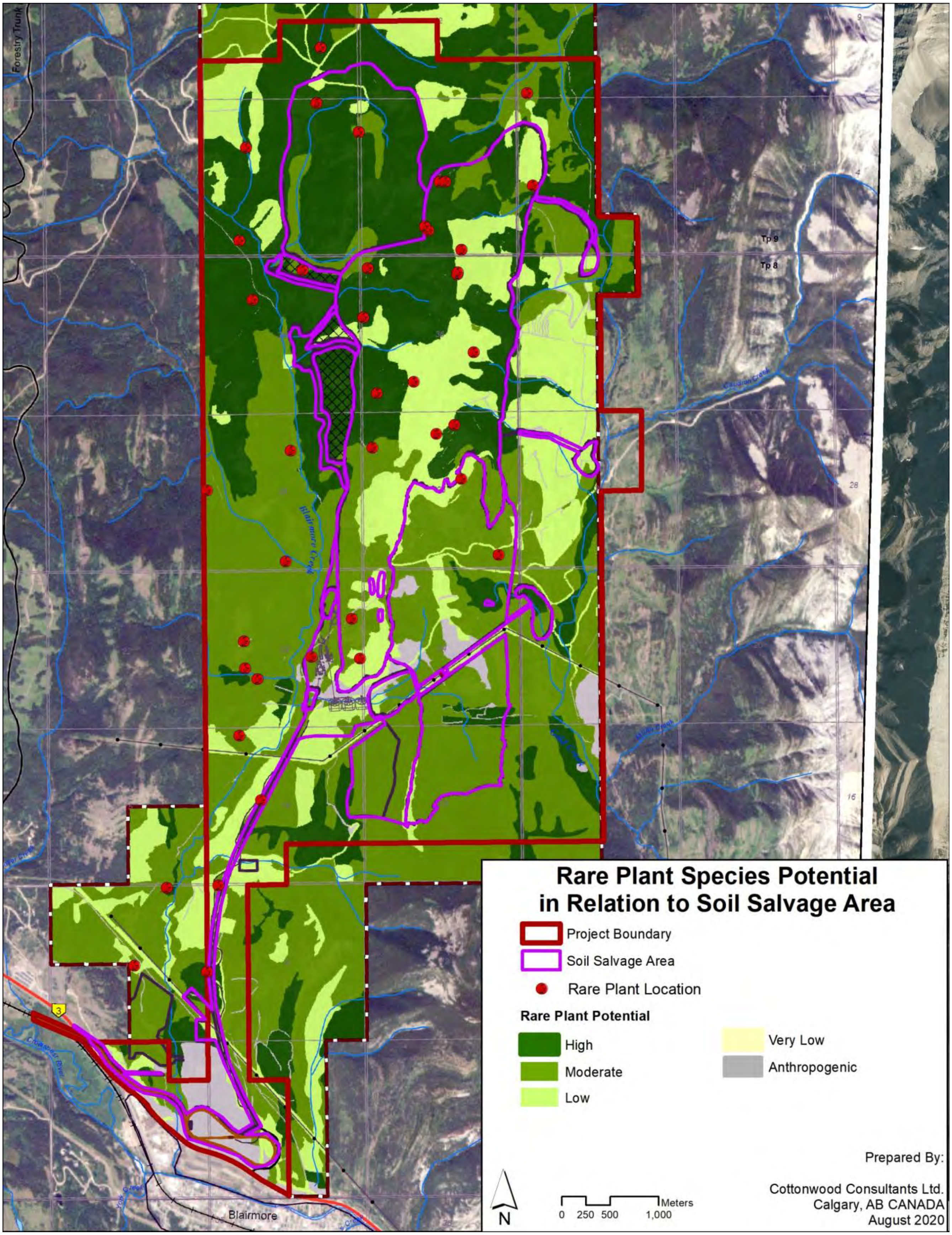


Figure 5. Within the footprint (soil salvage area), approximately 36.9% of the footprint (soil salvage area) is ranked as having high rare plant potential (base map -- pdf page 274, CIAR 42, Consultant Report 8, Vegetation).

3.3.1 Whitebark Pine, Limber Pine and dependent species

Background

Whitebark Pine is listed as "Endangered" under Schedule 1 of Canada's *Species at Risk Act (SARA)* (Government of Canada 2020*)*. Limber Pine has been proposed for listing as "Endangered" under Schedule 1 of Canada's *Species at Risk Act (SARA)* (Environment and Climate Change Canada 2017a).

On pdf page 139 of CIAR 42, Consultant Report 8, Vegetation, Benga states:

> *"The Project will disturb approximately 208.4 ha of whitebark and open grassland areas containing a sparse whitebark pine canopy, for a total of approximately 21,000 whitebark pine trees and less than 1,000 limber pine trees."*

With respect to limber pine, on pdf page 36 of CIAR 55, Attachment 2, Benga states:

> *"Benga proposes to plant a minimum of three times the number of trees removed due to operation of the Project (estimated at 1,000 trees thus 3,000 trees planted). Establishing limber pine by planting seedlings is feasible. According to Pigot and Moody (2013), "limber pine seeds germinate readily, and it is possible to produce good quality seedlings for outplanting in one growing season. Survival after planting appears to be high and planting is one of the more productive restoration activities…" As summarised in the Alberta Limber Pine Recovery plan, limber pine seed has been collected many times in the past in Alberta, and trees have been successfully established. Planting a minimum of three times the number of trees removed has been selected to account for mortality during planting, subsequent natural losses, uncertainty in long term survival, and to provide a buffer to ensure a net increase in the number of trees. Adaptive management (Section F.2.3) will be implemented throughout the reclamation period to reduce mortality from planting and to increase long-term survival."*

With respect to whitebark pine (WBP), on pdf page 123 of CIAR 69, Fifth Addendum, Supplemental Information Request Responses #1, Benga states:

> *"From a conservation and reclamation perspective, where salvage or a transplanting mitigation is not feasible, the primary value of individual whitebark pine (WBP) is in the collection of mature cones for seed ahead of clearing (as outlined in CR#8, Section 4.2.6.3)."*
>
> *"Collection of WBP cones occurs over more than one growing season, requires cone protection from seed predators, and qualified professionals with specific training to safely access the trees. To achieve this, Benga will engage qualified professional contractors to undertake the safe collection of WBP cones. For safety reasons no special attempt to salvage trees on steep and or unstable terrain will be undertaken."*
>
> *. . .*
>
> *"The natural limiting factors for WBP establishment is competition and seed cash sites for the Clark's Nutcrackers that are the primary seed dispersers. No physiological impediment to growth due to lower elevations have been reported. In the study area, WBP does occur at lower elevations and this has been described in the C5 Forest management unit with specific protections put in place for forest harvesting operations. As described in draft federal WBP recovery strategy (Environment and Climate Change Canada 2017) elevation*

is highly variable, with WBP observed growing as low as 765 m. For the Project, WBP will be established at elevations ranging at 1,500 m to 1,850 m."

. . .

"In regard to WBP populations, where possible, the mine development was designed to avoid the removal of trees if possible; however, based on the layout of the associated coal seams and required mine bench configuration to access the coal, complete avoidance of some WBP stands and/or individuals can not be incorporated into the mine plan.

On pdf pages 149 and 150 of CIAR 69, Fifth Addendum, Supplemental Information Request Responses #1, Benga states:

"The estimate of 21,000 whitebark pine (WBP) trees within the footprint is intentionally conservative and includes estimates of juvenile trees and seedlings. Benga is committed to planting three times the number of trees removed from mining and to support establishment of disease resistant trees wherever possible as this is the key component of recovery. Tree plantation success will be assured by application of adaptive management, active participation/engagement with recovery plans and groups, and use of best management practices as they evolve over time."

"Justification includes the high blister rust infection rate within the study area (mortality is occurring), the estimated 28.9 million WBP mature stems in Alberta and 44.4 million limber pine in Canada, and expected population decline from blister rust, mountain pine beetle, fire exclusion and climate change of 66% for WBP and 78% for limber pine over next 100 years. Loss of 21,000 trees from an area of high infection with subsequent mitigation that includes establishing 60,000 trees over a relatively short 30-year period of time (well within one natural disturbance rotation) is deemed to be not a significant impact. More assessment details and summary can be found in reply to part b of the question."

On pdf page 92 of CIAR 251, Tenth Addendum, Package 2, Vegetation and Reclamation, Benga states:

"The Whitebark Pine and Limber Pine Mitigation Plans (CR #8 (EIA) Section 4.2.6.3) include the following mitigations:

- *minimizing the Project footprint to avoid populations of whitebark pine where possible*
- *adhering to the mitigation approaches outlined in the Alberta Whitebark Pine Recovery Plan"*

On pdf page 107 of CIAR 251, Tenth Addendum, Package 2, Vegetation and Reclamation, Benga states:

"The distribution of whitebark pine and limber pine species have been confirmed via aerial assessment and plotted on Figure F.3.2-1. Pre-development counts estimated 20,692 whitebark and limber pine with less than 1,000 limber pine stems estimated across the entire Project Footprint. Since limber pine are difficult to distinguish from whitebark pine without cones and before the pollen season, at the time of assessment they were included in the whitebark pine counts. In the Project Footprint, whitebark pine individuals, sparse clusters, and mixed species stands were found on both east and west aspects along crest and upper slope positions (Figure F.3.2-1)."

. . .

"The reclamation plan will follow guidance provided in the Alberta Whitebark Pine Recovery Plan and Limber Pine Recovery Plan, established by the Alberta Whitebark and Limber Pine Recovery Team (2014a, and as updated). In addition to recommending a reduction of direct

mortality of the species, which has been considered throughout the development of the Project Footprint, Benga will develop and introduce white pine blister rust-resistant strains; conserve genetic diversity; and manage habitat and natural regeneration."

Incomplete Mapping of Whitebark Pine

On pdf page 40, CIAR 42, Consultant Report 8, Vegetation, Benga states:

"It is important to note that failure to observe an at-risk or rare plant occurrence does not mean absence of these species within a vegetation community."

While this is true, given the importance and endangered status of whitebark pine, it is my professional opinion that an even greater effort (than Benga undertook) was needed to accurately characterize its distribution in the project footprint (soil salvage area). This is necessary to more accurately determine the significance of the effects of the project on whitebark pine. Alberta Environment and Parks (2019) noted the importance of accurate inventory for both whitebark pine and limber pine:

"Direct mortality associated with industrial and recreational land use (which is governed by policy and legislation) affect both species, but overall impacts are low relative to the primary threats (Table 1). In Canada, these species currently lack legal protection on provincial lands outside of parks, and whitebark pine may be harvested during forestry operations. Land use impacts may have limited extent, but can have high local duration and severity. Grazing impedes limber pine seedling establishment, ski infrastructure and mountain recreational development may remove whitebark pine trees, as do rights-of-way for powerlines, pipelines, and resource roads. Careful planning, accurate inventory and diligent field assessment during project pre-planning and layout can avoid, minimize or mitigate impacts."

The northern part of the soil salvage area has been mapped by Environment and Climate Change Canada (ECCC 2017b) as potential critical habitat for whitebark pine (Figure 6). On August 2020, I undertook a local audit of the consultants' work on whitebark pine in this area (Figure 7). My survey transect extends north from a known occurrence of dense whitebark pine around the edge of the proposed rock disposal area. 107 individual whitebark pine trees were located along a 1173 m transect with 87 individuals within the rock disposal area. Undoubtedly, whitebark pine are more widely distributed than what is represented on Benga's maps and my transect. Given Benga's incomplete mapping of whitebark pine distribution in this potential critical habitat for whitebark pine, there is significantly more of the rock disposal area and potentially other mining area that supports whitebark pine than is acknowledged in Benga's documentation and its evaluation of cumulative effects. **The statements on avoiding populations of whitebark pine or reducing direct mortality throughout development of the Project Footprint are not supported by the mapped information that shows most of the Benga mapped whitebark pine and my new whitebark pine records are within the pit or rock disposal areas.**

The Project Review Section 79 (2) of the Species at Risk Act (Government of Canada 2002) states:

"The person must identify the adverse effects of the project on the listed wildlife species and its critical habitat and, if the project is carried out, must ensure that measures are taken to avoid or lessen those effects and to monitor them. The measures must be taken in a way that is consistent with any applicable recovery strategy and action plans."

It is my contention that Benga has not identified all the adverse effects on whitebark pine and has not taken measures to avoid or lessen the effects.

Critical Habitat for Whitebark Pine

While critical habitat for whitebark pine has not yet been legally protected, the reasons for, and the importance of, protecting it must be recognized. ECCC (2017b) states:

> *"The population and distribution objective for Whitebark Pine is to establish a self-sustaining, rust-resistant population of Whitebark Pine throughout the species' range that demonstrates natural seed dispersal, connectivity, genetic diversity and adaptability to changing climate. Broad strategies are presented to address the threats to the survival and recovery of the species. Implementation of these broad strategies is required to meet the population and distribution objective."*
>
> *"Critical habitat has been identified to the extent possible with the best available information to address the population and distribution objective. Critical habitat was identified to address the species' needs for seed dispersal (i.e., in relation to stand densities), survival, regeneration, and long-term recovery, within the species known range in Canada."*
> *. . .*
> *"It is acknowledged that White Pine Blister Rust (in combination with Mountain Pine Beetle, and climate change) currently poses the greatest threat to Whitebark Pine, and impacts cannot be eliminated or completely avoided through habitat preservation. However, based on demographic and genetic studies, it has been determined that recovery may be feasible by strategic restoration to increase rust resistance levels in natural populations, and by mitigating or avoiding human-related impacts within habitats that the species requires for survival or recovery."*
> *. . .*
> *"human-related activities associated with lower-impact threats can (cumulatively, and/or individually) degrade the species' resilience to primary threats, if left unchecked. In other words, if these activities continue without consideration for Whitebark Pine, the likelihood and feasibility of the species' survival and recovery will be reduced. Table 6 outlines human-related activities that are most likely to result in the destruction of critical habitat for Whitebark Pine. Appendix B provides additional information pertaining to the management of these activities. Destructive activities are not limited to those listed."*

Table 6 of ECCC (2017b) includes mines and mineral exploration as examples of activities resulting in the destruction of critical habitat for whitebark pine and detail some of the effects:

> *"Related IUCN Threats: # 1, 3, 4, 5, 6.1"*
>
> *"Seed dispersal habitat is required for continued natural dispersal (i.e., use by Clark's Nutcracker). Availability of suitable microsites within and proximal to seed dispersal habitats are required for recovery, and regeneration."*
>
> *"The prevalence of industrial, recreational, and/or commercial impacts will be site-specific. Individually most of the related threats are of negligible impact however logging is characterized as a low-impact threat in BC. These activities generally occur at the local scale, but can have cumulative impacts at the broader scale. It is not possible to determine thresholds at this time; however direct and cumulative effects are likely to be increasing."*

While ECCC (2017b) does not consider mining to be one of the significant threats to whitebark pine, it provides strategic guidance for local and/or cumulative impacts of "other threats" such as mining:

> *"Minimize localized and/or cumulative effects causing or contributing mortality to Whitebark Pine individuals that are cone-bearing, and/or that are not terminally-infected with a pathogen."*

ECCC Guidance and Whitebark Pine Requirements

Appendix B of ECCC (2017b) provides guidance to prevent destruction of critical habitat for whitebark pine:

"Avoid or minimize activities likely to result in destruction

- *Development and/or conversion of lands for industry, recreation, or commerce*
    - *Avoid cutting Whitebark Pine trees that are not terminally infected and/or that are cone-producing.*
    - *Identify, georeference, mark, and report Whitebark Pine trees that are putatively rust-resistant.*
    - *Avoid machine operation within identified critical habitat that results in damage to any pre-existing Whitebark Pine trees and/or the soil layer that supports them.*
    - *Avoid planting competitive conifer species/seedlings (e.g., Lodgepole Pine, Spruce, Fir) in critical habitat identified for Whitebark Pine.*
    - *Prevent introduction of alien invasive vegetation by ensuring equipment is clean."*

ECCC (2017b) also notes:

> *"Survival needs for Whitebark Pine are characterized as habitat required to allow individuals to persist and grow on the landscape throughout its range."*
>
> *"Within the areas it occurs, the microsites that are suitable for Whitebark Pine germination and growth are limited. Research indicates that seedlings require limited overstory and understory competition, avoidance of frost pockets, protection from shade and wind, protection from snow or soil movement, adequate growing space, and absence of crowding from other species"*
> *. . .*
> *"The habitat required to support individual trees includes root area, ectomycorrhizal fungal associations, and specific soil attributes at established suitable microsites as described. Maintaining integrity of the substratum layer is important for the persistence and viability of cached seeds."*
> *. . ."*
> *"Relative to other conifer species, Whitebark Pine is slow to reach reproductive maturity. It takes up to a century to achieve a self-sustaining population, and to replace stands and/or individuals that are lost to disturbance. Thus, it is crucial to maintain a range of recruitment opportunities and regeneration habitat (including suitable microsites for germination)."*

Keane et al. (2012) note:

> *"Practices and impacts potentially threatening to the maintenance of ECM diversity in the soil include tree cutting, soil removal, mechanical disturbance, soil compaction, erosion, mining activities, liming, N-deposition, fertilization, high-severity fire, reduction of tree age diversity, and promotion of certain grasses. Additional detrimental effects may result from*

removal of certain understory or reservoir plants, woody debris, nurse trees, and other microsite components (reviewed in Wiensczk and others 2002). In general, these practices should be minimized to maintain high ECM fungal diversity in the soil."

. . .

"Whitebark pine management strategies should consider factors known to help maintain diversity of ECM fungi in the soil. These include maintaining an intact forest floor, promoting the continuous presence of living host trees, and maintaining multiple age forests (Wiensczk and others 2002). In particular, maintenance of soil organic matter, nurse trees, logs (not stumps), and other microsite components may enhance fungal diversity (Tedersoo and others 2008). For whitebark pine, we know that ectomycorrhizae occur in soil as well as in nurse logs (Cripps and others 2008). Microsite plays a significant role in whitebark pine seedling establishment in general (McCaughey and others 2009). Management strategies that promote continuous host presence also function to preserve spore banks in soil (Kjöller and Bruns 2003). Since ECM fungi are successional, a mixed host age structure helps maintain fungal diversity for the next generation of trees. When continuity of the host is lost and plantings do not occur before spore banks become non-viable, it is possible that host-specific fungi will be lost."

. . .

"Managers should protect high-value trees, which are those both bearing cones and exhibiting phenotypic blister rust resistance . . ."

. . .

"Emphasize restoration treatments that minimize the mortality of whitebark pine, especially cone-bearing trees."

. . .

"Previously, planting success for whitebark pine was quite low due to the lack of guidelines and experience in these high-elevation systems. However, current efforts are showing great promise, and the Scott and McCaughey (2006) guidelines should help increase the survival of planted whitebark pine seedlings."

<u>Recovery Strategy</u>

Keane et al. (2012) outline a range-wide strategy for whitebark pine recovery:

*"1. **Promote rust resistance.** The most important action in restoring whitebark pine is to ensure that future populations of the species have some resistance to blister rust by increasing the frequency of trees with genetic resistance to the blister rust pathogen. All restoration plans and activities must first address how natural or planted whitebark pine regeneration will survive with blister rust, now a naturalized species in North America (Geils and others 2010). To accomplish this, managers must (a) support selective breeding programs to develop and deploy blister rust-resistant whitebark pine, (b) facilitate and accelerate natural selection for blister rust-resistant genotypes in stands by reducing competition to increase survival of healthy putative rust-resistant trees in high blister rust areas, providing openings for natural seed dispersal and seedling survival, and (c) plant seedlings from trees known to have some level of blister rust resistance."*

*"2. **Conserve genetic diversity.** The full genetic diversity across the range of whitebark pine must be preserved for the future by collecting and archiving seeds and growing and planting genetically diverse seedlings. During the process of selecting rust-resistant lineages for growing seedlings and planting, we must be careful not to lose the broad genetic diversity inherent in the species. Other critical activities include archiving pollen; developing seed orchards to produce blister rust-resistant seeds; and establishing clone banks to*

archive the selections possessing desirable characteristics of blister rust resistance, cold hardiness, and mountain pine beetle tolerance.”

“3. ***Save seed sources.*** *Mature, seed-producing, putatively rust-resistant whitebark pine trees in regions that are experiencing rapid decline must be protected from other native or exotic disturbances so that the apparent rust-resistant seeds can be harvested in the future. These disturbances include bark beetles, unwanted wildland fire, and timber cutting. Identification and prioritization of areas that contain rust-resistant and genetically diverse trees can be accomplished with comprehensive genetics profiles using data generated from regional genetics programs and collaborative partnerships with research.”*

“4. ***Employ restoration treatments.*** *Areas where whitebark pine forests are declining due to insects, disease, or advanced succession should be considered for restoration treatments to create sustainable whitebark pine populations. Proactive restoration includes managing to limit the spread of blister rust; using fire in successional advanced communities to encourage whitebark pine regeneration; implementing silvicultural cuttings to reduce competing vegetation to increase the vigor of surviving trees and reduce the likelihood of mountain pine beetle attacks; planting rust-resistant seedlings to accelerate the effects of selection; and promoting natural regeneration and diverse age class structures to maintain ecosystem function and reduce landscape level beetle hazard, and to provide large populations for selection for rust resistance.”*

In my professional opinion, developing a coal mine that would eliminate tens of thousands of individual whitebark pine trees would seem to be at odds with Strategy 3 (conserving genetic diversity) and with guidance to protect known high value trees that are both cone-bearing and blister rust resistant.

<u>Whitebark and Limber Pine Dependent Species—Clark’s Nutcracker</u>

At pdf pages 205, 206 and 208, of CIAR 69, Fifth Addendum, Supplemental Information Request Responses #1, Benga states:

“The Clark’s nutcracker has been described as a ‘keystone’ species because of the pivotal role it plays in seed dispersal and forest regeneration for a number of conifer species (Schaming 2015). The whitebark pine, also a keystone species, is an obligate mutualist that germinates almost exclusively from Clark’s nutcracker seed caches (Tomback 1978, Tomback 1982, Lorenz and Sullivan 2009, Keane et al. 2012, Schaming 2015).”

. . .

“The principal concern with respect to the impact of the Project on the Clark’s nutcracker is the predicted loss of habitats containing whitebark pine and limber pine, two important food sources for this species. The Project will disturb approximately 208.4 ha of whitebark pine and open grassland areas containing a sparse whitebark pine canopy, for an estimated total of approximately 21,000 whitebark pine trees and less than 1,000 limber pine trees (CR #8,).”

. . .

“While successful planting of whitebark pine and limber pine on reclaimed sites would mitigate habitat losses for Clark’s nutcracker, benefits to the species would be delayed many years into the future. McCaughey and Tomback (2001, cited in Alberta Whitebark and Limber Pine Recovery Team 2014a) report that cone production in whitebark pines does not begin before 25 to 30 years of age and that sizeable cone crops do not appear until 60 to 80 years of age.”

“Accordingly, effective mitigation for the Clark’s nutcracker is not expected to occur until 60 to 80 years after planting. If Benga’s reclamation team is successful in salvaging seeds from disease resistant trees within the mine area, there is also potential for augmenting the province’s seed bank and contributing to the recovery of whitebark pine and limber pine in the region, which could in turn benefit the Clark’s nutcracker over the long term.”

<u>Whitebark Pine Reclamation</u>

On pdf page 132 of CIAR 251, Tenth Addendum, Package 2, Vegetation and Reclamation, Benga states:

“The main elements of the research component of the program include:
- *soil management practices that encourage natural recovery and ecological function;*
- *the establishment of local native plant species;*
- *re-establishment of a commercially productive and ecologically appropriate forest cover including whitebark pine and limber pine; and*
- *achievement of biodiversity objectives to promote biodiversity, such as:*
  - *landform design including rough soil placement and irregular contour development; and*
  - *revegetation practices such as natural recovery, nurse crop establishment, direct soil replacement”*

It is clear from these statements that research is needed in order to potentially be successful in reclaiming habitats that will support whitebark pine and limber pine. This is not something that Benga knows how to do with any great assurance.

Figure 8 shows the significant difference between the topographies that exist today (pre-mine) and those that will exist at mine closure (post-mine). Benga confirms this at pdf page 141 and 142 of CIAR 69, the Fifth Addendum, Supplemental Information Request Responses #1:

“The natural variability and complexity of the existing terrain within the Project will not be duplicated by creation of re-contoured landscapes. The reclaimed landscape will be more homogenous than current conditions.”

. . .

“After mining and reclamation of Project infrastructure there will be a permanent loss of organic landforms and the extreme slopes in the upland terrain will be reduced to a maximum slope angle of 23°.”

On pdf page 147, CIAR 42, Tenth Addendum, Package 2, Vegetation and Reclamation, Table F.4.1-1 provides a comparison of slope classes and shows a significant reduction of slopes greater than 30% (910 ha pre-disturbance vs. 127 post reclamation). The loss of habitat features such as steeper slopes that currently support whitebark pine will be a challenge for long-term restoration of whitebark pine and other species of conservation concern in the more homogeneous post-mine topography.

<u>Conclusion</u>

The destruction of potential critical habitat for whitebark pine and the time frame involved to achieve a self-sustaining population presents a vexing problem for the northern portion of the mine site, including the rock disposal area. There are optimistic assumptions in Benga’s assessment, especially related to restoration of whitebark pine in the landscape. On pdf pages 8 to 10 of CIAR 251, Tenth Addendum, Package 2, Vegetation and Reclamation, Benga provides examples of successful initial work on whitebark restoration in British Columbia and Montana, including mines. While some of these early trials are promising, they do not yet represent successful re-establishment of biodiverse whitebark pine communities as defined in ECCC (2017b). As noted previously, ECCC (2017b) sounds a suitable cautionary note with respect to protection of critical habitat.

> "*human-related activities associated with lower-impact threats can (cumulatively, and/or individually) degrade the species' resilience to primary threats, if left unchecked. In other words, if these activities continue without consideration for Whitebark Pine, the likelihood and feasibility of the species' survival and recovery will be reduced.*"

Moody and Clason (2013) state:

> *"Industrial development in whitebark pine habitats is a cause for concern due to the potential for increased damage or mortality to a species with rising mortality rates from white pine blister rust and mountain pine beetle. Even when an industrial development has the potential for minimal impact, the cumulative effects of the development along with the above mortality agents must be considered. However, given the right industrial partner, there is potential to develop a long-term restoration strategy designed to reduce the impacts of industry, while also enhancing local whitebark pine populations outside of the development area. These potential collaborations between whitebark pine restoration ecologists and industry should be a source of cautious optimism in light of industrial development in whitebark pine habitats."*

While there is potential for cooperative work with the mining industry on whitebark pine recovery, it must include ways of protecting existing significant populations of whitebark pine, especially in areas where potential critical habitat has been mapped.

Lastly, some areas mapped as a1 Limber Pine/Juniper may at least partly fall into a whitebark pine vegetation type (pdf page 268, CIAR 42, Consultant Report 8, Vegetation). Either way it is mapped, the Limber Pine/Juniper type would be of significance due to presence of limber pine or whitebark pine.

For the reasons outlined in this section (destruction of thousands of trees within potential critical habitat for whitebark pine and extended recovery time over many decades), I recommend that the Grassy Mountain coal project not be approved in its current configuration.

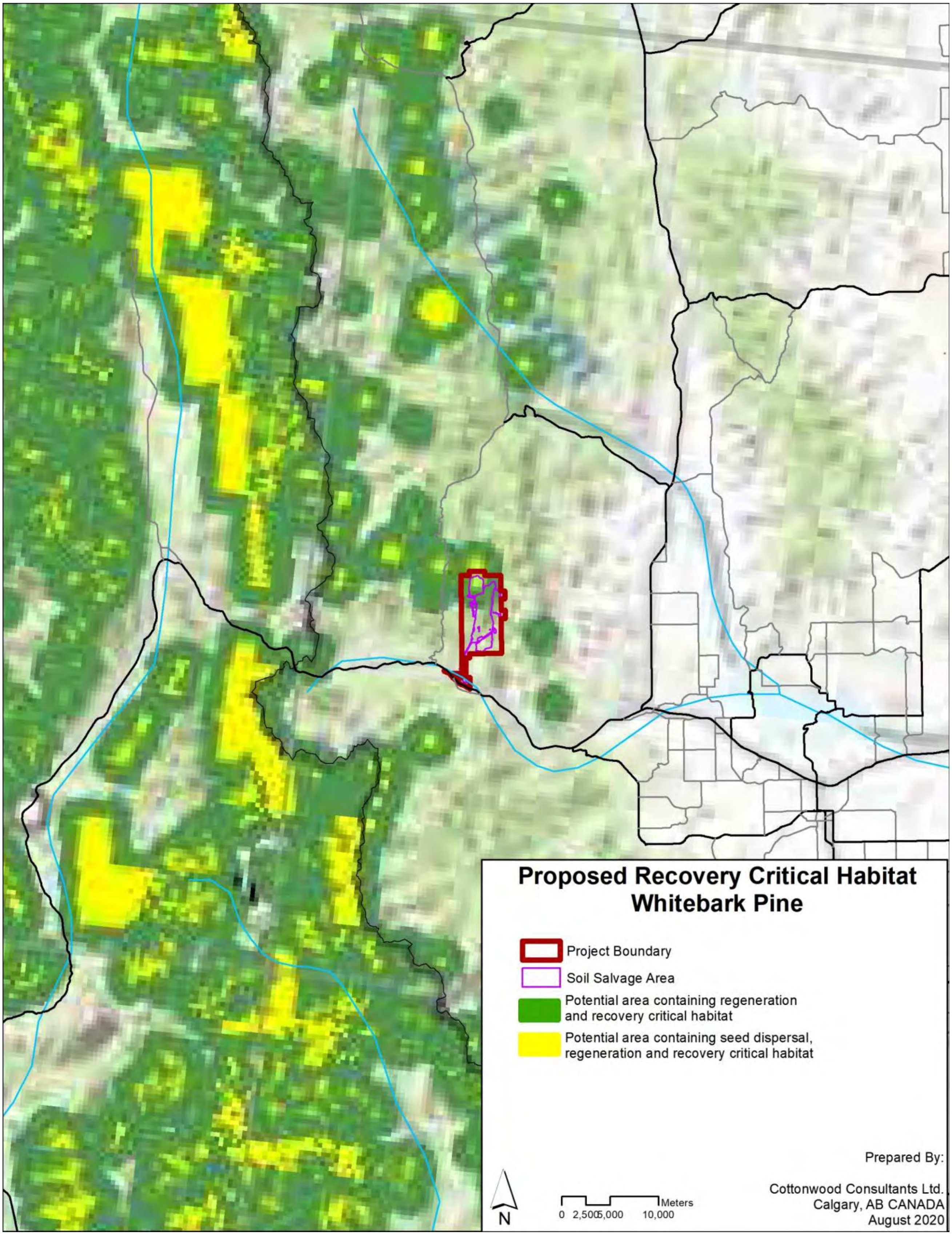


Figure 6. Potential area containing critical habitat for Whitebark Pine is represented by the yellow shaded polygons (units) comprising the known range, and the green shaded polygons (units) comprising the 2 km regeneration and recovery zone, where the criteria and methodology set out in Section 7.1 of Environment and Climate Change Canada (2017b) are met. Note overlap with northern part of proposed soil salvage area in the Grassy Mountain coal project.

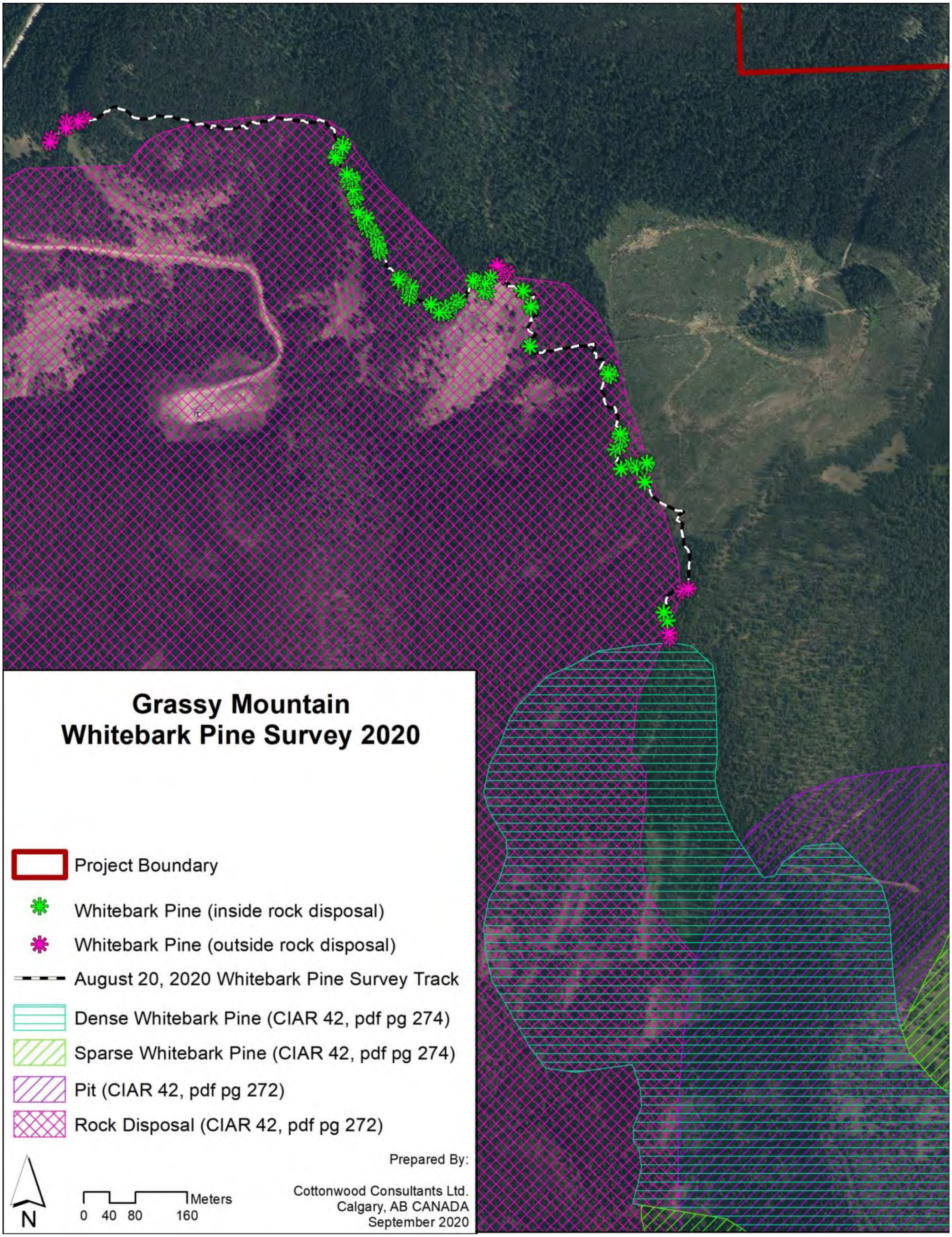


Figure 7. Detail of dense whitebark pine area and rock disposal area at north end of Grassy Mountain Coal Project. August 2020 survey track extends north from known occurrence of dense whitebark pine around the edge of the proposed rock disposal area. 107 individual whitebark pine trees were located along this 1173 m track, 87 of which were within the rock disposal area.

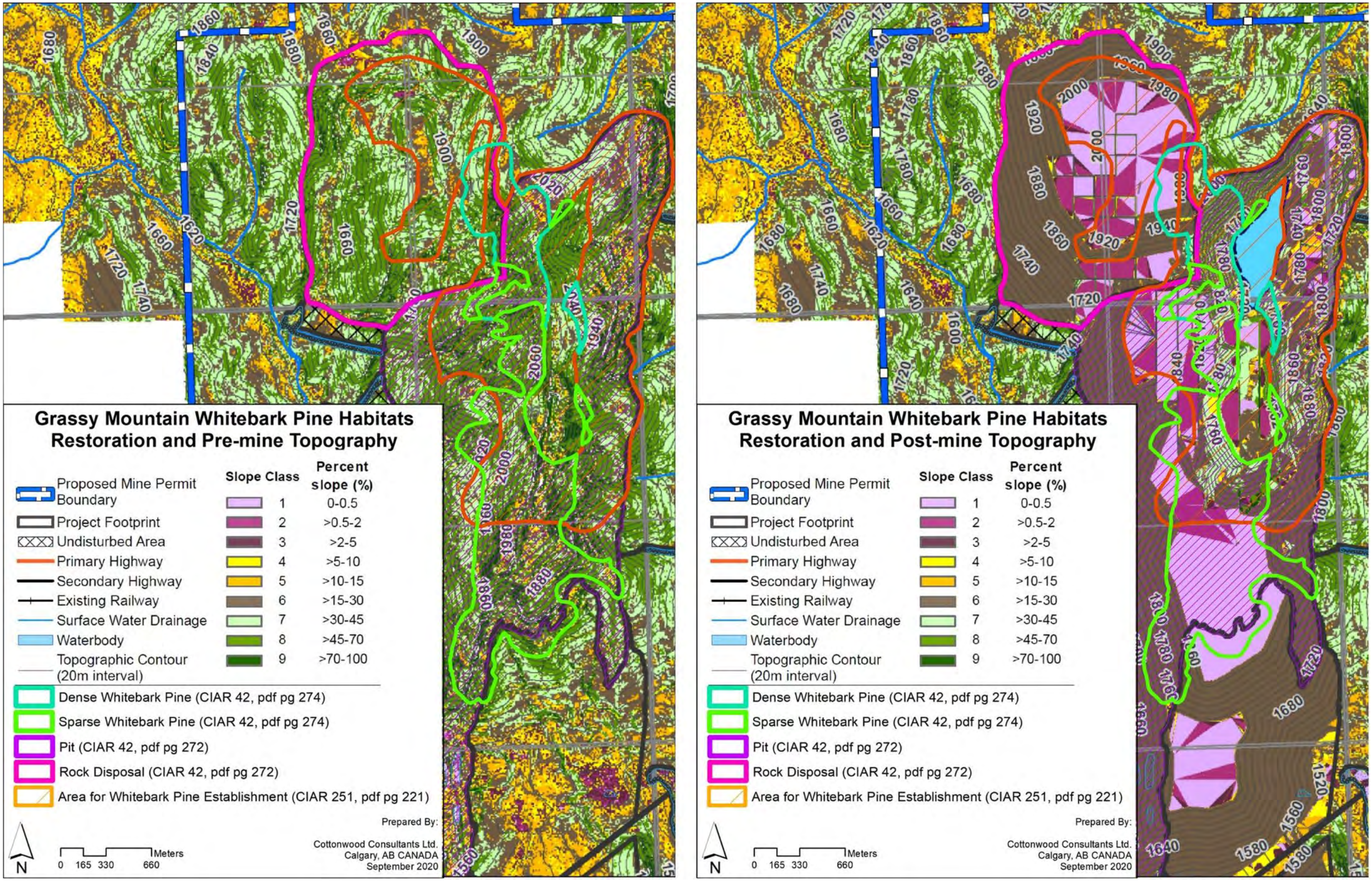


Figure 8. Pre-mine and post-mine topography in whitebark pine habitats (base maps and slope class legend from CIAR 251, Tenth Addendum, Package 2, Vegetation and Reclamation, pdf page 228; whitebark pine establishment area from CIAR 251, Tenth Addendum, Package 2, Vegetation and Reclamation, pdf page 221). The rock disposal area contains additional whitebark pine that was not mapped in CIAR 42. Note the significant flattening of slope in all mine disturbance types and waterbody in what is now dense whitebark pine habitat.

3.3.2 Little Brown Myotis

While Environment Canada (2015) does not consider mining a significant threat for Little Brown Myotis, there are site specific concerns that need to be addressed:

- *"Develop, implement, and promote beneficial management practices for the conservation of these species, their prey, and their habitat (e.g., related to nuisance wildlife control, wind energy, mining, forestry, agriculture, and gate design).*
- *Consider the species' requirements in management plans and policies for public lands, environmental assessments, and land-use (energy, forestry, mining, agriculture, etc.) planning initiatives.*
- *Support enforcement of existing acts and regulations pertaining to threats facing these species and their habitat, and encourage additional conservation where necessary.*
- *Where deemed necessary, increase compliance promotion and enforcement activities at sites particularly vulnerable to disturbance."*

There is no mention of the Atrum Elan South coal project in CIAR44 so the cumulative effects assessment is incomplete for Little Brown Myotis (Figure 11).

In CIAR 44, First Addendum, Wildlife Addendum, Little Brown Bat, pdf pages 24 and 25, discusses cumulative effects of potential new mining operations on Little Brown Myotis but does not discuss the Elan South project:

> *"Very little high or moderate-quality little brown myotis roosting habitat will be affected by the planned developments in the WRSA"*
> *. . .*
> *"Should Teck Coal Limited's planned mining operations (Elkview Baldy Ridge Extension and Michel Creek Coking Coal Project) disturb active hibernacula or maternity roosts, mortality of little brown myotis in the region may increase."*
> *. . .*
> *"The effects are predicted to not be significant at the regional level. The confidence level associated with these predictions is moderate and the probability of occurrence is moderate."*

The statement that very little high or moderate quality roosting habitat will be affected is misleading. Figure 10 shows that some of the few (and more extensive) areas of high or moderate suitability habitat in the area west of the Livingstone Range are within the project boundary, a significant portion of which lies within the soil salvage area. As noted in CIAR 44, First Addendum, Wildlife Addendum, Little Brown Bat, pdf page 37, there is a lack of high and moderate suitability habitat for Little Brown Myotis in the immediately surrounding region. As such, and in the absence of any data to the contrary in the assessment, it must be assumed that Little Brown Myotis must also be roosting in some project areas of mapped low or moderate habitat suitability given the significant use at bat survey stations A7 and A10.

In the soil salvage area, there are habitat complexes containing more mature forest immediately along some of the small drainages which have pools of slow-flowing open water that may be suitable foraging habitat for Little Brown Myotis. Even within areas mapped as moderate and low for Little Brown Myotis Habitat Suitability, e.g. around bat survey stations A7 and A10, there are significant numbers of bat passes for the Little Brown Myotis/Long-legged Myotis group (CIAR 44, First Addendum, Wildlife Addendum, Little Brown Bat, pdf pages 11, 13, 33. and 34).

Until further information was requested as part of this assessment process, there was little initial bat sampling in most of the soil salvage area. Only 3 of the 5 original survey sites (A7, A10, A12) were in the soil salvage area (Figure 9). Subsequent surveys done in the northern half of the study area to determine swarming showed more significant bat usage than would be inferred from Station A1 which is outside the soil salvage area and, unlike bat survey sites R1-7, R5a-3 and R5a-5, is not representative of the diversity of the pockets of mature habitats and streamside habitats in the Subalpine in the northern part of the soil salvage area.

Bat Survey Sites R1-7, R5a-3 and R5a-5 showed significant bat passes by Little Brown Myotis (CIAR 70, Sixth Addendum, Response Package for Additional Information, pdf pages 327-329 and 333-338). It is difficult to make an accurate assessment of cumulative effects on Little Brown Myotis and supporting habitats without sufficient data. Significant numbers of Little Brown Myotis have also been detected in areas classified as Nil or Low Habitat Suitability such as around Bat Survey Site M1. There are issues of seasonal use at different elevations and habitat types that may not have been fully captured in the original assessment and upon which the cumulative assessment is based. That, combined with the lack of attention to the Atrum Elan South coal project, makes any conjecture about the cumulative effects on Little Brown Myotis problematical.

As Benga notes in CIAR 70, Sixth Addendum, Response Package for Additional Information, on pdf page 287:

> *"The federal conservation objective for M. lucifugus in areas where white-nose syndrome does not yet occur is to maintain current population levels (Environment Canada 2015)."*

In my professional opinion, it is difficult to reconcile the approval of the Grassy Mountain coal project with this conservation objective when significant Little Brown Myotis use has been recorded in parts of the project area. The project would effectively remove a variety of productive habitats for Little Brown Myotis for decades or longer. Alone, this may not be sufficient reason to deny the project but it adds weight to other valued components of this project that emphasize the project area's environmental significance.

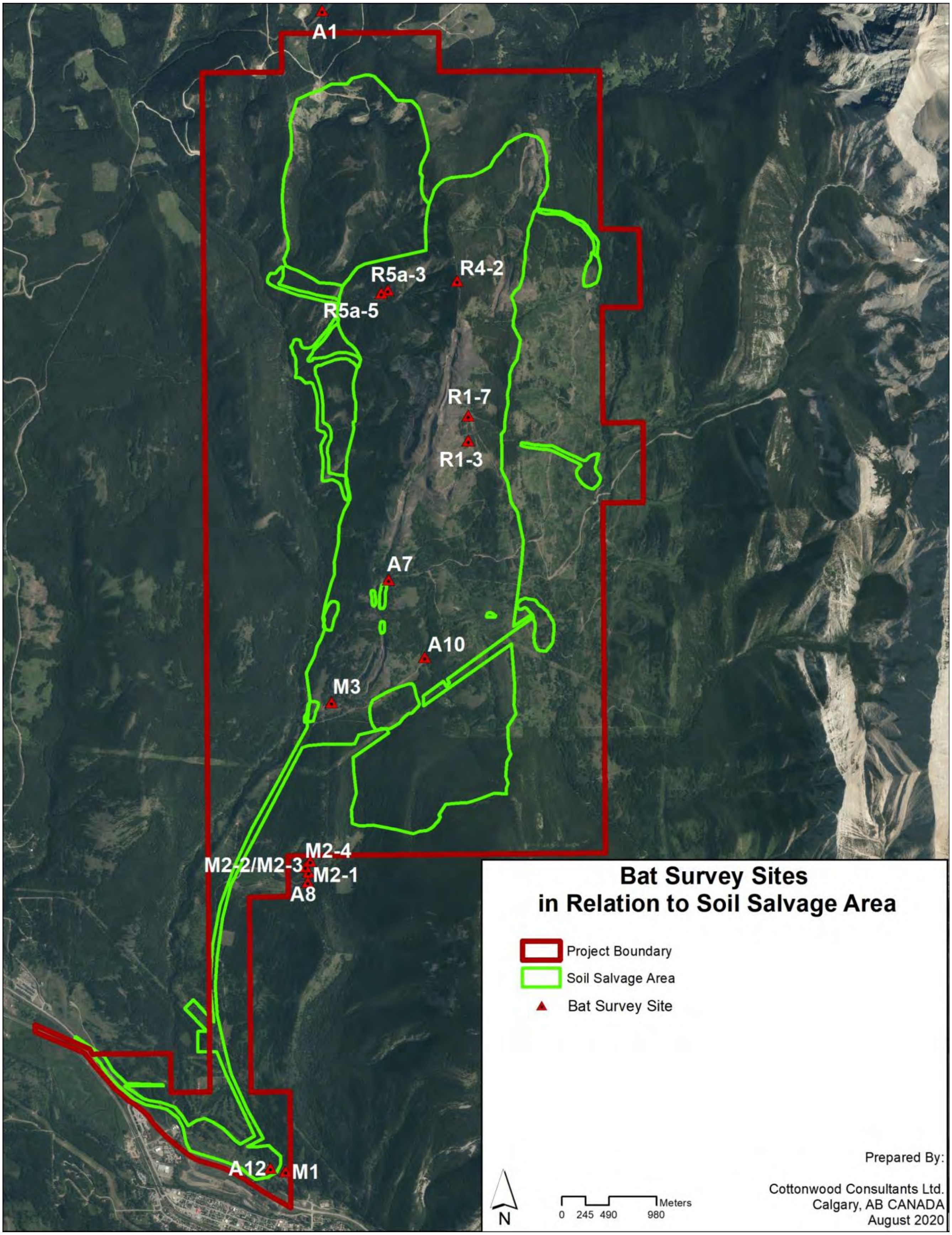


Figure 9. Distribution of bat survey sites relative to soil salvage area. Data from sites A1, A7, A8 and A12 were incorporated into the cumulative effects' assessment but M and R sites were not.

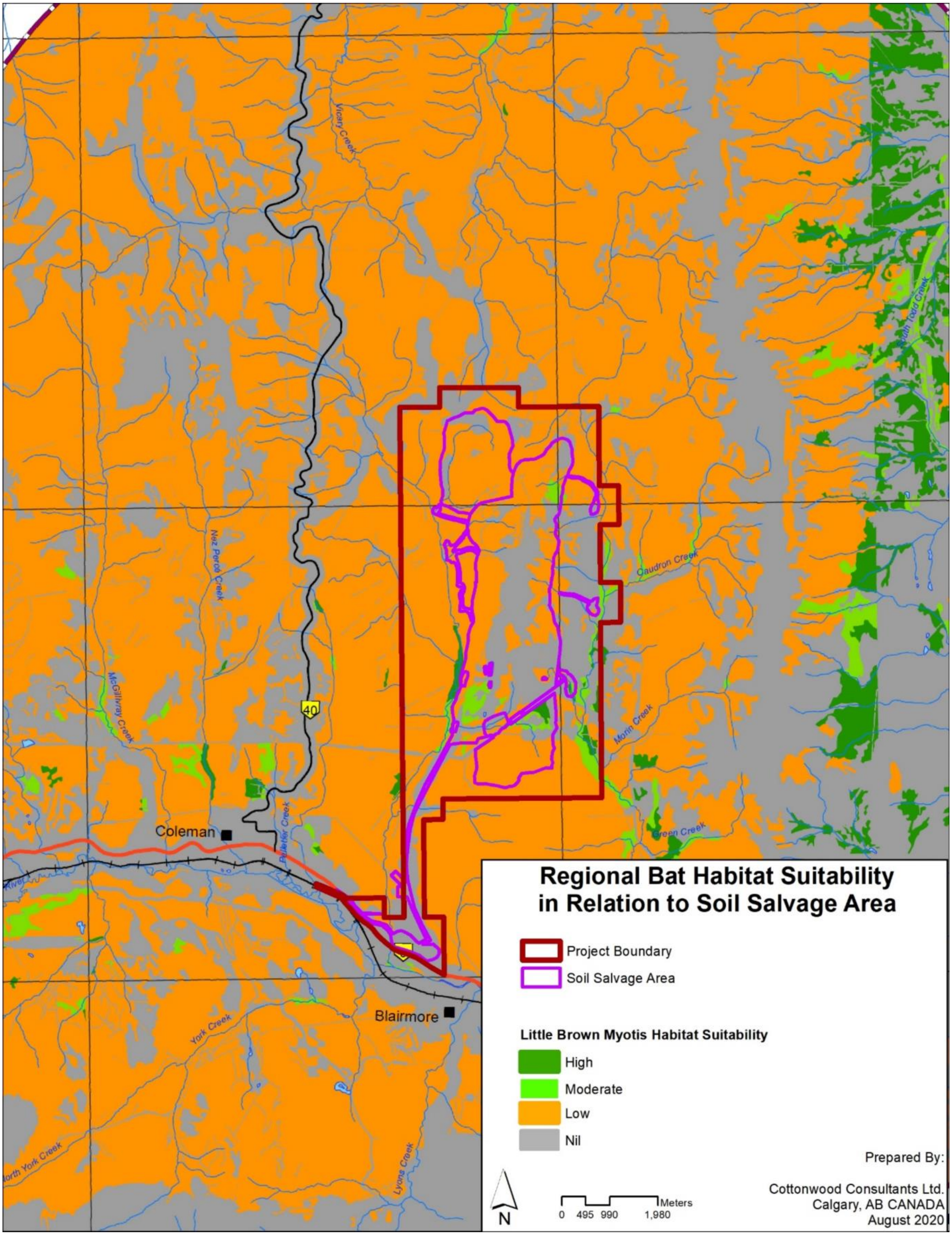


Figure 10. Some of the handful of areas of high or moderate suitability Little Brown Myotis habitat lying in the area west of the Livingstone Range occurs in the project boundary. Significant numbers of Little Brown Myotis have also been detected in areas classified as Nil or Low Habitat Suitability. Base map from CIAR 44, First Addendum, Wildlife Addendum, Little Brown Bat, pdf page 37.

3.4 Cumulative Effects

In an information request in CIAR 55, Attachment 2 at pdf page 123, the requirements of cumulative effects assessment are summarized:

> *"CEAA 2012 requires that any cumulative environmental effects that are likely to result from the designated project in combination with other physical activities that have been or will be carried out, be taken into account in the environmental assessment. The Guidelines require an analysis of the total cumulative effect on a VC over the life of the Project, including the incremental contribution of all current and proposed physical activities, in addition to that of the Project. The Agency's guidance on "Addressing Cumulative Environmental Effects under CEAA 2012" sets out the general requirements and approaches to consider cumulative environmental effects of designated projects and provides methodological options and considerations to support the implementation of CEAA 2012."*
>
> *"While existing conditions have been shaped by effects of past projects and activities, using only the current state of a VC in combination with future effects to fulfill the requirement of a cumulative effects assessment may not always provide a full understanding of the cumulative effects of successive projects from the past, present and future. If each successive project in an area uses a baseline into which past effects have been incorporated, the baseline is continually shifted and significant effects to VCs could be overlooked because of the absence of consideration of the effects of prior projects."*
>
> *"A cumulative effects assessment that fulfills the requirements of CEAA 2012 and the Guidelines would need to provide a clear understanding of the following:*
> - *how each VC was identified and the rationale for its selection,*
> - *the spatial and temporal boundaries for the assessment,*
> - *the sources of potential cumulative effects,*
> - *whether each VC has been affected by past projects and activities,*
> - *whether each VC will be affected by future projects and activities,*
> - *the measures that are technically and economically feasible to mitigate the potential cumulative effects,*
> - *the significance of any cumulative effects, including the VC-specific thresholds used for determination of significance, and*
> - *a follow-up program to verify the accuracy of the environmental assessment and the effectiveness of the mitigation measures (as required) for cumulative effects."*

When species or VC (valued components) are considered individually, it is easy to fall into the trap of ignoring the collection of environmentally significant features of the Grassy Mountain project area. There are multiple VCs, including species at risk, facing multiple threats, including disease, loss of habitat and climate change effects. In my professional opinion, an area of environmental significance that supports multiple species at risk is not a place to approve the destruction of tens of thousands of individuals (in the case of whitebark pine) or supporting habitat for multiple species of conservation concern, including federally listed species at risk. It could take decades, if not longer, to recover this habitat functionality even if techniques are perfected to restore such habitats. For some habitats and species, like rough fescue grassland and whitebark pine, the techniques to re-establish biodiverse communities are unproven and, for rough fescue grassland, attempts at restoration have been met with multiple failures. Benga acknowledges the negative, regional, and long term nature (extended) of the impacts (change in habitat availability and change in abundance) on pdf pages 507 and 508 of CIAR 70, Sixth

Addendum, Response Package for Additional Information, for the valued components (VCs) Little Brown Myotis, American Marten and Canada Lynx.

Projects like Grassy Mountain that are proposed in Environmentally Significant Areas where there are several species of conservation concern, including those listed as "at risk" federally, will only add to the overall decline of such species. Cumulative effects assessment must consider what is happening to an environmentally significant landscape and all its components rather than looking only at a few species' (VCs) statistics individually as has been done in the case of Grassy Mountain. The problem is compounded when professional judgement is applied and proposed mitigation assumed to be successful. Temporal effects for many VCs may be prolonged and, as a result, significant to the VCs.

3.4.1 Atrum Coal

The inclusion of all projects, including those in the planning stages, must also be part of the cumulative effects' assessment. **Nowhere in the responses on cumulative effects in CIAR 251 or in the summary of cumulative effects related to biodiversity in Appendix A-2, CIAR 70, Sixth Addendum, Response Package for Additional Information, or Appendix A-1 of CIAR 89, Eighth Addendum, Provincial and Federal Requests for Additional Information, is the Atrum Elan South coal project included in any cumulative effects evaluation.** Benga states at pdf page 375 of CIAR 89:

> *"Project is in the preliminary exploration phase. It has not been added in quantitatively as the project has not been defined or officially announced by the proponent[1]."*
>
> The footnote explains: "1 = *presented in this table to reflect the August 17, 2018 table update; however, these projects were not included in the cumulative effects assessment as they are either cancelled, undefined, or no definitive plans or information are available regarding approval date(s) and/or whether or when the activity or project will occur*."

Atrum Coal is actively evaluating the potential for a hard coking coal project immediately to the north of Grassy Mountain. In a 2018 news release, Atrum Coal (2018) states:

> *"Elan Coal has a total of 22,951 hectares (approximately 230km2) of prospective tenements located in a region with well established producing and near-term developing hard coking coal mines. The Elan South is one of the several potentially large hard coking coal projects within Elan Coal."*
>
> *"Elan South is approximately 13km north of Coleman, Alberta, and close to critical infrastructure (Figure 1 to 3). Elan South is the southernmost project within the Elan Coal assets and is immediately north of Riversdale Resources' Grassy Mountain hard coking coal project."*
>
> *"Elan South cover approximately 6,140 hectares, a land size similar to the Grassy Mountain project."*

From Atrum's website (Atrum Coal 2020):

> *"Atrum's flagship asset is the 100%-owned Elan Hard Coking Coal Project which is located in the Crowsnest Pass area of southern Alberta, Canada. Elan hosts large-scale, shallow, thick, Tier 1 hard coking coal (HCC) deposits of the Mist Mountain Formation.*

"Following significant exploration and field work programs in 2018 and 2019, Elan possesses a current JORC Resource estimate of 454 Mt (142 Mt Indicated and 312 Mt Inferred). Comprehensive quality testing, combined with review of substantial historical testwork data for the broader Elan Project, has confirmed Tier 1 HCC quality (Coke Strength after Reaction ranging from 69 – 71)."

"The Crowsnest Pass is a well-established mining province. The Elan South Project area is located 13km from an existing Canadian Pacific rail line with significant excess capacity, providing direct rail access to export terminals in Vancouver and Prince Rupert. Elan South shares its southern boundary with Riversdale Resources' Grassy Mountain Project, which is in the final permitting stage for a 4.5 Mtpa open-cut HCC operation."

"Around 30 km to the west of the Elan Project, Teck Resources Ltd operates five mines (the Elk Valley complex) producing approximately 25 Mtpa of Tier 1 HCC for the seaborne market. The coal seams at Elan correspond to those horizons of the same Mist Mountain Formation found in the Elk Valley HCC mines, and have similar rank ranges."

"A Scoping Study to evaluate development of the Elan Project, incorporating mining of both the Isolation South and Elan South areas, was completed in April 2020."

North of the Elan South prospect, Atrum indicates coal resources in the Isolation, Isolation South, and Savanna areas (Figure 11). Elan Coal continues to be active in those other areas. After an exploratory drilling program in the Isolation South area (Atrum Coal 2019), on May 27, June 1, July 23 and August 19, 2020, the Alberta Energy Regulator approved four new temporary field authorizations for Elan's Isolation and Isolation South areas in Townships 11, 12 and 13 – Ranges 3 and 4, West of the 5th Meridian (AER 2020a, b, c and d).

Alberta Energy (2020) states:

"Elan indicates that approved drilling exploration activities will continue through 2024 in order to assess the location and quality of metallurgical coal in the three properties. Elan also received a number of other approvals from the AER for coal exploration and drilling as well as for environmental work related to baseline monitoring."

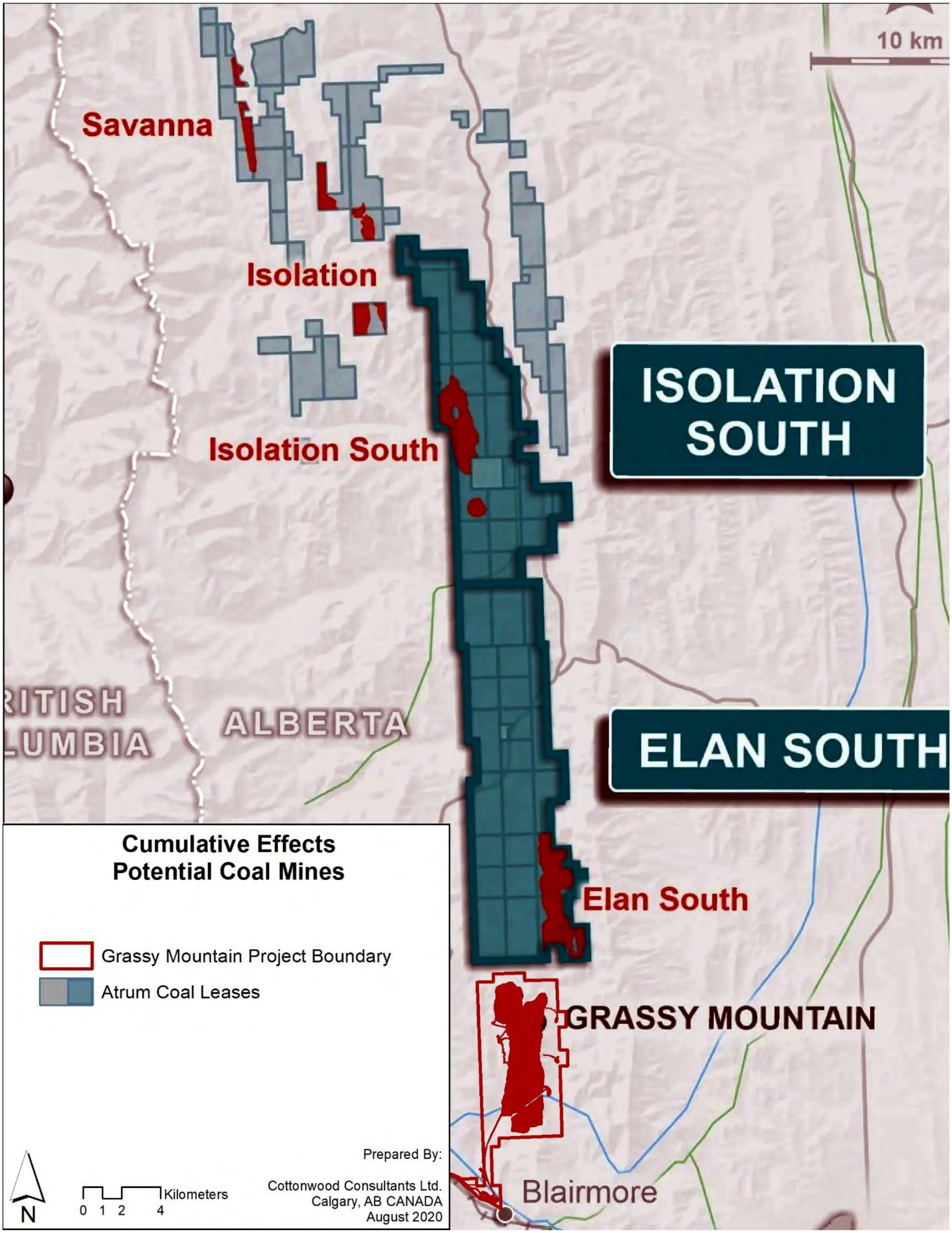


Figure 11. Potential coal mine locations being investigated or owned by Atrum Coal(Atrum Coal 2020). Active planning or exploration programs are being undertaken at Isolation South and Elan South.

3.4.2 Summaries of Effects

<u>Wildlife</u>

The significance of the effects of the project on all of the wildlife components described in CIAR 70, Sixth Addendum, Response Package for Additional Information, on pdf pages 539 to 544 and CIAR 89, Eighth Addendum, Provincial and Federal Requests for Additional Information, is universally described as “not significant”. This ranking is postulated despite reduced abundance being characterized in many cases as negative, **<u>regional in extent, of long-term duration and with long-term reversibility</u>**.

Currie et al. (2020) state:

> *“The “shifting baseline syndrome” coined by Daniel Pauly notes that the baseline by which we judge and determine population trends affects our perception of the state of ecosystems. We perceive a loss relative to the standard that we set, and consequently lose the knowledge of a less disturbed historical state — meaning that we’re adjusting baselines to new levels dependent upon the current state of wildlife, but are unable to recall how our ecosystems flourished historically.”*
>
> *“In the C-LPI, we use a benchmark year of 1970 as the basis of our analysis of trends in wildlife populations. This is largely due to limited data availability before that date. In interpreting the results of the C-LPI, the timeframe of 1970 to 2016 represents a comparatively small and recent analysis of the trends in Canada’s wildlife populations. For some of the species included in the C-LPI, the baseline year of 1970 may capture a period of especially low population numbers — an increase from 1970, then, doesn’t necessarily mean the population has reached its historical level. For instance, swift foxes were declared extirpated (locally extinct) in Canada in the 1970s, but through dedicated captive breeding and reintroduction programs the swift fox population had grown to 647 by 2009. Yet, despite an increase in abundance since 1970, the species is still considered Threatened due to its small population size and highly restricted distribution. The use of 1970 as a baseline year, then, may not fully represent the complete picture of wildlife trends in Canada. The consideration of historical trends (i.e., a baseline prior to 1970) is likely to reflect a greater loss of wildlife in Canada — consistent with the growing evidence that biodiversity, globally, is declining faster than at any other time in human history.”*
>
> *“The Canadian Living Planet Index (C-LPI) for nationally assessed at-risk species in Canada shows that* ***populations have declined, on average, by 59 per cent between 1970 and 2016*** (my emphasis) *(from 1.0 in 1970 to 0.41 in 2016; Figure 3a). The index includes 629 populations of 139 COSEWIC-assessed at-risk vertebrate species — representing just over half of at-risk vertebrate species in Canada. Results suggest that the decline is consistent across species groups (birds, fish, mammals, and amphibians and reptiles) . . . The average trend includes species that are both increasing (30 per cent) and decreasing (68 per cent) in abundance . . . The index is reflective of species currently assessed as at risk and does not include species that have improved in population size to the point where they are no longer considered at risk (<15 species in the dataset) or those that have gone extinct.”*

<u>Land Capability</u>

Effects on land capability are described in CIAR 89, Eighth Addendum, Provincial and Federal Requests for Additional Information, on pdf page 532 as neutral, moderate in magnitude,

regional in extent, extended in duration and **irreversible**. (my emphasis) The significance is stated as “not significant”.

Soil

Effects for soil biodiversity and ecological integrity are described in CIAR 89, Eighth Addendum, Provincial and Federal Requests for Additional Information, on pdf page 532 as negative, low in magnitude, regional in extent, **extended in duration** and with **partial long-term reversibility**. (my emphasis) The significance is stated as “not significant”.

On pdf page 67, 92 and 103 of CIAR 42, Consultant Report 7, Terrain and Soils, Benga states:

- *“forest litter (LFH), A and B horizons would be **salvaged in one lift and blended** (my emphasis) to be used as a reclamation material;*
- *no unsuitable overburden material will be incorporated in the root zone of the reclaimed profile;*
- ***reclaimed textures would become less sandy** (my emphasis) and more loam-like (Knapik and Rosentreter, 1999);*
- ***reclaimed soils would become more aggregated and become less friable** (my emphasis) (Knapik and Rosentreter, 1999);*
- *soil drainage on reclaimed sites would be well to moderately well; and*
- *a suitable growing medium (upland surface soil) at **average thickness of 20 cm would be applied on all reclaimed areas**. (my emphasis)”*

> *“Soil salvage, handling, storage (long term and short term stockpiles) and replacement may impact soil quality. Soil material salvaged from disturbance areas may be chemically and physically impacted through the removal, handling and storage, and replacement during reclamation. Potential physical and /or chemical alterations may impact the quality of the soil resource. This removal and subsequent replacement of the soil resource may initially reduce soil quality of the reclaimed soil profiles. As reclaimed soil profiles develop, **a similar level of capability to pre-disturbance conditions will be achieved over an extended period of time (e.g., decades)**. (my emphasis)”*

> *“The natural variability associated with the soil and landscape patterns will be removed at the time of soil salvage and handling. Reclaimed soil - landscape patterns will be more homogenous than baseline conditions because **reconstruction of the inherent variability associated with natural soil profiles is not possible**. (my emphasis)”*

Terrain

Effects for alteration of terrain are described in CIAR 89, Eighth Addendum, Provincial and Federal Requests for Additional Information, on pdf page 532 as neutral, moderate in magnitude, regional in extent, **residual in duration and irreversible**. (my emphasis) The significance is stated as “not significant”.

Terrestrial Vegetation

Effects on old growth forests are described in CIAR 89, Eighth Addendum, Provincial and Federal Requests for Additional Information, on pdf page 582 as positive, low in magnitude, local in extent, extended in duration and with long-term reversibility. The significance is stated as “not significant”.

Effects on vegetation species and community biodiversity are described in CIAR 89, Eighth Addendum, Provincial and Federal Requests for Additional Information, on pdf page 583 as positive, moderate to high in magnitude, local in extent, extended in duration and long-term reversibility. The significance is stated as “not significant”.

Effects on terrestrial vegetation are described in CIAR 89, Eighth Addendum, Provincial and Federal Requests for Additional Information, on pdf page 582 as neutral, high in magnitude, local in extent, **extended in duration** and with **long-term reversibility**. (my emphasis) The significance is stated as “not significant”.

On pdf page 156 of CIAR 69, Fifth Addendum, Supplemental Information Request Responses #1, Benga notes: “*Residual effects are assessed after reclamation*.” The approach to residual effects described by Benga incorporates a very long time frame for potential restoration of rough fescue grassland and whitebark pine. For these VCs, restoration as part of the Grassy Mountain project is an experiment with assurances given through well-defined process but probable outcomes are not yet supported in peer-reviewed literature.

Benga has its own doubts for successful restoration of foothills rough fescue grasslands on pdf pages 108 and 110 of CIAR 69**:**

> *“Benga acknowledges that restoration of foothills rough fescue inhabited lands is relatively unproven . . .”*

On pdf page 73 of CIAR 251, Tenth Addendum, Package 2, Vegetation and Reclamation, Benga indicates a reduction of biodiversity which may persist for some time:

> *“The ecosite phases impacted by Project development have mostly moderate to high biodiversity potential. After mine closure and reclamation, native species richness is expected to be lower than the intact naturally developed vegetation . . .”*

Rare Plants, including Limber Pine and Whitebark Pine

Effects on rare plants are described in CIAR 70, Sixth Addendum, Response Package for Additional Information, on pdf pages 535 and 536 as negative (removal of rare plants) to neutral or positive (whitebark pine), high in magnitude, local in extent, extended in duration and with long-term reversibility. The significance is stated as “not significant”. With respect to limber pine and whitebark pine (WBP), on pdf pages 159 to 161 of CIAR 42, Consultant Report 8, Vegetation, Benga states:

> *“Project effects on whitebark and limber pine is regional in extent due to the requirement for preservation of genetic diversity and potential disease resistant seed.”*
> *. . .*
> *“The duration of the effects are extended. Reclaimed land will require time to develop mature forests and grasslands and for the return of the natural processes of disturbance and succession. Until natural processes of disturbance and succession return to the landscape the opportunity for rare plant community development will be limited. The variety of open niches may promote establishment of individual rare species soon after reclamation but this will diminish over time as the plant communities establish equilibrium with site conditions. Both whitebark pine and limber pine are slow maturing species and will not produce seed for several decades after establishment. Duration for these species is also extended.”*
> *. . .*

"Effects are reversible in the long term with the planned mitigation. Reclaimed terrain and soils will support establishment of native communities including grasslands and the eventual return of natural process. Though in general the post reclamation topography will be more subdued, a variety of slopes, slope aspects, and lengths will be created."

. . .

"Effects will initially be of high magnitude with clearing of vegetation and mining operations exceeding that of large natural disturbances including fire and insect infestations that are more selective and less homogeneous."

. . .

"The project will have a negative contribution for some rare plants removed during clearing and mining as there is no assurance that they will return after reclamation. The project will have a positive contribution for whitebark pine with the establishment of disease resistant trees on the reclaimed landscape and additional creation of habitat with reclamation of historical mine areas. Where reclaimed terrain may support whitebark pine and limber pine, whitebark pine will be preferentially planted as it is more imperiled than limber pine. Project effects on limber pine will be neutral with preservation of genetic diversity but limited reestablishment."

. . .

"The confidence rating is high. Although the rare species rankings (S and G ranks) for many of the species found is uncertain, the effects of the Project are well understood."

. . .

"Even without mitigation the Project is not expected to have a significant effect on rare plants other than WBP. The direct removal of WBP and loss of habitat that would occur without mitigation are not significant factors (see response SIR 129a and SIR 129b). The potential loss of genetic diversity and of disease resistant trees would be significant. For this reason, the project effects on WBP without mitigation are considered significant."

. . .

"With mitigation the project effects are not significant. The project reclamation includes establishing terrain and species that may support diverse communities and will also assist in preservation of whitebark pine and limber pine in the region."

On pdf page 164 of CIAR 69, Fifth Addendum, Supplemental Information Request Responses #1, Benga states:

"The community components most sensitive to disturbance and to reclamation are communities comprised of later successional species and species that do not tolerate competition; specifically, some understory species, whitebark pine, and fescue grassland communities. The establishment of later successional species that are typically found in the understory of forest communities will take time."

Although whitebark pine occurs on a variety of sites, Environment and Climate Change Canada. (2017b), Ogilvie (1990), Hansen-Bristow et al. (1990), McCaughey and Schmidt (1990), Arno and Weaver (1990) and Mattson and Reinhart (1990) note the importance of slope orientation and warmer microclimates; younger soils with minimal horizon development; and steep slopes with ridge crests and rugged topography for this species. While Benga states that a variety of slopes will be created in the reclaimed landscape, a significant reduction of slopes greater than 30% will actually occur (pdf page 147, CIAR 42, Tenth Addendum, Package 2, Vegetation and Reclamation).

The conclusion of Benga that the cumulative effects are neutral or positive and not significant for whitebark pine (CIAR 70, Sixth Addendum, Response Package for Additional Information, on pdf pages 535 and 536) is ludicrous on its face and not supported by the evidence. As noted previously, there is whitebark pine distribution outside the area mapped by Benga and it has not considered the impacts of the Atrum Elan South coal project, nor has it factored in ECCC's (2017b) potential critical habitat. These facts and the long-time frames for restoration of whitebark pine means that the cumulative impacts are clearly more significant than represented by Benga. These facts may also undermine Benga's postulation of the cumulative effects of the project on Grizzly Bear and Clark's Nutcracker but the whitebark pine problem is troubling in its own right.

It is astounding that Benga believes that their contribution could be positive for whitebark pine, despite the destruction of tens of thousands of apparently healthy individuals--as noted on pdf page 81 of CIAR 42, Consultant Report 8, Vegetation: *"whitebark pine and limber pine identified within the LSA appeared relatively healthy . . ."*

Limber pine similarly occupies a variety of sites but is most prevalent on rocky sites with shallow soils, ridge tops and steep terrain (Alberta Whitebark and Limber Pine Recovery Team 2014b). For limber pine, the team notes:

> *"There are a number of other potential threats to this species, which on their own are not causing decline but, in concert with the main threats outlined above, could contribute to decline and thus should be minimized wherever possible."*
> *. . .*
> *"Unlike most other species at risk in Alberta, habitat loss is not the main threat affecting limber pine. However, given the ongoing declines resulting from other threats, habitat loss or alteration may exacerbate declines and would be particularly detrimental in suitable regeneration sites where resistance to white pine blister rust may potentially emerge. Adverse effects on habitat may include any alteration of sites during or following commercial or industrial activity that could inhibit natural regeneration of seedlings."*
> *. . .*
> *"The removal of individual trees during activities such as forestry, energy exploration and extraction, mining, and recreational trail development can occur without attendant alteration of habitat. Cattle may also damage or kill young trees while grazing. Such losses can exacerbate local population decline and may remove trees that are resistant to white pine blister rust."*
> *. . .*
> *"The loss of habitat and populations of limber pine is undesirable and should be minimized."*
> *. . .*
> *"Successful recovery of limber pine will require that losses of trees are minimized. This will be especially important for mature cone-producing trees and plus trees (i.e., those with apparent rust resistance), the latter of which may be rare and may have the potential to provide the material for propagation of white pine blister rust-resistant trees. Furthermore, minimizing mortality prevents genetic erosion at the population level. This objective refers predominantly to mortality from mountain pine beetle and fire but also to incidental death of limber pine trees from commercial, industrial, and recreational activities (e.g., forestry, energy sector exploration and development, mining, recreational trail development)."*

<u>Conclusion</u>

The plant communities, topography and soils on which whitebark pine, limber pine and other rare or at risk plants thrive today will be changed dramatically (Figure 8) and there are sufficient hedge words from Benga, e.g. "**<u>may</u>** (*my emphasis*) support diverse communities" that confirm my doubts about the potential success of reclamation for the least common and most sensitive species. **When cumulative effects are described as regional and of high magnitude for extended duration, with uncertain reclamation outcomes, it is inconceivable that the residual effects are "not significant". Stating what you would like to happen and putting in place research to find ways to make it work, do not guarantee success.**

On pdf page 156 of CIAR 69, Fifth Addendum, Supplemental Information Request Responses #1, Benga notes: "*Residual effects are assessed after reclamation thus any VC that cannot be reclaimed and will not return over time will be considered residual*." Given the difficulties of reclaiming certain vegetation types in any reasonable time frame, e.g. whitebark pine and foothills fescue grassland, it is difficult to reconcile the approach to residual effects described by Benga which acknowledges a long time frame for potential restoration. For some VCs like whitebark pine and foothills fescue grassland, restoration as part of this project is an experiment with assurances given through well-defined process but probable outcomes are not yet supported in peer-reviewed literature.

Given the difficulties of reclaiming certain vegetation types in any reasonable time frame, e.g. rough fescue grassland and whitebark pine, and the acknowledgement by Benga that "after reclamation" native species richness is expected to be lower, it is improper to characterize the residual effects as "not significant". In my professional opinion, regardless of extent, anywhere that Benga has identified effects that are of high magnitude and that are extended or long-term in duration, those should be classified as significant at some level.

This approach of arriving at "not significant" effects is also not supported by the evidence given the continued declining populations of many species. If each project takes the view that there is no significance to the effects that it has on habitats and species, the declines of species and the loss of valuable, sometimes irreplaceable habitats, will continue.

3.5 Pit Dewatering and Impact on Vegetation

A proposal to construct a fish rearing facility at Many Springs in Bow Valley Provincial Park west of Calgary had detailed investigations undertaken due to concerns related to the cone of drawdown associated with pumping of water from the vicinity of an environmentally significant fen (Cottonwood 1981). Due to the shallow rooting depth of several target plant species, effects on the fen vegetation and understory in the immediately adjacent forest edge were considered to be significant if there was a drop of >50 cm in the "capillary fringe" (the subsurface layer in which groundwater seeps up from a water table by capillary action to fill pores). The report noted that, if the >50 cm drop was permanent or for a major portion of the growing season, there would be poor growth, susceptibility to disease, and poor reproduction of the target fen species. The drawdowns associated with pumping were calculated to be from 16 cm to 2.35 m in the target fen area so the project was abandoned.

Smith et al. (2009) identified an issue with drawdown of 1 to 3.6 m in groundwater level on a property adjacent Transalta's Whitewood Mine near Wabamun west of Edmonton. Wetland and some surrounding upland forest vegetation on the adjoining property suffered catastrophic damage due to impact on the overlying water table aquifer and the resulting decrease in the elevation of the water table in a fen. Figure 12 illustrates the issues where the elevation of the water table after groundwater withdrawal is below the depth of the large tree rooting zone. The closest edge of this fen was situated about 960 m from the closest dewatering well. Matrix notes:

> *"as the water table declined in the fen area, the water supply for the mature, deeper rooted trees was most likely removed."*
>
> *"the root cause of tree mortality in the affected area is considered to be the Mine dewatering program since the drainage ditches and berms would have been insufficient to cause the observed widespread tree mortality by themselves."*

With respect to pit dewatering, at pdf pages 459 and 460, of CIAR 89, Eight Addendum, Benga states:

> *"The magnitude of the effect is assessed as low (residual effect is detectable but well within environmental standards) as drawdown within the bedrock aquifers will be negligible at the LSA boundaries (i.e., drawdown of less than 5 m).*
>
> - *The geographical extent of the effect is defined as local as all of the detectable drawdown will be contained within the mine permit boundaries. Effects are not predicted to be measurable at the LSA boundaries.*
> - *The duration of the impact is determined to be residual in duration as the effects will last past the Project decommissioning.*
> - *The frequency is determined to be continuous as drawdown will be consistent through the assessment period.*
> - *The reversibility of the effect is determined as irreversible as the effects will remain after cessation of the mining activities but will be diminishing with time as new groundwater equilibrium develops away from the pit.*
> - *The social/ecological context is classified as negative as the heads within the bedrock aquifers will be decreased.*
> - *The significance of residual effects is identified as not significant. After mitigation, effects within a portion of the mine permit boundary may exceed natural variability and/or guideline or threshold levels, but these impacts will not measurably change potential use of groundwater from bedrock aquifers across most of the LSA.*

- *The confidence rating is moderate as the assessment is based on data pertinent to the study area integrated into a site specific conceptual model and used for the development of a groundwater numerical model and a good understanding of cause-effect relationships; however, some data gaps exist.*
- *The probability of occurrence is high as pit dewatering will certainly create a decrease in head (drawdown) within the bedrock aquifers."*

The above assessment is focused on groundwater availability, not on potential ecosystem impacts. Elsewhere, Benga notes on pdf page 152 of CIAR 251, Package 2, Vegetation and Reclamation, Tenth Addendum:

> *"The development of the Project is expected to change the groundwater drainage characteristics of developed sub-catchments. The natural catchments within the mine footprint tend to have zones of groundwater recharge at higher elevation near the mountain ridges. At lower elevations, mid-slope or near the valley bottom, the groundwater regime transitions to groundwater discharge zones. In groundwater recharge zones, soil and sub-soil moisture is replenished only by precipitation and overland flow. In groundwater discharge zones, soil moisture is also replenished by groundwater."*
> *. . .*
> *"At closure, the groundwater quality and quantity on the reclaimed lands is expected to be similar to the natural groundwater conditions."*

On pdf page 246 of CIAR 42, Consultant Report 3, Hydrogeology, Benga maps the maximum extent of >5 m drawdown at long-term closure (Figure 13). This limit lies beyond the disturbance limit (soil salvage area).

I can find no discussion of the impacts on adjacent natural habitats. Drawdowns of less than 5 m due to pumping of groundwater have been shown to have impacts on plant growth, especially in wetlands and associated wetland-forest edges. The only discussion of effects on vegetation and groundwater relating to areas being reclaimed is on pdf page 152 of CIAR 251, Tenth Addendum, Package 2, Vegetation and Reclamation:

> *"The reclaimed groundwater drainage characteristics will have no material effect on reclamation as the dominant pine and grassland species to be used are naturally found from crest to lower slope positions and are tolerant of low moisture conditions."*

Dewatering of the pit is necessary to the operation of the mine but the duration of the dewatering impact being classified as residual and irreversible with the heads in the bedrock aquifers being decreased identifies a significant concern that has not been addressed from a biodiversity perspective.

There is insufficient information provided in the documentation to identify specific areas of concern. Fine scale resolution at submeter accuracy of actual drawdown is needed to identify the potential impact of dewatering on wetland areas, riparian areas, and spring-dependent plant communities and associated wildlife. **The lack of attention to the ecological effects of drawdown from pit dewatering on adjacent wetland areas, riparian areas, and spring-dependent plant communities is a potentially significant omission.**

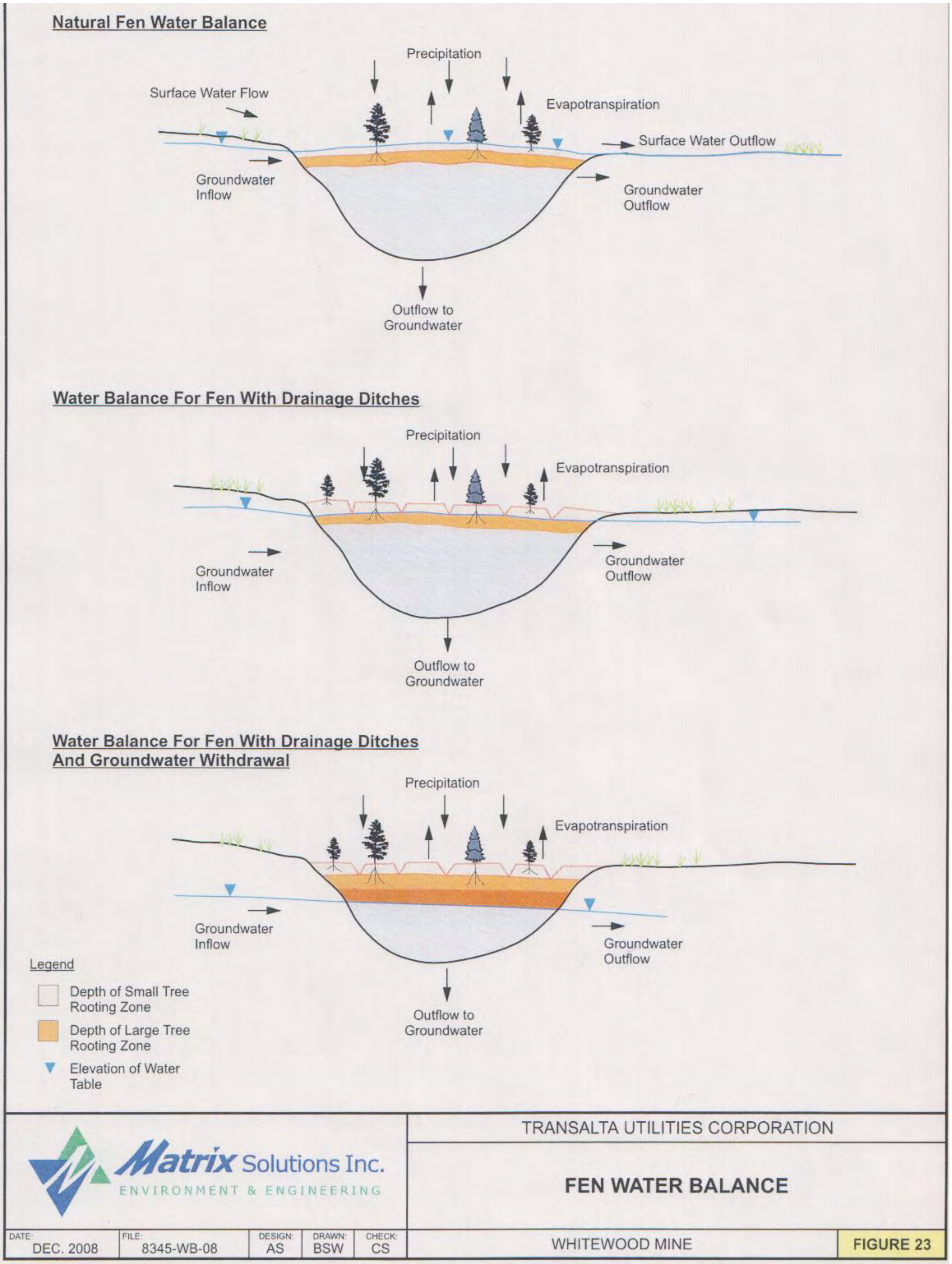


Figure 12. Model of water balance in fen under natural conditions as well as mine dewatering and drainage ditches impacts near Whitewood Mine west of Edmonton (Smith et al. 2009). The elevation of the water table after groundwater withdrawal is below depth of the large tree rooting zone.

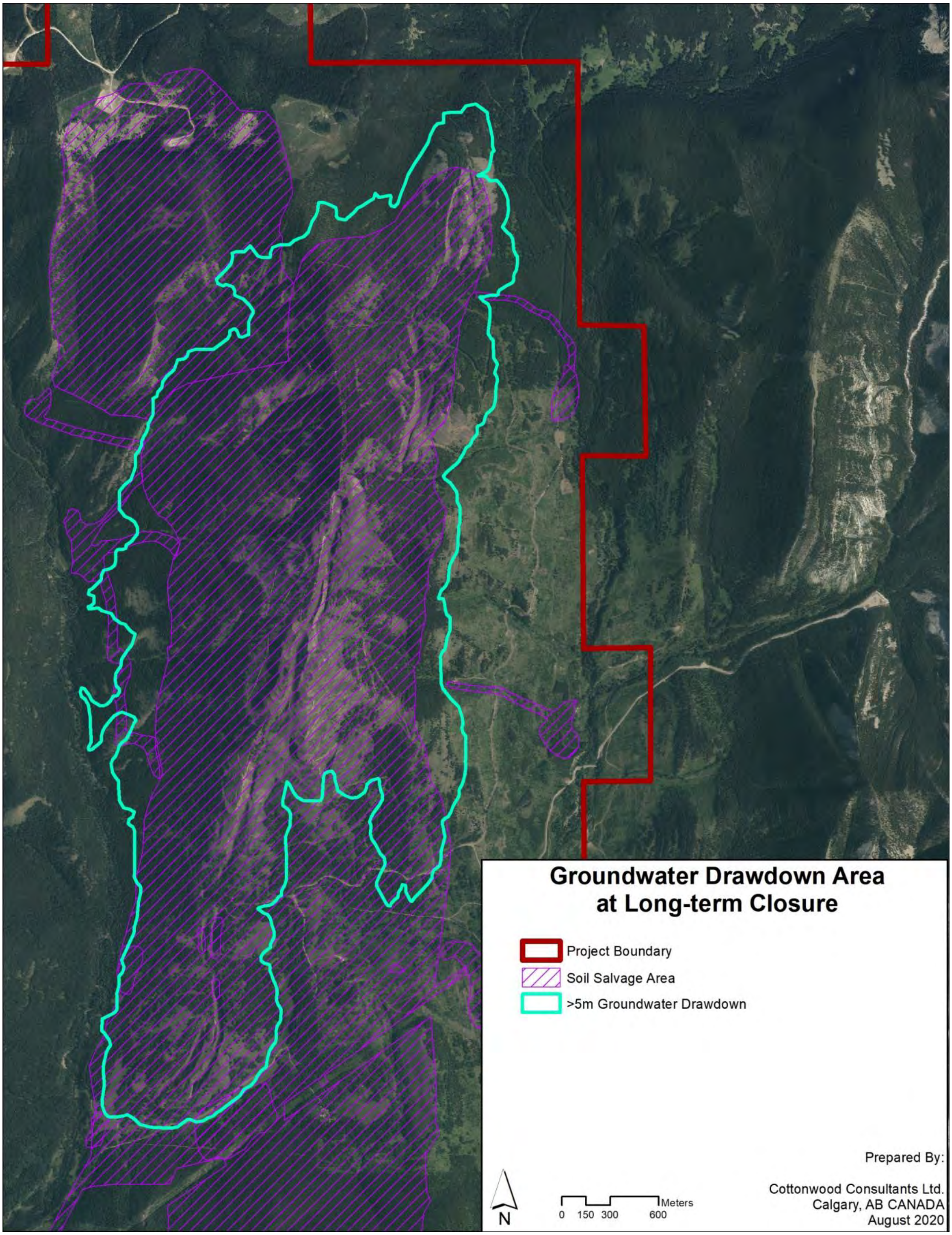


Figure 13. Groundwater drawdown >5 m at long-term closure (pdf page 246, CIAR 42, Consultant Report 3, Hydrogeology). Ecological effects on plant species can be seen at drawdown of less than 5 m in wetland and wetland edge habitats, including riparian vegetation.

3.6 Reclamation

The Government of Alberta (2019) defines the conservation and reclamation objective as:

> *"The objective of conservation and reclamation of specified land is to return the specified land to an equivalent land capability. AR 115/93 s2;167/93."*

Unfortunately, there is no updated guidance for coal projects. However, guidance has been updated for the oil and gas industry (pipelines, wellsites). The new guidance for reclamation for oil and gas wellsites on forested lands and grassland is instructive on equivalent land capability and reclamation, all criteria which apply for oil and gas development after 2007 (Alberta Environment and Sustainable Resource Development 2013a and b):

> *"The aim of reclamation under Environmental Protection and Enhancement Act is to obtain equivalent land capability. "Equivalent land capability" is defined in the Conservation and Reclamation Regulation as "the ability of the land to support various land uses after conservation and reclamation is similar to the ability that existed prior to an activity being conducted on the land, but that the individual land uses will not necessarily be identical." The 2010 Criteria are to be used to evaluate whether a site has met equivalent land capability. The criteria are based on land function and operability that will support the production of goods and services consistent in quality and quantity with the surrounding landscape."*
>
> *"The intent of the 2010 Criteria is to measure appropriate parameters and evaluate whether land function and operability is comparable to the surrounding area or an appropriate reference. The certification criteria describe the allowable changes in site conditions. They typically require landscape, vegetation, and soils assessments as was a component of the 1995 Update. In special cases, the operator may have to find representative land, soil and vegetation a short distance from the site or use available reference plant community or ecosite descriptions."*
>
> *. . .*
>
> *"A fundamental principle carried forward in these criteria is that the success of land reclamation is measured against the representative (adjacent) site conditions with due consideration for construction norms at the time of development. The criteria will be used to judge reclamation success and issue the reclamation certificate."*
>
> *. . .*
>
> *for forested lands: "For the Vegetation Assessment there is a **greater emphasis on vegetation as an indicator of equivalent land capability, ecosystem function and/or operability**. (my emphasis) This equates to greater assessment requirements for vegetation."*
>
> *. . .*
>
> *for grasslands: "For the Vegetation Assessment there is a **greater emphasis on grassland vegetation as an indicator of equivalent land capability, ecosystem function and/or operability**. (my emphasis) This equates to greater assessment requirements for vegetation."*
>
> *. . .*
>
> *"When assessors are using the 2010 Reclamation Criteria for Forested Lands every attempt should be made to utilize adjacent lands as a representative control and/or reference community for the assessment."*

The Alberta Energy Regulator (2020e) provides the general requirements for mine reclamation:

> *"When we approve a coal or oil sands mine or processing plant under the Environmental Protection and Enhancement Act (EPEA), this approval comes with terms and conditions for reclamation."*
>
> *"These include site-specific requirements for land conservation and reclamation during site construction and operation, such as soil salvage and storage."*
>
> *"The reclamation requirements in an EPEA approval are not comprehensive. Depending on the type of development, additional reclamation requirements may apply, such as those set out in other legislation (e.g., the Coal Conservation Act or the Public Lands Act) or in relevant regulatory policy (e.g., Land-use Framework regional plans)."*

In the absence of updated guidance for coal projects, the terms of reference for reclamation become particularly important if the Grassy Mountain coal project is approved. In my professional opinion, at a minimum, guidance for equivalent land capability provided in the criteria for oil and gas should be incorporated into the terms and conditions, especially criteria related to vegetation. I would go further than that guidance and emphasize the importance of landscape/topographic/slope and soil variety in order to achieve more of the elements of equivalent land capability for rarer species and plant communities. While I am fairly confident that Benga can achieve much of the equivalent land capability for more common habitat/plant community types, I am not confident of outcomes for most of the rarer/at risk species either in the short-term or extended duration.

4. LITERATURE CITED

Alberta Energy. 2020. Coal and Mineral Development in Alberta Year in Review, June 2020. Energy Operations Division, Coal and Mineral Development Unit, Alberta Energy, Government of Alberta, Edmonton. Website: https://open.alberta.ca/dataset/35ee97e3-63d7-4c32-9e3b-c64407f31221/resource/35666b7c-7c62-4adc-acf8-fb5106adb74e/download/energy-coal-mineral-development-year-2019-in-review-2020-06.pdf.

Alberta Energy Regulator. 2020a. Application A10104454, Elan Coal Ltd. Application for a new temporary field authorization. Website: https://webapps.aer.ca/pod/details?decisionnumber=A10104454

Alberta Energy Regulator. 2020b. Application A10104480, Elan Coal Ltd. Application for a new temporary field authorization. Website: https://webapps.aer.ca/pod/details?decisionnumber=A10104480

Alberta Energy Regulator. 2020c. Application A10104916, Elan Coal Ltd. Application for a new temporary field authorization. Website: https://webapps.aer.ca/pod/details?decisionnumber=A10104916

Alberta Energy Regulator. 2020d. Application A10105191, Elan Coal Ltd. Application for a new temporary field authorization. Website: https://webapps.aer.ca/pod/details?decisionnumber=A10105191

Alberta Energy Regulator. 2020e. Mine reclamation requirements. Website: https://www.aer.ca/regulating-development/project-closure/reclamation/mine-reclamation-requirements.html#general

Alberta Environmental Protection. 1995. Alberta's Montane Subregion, Special Places 2000 and the Significance of the Whaleback Montane. Natural Resources Service, Alberta Environmental Protection, Edmonton, AB.

Alberta Environment and Parks. 2019. Alberta Whitebark and Limber Pine Recovery Plan. Alberta Species at Risk Recovery Plan No. [#]. Edmonton, AB. 74 pp. Website: https://www.alberta.ca/assets/documents/alberta-whitebark-pine-and-limber-pine-recovery-plan.pdf

Alberta Environment and Sustainable Resource Development (ESRD). 2013a. 2010 Reclamation Criteria for Wellsites and Associated Facilities for Forested Lands (Updated July 2013). Edmonton, Alberta. 81 pp. Website: https://open.alberta.ca/dataset/9df9a066-27a9-450e-85c7-1d56290f3044/resource/09415142-686a-4cfd-94bf-5d6371638354/download/2013-2010-reclamation-criteria-wellsites-forested-lands-2013-07.pdf

Alberta Environment and Sustainable Resource Development (ESRD). 2013b. 2010 Reclamation Criteria for Wellsites and Associated Facilities for Native Grasslands (July 2013 Update). Edmonton, Alberta. 92 pp. Website: https://open.alberta.ca/dataset/3192a712-f484-44b3-ac10-24665690fc2f/resource/27278624-9d4b-4230-bf01-47b055a7d457/download/2013-2010-reclamation-criteria-wellsites-native-grassland-2013-07.pdf

Alberta Parks. 2020. Managing Parks and Protected Areas: Scientific Framework. Alberta Tourism Parks and Recreation, Edmonton. Available on the web at:

http://www.albertaparks.ca/albertaparksca/management-land-use/building-the-parks-system/scientific-framework.aspx.

Alberta Sustainable Resource Development. 2010. Industrial Activity in Foothills Fescue Grasslands — *Guidelines for Minimizing Surface Disturbance.* Prepared by Alberta Sustainable Resource Development, Lands Division. Edmonton, AB.

Alberta Whitebark and Limber Pine Recovery Team. 2014a. Alberta Whitebark Pine Recovery Plan 2014 – 2019. Alberta Whitebark and Limber Pine Recovery Team. Species at Risk Recovery Plan No.34. Edmonton, Alberta, Canada. Website: http://aep.alberta.ca/fish-wildlife/species-at-risk/species-at-risk-publications-webresources/plants/documents/SAR-WhitebarkPineRecoveryPlan-Jan-2014.pdf.

Alberta Whitebark and Limber Pine Recovery Team. 2014b. Alberta Limber Pine Recovery Plan 2014–2019. Alberta Environment and Sustainable Resource Development, Alberta Species at Risk Recovery Plan No. 35. Edmonton, AB. 61 pp. Website: https://open.alberta.ca/dataset/45ceb67a-7b44-4beb-a5a4-2b72a9b2e118/resource/05362a91-7f67-4af3-b8ea-e8e40f91a5dc/download/2014-sar-limberpine-recoveryplan-sep2014.pdf

Arno, S., and T. Weaver. 1990. Whitebark pine community types and their patterns on the landscape. Pages 97-105 *in* "Proceedings-Symposium on Whitebark Pine Ecosystems: Ecology and Management of a High-Mountain Resource". United States Department of Agriculture Forest Service Intermountain Research Station General Technical Report INT-270. Website: https://www.fs.fed.us/rm/pubs_int/int_gtr270.pdf

Atrum Coal. 2018. ASX Release, March 23, 2018, Atrum Coal Receives Elan South Coal Exploration Permit. Atrum Coal, Fitzroy, VIC, Australia. Website: https://www.asx.com.au/asxpdf/20180323/pdf/43sp234s202k88.pdf

Atrum Coal. 2019. ASX Release, October 21, 2019. Amended Isolation South Exploration Update. Website: https://www.asx.com.au/asxpdf/20191021/pdf/449pdyv84ky2wp.pdf.

Atrum Coal. 2020. Elan Hard Coking Coal Project. Website: https://www.atrumcoal.com/projects/elan-project/

Bradley, C., and M. Neville. 2010. Minimizing Surface Disturbance of Alberta's Native Prairie--Background to Development of Guidelines for the Wind Energy Industry. Foothills Restoration Forum and Prairie Conservation Forum. Website: http://www.albertapcf.org/rsu_docs/wind-energy-background-final-december-2010.pdf

Cottonwood Consultants Ltd. 1981. Potential impacts of water use for the Many Springs trout-rearing facility. Prepared by Cottonwood Consultants Ltd. for Brisbin, Gates and Partners, Calgary.

Cottonwood Consultants Ltd. 1987. Environmentally significant areas in the Oldman River Region: MD of Pincher Creek. Prepared by Cottonwood Consultants Ltd. for the Oldman River Regional Planning Commission, Lethbridge.

Currie J., J. Snider, and E. Giles. 2020. Living Planet Report Canada: Wildlife at Risk. World Wildlife Fund Canada. Toronto, Canada.

Environment and Climate Change Canada. 2017a. Environment and Climate Change Canada's Species at Risk Act (SARA) Listing Plan 2016-2018. Environment and Climate Change

Canada, Ottawa. Website: https://wildlife-species.canada.ca/species-risk-registry/virtual_sara/files/Ri-EcccListingPlan-v02-2017Oct-Eng.pdf

Environment and Climate Change Canada. 2017b. Recovery Strategy for the Whitebark Pine (*Pinus albicaulis)* in Canada [Proposed]. *Species at Risk Act* Recovery Strategy Series. Environment and Climate Change Canada, Ottawa. viii + 54 pp. Website: https://www.registrelep-sararegistry.gc.ca/virtual_sara/files/plans/rs_whitebark_pine_e_proposed.pdf

Environment Canada. 2015. Recovery Strategy for Little Brown Myotis (*Myotis lucifugus*), Northern Myotis (*Myotis septentrionalis*), and Tri-colored Bat (*Perimyotis subflavus*) in Canada [Proposed]. Species at Risk Act Recovery Strategy Series. Environment Canada, Ottawa. ix + 110 pp. Website: https://www.registrelep-sararegistry.gc.ca/virtual_sara/files/plans/rs_LittleBrownMyotisNorthernMyotisTricoloredBat_e_proposed.pdf

Fiera Biological Consulting. 2009. Environmentally Significant Areas Update. Prepared for Alberta Tourism Parks and Recreation, Edmonton. Website: https://albertaparks.ca/albertaparksca/library/environmentally-significant-areas-report/

Fiera Biological Consulting. 2011. Aquatic Environmentally Significant Areas in Alberta. Prepared for Alberta Environment and Alberta Sustainable Resource Development, Edmonton. Website: https://open.alberta.ca/dataset/4c6d0a07-0d0f-412b-a80d-ea2e557d20f6/resource/6f565595-3584-43f5-8c77-62e8291badc6/download/aquaticsignificantareas-2011.pdf

Fiera Biological Consulting. 2014. Environmentally Significant Areas, 2014 Update. Prepared for Government of Alberta, Edmonton, Alberta. Fiera Biological Consulting Report Number 1305. Website: https://albertaparks.ca/albertaparksca/library/environmentally-significant-areas-report/

Government of Alberta. 2018 (amended). South Saskatchewan Regional Plan, 2014-2024, an Alberta Land-use Framework Integrated Plan. Government of Alberta, Edmonton. Website: https://open.alberta.ca/dataset/13ccde6d-34c9-45e4-8c67-6a251225ad33/resource/e643d015-3e53-4950-99e6-beb49c71b368/download/south-saskatchewan-regional-plan-2014-2024-may-2018.pdf

Government of Alberta. 2019. Environmental Protection and Enhancement Act, Conservation and Reclamation Regulation, Alberta Regulation 115/1993, with amendments up to and including Alberta Regulation 198/2019. Government of Alberta, Edmonton.

Government of Canada. 2002. Species at Risk Act. Government of Canada, Ottawa. Website: https://laws-lois.justice.gc.ca/PDF/S-15.3.pdf

Government of Canada. 2020. Whitebark Pine (*Pinus albicaulis*). Website: https://species-registry.canada.ca/index-en.html#/species/1086-748

Hansen-Bristow, K. C. Montagne, and G. Schmid. 1990. Geology, geomorphology, and soils within whitebark pine ecosystems. Pages 62-71 *in* "Proceedings-Symposium on Whitebark Pine Ecosystems: Ecology and Management of a High-Mountain Resource". United States Department of Agriculture Forest Service Intermountain Research Station General Technical Report INT-270. Website: https://www.fs.fed.us/rm/pubs_int/int_gtr270.pdf

Keane, Robert E.; Tomback, D.F.; Aubry, C.A.; Bower, A.D.; Campbell, E.M.; Cripps, C.L.; Jenkins, M.B.; Mahalovich, M.F.; Manning, M.; McKinney, S.T.; Murray, M.P.; Perkins, D.L.;

Reinhart, D.P.; Ryan, C.; Schoettle, A.W.; Smith, C.M. 2012. A range-wide restoration strategy for whitebark pine (*Pinus albicaulis*). Gen. Tech. Rep. RMRS-GTR-279. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 108 p. Website: https://www.fs.fed.us/rm/pubs/rmrs_gtr279.pdf

Lancaster, J., R. Adams, B. Adams, and P. Desserud. 2016. Long-term Revegetation Success of Industry Reclamation Techniques for Native Grasslands: Foothills Fescue, Foothills Parkland, and Montane Natural Subregions; Phase 1-Literature Review and Case Studies-2014. Prepared for: Land and Forestry Policy Branch, Alberta Environment and Sustainable Resource Development. Website: https://open.alberta.ca/dataset/d9006d18-bcf6-441c-90f2-a9469aa8c624/resource/61ae5f43-0a62-443a-9d4b-263321786ab7/download/ff-fp-m-2014-phase1-lit-review-monitoring-report-2015-11-16.pdf

Mattson, D., and D. Reinhart. 1990. Whitebark pine on the Mount Washburn Massif, Yellowstone National Park. Pages 106-117 *in* "Proceedings-Symposium on Whitebark Pine Ecosystems: Ecology and Management of a High-Mountain Resource". United States Department of Agriculture Forest Service Intermountain Research Station General Technical Report INT-270. Website: https://www.fs.fed.us/rm/pubs_int/int_gtr270.pdf

McCaughey, W., and W. Schmidt. 1990. Autecology of whitebark pine. Pages 84-96 *in* "Proceedings-Symposium on Whitebark Pine Ecosystems: Ecology and Management of a High-Mountain Resource". United States Department of Agriculture Forest Service Intermountain Research Station General Technical Report INT-270. Website: https://www.fs.fed.us/rm/pubs_int/int_gtr270.pdf

Moody, R., A.J. Clason, 2013. Whitebark Restoration and the Mining Industry: Potential for collaboration? Nutcracker Notes Fall/Winter 2012/2013: 17-18. Website: https://bvcentre.ca/files/research_reports/Nutcr._Notes_No_._23_Moody_Clason_.pdf

Natural Regions Committee. 2006. Natural Regions and Subregions of Alberta. Compiled by D.J. Downing and W.W. Pettapiece. Government of Alberta. Pub. No. I/005. Website: https://www.albertaparks.ca/media/2942026/nrsrcomplete_may_06.pdf

Ogilvie, R. 1990. Distribution and ecology of whitebark pine in western Canada. Pages 54-60 *in* "Proceedings-Symposium on Whitebark Pine Ecosystems: Ecology and Management of a High-Mountain Resource". United States Department of Agriculture Forest Service Intermountain Research Station General Technical Report INT-270. Website: https://www.fs.fed.us/rm/pubs_int/int_gtr270.pdf

Smith, A., R. Pockar, P. Whitehead, and C. Smyth. 2009. Whitewood Mine tree stress and mortality investigation. Prepared for Trans-Alta Utilities Corporation, Calgary, by Matrix Solutions Inc., Calgary.

Sweetgrass Consultants Ltd. 1988. Environmentally significant areas of the Municipality of Crowsnest Pass. Prepared by Sweetgrass Consultants, Calgary, for Alberta, Forestry, Lands and Wildlife, Edmonton.

Sweetgrass Consultants Ltd. 1997. Environmentally Significant Areas of Alberta. Volumes 1, 2 and 3. Prepared by Sweetgrass Consultants Ltd., Calgary, AB for Resource Data Division, Alberta Environmental Protection, Edmonton, Alberta. Website: https://open.alberta.ca/publications/2073237

Timoney, K. 1998. Environmentally significant areas inventory of the Rocky Mountain Natural Region of Alberta, Final Report. Prepared by Treeline Ecological Research, Sherwood

Park, AB for Corporate Management Service, Alberta Environmental Protection, Edmonton, AB. Website: https://open.alberta.ca/publications/2073237

Wallis, C. 1980. Montane, foothills parkland and southwest rivers: natural landscapes survey, 1978-1979. Resource Assessment and management Section, Alberta parks, Edmonton.

Wallis, C., C. Bradley, M. Fairbarns, J. Packer & C. Wershler. 1986. Pilot rare plant monitoring program in the Oldman Regional Plan area of southwestern Alberta. Alberta Forestry Lands & Wildlife Technical Report T/148.

APPENDIX 1. Key CIAR Documents Reviewed

Riversdale Resources, Environmental Impact Assessment CIAR 42

Section D, Environmental Impact Assessment Methodology CIAR 42

Benga Mining Limited. 2016. Section D Environmental Impact Assessment Methodology. Prepared by Benga Mining Limited.

Section E, Environmental Assessment CIAR 42

Benga Mining Limited. 2016. Section E Environmental Impact Assessment Summary. Prepared by Benga Mining Limited.

Section F, Conservation and Reclamation Plan CIAR 42

Benga Mining Limited. 2016. Section F Conservation and Reclamation Plan. Prepared by Benga Mining Limited.

Appendices of CIAR 42

Appendix 1 - Alberta Energy Regulator Terms of Reference and Concordance Tables CIAR 42

Benga Mining Limited. 2015. Appendix 1 AER Terms of Reference and Concordance Tables. Prepared by Benga Mining Limited.

Appendix 2 - Canadian Environmental Assessment Agency Terms of Reference and Concordance Tables CIAR 42

Benga Mining Limited. 2016. Appendix 2a CEAA Terms of Reference. Prepared by Benga Mining Limited.

Consultant Report #3 - Hydrogeology CIAR 42

Millennium EMS Solutions. 2016. Grassy Mountain Coal Project Hydrogeology. Prepared for: Benga Mining Limited Operating as Riversdale Resources. Prepared by: Millennium EMS Solutions Ltd. Edmonton, Alberta.

Consultant Report 7, Terrain and Soils CIAR 42

Millennium EMS Solutions. 2016. Grassy Mountain Coal Project Baseline Soil Survey and Impact Assessment. Prepared for: Benga Mining Limited Operating as Riversdale Resources. Prepared by: Millennium EMS Solutions Ltd. Edmonton, Alberta.

Consultant Report 8, Vegetation CIAR 42

Millennium EMS Solutions. 2016. Grassy Mountain Coal Project Vegetation and Wetlands Assessment. Prepared for: Benga Mining Limited Operating as Riversdale Resources. Prepared by: Millennium EMS Solutions Ltd. Calgary, Alberta.

Consultant Report 9, Wildlife CIAR 42

Millennium EMS Solutions. 2016. Grassy Mountain Coal Project Wildlife Assessment. Prepared for: Benga Mining Limited Operating as Riversdale Resources. Prepared by: Millennium EMS Solutions Ltd. Calgary, Alberta.

Consultant Report 10, Land and Resource Use CIAR 42

Millennium EMS Solutions. 2016. Grassy Mountain Coal Project Land and Resource Use Assessment. Prepared for: Benga Mining Limited Operating as Riversdale Resources. Prepared by: Millennium EMS Solutions Ltd. Edmonton, Alberta.

Addenda of CIAR 42 with different CIAR document numbers

First Addendum to the Environmental Impact Assessment CIAR 44

Millennium EMS Solutions. 2017. Grassy Mountain Coal Project Wildlife Addendum, Little Brown Bat. Prepared for: Benga Mining Limited Operating as Riversdale Resources. Prepared by: Millennium EMS Solutions Ltd. Calgary, Alberta.

Fourth Addendum to the Environmental Impact Assessment CIAR 55

Benga Mining Limited. 2017. Attachment 2 Response to CEAA's Request for Additional Information issued December 05, 2016. Prepared by Benga Mining Limited.

Benga Mining Limited. 2017. Attachment 3 Response to CEAA's Request for Additional Information issued May 16, 2017. Prepared by Benga Mining Limited.

Fifth Addendum to the Environmental Impact Assessment CIAR 69

Benga Mining Limited. 2018. Supplemental Information Request Responses #1 Benga Mining Limited Grassy Mountain Coal Project CCA Applications No. 1844520 and 1902073 EPEA Application No. 001-403427 WA Applications No. 001-00403428, 001-00403429, 001-00403430 and 001- 00403431 PLA Applications No. MSL160757, MSL160758, LOC160841, LOC160842 and LOC970943. Prepared by Benga Mining Limited.

Sixth Addendum to the Environmental Impact Assessment CIAR 70

Benga Mining Limited. 2018. Response Package for Additional Information for the Grassy Mountain Coal Project Environmental Assessment – Requested by the Agency on February 28, 2018. Prepared by Benga Mining Limited.

Eighth Addendum Environmental Impact Assessment CIAR 89

Benga Mining Limited. 2018. Provincial and Federal Requests for Additional Information Response Package Grassy Mountain Coal Project Addendum 8. Prepared by Benga Mining Limited.

Tenth Addendum Environmental Impact Assessment CIAR 251

Benga Mining Limited. 2020. Grassy Mountain Coal Project. Joint Review Panel Request for Additional Information Response Package Addendum 10, Package 2, Vegetation and Reclamation. Prepared by Benga Mining Limited.

Benga Mining Limited. 2019. Grassy Mountain Coal Project. Joint Review Panel Request for Additional Information Response Package Addendum 10, Package 5, Surface Water

Quality, Hydrology, Hydrogeology, Fish and Fish Habitat, Cumulative Effects, Geotechnical, Reclamation, Wildlife, Land Use and EA Methodology. Prepared by Benga Mining Limited.

Eleventh Addendum Environmental Impact Assessment CIAR 313

Benga Mining Limited. 2020. Grassy Mountain Coal Project. Joint Review Panel Request for Additional Information Response Package to JRP IR Package 6, Reference Lists and Consolidated Mitigation Tables Addendum 11. Prepared by Benga Mining Limited.

Twelfth Addendum Environmental Impact Assessment CIAR 360

Benga Mining Limited. 2020. Grassy Mountain Coal Project. Joint Review Panel Request for Additional Information Response Package to JRP IR Package 7, Reference Lists and Consolidated Mitigation Tables Addendum 12. Prepared by Benga Mining Limited.

CLIFF WALLIS, P. BIOL.
SUMMARY

Cliff Wallis is a Professional Biologist, registered in the province of Alberta, who has 50 years' experience coordinating and undertaking biological surveys since the late 1960s. Cliff graduated from the University of Calgary in 1972 with a B.Sc. (with distinction) in Botany and Zoology. After working with Alberta Parks conducting biophysical inventories and planning parks, he established Cottonwood Consultants Ltd. in 1978. He has a diverse background in protected area systems planning, tourism projects, ecological studies, species at risk evaluations, environmentally significant features identification, protected area planning, environmental assessment, ecological restoration and interpretive planning. He has published numerous consulting and government reports as well as several articles in scientific and popular journals. Cliff holds an Authenticating Wetland Professional designation related primarily to Alberta's Wetland Policy in the field of wetland science.

Cliff has worked in a variety of Canada's Ecozones including the Boreal Shield, Taiga Shield, Taiga Plains, Prairies, Northern Arctic and Montane Cordillera and internationally in the grasslands of Inner Mongolia, the deciduous woodlands of Chongqing in SW China and the tropical and montane forests of Cameroon. He is conversant with vegetation, physical features, and wildlife identification and evaluation. Cliff coordinated or assisted on most of the environmentally significant area studies done to date in southern Alberta as well as a provincial overview. He conducted a variety of field studies on vascular and non-vascular plants, fish, amphibians, reptiles, birds and mammals, as well as on-line literature searches and extensive searches of archival material in government files, museums and universities.

Cliff has conducted field work and provided expert testimony to regulatory bodies on transmission lines, solar and wind farms, highways, pipelines, coal mining, natural gas fields, and dams. He worked on projects which have integrated protection and development of sensitive biophysical resources, including species at risk. He provided expert opinion to the Alberta Utilities Commission for transmission line, solar, and wind power projects; to the Alberta Energy Regulator (and its predecessors) for gas and oil projects; and to the Alberta Court of Queen's Bench in Edmonton related to pipelines and Environmentally Significant Areas.

Cliff served on the Alberta Caribou Committee, including its Research Subcommittee, from 2005-2012, providing advice on woodland caribou recovery planning to the Deputy Minister of Alberta Sustainable Resource Development. He was an environmental sector representative on the Standard Development Group for the 2019 Forest Stewardship Council National Forest Standard for Canada. He serves on the boards of the Milk River Management Society, Alberta Wilderness Association and Forest Stewardship Council (Canada) in addition to chairing the steering committee of the Great Plains Conservation Network. He currently serves on the task force making recommendations to Alberta's Minister of Environment and Parks regarding caribou and sub-regional planning in northwestern Alberta.

Of particular note are Cliff's involvement with hundreds of species at risk studies and status assessments in the Grasslands, Foothills, Mountains, Boreal Forest and Aspen Parkland; environmental assessment of the Trans-Canada Highway Twinning in Banff National Park; conservation analyses in western North America, including SW Alberta and its Montane Natural Subregion; field surveys of 1000s of wetlands in Alberta; numerous ecological land classifications and environmentally significant areas studies in Alberta (including Crowsnest Pass) and BC; constraints analyses for energy developments; monitoring pipeline construction and vegetation restoration; capacity building for nature reserve managers in Inner Mongolia; and providing training on monitoring, environmental assessment and biodiversity protection, including species at risk, for the City of Chongqing in southwest China.

Species at Risk: Rare Plants of the Boreal Forest, Parkland, and Grassland; Trans-Canada Highway Twinning -- Banff National Park; Piping Plover; National Historic Sites; Rare Plants Monitoring, Oldman River Region; Rare Plants and Wildlife of Sand Hills; Western Blue Flag; Daishowa FMA; Foothills Grassland; Onefour; PFRA Pastures; Wainwright Dunes; numerous subdivision applications, Calgary; City of Chongqing, Alberta Caribou Committee

- field surveys to identify and monitor rare plant and wildlife habitats, population size, and management problems; literature surveys to determine status; includes surveys and analysis as part of environmental assessment of development projects; workshops on approaches to species at risk management; advocacy for species at risk protection

Significant Features Analyses: Many Springs; Saskatoon Mountain; Coal Valley; Calgary Region; Oldman River Region (including Crowsnest Pass and M.D. of Pincher Creek); Red Deer Region; Palliser Region; Southeast Region; David Thompson; Lloydminster; Bow-Canmore Corridor; County of Newell; M.D. of Kneehill; Foothills Model Forest

- field/literature studies to determine significant landscape, fish, wildlife and vegetation features—Aspen Parkland, Boreal Forest, Grasslands, Rocky Mountains, Foothills

Resource Management Planning/Environmental Impact Assessment: Battle Lake; Beauvais Lake, Dinosaur and Cypress Hills; Dalinor Nature Reserve, Inner Mongolia; Trans-Canada Highway Twinning; Medicine Hat/Hatton; Suffield Shallow Gas; Access Pipeline

- collection and analysis of data for protected area management and environmental impact assessment of developments; participatory approaches to planning; training of protected area managers; appearance before regulatory boards and Court of Queen's Bench

Restoration (Reclamation) Planning and Implementation: Ross Creek; Pointe-aux-Pins Creek; Coal Valley; Milk River Canyon; Dinosaur Provincial Park; Norman Wells

- field studies and literature review; field implementation (site preparation; planting, monitoring) for coal, pipeline, and oil and gas developments

Systems Planning: Grasslands; Aspen Parkland; Red Deer River Corridor; and Southwestern Alberta Montane and River Valleys; Provincial Parks System

- literature/field studies to determine park potential and to analyze theme representation

Ecological/Biophysical Inventories: Kootenay Plains; Kazan Upland; Milk River; Bow Valley; Saskatoon Island; Young's Point; Coal Valley; Grizzly Ridge; Shepard Drainage; Lakeland, Yoho National Park; Waterton Lakes National Park, Frank Lake, Bearspaw, Edworthy; includes surveys and analysis as part of environmental assessment of development projects

- field studies of wetlands, wildlife, vegetation, and landscapes

Regulatory Processes: Alberta Utilities Commission on transmission line, substation, solar and wind projects; Energy Resources Conservation Board/AEUB on coal, shallow gas and coalbed methane projects; FEARO on Oldman River Dam, Express Pipeline (joint hearing with National Energy Board) and Suffield Encana Shallow Gas project (joint hearing with Energy Resources Conservation Board and CEAA); Court of Queen's Bench regarding Corridor Pipelines and ESAs; Surface Rights Board for Komant Property--Enbridge Woodlands Pipeline; and Bashaw Sour Oil and Pembina Pipeline projects (Alberta Energy Regulator)

- provided expert testimony on environmental impacts and managed expert panels

CLIFF WALLIS
SELECTED PUBLICATIONS

Pinel, H. & C. Wallis. 1972. A botanical investigation in the Drumheller area. Blue Jay 30: 169-194.

Kondla, N., H. Pinel, C. Wallis, & C. Wershler. 1973. Avifauna of the Drumheller area, Alberta. Canadian Field-Naturalist 87: 377-393.

Wallis, C. & K. Van Tighem. 1973. Young's Point-ecological survey. Alberta Parks Division, Edmonton.

Wallis, C. 1976. Milk River Canyon resource evaluation. Alberta Parks Division, Edmonton.

Wallis, C. and C. Wershler. 1978. Coal Valley wildlife monitoring program-1978 study. Luscar Ltd. Edmonton.

Wallis, C. and C. Wershler. 1979. Milk River Canyon: high plains survivor. Nature Canada 8: 36-45.

Wallis, C. and C. Wershler. 1981. 1980 Coal Valley Mine--wildlife monitoring program and habitat reclamation review. Luscar Ltd. Edmonton.

Wallis, C. & C. Wershler. 1981. Natural history inventory & assessment in the Many Springs area, Bow Valley Park. Alberta Energy & Natural Resources, Fish & Wildlife Division, Calgary.

Wallis, C. 1982. An overview of the Mixed Grasslands of North America. Pages 195-208 in Grassland ecology & classification symposium proceedings. B.C. Ministry of Forests Publication R28- 82060.

Wallis, C. & C. Wershler. 1984. Kazan Upland Resource Assessment for ecological reserves planning in Alberta. Alberta Energy & Natural Resources Report T/54, Natural Areas Technical Report No. 12. Public Lands Division, Edmonton.

Wallis, C., C. Bradley, M. Fairbarns, J. Packer & C. Wershler. 1986. Pilot rare plant monitoring program in the Oldman Regional Plan area of southwestern Alberta. Alberta Forestry Lands & Wildlife Technical Report T/148.

Wallis, C. and L. Allen. 1987. Assessment and monitoring of rare plants in Alberta, Canada. Pages 579-586 in "Conservation and management of rare and endangered plants, proceedings of a California conference on the conservation and management of rare and endangered plants". California Native Plant Society, Sacramento, California.

Cottonwood Consultants Ltd. 1987-89. Environmentally Significant Areas in the Oldman River Region (7 Counties and MDs). Resource Evaluation and Planning, Alberta Forestry, Lands and Wildlife.

Wallis, C.A. 1987. Critical, threatened and endangered habitats in Alberta, pp. 49-63, in, Proceedings of the workshop on endangered species in the prairie provinces by Geoffrey L. Holroyd et al. Provincial Museum of Alberta Natural History Occasional Paper No. 9, Edmonton, AB.

Wallis, C. 1987. What is successful reclamation--the public's perception. Pages 107-110 in "Reclamation targets for the 1990s, proceedings of a symposium". Alberta Society of Professional Biologists/Canadian Society of Environmental Biologists, Edmonton.

Achuff, P., J. Godfrey and C. Wallis. 1988. A systems planning natural history framework and evaluation system for Alberta Recreation and Parks. Prepared by Kanata Heritage Research and Interpretation, Calgary for Alberta Recreation and Parks, Edmonton.

Sweetgrass Consultants Ltd. 1988. Environmentally significant areas of the Municipality of Crowsnest Pass. Prepared by Sweetgrass Consultants, Calgary, for Alberta, Forestry, Lands and Wildlife, Edmonton.

Sweetgrass Consultants Ltd. 1989. Environmentally significant areas of the County of Paintearth. Prepared by Sweetgrass Consultants, Calgary, for the Red Deer Regional Planning Commission, Red Deer.

Godfrey, J. and C. Wallis. 1989. An evaluation of the Ministry of Recreation and Parks'

conservation-outdoor recreation system and identification of candidate areas for the Mixed Grassland, Northern Fescue Grassland, Foothills Grassland, Central Parkland, Foothills Parkland, and Rocky Mountain Montane Biogeographical Zones. Prepared by Kanata Heritage Research and Interpretation, Calgary for Alberta Recreation and Parks, Edmonton.
Cottonwood Consultants Ltd. 1990. Bow/Canmore Corridor environmental issues analysis. Alberta Tourism, Edmonton.
Wallis, C. 1990. Reconnaissance survey of saline wetlands and springs in the grassland-parkland region of eastern Alberta. Prepared by Cottonwood Consultants, for World Wildlife Fund Canada, Toronto.
Smith, W. and C. Wallis. 1991. An exploration of the alternatives to the Oldman Dam Project, southern Alberta. Prepared for Friends of the Oldman River, Calgary and Oldman Dam Environmental Assessment Review Panel, Vancouver.
Wallis, C. 1992. Communications plan for Antelope Creek Ranch. Prepared by Cottonwood Consultants, Calgary, for Antelope Creek Habitat Development Area, Brooks.
Sweetgrass Consultants Ltd. 1994.Preliminary inventory of Environmentally Significant Areas within the Foothills Model Forest. Prepared by Sweetgrass Consultants Ltd., Calgary, AB for Foothills Model Forest, Hinton, Alberta.
Ecological Stratification Working Group. 1995. A national ecological framework for Canada. Agriculture and Agri-Food Canada, Research Branch, Centre for Land and Biological Resources Research and Environment Canada, State of the Environment Directorate, Ecozone Analysis Branch, Ottawa/Hull. (Cliff Wallis was a regional contributor)
Cottonwood Consultants Ltd. 1995. Gwich'in Territorial Park, Biophysical Inventory. Prepared for Gwich'in Tribal Council, Inuvik.
Avens Associates Ltd. 1996. Mount Pelly Territorial Park, Archeological Survey and Biophysical Inventory. Prepared for NWT Department of Economic Development and Tourism.
Bradley, C. and C. Wallis. 1996. Prairie ecosystem management: an Alberta perspective. Prairie Conservation Forum, Occasional Paper 2, Lethbridge, Alberta.
Sweetgrass Consultants Ltd. 1997. Environmentally Significant Areas of Alberta. Volumes 1, 2 and 3. Prepared by Sweetgrass Consultants Ltd., Calgary, AB for Resource Data Division, Alberta Environmental Protection, Edmonton, Alberta.
Wallis, C. and C. Wershler. 1997. Waterton Lakes National Park, Ecological Land Classification (Wildlife Component) 1995-96. Prepared by Cottonwood Consultants Ltd. Calgary, Alberta for Canadian Heritage, Waterton Lakes National Park, Alberta.
Cottonwood Consultants Ltd. 1999. American White Pelican, California Gull, Caspian Tern, Double-crested Cormorant, Great Blue Heron and Ring-billed Gull Colony Surveys -- Alberta 1998. Prepared for Ducks Unlimited Canada, Edmonton.
Cottonwood Consultants Ltd. 2000. Vegetation Assessment for Reclamation Planning, Imperial Oil Site (Norman Wells). Prepared for Komex International, Calgary.
Wallis, C. and C. Wershler. 2001. Natural History Inventory, 2000, Grizzly Ridge Wildland Provincial Park. Prepared for Alberta Environment, Valleyview.
Alberta Sustainable Resource Development. 2002. Surveys of Plant Species Potentially at Risk, Foothills Fescue Grassland. Alberta Sustainable Resource Development, Fish and Wildlife Division, and Alberta Conservation Association, Wildlife Status Report, Edmonton, AB.
Sweetgrass Consultants Ltd. 2006. Environmentally Significant Areas of City of Medicine Hat Properties. Prepared by Sweetgrass Consultants Ltd. for Police Point Nature Center/Grasslands Naturalists.
Wershler, C. and C. Wallis. 2010. Innisfail Ecospace Inventory. Prepared for the Town of Innisfail by Sweetgrass Consultants Ltd., Calgary.
Sweetgrass Consultants Ltd. 2017. Nose Hill Park Bird Monitoring, 2006 and 2015. Prepared by Sweetgrass Consultants Ltd., Calgary for City of Calgary Parks.
Wallis, C. 2019. A Continental (Great Plains) Approach to Grassland Conservation. America's Grasslands Conference, August 2019, Bismarck, North Dakota, USA (in press).

CLIFF WALLIS

ACHIEVEMENTS, AWARDS

- Cliff Shaw Award, Saskatchewan Natural History Society, 1972
- Governor-General's Canada 125th Anniversary Medal, 1992
- Prairie Conservation Award, World Wildlife Fund, 1992
- Peggy Thompson Award, Alberta Society of Professional Biologists, 1993
- J.B. Harkin Medal, Canadian Parks and Wilderness Society, 1997
- Douglas H. Pimlott Award, Canadian Nature Federation (now Nature Canada), 2003
- “Ernie” Award, Alberta Wilderness Association, 2004

THIS DIPLOMA CERTIFICATE

IS TO CERTIFY THAT

Clifford A. Wallis

having complied with the requirements of the
Professional and Occupational Associations Registration Act of Alberta
on March 1, 1991
is admitted and registered as a member of the

ALBERTA SOCIETY OF PROFESSIONAL BIOLOGISTS

and is entitled to practice Professional Biology
within the province of Alberta using the title of

PROFESSIONAL BIOLOGIST

In witness whereof the seal has been hereto affixed
this 17 day of December 1991.

<Original signed by>

President

<Original signed by>

Registrar

September 21, 2020

Ms. Ifeoma Okoye
Ackroyd LLP
15th Floor First Edmonton Place
10665 Jasper Avenue
Edmonton, Alberta T5J 3S9

Re: Coalition of Alberta Wilderness Association and Grassy Mountain Group
Benga Mining Limited Grassy Mountain Coal Project
Noise Impact Assessment Review

Ms. Okoye:

Ackroyd LLP legal counsel representing the Coalition of Alberta Wilderness Association and Grassy Mountain Group (the Coalition) retained FDI Acoustics Inc. to review the documents filed with the Joint Review Panel of the Impact Assessment Agency of Canada and the Alberta Energy Regulator (AER) relating to the environmental noise impact of the proposed Benga Mining Limited (Benga) Grassy Mountain Coal Project. This correspondence documents the findings of the review completed by FDI Acoustics.

Source Documents

FDI Acoustics used documents found in the application including the Noise Impact Assessment for the proposed development, the Project Description, and responses to Information Requests.

Directive 038

Directive 038 regulates environmental noise emissions from developments under the jurisdiction and licensure of the AER. Directive 038 requires the inclusion of the noise emissions from all regulated energy industry developments in the preparation of an NIA. In practice this includes noise from developments under the jurisdiction of the AER along with developments under the jurisdiction and licensure of the Alberta Utilities Commission (AUC). The AUC regulates environmental noise emissions through their regulation known as Rule 012, Noise Control (Rule 012). In summary, AUC Rule 012, Noise Control closely follows the technical aspects, methods for assessment and the reporting criteria of AER Directive 038. AUC Rule 012 specifically requires the inclusion of other energy-industry noise sources when assessing the environmental noise impact of a facility (development).

The two regulations are receiver-oriented noise regulations. Directive 038 and Rule 012 specify allowable sound levels for developments and temporary activities under their respective jurisdictions at designated receptor points (dwelling units). In situations where there is no dwelling unit within 1500 metres of the built-up area of a development, the regulations require that the cumulative sound level of the existing and proposed developments comply with a nighttime permissible sound level of 40 dBA L_{eq}. The specified allowable sound level limits are defined as the permissible sound levels (PSLs). Multiple development and/or activity environments require that the combined sound level contribution of all regulated developments and activities comply with the applicable PSLs.

The regulations require that all developments and activities licensed after October 17, 1988 meet the PSLs. Directive 038 is applicable to coal mining activities under the licensure of the AER. Actual compliance with the Permissible Sound Levels of Directive 038 or Rule 012 is only determined by comparing the measured valid comprehensive sound level to the applicable permissible sound levels of a comprehensive sound survey. Although it is not mandatory to complete a comprehensive sound survey after the commissioning of a new, expanded or modified development, both the AER and the AUC expect that the comprehensive sound level of the regulated development and/or activity complies with the applicable PSLs. The regulatory agencies may request the completion of a comprehensive sound survey as a licensing condition or in response to a concern from the community regarding the sound of a licensed activity or development. The PSLs are derived from information regarding the area dwelling unit density; proximity of a dwelling unit to heavily travelled transportation route that includes motor vehicle routes, rail lines, aircraft flyways and other specified adjustments. Both regulators recognize that there may be situations that warrant special circumstances.

Noise Impact Assessment

The Noise Impact Assessment dated June 28, 2016 acknowledges the presence of existing energy industry developments within the noise study area for the project under the regulation of the AER. The presence of existing and approved energy industry developments within the noise study area for the project requires that in the preparation of the NIA one is to include the noise emissions of all energy related developments. The Noise Impact Assessment describes the developments as well sites without any noise generating equipment. FDI Acoustics notes the well sites in the noise study area do not appear to have any noise generating equipment. FDI Acoustics notes there are no other regulated noise generating developments in the noise study area for the project.

The Noise Impact Assessment reports the impact for the mining years 1, 6 and 18 and acknowledges the results represent “snapshots” of the noise impact of the operations to the community due to the ever changing topography, landscape and mining equipment movements. The Noise Impact Assessment indicates the operations are predicted to comply with the Permissible Sound Levels at all receptors assessed for each of the three mining years examined.

FDI Acoustics acknowledges the process followed in the preparation of the Noise Impact Assessment follows similar strategies employed by FDI Acoustics when assessing the noise impact of mining operations whereby select years over the life of the project are chosen for study and the noise impact of each year for each receiver is calculated and compared with the permissible sound levels.

Section 5.4.1 of the Noise Impact Assessment describes the mitigation measures associated with the rock disposal and indicates if the mitigation measures are not followed that the results of the assessment for the two residential receptors east of the mine permit boundary that indicate compliance may exceed the permissible sound level due to shielding that may be provided by the mine in the selection and development of the haul routes. The haul route mitigation indicates Benga is required to commit to daytime operations in the construction of waste rock berms in the “eastern most areas” until activities are further to the west and at lower elevations. The Noise Impact Assessment acknowledges that berms or natural barriers are necessary for compliance.

The Noise Impact Assessment acknowledges blasting operations may be issue and recommends blasting operations be restricted to daytime periods and limitations placed on blasting when there are periods of cloud cover that may cause acoustical reflections. The mitigations recommendations also suggest the use of smaller localized blasts as a mitigation measure. The Noise Impact Assessment acknowledges there are no limits on blasting noise and recommends that Benga minimize the effect of blasting operations to the community.

FDI Acoustics agrees with the general mitigation measures described in the Noise Impact Assessment for blasting and vehicle back-up alarm systems.

Conclusion & Recommendations

FDI Acoustics notes the results of the Noise Impact Assessment are contingent on the noise emissions of the facilities built by Benga Mining and the equipment employed by Benga Mining at the Grassy Mountain Mine. Appendix I of the Noise Impact Assessment lists the octave band sound power levels of the facilities and equipment proposed for use and development at the mine and coal loading facility. FDI Acoustics recommends that Benga retain a qualified acoustical consultant to confirm the mine equipment sound power levels as the date of preparation of the Noise Impact Assessment precedes any purchases of the mining equipment by Benga. Where the confirmation program discovers that an item exceeds the values presented in Appendix I then Benga will be required to report the necessary mitigation measures and/or recomplete the Noise Impact Assessment to demonstrate how administrative measures will reduce the noise impact of the items to the community. FDI Acoustics notes the table of source sound power levels includes a conveyor belt value per meter of length. FDI Acoustics recommends that in the selection of a conveyor supplier Benga have potential suppliers supply mock-ups or direct Benga to site(s) where the installed equipment is lower or satisfies the noise limitations placed on this item in Appendix I. FDI Acoustics recommends an independent review of the noise emissions of the final design of the conveyor system due to length and exposure of this significant noise source to the community. FDI Acoustics also recommends that Benga employ third party noise emission studies of the proposed coal rail loadout systems as is with the conveyor system the rail loadout facilities are near the community.

As a condition of approval FDI Acoustics recommends that Benga file five-year mine plan noise impact assessments with the AER. This condition will ensure the noise impact assessment reflects the operations and the equipment at the mine. Should a noise complaint occur after start-up, FDI Acoustics recommends that Benga report the complaint to the AER along with the action plan to address the complaint.

Questions regarding this review may be addressed to the writer.

Sincerely

FDI Acoustics Inc.

<Original signed by>

James Farquharson, CET, INCE

JAMES G. FARQUHARSON, C.E.T., INCE

Principal, FDI Acoustics Inc.

PROFESSIONAL EXPERIENCE

Mr. Farquharson has 30+ years of experience with environmental noise issues. His experiences in the mining sector include ambient (baseline) noise monitoring surveys, compliance noise monitoring surveys, mining noise impact assessments, transportation noise modeling, rail terminal assessments, heavy haul equipment assessments. His experiences in the mining sector are augmented with experience in aggregate operations assessments and noise control coupled with construction noise assessment and noise control. His career has included assessments for project proponents as well as representing the interests of intervening parties on environmental noise issues. These diverse experiences give him a unique perspective in the evaluation of environmental noise issues. Mr. Farquharson is known for his practical approach to environmental noise issues.

FDI Acoustics Inc President	July 2008 – Present
Faszer Farquharson & Associates Ltd. Principal	March 1998 – July 2008
Patching Associates Acoustical Engineering Ltd. Senior Acoustical Consultant	February 1995 – February 1998
HFP Acoustical Consultants Ltd. Project Consultant	March 1989 – February 1995
James Farquharson, CET Oil & Gas Production Consultant	November 1988 – February 1989
Dresser Canada Inc. Technical Account Representative	July 1980 – October 1988

MEMBERSHIPS AND PROFESSIONAL AFFILIATIONS

Institute of Noise Control Engineers, Member (INCE)
The Association of Science and Engineering Technology Professionals of Alberta (ASET)
Society of Petroleum Engineers (SPE), Life Member
Canadian Acoustical Association

SELECTED PROJECT EXPERIENCE

- Project Principal – Noise Impact Assessment, Bow City Power Plant and Bow City Thermal Coal Mine, Bow City Power: Principal consultant for acoustic issues with regards to a proposed thermal coal mine development and thermal generating station. The project included an examination of the ambient noise environment, mining operations noise impacts over the project lifetime and the noise impact of the thermal generating station and associated carbon dioxide capture development.

- Project Principal – Noise Impact, Calgary Blue Line Extension Functional Planning Study, WSP Canada: Principal consultant for acoustic issues with regards to the project. The project included rail and traffic noise modelling to communities adjacent to the alignment. The modelling included the examination of mitigation measures where the results of the initial modelling indicated that predicted sound levels would exceed The City of Calgary Surface Transportation Noise Policy.

- Project Principal – Comprehensive Sound Survey, Highvale Mine, TransAlta Utilities: Principal consultant for a comprehensive sound survey for mining operations at the Highvale Mine. The project included a multiple day noise monitoring survey at multiple residences near the thermal coal mine to determine if the operations complied with the Permissible Sound Levels of the Alberta Energy Regulator (AER) Directive038, Noise Control.

- Project Co-Principal - Environmental Noise Impact Assessment, Genesee Mine, EPCOR: Project Principal for mining equipment noise measurement and assessment. Efforts included the assessment of noise from mining operations and the development of noise control measures suitable for mining equipment.

- Expert Witness – Friends of Lamont County, Alberta Sulphur Terminals, Sulphur Forming and Shipping Facility, Bruderheim, Alberta: Provide review and representation on environmental acoustic issues to an intervening party with respect to a proposed rail loading facility. The project included environmental noise impact assessment review, background sound monitoring surveys, study area review and responses to questions from the project applicant and the Natural Resources Conservation Board. The project culminated in a multiple day public hearing in which Mr. Farquharson presented oral testimony regarding his findings.

- Co-Chair – Measurement and Modelling Technical Subcommittees and Review Committee Member Alberta Energy & Utilities Board (now known as the Alberta Energy Regulator), Noise Control Directive 99-8 Review. Co-Chaired two subcommittees each tasked with developing revisions to Directive 038. The subcommittee membership included participants from the regulator, professionals with an interest in the subject, academia, and the public. Recommendations from the subcommittees were presented to the review committee for discussion and submission to the regulatory body. The efforts of the committees resulted in the most comprehensive review of the regulation since coming into effect in 1988.

Benga Mining Limited

Proposed Grassy Mountain Coal Project

Critique of Evidence Related to Socio-Economic Effects and Economic Benefits

1. Introduction

The decision as to whether the Application by Benga Mining Limited to construct and operate a mine producing 4.5 million tonnes of coal per year at a location within the Municipal District of Ranchlands and the Specialized Municipality of Crowsnest Pass in southwest Alberta will ultimately depend on the evidence received and reviewed by the Joint Review Panel pertaining to adverse environmental effects and project benefits. In order to make the correct decision, it is incumbent upon the Panel to ensure that it has correct and accurate information about Project effects. The purpose of this analysis is to review the Applicant's evidence related to socio-economic impacts and Project benefits to ensure that Panel has a clear and accurate understanding of what these effects will be. This analysis focuses on two aspects of the Application. These relate to evidence related to Project benefits and economic impacts and evidence related to population changes and the resulting socio-economic effects.

2. Project Benefits

2.1 The Need to Describe Project Benefits

Section E.11 of the Application notes that the AER Final Terms of Reference for the socio-economic assessment call for:

8.2 [A] Describe the socio-economic impacts of construction and operation of the Project including:

a) impacts related to

ii. regional and provincial economic benefits

2.2 The Applicant's Description of Project Benefits

In its application, Benga describes the benefits of its project as follows (Section A.2.7 of Volume 1 on Pages A-6 and A-7):

> *The Project will create economic benefits for a significant portion of the local and regional population. In concert with its environmental responsibilities, Benga, through the development of the Project, will drive major economic development, employment and community benefits for the local region and neighboring Aboriginal Group communities.*
>
> *Development of the Project will provide the following benefits:*
>
> - *receipt of revenue in the form of production royalties, licence fees and taxes by municipal, provincial and federal governments;*
> - *a material diversification of revenue for both the municipal and provincial governments given the limited metallurgical coal developments in the Crowsnest Pass and Alberta;*

- *material economic development in southwest Alberta, an area that is trailing the remainder of Province economically;*
- *use of goods and services provided by local, regional and provincial contractors and retailers;*
- *opportunities for Alberta and Canadian (with a focus on the local public and Aboriginal Groups) engineering firms, contractors, manufacturers and suppliers to compete in the supply of goods and services;*
- *employment which includes skilled, well paid, full time positions; and*
- *development of the Project in an environmentally responsible manner and one that allows the full rehabilitation of the Grassy Mountain area at the conclusion of the project in a fashion that is much more sustainable long term than prior mining in the area has currently left it.*

Unfortunately, Benga has chosen not to quantify these effects in Section A.2.7 of Volume 1 in a way that would allow the Panel to conclude whether project benefits are of significant magnitude to be able to justify any adverse effects.

This deficiency was partly addressed in Benga's August 2020 submission, with Section 6.0 of that document describing project benefits. This assessment quantified the total impacts (direct, indirect and induced impacts of construction and operation in Alberta and BC in terms of effects on GDP, labour income and employment. It also described annual property tax payments to the Municipal District of Ranchland #66 and the Specialized Municipality of Crowsnest Pass as well as annual total payments of provincial and federal taxes and provincial royalties. In that document it asserts:

> *To put it plainly, the Project will result in overall positive economic and fiscal effects within the regional study area, including the Municipality of Crowsnest Pass, the Municipal District of Ranchland #66, as well as to the neighbouring communities of Sparwood, Elkford and Fernie in British Columbia.*

However, aside from describing property tax revenues to regional governments in Alberta, there is no quantification of regional effects on employment or labour income at a regional level.

2.3 Review of the Applicant's Evidence

After careful consideration of the Applicant's evidence, including the socio-economic impact assessment (presented as Consultant Report #11) from which the benefit estimates were derived, there are a number of reasons why the information in the socio-economic portion of the application does not clearly or accurately portray the benefits of the project. These reasons are as follows:

1. The measures of project benefits contained in the socio-economic assessment are a combination of economic impacts and economic benefits, and this can cause significant confusion in interpretation.
2. There is no discussion about the reliability of the estimates.
3. There is insufficient information about the methodology used to estimate project impacts for the validity of the estimates to be verified.
4. The impact indicators that were used double count project effects.
5. The methods used to present some benefit indicators misrepresent actual effects.

The rationale for these conclusions is presented below.

2.3.1 Confusion between Impacts and Benefits

Despite the fact that the terms of reference for the socio-economic assessment call for an assessment of regional and provincial economic benefits, the assessment provides estimates of economic benefits and impacts which are different measures of economic activity. Because they represent net additions to Alberta income, the estimates of income taxes, property taxes and royalties produced by the Applicant represent benefits of the Project. However, the measures of GDP, labour income and employment reported in the Socio-Economic Assessment (Consultant Report #11 of Volume 7 of the Application), which include direct, indirect and induced effects associated with Project spending, are economic impacts that show how this spending would flow through the provincial economy (distributional effects). Thus, economic flows (impacts) are not necessarily benefits and should not be considered as such.

There has been considerable confusion over the difference between economic benefits and economic impacts and how this information is used in public interest decisions. In the case of the Northern Gateway project, various intervenors argued that the description of the project's economic impacts being described as benefits was incorrect and the Joint Review Panel agreed and then requested that the proponent undertake a project benefit/cost analysis in order to understand the net economic benefits of the project, but in its decision the Panel still used the description of project impacts as being the benefits of the project. In the case of the Trans Mountain pipeline expansion, interveners again argued that impacts were being improperly cast as benefits, but the Joint Review Panel explained that this was a standard approach and no further economic analysis was required.

The issue appears to lie in terms of how economic impact measures are being interpreted. The source of information used to estimate economic impacts is the 2015 versions of Alberta Economic Multipliers produced by Alberta Treasury Board and Finance[1]. This document explains that economic multipliers are derived from input-output models of the provincial and national economy as produced by Statistics Canada and says:

> I/O models are based on tables that describe the flow of commodities through the economy from producers in one industry to another industry, and to final demand.

Thus, the models are able to show direct effects, such as hiring someone to construct a project, indirect effects, such as the employment of people to make the materials used in construction, and induced effects, which occur when people directly or indirectly employed by the project spend their money on consumer goods and services.

The Alberta Treasury Board and Finance report also notes the following caveats and limitations about I/O tables and the resulting multipliers:

1. *The relationship between industry inputs and outputs is linear and fixed, meaning that a change in demand for a commodity or for the outputs of any industry will result in a proportional change in production. The model cannot account for economies/diseconomies of scale or structural changes in production technologies, an assumption which does not necessarily hold in the actual economy.*
2. *Prices are fixed in the model.*

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1 Available at https://open.alberta.ca/publications/alberta-economic-multipliers

3. *I/O models reflect industry averages for technology use and average input costs. For these and other reasons, an I/O model will not provide a totally complete or absolute measure of the impact of economic change.*
4. *I/O models are static and do not take into account the amount of time required for changes to happen.*
5. *There are no capacity constraints, and all industries are operating at capacity. This implies that an increase in output results in an increase in demand for labour (rather than simply re-deploying existing labour). It also implies that there is no displacement that may occur in existing industries as new projects are completed.*

The question of whether impacts can be considered benefits must be examined in the context of these caveats and limitations.

When can economic impacts be considered benefits? While the answer ultimately depends on the size of the shock (the investment or purchase) and whether or not the economy is operating at full capacity, the answer is usually no. In the case of construction workers (direct employment), labour income is both a project cost and an employment benefit and they would offset each other, resulting in no net increase in provincial activity. There would only be benefits if these workers were otherwise unemployed or under-employed but, as noted in caveat #5, the model assumes that all industries are operating at full capacity so that an increase in demand would result in all new construction jobs, whereas the reality is that construction workers would redeploy from one project to another. Under present conditions, it might be reasonable to assume that 15% of direct project construction labour costs could be considered benefits. In an economy operating at near capacity, project employment could actually represent a net total cost if project demands caused labour shortages that then drive up the cost of labour for all construction projects but this cannot be predicted by the model because it assumes all prices remain fixed (caveat #2).

Indirect impacts can also not be considered benefits in most cases. Purchases of the goods and services needed to support project construction or operation will not necessarily cause an increase in the production of those goods and services (an economic expansion). For example, the required goods may already have been produced and are sitting in inventory awaiting purchase. Alternatively, if the project had not purchased those goods and services, they may have been purchased by someone else. These effects cannot be predicted by the I/O model because, as noted in caveat#1, the model assumes that a change in demand results in a proportional change in production, regardless of the fact that it may make some time for changes in output to occur (caveat #4). The model also cannot account for substitution effects where products in short supply might be sourced from another province or country. The question of what level of purchases of goods and services might support an economic expansion (a benefit) requires information about capacity constraints and substitution effects that is simply not available.

Induced effects are also not considered to be benefits because, in the absence of the project, people would have been employed elsewhere or receiving unemployment benefits and would have been spending money on consumer products and services anyway. Additional spending on consumer products or services would only occur if there was an overall increase in income, and the model cannot determine this because it assumes that the price of labour remains fixed (caveat #2).

What economic impacts can be considered benefits? Operational employment can be considered a benefit because these are new jobs. Although these jobs can be filled by redeployment of other workers, this would subsequently create vacancies for others such that eventually some unemployed people would become employed. Operational labour income can be considered a benefit for the same reason. And as noted previously, income and property tax payments and royalties can also be considered benefits. But there are very limited circumstances under which indirect or induced effects or direct construction effects can be considered benefits and the Panel should be cautioned not to considered these effects in its understanding of project benefits.

2.3.2 Reliability of Impact Estimates

The assessment of economic impacts is based on information provided by Benga related to the cost of construction ($730 million ($2015)) and annual cost of operation ($225 million (2015$)). These numbers were provided in the initial application and were reaffirmed in the response to information request 6.3 in CIAR #313. These are just estimates however, and have likely been developed in the context of a standard engineering cost estimation classification system. An example of one such classification system from the Association for the Advancement of Cost Engineering (AACE International, 2005)[2] is provided below.

This shows that there is considerable expected variability in the cost estimates depending on how well project engineering has been defined. Projects engineered at a conceptual level (Class 5) have a very high range of variability in cost accuracy (-50% to +100%) while projects engineered at a feasibility level (Class 4) have a smaller but still relatively large variability in cost accuracy (-30% to +50%).

	Primary Characteristic	*Secondary Characteristic*			
ESTIMATE CLASS	**LEVEL OF PROJECT DEFINITION** Expressed as % of complete definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical variation in low and high ranges [a]	**PREPARATION EFFORT** Typical degree of effort relative to least cost index of 1 [b]
Class 5	0% to 2%	Concept Screening	Capacity Factored, Parametric Models, Judgment, or Analogy	L: -20% to -50% H: +30% to +100%	1
Class 4	1% to 15%	Study or Feasibility	Equipment Factored or Parametric Models	L: -15% to -30% H: +20% to +50%	2 to 4
Class 3	10% to 40%	Budget, Authorization, or Control	Semi-Detailed Unit Costs with Assembly Level Line Items	L: -10% to -20% H: +10% to +30%	3 to 10
Class 2	30% to 70%	Control or Bid/ Tender	Detailed Unit Cost with Forced Detailed Take-Off	L: -5% to -15% H: +5% to +20%	4 to 20
Class 1	50% to 100%	Check Estimate or Bid/Tender	Detailed Unit Cost with Detailed Take-Off	L: -3% to -10% H: +3% to +15%	5 to 100

Notes: [a] The state of process technology and availability of applicable reference cost data affect the range markedly. The +/- value represents typical percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50% level of confidence) for given scope.
[b] If the range index value of "1" represents 0.005% of project costs, then an index value of 100 represents 0.5%. Estimate preparation effort is highly dependent upon the size of the project and the quality of estimating data and tools.

2 AACE International Recommended Practice No. 18R-97 COST ESTIMATE CLASSIFICATION SYSTEM – AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION FOR THE PROCESS INDUSTRIES TCM Framework: 7.3 – Cost Estimating and Budgeting. Available at: https://www.costengineering.eu/Downloads/articles/AACE_CLASSIFICATION_SYSTEM.pdf

There is no information in the Application as to whether the cost estimates used as the basis for estimating economic impacts represent a Class 5, Class 4 or even Class 3 cost estimate, And, in the absence of this information, it is not possible for the Panel to understand whether the cost information which forms the basis for the entire assessment of project benefits and economic impacts is of sufficient reliability to support the conclusions presented in the application.

While there is some uncertainty in the cost estimates used as the starting point for the analysis, the use of standardized multiplier coefficients to estimate project impacts adds to this uncertainty. Economic multipliers represent a standardized way of showing how the effects of an investment in any given industry or a particular commodity would be distributed through provincial and national economies in terms of direct, indirect and induced effects. The multipliers are derived from analysis of the input-output tables developed by Statistics Canada and reflect conditions for the specific year that the model was derived. However, the published multipliers for selected industries reflect an industry "average" that is based on industry activity in the base year of the model.

This is particularly problematic for the various construction industries because there is no way of knowing whether the spending profile for a proposed project actually matches the industry average spending profile for that particular year. For example, the published multipliers for the "Oil and gas engineering construction industry" in any given year could reflect construction of an oil sands plant, a gas transmission line, or a petrochemical plant, or some combination thereof, so that the resulting average is not reflective of any specific type of project. Thus, use of the published multipliers to estimate project effects may substantially increase the uncertainty inherent in those estimates.

This is further complicated by the fact that, for some industries, such as the coal mining industry in Alberta in 2011 (which was used in this analysis), the multipliers were derived using such a small data set that certain multiplier estimates were withheld due to concerns over confidentiality. In this case, Table 2 of the Alberta Economic Multipliers for 2011, which describes the relationship between direct and indirect impacts, shows no multipliers for the coal mining industry. Thus, published multipliers are incomplete, and there is no way of knowing whether the direct effects of operating coal mines in Alberta reflect the proposed direct effects of operating the proposed mine, thereby adding to uncertainty.

It should be noted that the Applicant did submit additional evidence regarding total project impacts (direct, indirect and induced) in Information Response 6.3 of Addendum #11 (CIAR #313). Impact estimates were derived using the 2016 Statistics Canada Input/Output model using the same project cost data and the new results are compared with the estimates contained in the original submission (Consultant Report #11 of Volume 7 of the Application (CIAR #42)) in the tables below.

	Alberta			**BC**		
Construction	**2011**	**2016**	**Change**	**2011**	**2016**	**Change**
GDP (millions)	$225	$265	18%	$56	$70	25%
Labour Income (millions)	$150	$192	28%	$45	$49	9%
Employment (person-years)	1215	1660	37%	810	475	-41%

Operations	Alberta			BC		
	2011	2016	Change	2011	2016	Change
GDP (millions)	$99	$95	-4%	$27	$38	41%
Labour Income (millions)	$42	$62	48%	$12	$27	125%
Employment (person-years)	640	610	-5%	410	250	-39%

This comparison shows huge variability in the economic impact estimates, despite the fact that they were derived using the same cost information, and demonstrates the additional uncertainty that using multiplier coefficients adds to the variability inherent in the construction and operating cost estimates. Furthermore, the use of total multipliers means there is no way of knowing whether the observed changes in economic impacts are due to differences in the direct, indirect or induced effects, making it impossible to identify possible reasons that might explain the differences.

The only way of reducing uncertainty associated with the use of multipliers to estimate impacts is to undertake custom runs of the Statistics Canada input-output model using actual construction and operating cost data for the project. This was not done in this case, so there is expected to be considerable uncertainty in the impact assessment estimates contained in the Application.

2.3.3 Lack of Transparency Resulting in the Inability to Replicate Calculations

Another key methodological issue is that, based on the information contained in the socio-economic report, it is not possible to replicate the results contained in the Application based on the information available. The estimates of project impacts on income, for example, for both construction (Section 4.3.1 of Consultant Report #11 of Volume 7 of the Application) and operation (Section 4.3.2) note that these impacts are estimated using published statistics, which appear to come from source AF 2015, the 2011 Alberta Economic Multipliers which were published by Alberta Treasury and Finance in 2015. This report provides economic multipliers for various industries and commodities and are based on the results of the 2011 Input-Output Tables produced by Statistics Canada. A key task in using these tables is to select the multipliers for the correct industry or commodity. This is relatively easy for the operation phase because coal mining is listed as one of the industry codes (BS21210) used in the input-output tables. This is not the case however, for coal mine construction. The input output tables contain nine industry categories related to construction and these are listed below.

BS23A00 Residential building construction
BS23B00 Non-residential building construction 0
BS23C10 Transportation engineering construction
BS23C20 Oil and gas engineering construction
BS23C30 Electric power engineering construction
BS23C40 Communication engineering construction
BS23C50 Other engineering construction
BS23D00 Repair construction
BS23E00 Other activities of the construction industry

None of these relate to coal mine construction, so the question becomes which industry category or categories were used select the multipliers for estimating project effects on labour income, GDP or employment? This is not clearly explained in the application so it is impossible to ascertain whether the project effects for construction provided in the application were appropriately calculated.

In an attempt to determine which industry multipliers were used, the total labour income effects during construction ($150 million) in Alberta were compared with total construction spending in Alberta ($336 million – see Table 4.1) and this suggests a total multiplier of 0.446, which does not match any of the total multipliers contained in Table 5 (Alberta Total Multipliers – Industries) from AF 2015. In fact, the published multipliers were typically in excess of 0.500, with the exception of the range of the “Electric power engineering construction” and “Communication engineering construction” industries, which are lower and clearly not relevant to construction of a coal mine. An examination of the revised total project impacts (direct, indirect and induced) in Information Response 6.3 of Addendum #11 (CIAR #313) also shows that numbers presented in that document did not match any of the 2016 construction industry multipliers. So based on this information, it is not evident how the economic impacts of project construction were estimated and so the accuracy of the estimates in the application cannot be validated.

In situations where a proposed project cannot be readily classified into one of Statistics Canada’s industry classifications, the use of industry multipliers is not appropriate, unless spending can be apportioned among the various categories, so customized runs of the input-output model using detailed expenditure information must be undertaken to correctly estimate project effects.

2.3.4 Failure to Estimate Operational Effects using Revenues Rather Than Expenditures

The information contained in the application related to the impacts of coal mining operations appears to be incorrectly estimated. Based on annual expenditures in Alberta of $120 million per year during operations (Table 4.2) and estimates of total annual impacts on GDP of $99 million and $42 million in labour income, the estimated total multipliers would be 0.825 for GDP and 0.350 for labour income. These closely match the total multipliers for the coal mining industry in Alberta as per Table 5 (Alberta Total Multipliers – Industries) from AF 2015, which are 0.815 for GDP and 0.352 for labour income. Similarly, the revised total project operating impacts (direct, indirect and induced) in Information Response 6.3 of Addendum #11 (CIAR #313) suggest multipliers that closely match (but not exactly match) the 2016 Statistics Canada multipliers.

The problem is however, that the published industry multipliers relate to the value of industry output (i.e. revenues), not expenditures, which appear to have been used to estimate effects. Using an expenditures-based approach would preclude consideration of the operating surplus (earnings before interest, taxes, depreciation, and amortization). In this case, a coal mine producing 4.5 million tonnes of coal per year at $140CDN per tonne would have revenues of $630 million and the total economic effects should have been calculated using this number.

Using the expenditure-based approach to calculated impacts creates other problems. At first glance it would appear that the revised total project impacts (direct, indirect and induced) in Information Response 6.3 of Addendum #11 (CIAR #313), which shows total employment impacts of 610 person-years in Alberta, closely match the estimates produced using 2016 Statistics Canada multipliers, which suggests total employment impacts of 648. However, the direct employment effect calculated using the 2016 Statistics Canada multiplier suggest that there would be 260 mine jobs, and this is much lower than the 385 jobs that Benga is claiming as direct employment.

So, in examining these numbers, it is evident that the estimates were not simply derived using published industry multipliers and, without having a lot more detailed information as to how the impact estimates are derived, the Panel should not have any confidence in the veracity of the impact numbers in the application.

2.3.5 Inconsistent Use of US and Canadian Dollars in the Analysis

An additional serious issue arises in the analysis of operating impacts. While the economic assessment assumed a coal prices of $140 CDN per tonne (see Section 4.4.2), however, Benga's responses to Information Request 6.3 in CIAR #313 relates to its price assumption of $140US per tonne, and its sensitivity analysis of US$100 per tonne and US$200 per tonne. Clearly there is some confusion about whether the socio-economic assessment even used the correct price information to estimate impacts. At a current exchange rate of $0.7CDN per $1US, the annual project revenues would be $900 CDN million, not $630 million.

2.3.6 Incorrect Accounting of Construction Employment

In Section 4.5 of the Socioeconomic Assessment (Consultant Report #11), the Applicant notes that there would be 845 person-years of on-site construction employment over the two years of construction, and that there would be an average of 120 people employed at any one time, peaking at 195 workers during the sixth quarter of the construction schedule.

If an average of 120 people is employed during each quarter for two years, then this would total 240 person-years, not 845. In order to have 845 person-years, you would have to have an average of 420 people working for two years. This is 3.5 times the number claimed. Due to this error, the size of the construction camp would have to be increased substantially, and the potential impacts of a much larger workforce on the nearby community could become adverse and significant.

2.3.7 Inconsistencies in Cost of Labour

Another problem is that estimates of average labour income per person-year of employment reported in the analysis are much lower than would be suggested by the multipliers for the coal mining industry. The analysis reports total labour income impacts of $42 million per year in Alberta (Section 4.3.2) and total employment impacts of 640 person-years (Section 4.5.8), which suggests an average of $65,600 per person year. However, according to the total employment multipliers for the coal mining industry from Table 5 of Alberta Total Multipliers – Industries(AF 2015), every $1million in output would produce $352,000 in labour income and 3.8 person-years of employment (the multiplier coefficient for employment is 0.038 jobs per $10,000) suggesting an average of $92,630 per person-year, a 40% difference. Thus, there is no consistency between the results of the impact assessment presented in the application and the published multiplier coefficients upon which the analysis is supposed to be based.

An additional problem occurs in the updated analysis presented in Information Response 6.3 of Addendum #11 (CIAR #313). This suggests $62 million in labour income in Alberta for 610 person-years of employment, or an average of $101,640 per person-year, and $27 million for 250 PYs in BC, for an average of $65,850 per person-year. So, the numbers suggest that workers who decide to live in BC would be earning 35% less than their Alberta counterparts. This is clearly incorrect, and shows the inconsistencies in how labour costs are considered.

2.3.8 Double Counting

The socio-economic assessment describes project impacts and benefits using a number of monetary indicators including:

1. Effects on GDP
2. Effects on labour income
3. Effects on provincial royalties
4. Effects on municipal property taxes
5. Effects on provincial and federal income taxes.

According to Statistics Canada[3], GDP at basic prices (which reflects the multipliers using in the 2011 Alberta Multiplier Tables) includes:

- wages and salaries, supplementary income and mixed income (which together represent labour income),
- taxes and subsidies on production (which includes municipal property taxes and natural resource taxes and licences), and
- operating surplus, which represents earnings before interest, taxes, depreciation and amortization.

With the measure of GDP effects inherently including all of the other effects, listing GDP as well as the other effects as benefits means that the Applicant is actually double counting. The Panel is advised to consider this when interpreting which of the listed benefits can be considered as actual benefits.

2.3.9 Misrepresentation of Effects

While the socio-economic assessment provided as Consultant Report #11 in Volume 5 of the Application describes most project impacts in terms of annual average impacts during operation, it describes the Project's fiscal effects (Section 4.4.2) in terms of the sum total of all future royalty and income tax payments to the provincial government over the operating life of the project in terms of their total present value (PV). The use of PV, which involves discounting the sum total of all future values to their present value equivalents, is typically used in benefit/cost analysis which, as noted previously, is very different from economic impact assessment. The use of PV to describe fiscal effects results in very large numbers. However, these numbers should not be used by the Panel in its interpretation of project benefits because they are inconsistent with the approach used to characterize other project effects and, unless actually being used in a benefit/cost analysis, the PV estimate describes a situation that cannot occur: fiscal effects are paid annually whereas the PV approach shows the total value if all future taxes and royalties are paid at once.

It is noteworthy that whereas the original Application did not contain information on the average annual royalty and tax costs that would be paid during operation, the annualized values are described in the response to Information Request 6.3 in Addendum #11 (CIAR#313). However, as was noted previously, these estimates are based on coal rates expressed in US dollars, while the original estimates appear to have been based on coal prices expressed in Canadian dollars and the fiscal effects are expressed in 2019$ whereas all other impact estimates are expressed in

3 Statistics Canada 2013. Estimating Economic Impact. Workshop presentation made by Andreas Trau in Edmonton on September 25, 2013.

2015$. This use of different currencies and different base years to describe project impacts further adds to the uncertainty inherent in the analysis, adding to the lack of confidence in the validity of the estimates of project impacts and benefits.

2.4 Summary of Findings Related to Economic Benefits

Our analysis shows that the Applicant's evidence shows that there is insufficient reliable information for the Panel to be able to conclude that there would be large or significant regional or provincial economic benefits. The analysis does not describe Project benefits, but instead confuses benefits with impacts, such that the so called "benefits" have been mischaracterized or misinterpreted and are misleading in the context of understanding the Project's economic effects. Furthermore, since the results of the analysis cannot be replicated, are based on assumptions that have not been made apparent, and contain inconsistent information, the Panel does not have sufficient reliable information to understand the nature or magnitude of the Project's economic benefits.

2.5 Failure to Consider Opportunities for Enhancement of Benefits

The practice of preparing environmental impact assessments has typically focused on identifying potential adverse effects and then developing mitigation strategies to ensure that these effects are not significant. For socio-economic impacts however, the effects can be positive, or adverse and positive at the same time, and there are opportunities for applicants to adopt strategies that would enhance positive effects, especially at the regional level. While the socio-economic assessment claims that the project "will create employment opportunities at both the regional and provincial population level"[4] there is no quantification of the extent of these regional effects nor is there any information about the Applicant's future commitments to ensure these regional effects actually occur.

A review of the 2016 Census[5] indicates that there are significant opportunities for the Applicant to improve regional economic conditions. For example, there is a small Aboriginal[6] population in Crowsnest Pass (395 people or 7% of the population) and they are:

- younger than the general population (average age of 34.7 years compared to 45.8 years for the general population),
- more likely to participate in the labour force (labour force participation rate of 63.6% compared to 59.2% for the general population)
- more likely to be unemployed (unemployment rate of 20% compared to 8.8% for the general population)
- had lower incomes (an average income of $42,632 compared to $51,491 for the general population)
- lower levels of training in the trades (9.1% had an apprenticeship or trades certificate or diploma compared to 13.6% of the general population)

4 See Section 4.5.9 of Consultant Report #11 of Volume 7 of the Application (CIAR#42).

5 Aboriginal Population Profile, 2016 Census, for Crowsnest Pass https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/abpopprof/details/page.cfm?Lang=E&Geo1=CSD&Code1=4815007&Data=Count&SearchText=Crowsnest&SearchType=Begins&B1=All&C1=All&SEX_ID=1&AGE_ID=1&RESGEO_ID=1&TABID=1

6 This is the terminology used by Statistics Canada.

Had the Applicant done a more comprehensive investigations of socio-economic conditions in the region, it could have recognized opportunities for enhancing potential Project benefits by committing to providing training for this segment of the population. A similar analysis could have been done on the basis of gender to identify potential opportunities to enhance regional benefits.

In the absence of a strategy to encourage regional participation in the labour force and to facilitate procurement of goods and services from local and reginal businesses, it is unclear as to how the Applicant will achieve any of the regional benefits it is claiming to support its Project.

2.6 Lack of Clear Direction for Describing Project Benefits and Economic Impacts

A large part of the problem in this application and in many other applications is that while the Guidelines contain a clear requirement to describe a project's economic benefits, there are no clear directions as to how this should be done. There are no clearly stated or consistent guidelines or rules for describing or quantifying economic benefits and a review of recent practice shows that different agencies use different practices and that even panels constituted under the same legal authorities have sometimes used different economic metrics to describe project benefits, leading to considerable confusion and what can only be described as "misleading". This needs to be addressed in future. Perhaps Canada should consider what the United States has done, with the USA Environmental Protection Agency have produced a set of guidelines for preparing economic analysis.[7] This document describes best practices for both benefit/cost analysis and economic impact analysis, and provides direction on when these two different approaches should be used.

3. Population and Other Socio-Economic Effects

3.1 Applicant's Information

According to Consultant Report #11 of Volume 7 of the Application which is the basis for the description of Project effects on the population in the region, the project would create 385 new direct jobs during operation (Section 4.5.5). It also shows that Project operation would result in a net population increase of 810 people, consisting of 490 in-migrants assumed in Alberta portion of RSA and 320 in the BC portion (Sparwood) (Section 5.3.1.2). According to Table 5.2 of that document, the population of the Alberta portion of the RSA is expected to increase from 5,108 in 2021 under the Base Case to 6,230 in 2021 under the Application Case for an increase of 1,122, while the population of the BC portion would increase by 662. Based on this population increase it was estimated that 168 new houses would be required in the Alberta portion of the RSA and 109 in the BC portion (Section 6.3.2). Project impacts on population are considered to be low and insignificant (Section 5.5) as would be effects on housing (Section 6.5).

The population information was amended in Addendum #5 of the Application (CIAR #69) to reflect new population information generated by the 2016 census. The revised information showed a population of 5,470 in 2021 for the Alberta portion of the RSA under the Base Case to 6,130 in 2021 under the Application Case for an increase of 633 (half the previous estimate), while the population of the BC portion would increase by 430. It was noted in the response that

7 USEPA. 2016. Guidelines for Preparing Economic Analysis. Available at: https://www.epa.gov/environmental-economics/guidelines-preparing-economic-analyses

the direction and magnitude of these population effects are generally in line with those provided in the filed application. The estimates of demand for housing were not changed as a result of the revised population estimates.

The population effects were revised again in October 2018 (Section 12 of Addendum #8, CIAR 89). This version showed a population of 5,108 in 2021 for the Alberta portion of the RSA under the Base Case to 5,691 in 2021 under the Application Case for an increase of 660, while the population of the BC portion would increase by 428.

3.2 Problems with the Applicant's Information

There are some critical problems with the Applicant's information related to population effects and demand for housing.

3.4.1 Employment of Local Residents during Operations

Based on the Applicant's assertion that there would be 385 operational jobs and 810 in-migrants, it is unclear how many of these jobs are expected to be filled by existing residents of the RSA. This is never stated although there is a comment (Section 6.3) that "the majority of operations workers are assumed to migrate to the region". However, in Table 4.2 of that report, it is indicated that $15 million in annual labour costs during operations would be paid to Albertans living outside the RSA. Does this then mean that one -third of the labour force or about 130 workers would be Albertans living outside the RSA and that they would be commuting to work, which would then mean living in commercial accommodation where they might be competing with tourists during the summer season? There is no mention of this.

However, when you consider the estimated number of in-migrants per job (810/385= 2.1), which is consistent with the situation in Crowsnest Pass as of 2016 (1.80) and Sparwood (1.97), this suggests that all of the workers would be in-migrants. This means that no existing residents of the RSA would be employed by the Project. A clear statement from the Applicant on the number of existing residents of the Alberta and BC portions who would be hired is needed if the Panel is to fully understand the potential demographic impacts of the Project and how this could affect future demands for municipal services and infrastructure.

3.4.2 Changes in Population

The assertions related to population effects are also unclear. At one point in the initial application the Proponent asserts that Project operation would provide 385 jobs and bring in 810 in-migrants, but Table 5.2 of that document shows a population increase of 1,784 (the difference between the Base Case and the Application Case) with an increase of 1,122 in the Alberta portion of the RSA and 662 in the BC portion. These numbers are 2.2 times higher than the estimated number of in-migrants, with no explanation. While the Applicant subsequently amended the population change to 1,063 (the difference between the Base Case and the Application Case with 633 in the Alberta portion of the RSA and 430 in the BC portion), this is still 30% higher than the estimated number of in-migrants and there is no explanation as to why the population estimate is higher.

The assumptions that all of the workers would be in-migrants to the RSA and that 490 in-migrants will settle in Alberta portion of RSA and 320 in the BC portion are also problematic. First, there is no reason or explanation as to why this 60%/40% split between Alberta and BC was assumed. Why would 40% of the labour force choose to live in the BC portion of the RSA when:

- average monthly shelter costs per owned dwellings were 14% higher in BC (2016 census);
- median dwelling costs were11% higher in BC (2016 census);
- people living in BC have to pay a 7% provincial sales tax while Albertans pay none;
- while workers earning the average estimated annual wage ($45 million/385=$116,883) would pay lower income taxes in BC, any workers earning more than $140,000 per year, such as all project managers and senior employees, would pay much lower taxes in Alberta;
- workers living in Sparwood would have to commute at least 80 kilometres per day and would be likely to pay at least $2500 per year in terms of fuel costs; and
- the nearest major opportunities for shopping are in Alberta (Calgary and Lethbridge) not in BC.

Second, the assumption of a 60/40 split is also problematic in the context of the expected payment of labour income. Table 4-2 shows $35 million in labour costs for Albertans and $10 million for BC but, based on the assumed distribution of labour and number of in-migrants, this would suggest the average labour income per job would be $150,214 for people living in the Alberta portion of the RSA ($35,000,000/233) and $65,789 in BC ($10,000,000M/152). This makes no sense because the calculated average wage in BC is well below the provincial average for the coal mining industry[8].

It should be noted that a considerable number of people working at the coal mines in the Elk Valley in BC have chosen to live in the Crowsnest Pass and commute to work, likely for the reasons noted above. For example, an article related to the Teck's Coal Mountain operation in BC (which is now closed) showed that 72 of the 214 employees (34%) lived in Crowsnest Pass and only 22% lived in Sparwood.[9] A second article indicated that, in 2016, about 200 residents of the Crowsnest Pass were employed by Teck Resources in the Elk Valley.[10] Even this number may be conservative however, because the 2016 Census showed that some 535 residents of the Crowsnest Pass were employed in the mining, quarrying and oil and gas extraction industries, and there were no active coal mines in Alberta in southern Alberta[11]. Thus, available information suggests that a high percentage of workers at coal mines in southeast BC would rather live in Alberta than in BC, despite the proximity of BC communities like Sparwood.

In terms of population effects, the Applicant has stated that the Project impacts on population are considered to be low and insignificant in both the Alberta and BC portions of the RSA. In absolute terms, this might appear to be so: according to Addendum #8 of CIAR#89, there would be a population increase of 1,088 (the difference between the 2021 Base Case and the 2021

8 According to the published multipliers from the 2014 Input/Output Model for BC, workers in the coal mining industry had average labour income of $146,290 per job.

9 Crowsnest Pass Herald, 2016. Pass top lose major employer when mine closes. Available at: http://passherald.ca/archives/160914/index3.htm

10 Doherty, Jeff. 2016. The Case for Coal: The Proposed Open Pit Mine in the Crowsnest Pass. Alberta Venture. Available at: https://www.albertaventure.com/the-case-for-coal-the-proposed-open-pit-mine-in-crowsnest-pass/2/2697

11 Alberta Energy. 2017. Coal and Mineral Development in Alberta Year in Review January 2017. Available at: http://www.assembly.ab.ca/lao/library/egovdocs/2016/aleo/162955_16.pdf

Application Case). However, in relative terms, these increases are huge. The Applicant is suggesting that the 12.9% population increase over a year or two expected in Crowsnest Pass, is not significant, in a community which has not experienced an annual population change of more than 2% in the last 17 years.[12] A similar 12.1% increase is predicted for Sparwood, which experienced an average annual population growth of 0.6% per year between 2011 and 2016. But what if the assumed 60/40 population split is incorrect, especially given the relative advantages of living in the Alberta portion of the RSA as identified above? If all of the proposed population occurred in Alberta, this would represent an expected population increase of 1,088, which would represent a 21.3% increase in the population of the Crowsnest Pass. In either case, a short-term population increase of 12% or more cannot be considered insignificant for communities the size of Crowsnest Pass or Sparwood, especially in terms of the demand for housing, infrastructure or services.

3.4.3 Effects on Housing

In terms of housing, the Applicant has indicated that a total of 277 new housing units will be required (Table 12-6 of Addendum #8 of CIAR#89). It is unclear how this number was derived. With the projected population increase of 1,088 and 277 new housing units being required, this suggests an average of 3.93 new residents per new housing unit. This is hardly in line with current conditions (2016) which saw 2.29 people per dwelling in Crowsnest Pass and 2.15 people per dwelling in Sparwood. The Alberta average is 2.6 people per dwelling. This suggests then that, in order to accommodate the proposed population change, the total demand for housing would be in the range of 475 to 500 units, which would involve some purchase of existing units (although this number is not specified) and some new construction.

It would appear that the Applicant is assuming that in-migrants would purchase about 200 to 225 existing dwelling units in the area. The question is then whether the existing housing would be of interest to the incoming workers and their families? A review of available information suggests that this number is overstated for the following reasons:

- The available housing stock is very old: 70% of housing in Crowsnest Pass and 67% of housing in Sparwood was constructed prior to 1981[13]
- As noted in the Application (Section 6.2.1 of Consultant Report #11 of Volume 7), a considerable portion of housing is in need of major repair. As of 2016, 9% of housing in the Crowsnest Pass and 5% of housing in Sparwood require major repairs.
- Project workers will have much higher incomes that existing residents. The estimated average labour income per job for Project workers ($116,880) is 48% higher than the average employment income reported for full-time workers in Crowsnest Pass and 33% higher in Sparwood.[14]

These statistics suggest that there will be a major mismatch between the housing expectations of the incoming and relatively well-paid project workers and the available supply of housing, especially in Crowsnest Pass. For this reason, it is highly likely that many more than 277 new housing units will have to be constructed. The correct number is more likely to be in the range of 400 new dwellings. And even if 277 proved to be the correct number, the demand for existing

12 Based on annual population estimates for the Crowsnest Pass from the Alberta Regional Dashboard, available at https://regionaldashboard.alberta.ca/region/crowsnest-pass/#/

13 Based on statistics in the 2016 Census.

14 Based on statistics in the 2016 Census.

houses is very likely to push prices up and this could then adversely affect existing residents, a large percentage of whom are considered to have low income[15].

The construction of 400 new dwellings in time for the incoming operational workforce will represent a significant challenge. According to the 2016 Census, 100 new dwellings were constructed in Crowsnest Pass between 2011 and 2016, which suggests an average of about 20 per year, while an average of about 25 new dwellings per year were constructed in Sparwood. So, the construction of 400 new dwellings in two years would be the equivalent of four to five times the normal pace of residential construction. This would severely tax the capability of the local construction industry, especially with mine construction underway at the same time, and could prevent other planned construction projects from proceeding. Assuming a final price of $500,000 per house, including serviced land costs of $100,000, the total value of new residential construction could be in the range of $160,000,000 and could require 540 person-years of labour[16]. Obviously, this is beyond the capacity of the local construction work force so contractors will have to be brought in, but where will they find accommodation: in the project construction camp or local commercial accommodation, where they could be competing for space with tourism?

A related question is who is going to pay the up-front costs for providing this housing? It is unlikely that, without loan guarantees or financial assistance, contractors would be able to secure the investment necessary to start house construction before the mine is up and running.

Are there sufficient serviced lots available? Section 6.3.2 of Addendum #8 (CIAR#89) notes that there were 119 serviced lots available in Sparwood as of 2015 and that Crowsnest Pass had lots that were available to be serviced. But that was five years ago and assuming that residential development in Sparwood continued at the rate of 25 dwellings per year, as was observed between 2011 and 2016, there could be no serviced lots left. So, if new serviced lots need to be brought into play, who is going to pay for the costs of servicing? This would be a huge burden to a municipal government or developer because of the magnitude of development and the time lag between development and cost recovery.

This review of the Applicant's views on potential effects on housing should show that there is considerable uncertainty as to whether these effects will be "not significant", as claimed and the Application fails to recognize that there could be adverse as well as positive effects. There are too many unknowns to say exactly what will happen and this has been acknowledged by the Applicant, which has stated "the settlement patterns of in-migrants is subject to uncertainty and may vary across the RSA as individuals respond to housing availability and affordability."[17] Without careful management, housing could become a huge issue for Crowsnest Pass and Sparwood. The Applicant has committed to ongoing consultations with local governments and addressing "additional housing and land development mitigation measures" as part of "a separate regulatory application for any future development or expansion to the Grassy Mountain Mine project". However, the Applicant needs to be more proactive in resolving housing issues, especially given the magnitude of the investment required. The Applicant's apparent underlying assumption that the market will take care of housing for its employees is unrealistic given the

15 According to the 2016 Census, 11.0% of people living in private households in the Crowsnest Pass and 8.5% in Sparwood are considered to fall below the threshold for low income measures (after tax).

16 Calculated using multipliers for the Alberta residential construction industry from the 2014 Input/Output Table produced by Statistics Canada.

17 Section 6.3.2 Consultant Report #11 of Volume 7 of the application (CIAR #42).

magnitude and timing of new housing demands and the potential for adverse effects on existing residents if things go wrong.

3.4.4 Effects on Social Services

The Applicant's assessment of potential Project effects on social services in the RSA is dependent on its predictions of population effects and its understanding of the availability of social services. There are two problems. One is that, as noted in Section 3.4.2 above, the Applicant's predictions of population change are dependent on its assumed 60/40 split on the in-migrant population between Crowsnest Pass and Sparwood and this might not be the case. Potential effects on social services in Crowsnest Pass could be much larger than predicted if more than 60% of the workforce chooses to live in that part of the RSA. Under the worst case, where all new in-migrants decide to settle in Alberta, there could be a very significant increase in demand for services. The second problem is that the Applicant's understanding of the availability of social services in the RSA is based on information from 2015. It is not known whether conditions have changed since then.

Despite these issues, the Applicant identified the additional social services labour (21 full-time equivalent positions) that would be required to accommodate the additional demands of the Project workforce (see Table 7.2 of Consultant Report #11 of Volume 7 of the application (CIAR #42). It also says:

> *The ability of local service providers to respond in a timely and appropriate manner to increase service demands will be contingent on the availability of increased resources to meet those demands. This includes: increased funding from various levels of government; improved and new infrastructure 9e.g. buildings and equipment) being planned for and built in a timely manner; and the ability to attract and retain additional staff.* [18]

A careful reading of its proposed mitigation strategies (Section 7.4) indicates that it proposes to provide support for its employees, provide financial and in-kind support to local programs and initiatives where appropriate, and working with services providers, government and others to assist in addressing the effects of its project. On this basis, the Applicant concludes that the effects of its Project on social services will be "not significant".

An inherent assumption in reaching this conclusion is that the provincial and local governments will be expected to pay most of the costs of additional manpower and facilities to address the incremental demands of project workers and their families. Benga is assuming that any costs faced by local government will be covered by the predicted increase in annual municipal tax payments, while any costs faced by the provincial government will be covered through revenues in the form of annual royalties and income taxes.

There are some problems with this reasoning. First, it assumes that the provincial government will automatically pick up any additional costs though per capita spending, but this is not necessarily how provincial budgets work. This is especially problematic when the provincial government is downloading some of its financial obligations onto municipal governments. Furthermore, there is a time lag between when the provincial government will be expected to pay for expanding infrastructure and services (prior to commencement of operations) and when it starts to receive the full amount of royalties and income tax payments, which may not be until

18 Section 7.4 of Consultant Report #11 of Volume 7 of the application (CIAR #42).

several years after operations commence. Also, the level of investment required to accommodate the demands associated with a 13% to 21% population increase could easily exceed the budget capacity of the Specialized Municipality of Crowsnest Pass, which only has an annual budget of about $17 million[19].

Second, while municipal governments will also be expected to pay for expanding infrastructure and services prior to commencement of operations, the full amount of property tax payments may not occur immediately, resulting in short term spending issues unless municipal governments use debt financing, which is actually placing a burden on existing municipal tax payers. But more importantly, there is no guarantee that the municipal governments affected will receive municipal tax payments that match their additional costs. There is no mechanism for Sparwood to receive any additional tax revenues from the company, even though it is assumed that 40% of Project-related population effects will occur there. Furthermore, as noted in Section 4.4.1 of Consultant Report #11 of Volume 7 of the Application (CIAR #42), it is expected that the MD of Ranchland #66 will receive 80% of the annual Project municipal taxes while experiencing almost no population effects while the Specialized Municipality of Crowsnest Pass, which will face the burden of costs in the Alberta portion of the RSA will only receive 20%. While the Applicant has indicated the MD of Ranchland #66 was willing to enter into a revenue sharing agreement with the Specialized Municipality of Crowsnest Pass once operations began, this was referenced to discussions in 2013. And, without further details, there is no guarantee that final agreement will ensure that the Specialized Municipality of Crowsnest Pass receives tax revenues commensurate with its increase in costs.

Based on these considerations, it is evident that the Applicant's conclusion that Project effects on social services will be "not significant" is contingent on having the municipal and provincial governments in Alberta make all of the required investments in infrastructure and services in a timely manner. If the Alberta governments are unable to fulfil their expected obligations to social service expansion, the resulting effects on social services may well become significant and adverse, especially in the short term. But the Applicant does not see any such effects as being their responsibility. The Applicant has identified no mechanisms for it to address adverse social service effects or their costs in BC.

3.4.5 <u>Effects on Infrastructure</u>

In Section 8.3.2 of Consultant Report #11 of Volume 7 of the Application (CIAR #42), the Applicant acknowledges that:

> *The additional demand for municipal infrastructure requirements driven by the population increase estimated under the Application Case assumptions will exceed the current and planned levels of municipal infrastructure in Crowsnest Pass but not in Sparwood.*

However, Benga has concluded that the effects associated with the Project-related increase in populations would be "not significant" because it would provide municipalities with adequate warning so the municipalities could undertake the required expansions and upgrades and has offered the service of a municipal planner.

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19 Municipality of Crowsnest Pass Consolidated Financial Statements December 31, 2019. https://www.crowsnestpass.com/public/download/files/118186.

Again, its conclusion of "not significant" is dependent on the actions of municipal governments being able to make the necessary investments in a timely manner. If these investments cannot be made or prove to be insufficient and adverse effects do occur, the Applicant does not see any such effects as being their responsibility.

3.3 Summary

In conducting a socio-economic assessment of any project, population change is usually the driver for understanding potential effects on housing, social services and infrastructure. If the population effects are incorrect, then the assessment of all other effects may also be potentially incorrect. In this assessment, the Applicant assumed a 60/40 split in term of the distribution of population effects during operations between the Alberta and BC portions of the RSA. There was no explanation or rationale as to why this split was chosen. Our analysis suggests that there is no reason to believe that this distribution is correct and it is likely that a much higher percentage of the operating workforce will choose to live in the Alberta side, potentially increasing the population in Crowsnest Pass by as much as 21% over two years. This is a significant and potential adverse effect, as could be the resulting effects on housing, social services and infrastructure. By pointing at the market to solve the potential housing issues and at the provincial and municipal governments to solve social services and infrastructure issues, the Applicant has shown no real interest in attempting to mitigate its effects on the communities. For this reason, it should not be granted the social licence to construct and operate the Grassy Mountain Coal Mine.

4. Conclusions and Recommendations

4.1 Conclusions

The Applicant's evidence with respect to project benefits and economic effects does not make a compelling case for the Project to be found to be in the public interest. The project benefits described in the Application have proven to be mischaracterized (impacts are not benefits) and are misinterpreted, misleading and potentially incorrect. Consequently, the Panel is not in a position to makes draw any conclusions about the nature or magnitude of the Project's economic benefits.

The Applicant's evidence with respect to project effects on population and other socio-economic indicators also does not make a compelling case for the Project to be given social licence to construct or operate the proposed coal mine. By using an arbitrary 60/40 split in term of the distribution of population effects during operations between the Alberta and BC portions of the RSA, the Applicant was able to dilute the magnitude of impacts on each community in order to keep them below thresholds that would be considered significant. For various reasons it is likely that a higher portion of project workers will choose to reside in the Alberta portion of the RSA, potentially resulting in a population increase in the Crowsnest Pass of between 13% and 21% over two years, which is significantly higher than the annual population changes of -2% to +2% observed over the last 17 years. And if these population effects are found to be significant, then so will the resulting effects on housing, social services and infrastructure. The Applicant has offered no tangible support to mitigate any such adverse effects, arguing that the market will sort out any housing issues and that it is the responsibility of the provincial and municipal governments to address social and infrastructure issues.

4.2 Recommendations

Based on these conclusions, it is recommended that the Application be denied pending receipt of additional information related to whether the project is in the public interest (do total benefits exceed total costs) and the commitments the Applicant is willing to make to ensure that socio-economic effects remain not significant. As a minimum, the following additional information is required:

1. A proper benefit/cost analysis should be undertaken. This would examine the flow of benefit and costs over time by comparing with and without the project cases, and use discounting to determine a net present value. The assessment of project costs should include the annualized probability of accidents and malfunctions and their associated costs. The work should be consistent with the Canadian Cost-Benefit Analysis Guide produced by the Treasury Board of Canada[20]. The benefit/cost analysis of the Northern Gateway Pipeline Project, which was submitted to the Joint Review Panel, should be used as an example.
2. Develop a Project economic enhancement strategy whereby opportunities for regional employment and purchasing are identified. The current analysis suggests that no current residents of the RSA would be hired during operations and the Applicant should be required to identify any barriers to participation that may exist related to age, gender, ethnicity, or family structure and provide a strategy that will address these barriers and increase local participation. The Applicant should undertake an inventory of local businesses and their capacity and provide those businesses with a description of its expected demands for goods and services, including specifications, such that local companies can effectively compete for project contracts during construction and operation. A plan for annual reporting on regional employment and procurement would be required.
3. A detailed Project housing strategy needs to be developed on the assumption that housing availability as well as other economic considerations will ultimately determine where workers and their families choose to reside. The housing strategy should include a detailed description of the types of workers the project is expected to attract, their housing expectations, a review of current supply of dwellings and lots (serviced and unserviced), options for addressing demand though new construction and upgrading in one or more communities, the ability of different communities to accommodate this demand in a timely and most-cost effective manner, and the Applicant's commitments for ensuring this strategy is adopted at minimal cost to affected municipal governments. An implementation timeline needs to be identified and should consider a phased in approach where operation workers are accommodated in the construction camp until such time as housing is available. This would include requirements for annual reporting
4. Use the completed housing strategy to prepare a revised assessment of potential social and infrastructure effects that will provide guidance to municipal governments on the size and timing of needed investments in infrastructure and services. The Applicant is expected to work with municipal governments to develop a plan for financially supporting the development of services and infrastructure, including municipal tax offsets for investments made prior to or during the early years of operations.

20 Available at https://www.tbs-sct.gc.ca/rtrap-parfa/analys/analys-eng.pdf

Once this information is submitted, the Panel will be in a much better position to be able to make a public interest determination.

Should the Panel decide that the existing evidence contained in the Application and addressed during the hearing is sufficient to be able to make a public interest determination, it is suggested that the resulting approval contain the following terms and conditions that will ensure that any adverse socio-economic effects on the community are minimized and positive effects are enhanced:

1. Develop a Project economic enhancement strategy as described above and provide annual reports to demonstrate the success of the strategy.
2. A detailed Project housing strategy, as described above, needs to be developed in consultation with potentially-affected municipalities. The Applicant should be directed to assist with financing to ensure that sufficient housing is available in a timely manner and completed with the understanding that any financial investment made at the outset would be recovered through reduced municipal taxes in future years. Annual reporting of housing issues would be required.
3. The Applicant is expected to work with municipal governments to develop a plan for financially supporting the development of serv ices and infrastructure, including municipal tax offsets for investments made prior to or during the early years of operations.
4. Work with Teck in BC to understand the nature of its financial supports to Sparwood and commit to providing similar supports proportional to the size of its workforce that chooses to live there.
5. Insist that a draft of the revenue sharing agreement between the MD of Ranchland #66 and the Specialized Municipality of Crowsnest Pass be tabled with the Panel so that it can ensure revenue sharing proportional to project costs.

It should be noted that there does not appear to be any mechanism by which terms and conditions related to socio-economic conditions can be enforced. Consequently, it would be preferable to have the missing information provided to the Panel before it makes its determination so that most issues have been resolved during the project design/review/approval process. The Panel can also be more specific with respect to the terms and conditions related to managing socio-economic effects. Approving the project at this point in time and then tacking on terms and conditions related to socio-economic effects is no guarantee that they will be successful in ensuring that adverse effects do not occur.

JOHN P. THOMPSON, B.A., M.E.S.

Summary

John Thompson is a resource and environmental economist and Principal of Watrecon Consulting. With more than 40 years of experience, he specializes in assessing the economic, social and human impacts of resource development projects, plans, programs, and policies in western and northern Canada. Although he has spent the majority of his time working as a consultant, he was Senior Economist for Alberta Environment for seven years, spent another seven years as Senior Economist/Social Scientist and Director, Board Reviews, for the Natural Resources Conservation Board (an Alberta regulatory board), and also was a policy analyst researcher for the Alberta Water Research Institute. Since returning to consulting in 2003, John has focused on three main areas of practice: socio-economic and economic impact assessment; ecological economics in support of land use planning in the NWT and Ontario; and water management.

Education

B.A. (Economics), University of British Columbia, 1973.
M.E.S. (Natural Resource Management/Welfare Economics), York University, 1977.

Professional History

March 2003 to date	Principal, Watrecon Consulting

Watrecon Consulting is a sole proprietorship that specializes in assessing the economic, social and human impacts of resource development projects, plans and policies. While Watrecon initially focused on evaluating water issues and projects in the context of the Alberta *Water for Life* strategy, it has participated in wide range of other studies, including socio-economic impact assessments, economic impact assessments and studies of ecological goods and service values. Socio-economic impacts assessments were completed for a proposed heavy oil development near Peace River, a proposed First Nations casino, and a small cross-border sweet gas pipeline. Watrecon also assessed the economic impacts of the Capital Region River Valley implementation plan for the North Saskatchewan River. Most recently, Watrecon complied a socio-economic baseline of the effects that Teck's Cardinal River coal mine were having on the nearby community of Hinton and examined how mine closure will affect these conditions. Watrecon has also undertaken input-output modelling, of projects proposed by Methanex, Pembina Pipeline Corporation and Field Upgrading Limited as part of their applications under Alberta's petrochemical feedstock diversification program. Watrecon recently worked with Anielski Management to assess potential changes in ecological goods and services values that would result from implementation of three proposed projects (flood protection, land reclamation and water quality improvement) in Ontario's Greenbelt. He also conducted a peer review for the Suzuki Foundation of a draft report on research related to Woodland Caribou habitat restoration economics in British Columbia.

August 2013 to September 2017	Senior Resource Economist, Stantec

John worked part-time for Stantec in its Burnaby office, where he provided senior review and mentoring for the socio-economic group, and for the Edmonton office, where he undertook economic modelling studies for clients submitting proposals under Alberta's petrochemical feedstock diversification program. He prepared the economic assessments of proposed LNG projects in BC (PNW LNG, and Kitimat LNG) and associated pipelines (PR Gas Transmission) in British Columbia. He also prepared socio-economic assessments for proposed mines in British Columbia (Blackwater and Sukunka) and Ontario (Stillwater and Premier) and an existing mine in Alberta (Teck Cardinal River). Much of this work involved modeling of the provincial and national economic impacts of proposed projects, using either the Statistics Canada Inter Provincial Input-Output Model, or provincial input/output models.

September 2005 to July 2013	Senior Resource Economist, AMEC Earth & Environmental

John oversaw the operations of the Human Environment Group in AMEC's Edmonton office. The majority of the work involved preparing socio-economic impact assessments of various projects, including shallow gas development on the Suffield National Wildlife Area, EnCana's Borealis Project northeast of Fort McMurray, gold/copper, molybdenum and coal mines in British Columbia, a diamond mine in Saskatchewan, various mines in Ontario, twinning of Highway 63 in Alberta, and Enbridge's proposed Northern Gateway Project, where he appear as an expert witness at the hearings on socio-economic effects and the potential effects of terrestrial and marine oil spills. John was also hired by the Cumulative Environmental Management Association in Alberta to develop socio-economic indicators related to oil sands development and management of the South Athabasca River basin. He also oversaw the preparation of a multi-objective study to evaluate a range of technical options for emissions management at the Trail operations of Teck Metals Ltd.

John also managed and/or conducted numerous water studies in support of Alberta's *Water for Life* strategy. These included preparing a detailed assessment of licensed water allocations and actual water use by six sectors in each of 12 river basins in Alberta and preparing 20-year water demand forecasts and conducting a similar assessment of current and future water use for the two sub-basins in the Beaver River basin. John conducted a review of AENV's Guidelines for Water Conservation and Allocation for Oilfield Injection, prepared a full cost accounting of the capital and operating costs of water management infrastructure owned by Alberta's irrigation districts, and a SWOT (strengths, weaknesses, opportunities, threats) analysis of using economic instruments to manage water quantity and quality. John managed a project where he worked with two professors from the University of Calgary to examine water legislation in five Canadian provinces and seven states to determine how water rights were allocated and the rules regarding inter- and intra-basin transfers. A detailed assessment of current and future water use in each on 12 sub-basins in the North Saskatchewan River Basin was undertaken for the North Saskatchewan Watershed Alliance.

He also completed five studies in the NWT for Aboriginal Affairs and Northern Development and Parks Canada related to the potential creation of protected areas, including the newly established Thaidene Nene National Park Reserve. All of the studies involved assessing the benefits of creating protected areas (environmental and economic) against the costs (lost opportunities for non-renewable resource development), to help identify appropriate protected area boundaries. John has also undertaken ecological economic studies related to the value of fish and wildlife resources, recreational resources, ecological goods and services, and national and provincial parks and protected areas.

August 2008 to December 2009	Policy Analyst, Alberta Water Research Institute

The Alberta Water Research Institute was established in 2007 to coordinate world class and leading-edge research to support Alberta's provincial water strategy, specifically related to safe, secure drinking water supplies, healthy aquatic ecosystems, and reliable, quality water supplies for a sustainable economy. John's role involved reviewing Alberta's water legislation and policies in the context of similar legislation and policies in other jurisdictions to determine opportunities for change and improvement. He was also involved in advising the Institute on water values and pricing and how economic instruments can be used to support provincial water policies.

January 1997 to February 2003	Director, Board Reviews; Senior Economist/Social Scientist Natural Resources Conservation Board

Managed the group responsible for overseeing board review and hearing process. Ensured that reviews were conducted in accordance with legislation (*Agricultural Operation Practices Act* and *NRCB Act*) and assisted Board members in screening requests for reviews under *AOPA*. Other responsibilities included organizing hearings or mediation sessions, analyzing submissions and transcripts, providing written summaries of evidence for decision reports, decision report editing, and ensuring that Board decisions were released according to NRCB protocol. Made numerous presentations to stakeholder groups and others to explain the new procedures under *AOPA*.

Provided technical expertise to the Board by evaluating socio-economic components of applications and conducting cross-examinations during hearings, including Dunvegan Hydroelectric Project, UIS Silica Mine, and Little Bow Project/Highwood Diversion Plan. Supported EUB by evaluating socio-economic components of Cheviot coalmine and Rossdale power project during project hearings. Conducted peer review of benefit cost component of Meridian Dam Feasibility Study for Alberta Environment

June 1994 to January 1997	Senior Manager, Strategic Management Division, Alberta Environmental Protection

- Responsible for Economic Evaluation Team which conducted benefit/cost analyses, social and economic impact assessments, and financial feasibility studies of departmental policies, programs and projects, and provides economic advice in support of policy development and strategic management. Team also conducted multi-objective evaluations in support of departmental resource planning initiatives. Involved in defining sustainable development, resource conservation and biodiversity strategies for Alberta.
- Co-Chair, Timber Valuation Task Force. Responsible for developing standard procedures for valuation of forest resources in Alberta.
- Co-Leader, Other Uses Component, Northern River Basins Study. Responsible for design and implementation of studies to collect information on use of aquatic resources by residents of the Athabasca, Peace and Slave river basins and public presentations of information.
- Received Premier's Award of Excellence (Gold) for work as part of Fort McMurray Oil Sands Review Team in 1998.

January 1990 to June 1994	Head, Economics and Water Use Section, Planning Division, Alberta Environment, Edmonton, Alberta Acting Head Water Conservation Section, Planning Division, Alberta Environment, Edmonton, Alberta

- Supervisory and administrative responsibilities for a planning support team within Planning Division as well as being the senior economist for Alberta Environment and managing departmental water conservation activities.
- Departmental roles include being part of the team responsible for drafting the new water resources policy and legislation, conducting an assessment of the potential for using economic instruments to achieve environmental objectives, and providing economic advice and conducting evaluations for various Services within the Department.
- Within Planning Division, responsibilities included the supervision of consultants and staff conducting benefit/cost analysis and other economic analyses of water development projects, developing methods to assess the economic benefits of water quantity/quality changes, providing evaluation advice and economic forecasts to resource planners, and representing the Division on various inter- and intra-Departmental committees. Provided technical assistance on multi-objective evaluations of water and resource development plans.
- Represented Alberta on the CCME Municipal Water Use Efficiency Task Force which developed a national municipal water efficiency strategy.

August 1986 to December 1989	Principal, Thompson Economic Consulting Services, Calgary, Alberta

- Active involvement in all company projects at both research and management levels. Responsibilities included the design and completion of project research, technical analysis, supervision of field staff, report writing and project management.
- Economic analyses included economic impact assessment (including use of input-output analysis and development of regional multipliers), benefit/cost analyses, and assessments of commercial (financial) feasibility. Also responsible for the design and implementation of survey research programs and the statistical analysis of research results.
- Areas of expertise included economic evaluations of provincial and national parks, recreational facilities, and fish and wildlife resources in Alberta, the Yukon and NWT. Other studies assessed the economic impacts of a hydroelectric project (Yukon), a pulp mill (Alberta-Pacific), a coal mine (Menalta Coals Ltd.), transmission lines (Canadian Electrical Association), hazardous waste disposal practices (Environment Canada), lake stabilization (Alberta Environment), and wetlands (Canadian Wildlife Service).

September 1983 to July 1986	Resource Economist, Reid Crowther & Partners Ltd., Calgary, Alberta.

Provided economic support services for various engineering departments as well as research involvement in:

- preparation of economic and demographic forecasts for planning studies;
- survey research designs for recreation and parks studies, including implementation and data analysis;
- cost-effectiveness and cost-benefit analyses of alternative engineering schemes;
- research on compensation and mitigation programs; and
- technical report writing and editing.

May 1977 to August 1983	Senior Resource Economist, Canadian Resourcecon Ltd., Vancouver, B.C.

Major research involvement in:

- establishing the economic values associated with the recreational and commercial use of fish and wildlife resources in British Columbia;
- reviewing policies for compensation for loss of renewable resources in northern Canada;
- inventorying land-use and recreation resources;
- socio-economic studies of hydroelectric projects and highways;
- economic feasibility and benefit-cost studies of aluminum smelter and petro-chemical plant;
- survey research programs for assessing recreation activity and values; and
- energy demand forecasting for natural gas, LPG and refined petroleum products in the residential and commercial sectors.

May 1976 to August 1976	Environmental Planner, Environmental Assessment Team, Land-Use Coordination Branch, Ontario Ministry of Natural Resources.

February 1975	Researcher, Inquiry Appraisal Team, Berger Commission on the Mackenzie Valley Pipeline, Ottawa.

Volunteer Experience

North Saskatchewan Watershed Alliance, Director at Large (2013 to present)

Canadian Water Resources Association, Alberta Branch: Treasurer (1998 to 2010)

Gregg Lake Cottage Owners: Founding member and representative (1994 to present)

Ceyana Canoe Club: Executive, various positions (1990 to 2005)

Edmonton Breast Cancer Survivors Dragon Boat Team: Coach and co-founder (2000 to 2003)

Edmonton Dragon Boat Festival Association: Race Director (1997 to 2000).

Calgary United Way Voyageur Challenge: Event Coordinator (1984 to 1989).

Expert Witness Experience at Hearings

National Energy Board hearings on the Northern Gateway Pipeline Project were held in 2013. Technical support was provided to the hearing panel that heard evidence related to project need and national provincial effects. Served as an expert witness on three panels: the socio-economic effects of terrestrial pipeline operations (Prince George); the socio-economic effects of routine marine operations (Prince Rupert); and the socio-economic effects of marine spills (Prince Rupert).

British Columbia Public Utilities Commission hearings on an application by B.C. Hydro to construct a hydroelectric dam at Site C on the Peace River. Hearings were held in 1981/82. Testimony was presented on the impact of the proposed dam on recreation, wildlife and fisheries values.

Federal Assessment Review Board on an application to twin the Trans-Canada Highway through Banff National Park. Hearings occurred in January 1982. Testimony was presented on the socio-economic impacts of the project.

Yukon Territorial Commission to investigate proposed guidelines for regulation of the placer mining industry. Hearings occurred in September 1983. Testimony was presented on the socio-economic impacts of sediment discharges and the proposed regulations.

Papers and Publications

Schindler, D.W., W.F. Donahue and John P. Thompson. 2007. “Future Water Flows and Human Withdrawals in the Athabasca River” in Running Out of Steam? Oil Sands Development and Water Use in the Athabasca River Watershed: Science and Market based Solutions. Prepared for the Munk Centre for International Studies and The Environmental Research and Studies Centre at the University of Alberta.

Watrecon Consulting. 2005. Environment for Growth: People to Water or Water to People? A discussion paper prepared for the Alberta Institute of Agrologists. Presented to the AIA annual conference in Banff (April 2005) and the national conference of the Canadian Water Resources Association (June, 2005).

Thompson, John P. and Tom Koren. 1999. Moving from Public Information to Collaboration: The Gregg Lake Pipeline. Presented to the International Association for Public Participation at Banff.

Thompson, John P. and Anna Kozlowski. 1997. The Economic Importance of the Alberta Licensed Resident Sport Fishery in 1994. Alberta Environment. Edmonton.

Kozlowski, Anna and John P. Thompson and 1997. The Lesser Slave Lake Sport Fishery: Licensed Resident Angling Activity and Economic Importance in 1994. Alberta Environment. Edmonton.

Dobson, Stephen and John Thompson. 1996. Parks and Protected Areas: Their Contribution to the Alberta Economy – A Discussion Paper. Alberta Environment, Edmonton.

Thompson, John. P. 1994. "The Economics of Water: An Alberta Perspective" in Day, T.J., E. Blais and N. Barnes (eds.) Water: A Resource in Transition. Proceedings of the 47th Annual Conference of the Canadian Water Resources Association, Winnipeg, Manitoba, June 14-17, 1989.

Thompson, John. P. 1994. "Water Conservation Through Legislation, Regulatory and Policy Change in Alberta" in Shrubsole, Dan and Don Tate (eds.) Every Drop Counts, Proceedings of Canada's First National Conference and Trade Show on Water Conservation, Winnipeg Convention Centre, Winnipeg, Manitoba, February 4-6, 1993, published by Canadian Water Resources Association.

Thompson, John. P. 1994. "Water Conservation Statistics: An Alberta Government Perspective" in Shrubsole, Dan and Don Tate (eds.) Every Drop Counts, Proceedings of Canada's First National Conference and Trade Show on Water Conservation, Winnipeg Convention Centre, Winnipeg, Manitoba, February 4-6, 1993, published by Canadian Water Resources Association.

Thompson, John and D. A. Young. 1992. "The Optimal Use of Prairie Pothole Wetlands: An Economic Perspective" in Canadian Water Resources Journal, Vol. 17, No. 4, Winter 1992,

Sen, Amode R. and John P. Thompson. 1992. "Lattice Design in the Bow River Recreation Survey" in Journal of Applied Statistics, Volume 19, No. 1, 1992, pp 27-39.

Thompson, John and Joe Lennon. 1991. "Impact of Land use of Rivers: Water Use Trends Revisited" in Hanna, Glenda, Tim Pyrch and C. Val Smyth (eds.). 1991. Flowing to the Future: 1991. Proceedings of the Alberta Rivers Conference, April 25-29, 1991.

Thompson, J. P. and Don A. Young. 1990. Prairie Pothole Wetlands: Functions and Evaluation. Report 7 of Wetlands Are Not Wastelands, prepared for State of the Environment Reporting, Canadian Wildlife Service and Wildlife Habitat Canada.

Thompson, J. P. 1990. Plastics or Paper: What Are the Alternatives? An Economic Perspective. Faculty of Continuing Education, University of Calgary, September 28, 1989.

Thompson, J. P. 1989. "The Economic Value of Water in Alberta" in Bradley, C., et al. (eds.). 1990. Flowing to the Future. Proceedings of the Alberta Rivers Conference, University of Calgary, May 11-13, 1989.

Thompson, J. P. 1989. "Resource Opportunity Costs: An Economic Rationale for Compensation and Mitigation" in Delisle, C.E. and M.A. Bouchard (eds.). 1990. Managing the Effects of Hydroelectric Development. Canadian Association of Environmental Biologists, Montreal, April 6-7, 1989.

Thompson, J. P. 1989. The Importance of Rivers for Urban Recreation: The Case of the Bow River. Applied Aquatic Studies Workshop, University of Alberta. February 21, 1989.

Thompson, J. P., R. C. Scace and A. R. Sen. 1987. The Bow River Recreation Study. Volumes 1 to 4. Alberta Forestry, Lands and Wildlife.

Thompson, J. P. 1981. Aluminum Smelting in the Yukon: An Assessment of Economic Viability. Westwater Research Centre, Vancouver.

Thompson, J. P. et al. 1972. Kluane National Park: A Scenic and Wilderness Resource Inventory. Published under OFY Grant 550-0058.

Major Project Experience

Socio-economic Impact Assessments

1. **Cardinal River Operations Social Baseline Assessment 2020, Alberta –** Mr. Thompson undertook this assessment of socio-economic conditions in communities most affected by Teck's Cardinal River mine and determined the extent to which the mine has affected these conditions since 2014 and described the effects that closure of the mine in 2020 will have upon these communities. (2019)

2. **Cardinal River Operations Social Baseline Assessment 2014, Alberta** – Mr. Thompson undertook this assessment of socio-economic conditions in communities most affected by Teck's Cardinal River mine and determined the extent to which the mine has affected these conditions. The actual socio-economic impacts were compared to the predictions of socio-economic effects as described in the application submitted by Cardinal River Coals to construct and operate the Cheviot Coal Project and the associated decision reports issued by the Alberta Energy and Utilities Board (AEUB) in 1997 and the AEUB-Canadian Environmental Assessment Agency (CEAA) Joint Review Panel in 2000. (2014)

3. **Blackwater Project EIA, British Columbia -**Mr. Thompson completed the economic impact assessment of a proposal by New Gold Inc.to construct and operate an open-pit gold mine in Central BC, south of Vanderhoof. This involved preparing an economic baseline for that community as well as communities in a larger regional assessment area that included Prince George, and using information from input/output analyses conducted by BC Stats to describe the project's effects on the regional and provincial economies. (2013)

4. **Marathon PGM-Cu Project EIA, Ontario -** Mr. Thompson prepared a supplemental information request resulting from the review of Stillwater Canada's proposal to construct and operate an open-pit gold mine near Marathon. This involved preparing a detailed assessment of the project's potential impacts on provincial, regional and municipal government revenues and preparing a sensitivity analysis on the assumptions used to estimate the project's economic impacts. (2013-2014)

5. **Compliance Coal Corporation, Raven Underground Coal Mine, British Columbia -** Mr. Thompson prepared the socio-economic baseline for this proposal underground coal mine that would be located in the Comox Valley on Vancouver Island. He used the BC Stats input/output model to develop estimates of

the potential provincial and regional economic effects of the proposed project. (2012)

6. **Rainy River Resources Ltd. Rainy River Gold Project, Ontario, British Columbia -** Mr. Thompson oversaw preparation of the economic baseline for communities in northwest Ontario, including Rainy River, that could be affected by this proposed open pit mine. He also provided senior review of the economic modelling that was completed to estimate project effects during construction, operation and closure. (2013)

7. **Barrick-Hemlo, Open Pit Expansion Feasibility Study, Ontario -** With the current underground and surface mining operations expected to cease in the near future, this project involved assessing current and future economic and social conditions in the area around Marathon, and then determining how these conditions would change if the open pit operations were to be extended. Mr. Thompson oversaw preparation of the economic baseline for the area and economic modelling of future conditions, with and without expansion, to identify project effects. (2011-2012)

8. **Shore Gold Inc. Star Diamond Mine, Saskatchewan -** Shore Gold is proposing a diamond mine in the Fort à la Corne forest in central Saskatchewan. Mr. Thompson prepared the economic baseline information for urban and rural communities in the vicinity of the proposed mine, including the City of Prince Albert and various First Nation reserves. Using the Statistics Canada input/output model he developed estimates of the potential provincial and regional economic effects of the proposed project. (2010-2012)

9. **Avanti Mining Corp. Kitsault Molybdenum Project, British Columbia -** Avanti is proposing to redevelop a molybdenum mine on Alice Arm on the north coast of BC. Mr. Thompson prepared the economic baseline for communities near the proposed mine, including the Nisga'a communities, Terrace, Hazelton, New Hazelton, Smithers and numerous First Nation reserves. Using information from the BC Stats input/output model he prepared estimates of the potential provincial and regional economic effects of the proposed project. (2012)

10. **Mt. Milligan Gold-Copper Mine, British Columbia -** Mr. Thompson completed an assessment of Terrane Metals Corp's proposed gold-copper mine at Mt. Milligan. This involved preparing detailed baseline assessments of economic and social conditions in Fort St. James and Mackenzie as well as other nearby communities, including various Aboriginal communities. The potential economic effects of constructing and operating the mine were estimated using the BC input-output model. Various mitigation and enhancement strategies were developed to enhance the benefits of the project and minimize any adverse effects. (2010-2012)

11. **Chinook Coal Project: Cost-Benefit Analysis and Economic Impact Assessment, Alberta -** Mr. Thompson worked with Praxis to assess the social and economic impacts of a proposed coal development in the Crowsnest Pass. Mr. Thompson also prepared a financial feasibility of the project and a benefit/cost analysis. (1980)

12. **Socioeconomic Impact Analysis for Yukon Placer Mining Guidelines**, **Yukon -** As part of their initiative to regulate sediment discharges by the placer mining industry in an attempt to reduce impacts on salmonids, Environment Canada hired Mr. Thompson to examine the potential benefits and costs of implementing the guidelines. He provided testimony at public hearings on the guidelines. (1979)

13. **Aluminum Smelting in the Yukon: An Assessment of Economic Viability, Yukon -** As part of investigations into potential hydroelectric development Yukon, Mr. Thompson assessed the conditions under which an aluminum smelter might be viable. This study was prepared for the Westwater Research Centre in BC. (1981)

14. **Pacific NorthWest LNG Project EIA, British Columbia -** Mr. Thompson completed the economic impact assessment of a proposal by the Pacific NorthWest LNG Limited Partnership to construct and

operate a 12 million tonne per annum LNG export facility on Lelu Island near Prince Rupert. This involved preparing an economic baseline for communities and reserves in the immediate vicinity of Prince Rupert, and assessing project effects on the Canadian, BC and local economies using information from custom runs of the Statistics Canada Interprovincial Input/Output Model. The assessment examined effects on employment, income, training and municipal government finances. (2013-2018)

15. **Prince Rupert Gas Transmission Project EIA, British Columbia -** Mr. Thompson completed the economic impact assessment of a proposal by the Prince Rupert Ga Transmission Ltd. to construct and operate a natural gas pipeline that would be up to 48" in diameter and would transport natural gas approximately 900 km from Hudson's Hope in northeast BC to a proposed LNG facility on Lelu Island near Prince Rupert. This involved preparing an economic baseline for communities and reserves in six regions along the pipeline corridor, as well as Prince George, Terrace and Smithers. Project effects on the Canadian, BC and local economies were assessed using information from custom runs of the Statistics Canada Interprovincial Input/Output Model. The assessment examined Project effects on employment, income and training. (2013-2018)

16. **Northern Gateway Pipeline EIA, Alberta and British Columbia -** Mr. Thompson coordinated the economic and social impact assessment of Enbridge's proposed 1200-kilometre pipeline that would transport heavy oil from Edmonton, Alberta to Kitimat, BC. This involved developing baseline economic and social conditions for aboriginal and non-aboriginal communities along the pipeline route, determining the demands that pipeline construction and operation will have upon these communities, identifying appropriate impact mitigation strategies, and presenting evidence at the NEB hearings on the project. (2007-2013)

17. **Suffield In-Fill Natural Gas Drilling Program, Alberta -** As part of EnCana's application to drill an additional 1,500 shallow gas wells in the Suffield National Wildlife Area, Mr. Thompson prepared an assessment of economic and social effects. This involved preparing a socio-economic baseline, estimating the potential effects of construction and operation, and preparing for public hearings. (2007-2008)

18. **EnCana Borealis In-Situ Oil Sands Mining Project, Alberta -** EnCana proposed using steam assisted gravity drainage (SAGD) thermal technology to produce 35,000 barrels of bitumen per day from oil sands located northwest of Fort McMurray. John prepared a socio-economic assessment of the proposed project, specially related to the potential effects on Fort McMurray. The work involved determining baseline characteristics, especially related housing and services that were under stress due to the extensive development occurring around the community. Potential effects were estimated and strategies to minimize potential project effects were identified. (2006-2007)

19. **Shell Canada Limited, Carmon Creek Project EIA, Alberta -** An economic impact assessment of a proposed expansion of Shell's existing in-situ oil sands operation located north of the Town of Peace River, Alberta was undertaken using provincial and regional multipliers and through consultations with regional economic development contacts. (2005-2006)

20. **Fort McMurray Oil Sands Review, Alberta -** Mr. Thompson provided socio-economic support to the Alberta Environment Team that commenced reviewing oils sands development in 1997. In 1998 the team received the Premier's Award of Excellence (Gold). (1997-1998)

AGRICULTURE

21. **Alberta Agricultural Operation Practices Act -** While with the NRCB, Mr. Thompson worked on the development of legislation and regulations related to manure management in Alberta and assisted applicants in preparing for and participating in Board hearings under the Act. (2003-2004)

ROADS AND HIGHWAYS

22. **Trans-Canada Highway in Banff National Park, Alberta -** On behalf of Public Works Canada, Mr. Thompson prepared the socio-economic impact assessment of the proposed twinning of the second phase of the Trans-Canada Highway through Banff from Kms. 13 to 26.5 and testified before the Federal Environmental Assessment Board regarding this proposal. (1981)

23. **Proposed Nanaimo Bypass Highway, British Columbia -** As part of a multi-disciplinary team, Mr. Thompson helped assess the impacts of the proposed bypass highway on land use, recreation, mineral resources, traffic, and community structure and stability. The study was done for the B.C. Ministry of Highways and Transportation. (1980)

Air Quality

24. **Development of Long-Term Funding Options for Ambient Air Quality Monitoring in Alberta -** In response to Alberta Environment's commitment to develop options for sustainable long-term funding mechanisms that assure equitable contributions from all emitters, Mr. Thompson was part of a study team that assessed funding methods being used in other jurisdictions, reviewed existing Alberta air emissions information, and developed a number of funding options based on various assumptions about which emissions and/or emitters should be used as potential sources of funding revenues. The study determined that it would not be possible to fully implement an emitter pay program as the basis for funding monitoring because there is currently insufficient information on the full range of emissions of concern and the sources of those emissions. (2010-2011)

Economic Impact Analysis

25. **The Economic Importance of the Alberta Licensed Resident Sport Fishery in 1994, Alberta -** An assessment of the economic impacts of expenditures by licensed anglers in Alberta was prepared using the results of a survey conducted by Alberta Environmental Protection. This study specifically examined inter-regional expenditure patterns. (1994)

26. **Prairie Pothole Wetlands: Functions and Evaluation, Canada -** This study was one of the first to describe and quantify the functions of prairie wetlands. It was prepared for State of the Environment Reporting, Canadian Wildlife Service and Wildlife Habitat Canada in collaboration with Don A. Young, a biologist. Using questionnaires, Mr. Thompson developed estimates of the economic contributions of two large pothole wetland areas in Saskatchewan. The results were published as Report 7 of the "Wetlands Are Not Wastelands" series of publications by CWS. (1990)

27. **Recreational Use of Fish and Wildlife in British Columbia -** Mr. Thompson worked with the B.C. Ministry of Environment to design and implement surveys that determined the use of fish and wildlife resources by BC residents and non-residents and the economic values associated with that use. (1981)

28. **Assessment of Sportfishing Data for Kitimat Arm, Skeena River and Thompson River. British Columbia -** As part of the Salmonid Enhancement Program implemented by Fisheries and Oceans Canada, Mr. Thompson quantified recreational angling activity for three major fisheries and quantified the economic benefits derived from that activity. 1981)

29. **Economic and Resource Management Aspects of the Commercial Use of Fish and Wildlife in British Columbia -** To assist the B.C. Ministry of Environment understand commercial use of fish and wildlife resources, Mr. Thompson surveyed big game guides, fish cap operators and their clients to determine activity levels and the extent to which their expenditures contributed to the provincial economy. (1980)

Forestry Services

30. **Timber Valuation Task Force, Alberta -** While working with Alberta Environmental Protection, Mr. Thompson served as co-chair of the Task Force which was responsible for developing standard

procedures for valuation of forest resources in Alberta. (1996)

31. **Review of the Economic and Social Implication of the Alberta-Pacific Forest Industries Bleached Kraft Pulp Mill, Alberta -** Mr. Thompson was hired by the Alberta-Pacific Environmental Impact Assessment Review Board to conduct an independent review of the evidence related to the socio-economic impact assessment of the proposed mill. (1989)

MULTI-OBJECTIVE EVALUATION

32. **Fox Creek-Knight Integrated Resource Plan, Alberta –** While working for Alberta Environment, Mr. Thompson worked with industry stakeholders and various government agencies to identify a preferred plan for energy and forest development and protection of caribou habitat. He coordinated the process of identifying key management objectives and ranking plan options in terms of being able to meet those objectives and then assigning weights to the various objectives to determine the preferred alternatives. A risk analysis exercise was also completed. (1994)

33. **Teck Effluent Management Study, Trail Smelter, British Columbia** – This study was undertaken to determine a preferred technical option for eliminating all spills to the Columbia River and to groundwater and to reduce total emissions from the Teck Metals Ltd. lead-zinc smelter at Trail. A technical evaluation of the various options was done using a selected number of management objectives and then using various weighting strategies for these objectives to determine the preferred option. Weighting schemes were developed by Teck staff to reflect their perceptions of the priorities of different interest groups, including the Teck Board of Directors, Teck employees, provincial regulators and the local public. (2011)

POLICY & REGULATORY REVIEW & DEVELOPMENT

34. **Natural Resources Conservation Board, Alberta -** Mr. Thompson served as review coordinator for the joint NRCB-EUB review of the proposed Dunvegan hydroelectric power project on the Peace River and for the joint NRCB–CEAA review of the Little Bow Project/Highwood Diversion Plan. As review coordinator, he oversaw hearing administration and records management, provided information on the hearings process to interested parties, and served as a media/public information contact. Mr. Thompson also reviewed project information from a socio-economic perspective, summarized evidence, prepared cross-examination material, and assisted in the preparation and editing of the decision reports. (1998-1999)

35. **Alberta Energy and Utilities Board, Alberta -** Mr. Thompson assisted the EUB in its joint review with CEAA of the Cheviot coal mine and with the proposed expansion of the Rossdale power plant in Edmonton. He was responsible for reviewing the socio-economic evidence submitted to the review panels, preparing cross-examination, and preparing decision reports. (2000-2002)

36. **Alberta Water Act -** As part of the committee of senior civil servants responsible for drafting the new water legislation, Mr. Thompson participated in two rounds of open houses throughout Alberta, analyzed public comments on the existing and proposed legislation, and assisted in drafting the content and wording of the legislation. (1995-1996)

37. **CCME Municipal Water Use Efficiency Task Force, Canada -** Mr. Thompson represented Alberta on developing a national municipal water efficiency strategy for the Canadian Council of Ministers of the Environment. (1994)

38. **Compensation Policies for Renewable Resources, NWT and Yukon -** Mr. Thompson participated in three studies that examined the issue of compensation for loss of renewable resources in northern Canada. For the Government of the Northwest Territories he prepared a review of policy options for renewable resource compensation in 1982 and assessed compensation issues related to water management in 1985. In 1983 he developed a compensation policy for fish and wildlife resources for the Council for Yukon

Indians. (1982-1985)

Recreational Development

39. **Bow River Recreation Study, Alberta -** The study, conducted for Alberta Forestry, Lands and Wildlife, used field surveys and monthly household surveys over a 12-month period to determine recreational use of a 111-kilometre reach of the Bow River in the vicinity of Calgary. Mr. Thompson was responsible for study design, supervision of field staff, and analyzing the results to determine annual use and the resulting economic benefits and impacts. (1986-1987)

40. **Riding Mountain National Park Clear Lake Marina Demand Study, Manitoba -** To study the potential demand for a marina facility on Clear Lake, Mr. Thompson conducted a survey of park users to determine their participation in boating, their interest in a marina, and their willingness to pay to use a marina facility. The data was used to develop a set of recommendations marina size and operations. The study was completed for Parks Canada, Prairie and Northern Region. (1984)

41. **Resource Evaluation and Impacts on Recreation, Kemano Completion Hydroelectric Project, British Columbia -** As part of the impact assessment for the proposed expansion of the Kemano power project, Mr. Thompson conducted the baseline recreational use assessment for ALCAN Smelters and Chemicals. Using a combination of traffic counters and interviews by field crews, the study determined current recreational use in the Nechako and Morice river basins. (1979)

Regional and Community Planning

42. **Implementation of Alberta's Capital Region River Valley Plan, Alberta -** Mr. Thompson's role on this multi-disciplinary team is to prepare a benefit-cost assessment of the proposed plan, by examining the capital and operating costs of plan implementation versus the resulting recreational, tourism, health and educational benefits. (2005-2006)

43. **Tuktoyaktuk Airport Relocation Study, NWT -** With opportunities for residential development in Tuktoyaktuk limited by the location of the airport, the Hamlet commissioned a study to assess options for relocating the airport. Mr. Thompson worked as part of an engineering team to assess these alternatives. (1986)

44. **Capital, Operation and Maintenance Costs Associated with the Population Impacts Resulting from the Establishment of a Nunavut Territory, Nunavut -** Mr. Thompson worked as part of an engineering team hired by Indian and Northern Affairs to determine the population impacts and associated costs of expanding an existing community in the NWT to serve as the administrative capital of a separate Nunavut Territory. (Indian and Northern Affairs) (1985)

45. **Whitehorse Waterfront Development Plan, Yukon -** Mr. Thompson estimated the economic impacts of implementing the waterfront development plan developed for the City of Whitehorse. (1985)

Parks and Protected Areas Assessments

46. **Landscape Analysis: Proposed Thaidene Nene National Park, NWT -** Parks Canada commissioned this study to determine whether economic assessments of ecological goods and services (EG&S) values could be used to support land use planning at a landscape level, using a proposed national park on the east arm of Great Slave Lake as an example. The first phase of the study examined the methodologies used to assess EG&S and concluded that the conventional approaches being used in other studies would not apply to the study area because there is little information on the ecological functionality or values of landscapes in the Canadian north. The second phase of the study involved using Traditional Knowledge and other information to map the importance of the area to residents of the community of Lutsel K'e. This information was then combined with information about the mineral and renewable energy potential of the area to help identify the potential economic benefits and costs and economic impacts associated with three

potential boundary options for a national park, including the no protection option. (2010-2013)

47. **Socio-Economic Assessment of Candidate Protected Areas in the NWT -** Socioeconomic studies of four candidate protected areas were undertaken in accordance with the NWT Protected Areas Strategy. These areas included Edéhzhíe, Ts'ude niline Tu'eyeta (Ramparts), Ka'a'gee Tu and Dinàgà Wek'èhodì (Kwets'ootl'àà). Most of the studies were undertaken in two phases. The first phase involved preparing a socio-economic profile of nearby communities, which included many of the communities along the Mackenzie River, and quantifying the economic benefits being provided by the area. The second phase involved evaluating the potential economic benefits and costs of various boundary options, including no protection. This typically involved using available information on mineral, oil and natural gas potential and the value of ecological goods and services being provided by the area. The results of the study were presented to the Working Groups established for each candidate areas and preparing plain language versions of the final reports. (2010-2013)

48. **Parks and Protected Areas: Their Contribution to the Alberta Economy -** Mr. Thompson used visitor expenditure data and economic impact analysis to quantify the economic value of parks and protected areas in Alberta. The resulting Alberta Environment discussion paper found that parks and protected areas can contribute more employment and income per acre of land than agriculture or forestry. (1996)

49. **National Park Studies, Canada -** The Canadian Park Service hired to Mr. Thompson to conduct visitor surveys, assess park impacts, and prepare socio-economic data for parks planning. Projects include development of a data base in support of the Elk Island National Park Management Plan in 1989, an assessment of the impacts of private-sector construction in Banff, Jasper and Waterton National Parks in 1989, a visitor profile and assessment of economic impacts for northern park (reserves) and historic sites in 1989, and a visitor exit survey for Klondike National Historic Sites in 1988. (1988-1989)

50. **Provincial Park Studies, Alberta -** Mr. Thompson worked with Alberta Recreation and Parks to develop an economic evaluation framework in support of parks planning in 1986 and implemented and/or analyzed surveys to assess park use in 1984 and 1987 and auto access camping in 1988. He also assessed the impacts of two proposed inter-provincial parks (Cypress Hills and Cold Lake/Meadow Lake) in 1988. (1984-1989)

Water Resources Management

51. **Current and Future Water Use in Alberta -** This study was conducted for Alberta Environment and involved determining the status of surface and groundwater licenses and actual water use by six major water use sectors for each of 12 river basins. Twenty-year forecasts of water use were also and prepared. (2007)

52. **Current and Future Water Use in Beaver River Basin, Alberta -** This study was conducted for Alberta Environment, Northern Region, and involved determining the status of surface and groundwater licenses and actual water use in the two major sub-basins in the Beaver River watershed. Twenty-year forecasts of water use were also and prepared. (2008)

53. **Current and Future Water Use in the North Saskatchewan River Basin, Alberta -** This study was conducted for the North Saskatchewan Watershed Alliance, and involved determining the status of surface and groundwater licenses and actual water use in 12 sub-basins in the North Saskatchewan River watershed. Twenty-year forecasts of water use were also and prepared. (2007)

54. **Key Water Management Issues in Alberta -** This two-part project conducted for Alberta Environment initially involved conducting interviews with government personnel involved in water management issues to identify the key existing and emerging issues facing the province. An assessment of potential non-regulatory options, including market-based instruments, was then undertaken for the six most important

issues. (2007)

55. **Full Cost Accounting for Irrigation District Water Management Infrastructure, Alberta -** This study was conducted in support of Alberta's Water for Life Strategy and involved determining the total and average cost, including capital and operating costs, of delivering a cubic decametre of water through the works of each of Alberta's 13 irrigation districts. (2007)

56. **Review of Guidelines for Water Conservation and Allocation for Oilfield Injection, Alberta -** When the oilfield injection policy and guidelines were issued, they included a requirement for proponents to submit an economic evaluation of alternative water supplies. This project involved conducting a critical review of these requirements and advising Alberta Environment on how to use economic information to support their decisions to issue water licences. (2007)

57. **Full Cost Accounting for Alberta Water Management Infrastructure, Alberta -** This study was conducted in support of Alberta's Water for Life Strategy and involved determining the total and average costs, including capital and operating costs, of delivering a cubic decametre of water through selected provincially-owned water management projects. (2006)

58. **Assessment of Water Supply Alternatives for the Western Irrigation District, Alberta -** The Government of Alberta proposed the development of a new storage reservoir and accelerated canal rehabilitation to address the WID's need for additional secure water rights and improved conveyance efficiency. Mr. Thompson prepared a benefit/cost analysis to assess the net benefits of the proposed solution and examined how this would affect WID finances. (2008)

59. **Battle River Basin Water Use Assessment and Projections, Alberta -** As background to the basin planning study being undertaken by Alberta Environment, Mr. Thompson conducted an extensive review of current water allocations in the Battle basin to determine current allocations and use by each water use sector. A forecast of future was use was prepared and the potential for addressing future water demand through supply enhancement and demand management (conservation) was assessed. Mr. Thompson also examined recreational use of surface water in the Battle basin. (2005)

60. **Special Areas Water Supply Project, Alberta -** Mr. Thompson prepared or helped prepare three different socio-economic assessment studies of this water storage project for the Special Areas Board in east central Alberta. The studies included a benefit/cost analysis, an economic impact assessment, and an assessment of whether the project was consistent with Alberta Government water and regional development policies. (1992, 2005, 2018)

61. **People to Water or Water to People?, Alberta -** Mr. Thompson was retained by the Alberta Institute of Agrologists to prepare a discussion paper on emerging water issues in southern Alberta. This paper was presented to the AIA annual conference in Banff (April 2005), the national conference of the Canadian Water Resources Association (June, 2005), and AIA seminars in Edmonton and Red Deer. (2005)

62. **Northern River Basins Study, Alberta -** Mr. Thompson served as co-leader of the Other Uses Component of the study. He was responsible for designing and implementing surveys to collect information on the use of aquatic resources by residents of the Athabasca, Peace and Slave River basins. He was the primary author of several NRCB reports and presented the study results at public forums. (1995-1996)

63. **Water Management Projects, Canada -** Mr. Thompson has conducted and/or managed socio-economic impact assessments and/or benefit/cost analyses for numerous water management projects in western and northern Canada. In Alberta he conducted various studies for Alberta Environment, including the Little Bow Project/Highwood Diversion Project (1993), Pine Coulee Project (1992), Buffalo Lake Stabilization (1990), and the stabilization of Gull Lake (1986). He also peer reviewed economic assessments of the proposed Meridian and Milk River dams. He assessed the impacts of Carrot River channelization for the

Saskatchewan Water Corporation in 1985. In BC he prepared the resource evaluation for the Peace River Site C hydroelectric project for the BC Hydro and Power Authority and provided evidence at the BC Public Utilities Board hearings in 1982. In the Yukon he assessed the impacts of the North Fork Klondike Hydroelectric Project for the Yukon Electric Company in 1985 and conducted preliminary land use and socio-economic assessments of potential hydroelectric projects in the Yukon for the Northern Canada Power Commission in 1981. (1981-1993)

ACKROYD LLP
BARRISTERS & SOLICITORS

IFEOMA M. OKOYE, LLM
<contact information removed>

ASSISTANT: SANDRA L.
<contact information removed>

OUR FILE No. 154436 /IMO

YOUR FILE No. 80101

September 21, 2020

EMAIL TO iaac.grassymountain.aeic@canada.ca

Grassy Mountain Coal Project Joint Review Panel
c/o Canadian Environmental Assessment Agency
160 Elgin Street, 22nd Floor
Ottawa Ontario Canada K1A 0H3

Attention: Samantha Sabo, Acting Panel Manager

Dear Madam:

Re: Benga Mining Limited/Riversdale Resources - Grassy Mountain Coal Project
AER Application Nos. 1844520 and 1902073
Impact Assessment Agency of Canada Reference No. 80101
Submissions of the Coalition of Alberta Wilderness Association and the Grassy Mountain Group

Please find attached Appendix A to the submissions of the Coalition of Alberta Wilderness Association and the Grassy Mountain Group ("Coalition").

Yours truly,

ACKROYD LLP

Original signed by

IFEOMA M. OKOYE
IMO/sl
Encl.

JOINT REVIEW PANEL

Submissions of Norman Watmough, Connie Watmough and Tyler Watmough

Sun Cured Alfalfa Cubes Inc. is the registered owner of SE 19-8-3-W5M ("SE 19"). Connie and Norman Watmough are the shareholders of Sun Cured Alfalfa Cubes Inc. Tyler Watmough is Connie and Norman's son.

We are concerned about Benga's proposals to construct and operate a surface metallurgical coal mine, a coal handling and preparation plant with associated infrastructure, an overland conveyor system and a new rail track (the "Project").

We are also concerned about Benga's proposed application for a licence to divert surface and groundwater for use in the Project. We are further concerned about Benga's proposal to construct two external overburden dumps adjacent to the pit.

Nature of our concerns with the Project

(a) Land Use Impacts and Access Restriction

We have owned SE 19 for 27 years now. The primary use for SE 19 was for grazing our cattle and also for family social events and or recreation. We used to graze 50 head of cattle every summer on our property along with renting additional grazing land from our neighbours, the Donkersgoed (owners of SW 19) and Lee Brewerton (previous owner of NW 19). Unfortunately, we have lost the opportunity to graze one of these properties since Benga Mining Limited ("Benga") purchased NW 19 a couple of years ago and has since allowed a grazing co-op to graze their cattle on it.

Grazing our cattle on our property alone is not economically viable so we have lost the opportunity to graze a portion of our cattle herd since Benga has increased its presence in the neighbourhood. Over the years we would graze around 25 cow/calf pairs at a rate of $1.40 per head per day for about 110 days. So we now have an increase in grazing expenses of $3850 per year as a result of the proposed mine. In addition, all of the corals and collection facilities that took many man hours to build are also useless as we no longer use them to gather cattle.

The road to access our property, SE 19, is through section 24-8-4-W5M which will be affected by the Coal Handling Processing Plant and Infrastructure as well as the Central and South rock disposal areas. See Figures A.1.0-2 and A.4.0-1. There is an easement on Section 24 that protects our right to access our property. We note that the Donkersgoed have referenced this easement in their submission. Our property enjoys

the benefit and the burden of having this road access pass through our property for the use of other dominant landowners.
Currently, Benga's exploration activities have restricted our access to our property. Any time we plan to go to our property, we have to come back and meet our guests at the locked gate to let them in. This has definitely become an inconvenience for us.

We have a seasonal residence and various camping stalls on SE 19. We also have two free flowing springs that provide water to our residence. Every year, we host our family social gatherings on SE 19. We take our children (2) and 3 grandchildren (aged 15, 17 and 18 years) to SE 19 to enjoy the beauty and wildness of SE 19. Our friends also come up to spend some time with us, all with a view to be one with nature, enjoy the peace and tranquility of one of Alberta's last undeveloped areas. Our children and grandchildren enjoy fishing in the waters, riding their quads and camping out in the wilderness. The beauty of SE 19 cannot be reproduced or replaced if destroyed, which the mine will do if permitted to proceed.

SE 19 is meant to be our legacy to our family. We have worked hard for this land. If the project is approved, our dreams and plans for our land will be destroyed.

(b) Noise and dust concerns

SE 19 is located adjacent to the mine permit boundary as Benga indicates at Figure A.10-2 of its application. SE 19 will be close to Benga's south rock disposal area and proposed water pipeline/service route.

We are concerned that the peace, tranquility and clean air that we enjoy on our lands will be destroyed by Benga's proposed mine project. The Grassy Mountain area is known for its strong winds. It is not uncommon for wind speeds to exceed 100 km per hour. SE 19 is located directly east of the south disposal rock areas and the mine permit boundary and if the wind direction is from the west to the east, our property including our drinking water (the two springs) will be covered in black coal dust if this project is allowed to proceed.

The increase in traffic and the noise from the blasting operations will increase the noise levels on SE 19 thereby disturbing the peace and quiet that we currently enjoy on SE 19.

(c) Access Concerns

As indicated above, the only access to SE 19 is through the Grassy Mountain Road. If this access is blocked as Benga proposes to do, we will not have any access to our property. Without access, our land is virtually worthless.

(d) Water Concerns

We are concerned about the potential pollution of our springs from dust from the mining operations and from the leaching of selenium from mining wastes dumped in the south rock disposal areas. Benga identifies at page A-25, paragraph A.6.4 in its August 2016 Application that "leaching of selenium out of the rock disposal areas is a possibility". A leaching of selenium from the rock disposal areas and dust from the mining operations are likely to affect our water source.

This situation already exists in the Elk Valley with the leaching of selenium from the coal mines in this area into the watershed and eventually leading to contamination of Lake Koocanusa. Why allow Benga's operation to potentially leach selenium into the Old Man River watershed affecting the water quality downstream, having a significant impact on all towns and cities as well as irrigation districts that supply water to agricultural producers? Does the potential economic gain outweigh the most valuable resource in the world? WATER. Reduction of water levels available to irrigation districts may impact food production in the area and people's livelihoods significantly.

Also, using clean, uncontaminated mountain water to wash coal will mean less water in the streams and rivers to supply all of the communities and districts downstream, meaning potential water shortages.

We are also concerned about Benga's proposal to discharge "treated" wastewater into Gold Creek. Gold Creek is a fish bearing creek that is the source of our drinking water. Gold Creek is a tributary to the Old Man River. Many communities such as Lethbridge, Medicine Hat and Saskatoon rely on this watershed. We believe that discharging the "treated" wastewater into Gold Creek will be harmful to the fish and affect the quality of water to our residence.

(e) Property Devaluation

We are concerned that the proximity of the mine and its associated facilities to SE 19 will devalue SE 19. No one will want to live near a mine and a mining plant. The presence of the mine will discourage potential purchasers from buying our land. Also, the destruction of the only viable access to SE 19 will make SE 19 totally unsaleable and unusable as access to a property is usually a strong consideration to a purchaser.

(f) Air Pollution and health concerns

We are concerned that the existence of the mine pits and the south disposal areas in close proximity to SE 19 will affect the quality of air on SE 19. We will be exposed to compounds such as sulphur dioxide, nitrogen oxides, and other substances that are released from mining activities.

(g) Geographic location of the project

The proposed location of the project will see a destruction of a beautiful landscape that has served its residents, wildlife and aquatic organisms over many years. We already know the negative environmental impact coal mining can have on a mountain region as seen from the Elk Valley Mines in British Columbia. As seen in the news, there is potential litigation from the United States against the coal mining companies and the BC government for the contamination of Lake Koocanusa. See **Tab 1** for some media reports. The Elk Valley mine was a similar mining operation as Benga's proposed mine. Maybe we should learn from their mistakes and not allow this project to proceed. Grassy Mountain with all its beautiful lakes, creeks, and landscape will cease to exist and will be replaced with a dusty environment, unusable for future generations and totally worthless.

Contact Details

Connie and Norman Watmough
<contact information removed>

Requested Disposition

We respectfully request the Joint Review Panel to recommend a denial of Benga's applications.

Respectfully submitted,
Connie and Norman Watmough
Tyler Watmough

British Columbia

Americans blame Canadians for delaying damning report on B.C. toxins in transboundary waters

Commission's Canadian members refused to endorse report on selenium in the Elk River watershed

The Canadian Press · Posted: Jul 08, 2018 1:12 PM PT | Last Updated: July 9, 2018

Canadian members of the International Joint Commission are blocking the release of information on contaminants in waterways shared with the U.S., according to their southern counterparts. Large doses of the pollution could harm wildlife. (The Salt Lake Tribune via The Associated Press)

comments

United States officials are accusing their Canadian counterparts of sitting on damning new data about toxic chemicals from southern British Columbia coal mines in water shared by both countries.

In a letter to the U.S. State Department, Americans on the International Joint Commission say Canadian members are blocking the release of information on contaminants that are many times above guideline levels.

"Canadian commissioners have not been willing to submit a report that addresses selenium pollution in transboundary waters of the Kootenay River drainage,'' says the letter to the State Department's director of Canadian affairs.

The commission was created in 1909 as a way to discuss water that crosses the U.S.-Canada border.

The B.C. dispute, brewing for decades, burst open in June when the commission's two Canadian members refused to endorse a report on selenium in the Elk River watershed just north of the border.

- **Mines blamed for high selenium levels in B.C.'s Elk River**

'Astronomical levels' of selenium

Trace amounts of selenium are healthy, but large doses can lead to gastrointestinal disorders, nerve damage, cirrhosis of the liver and even death in humans. In fish, it causes reproductive failure.

The report documents increasing selenium in Canadian water flowing into the transboundary Koocanusa reservoir.

All five waterways in the report have selenium levels at the maximum or above B.C.'s drinking water guidelines. Two are four times higher.

The study says the level of selenium in the Elk and Fording rivers is 70 times that in the Flathead River, which doesn't get runoff from five coal mines operated by Teck Resources.

Lake Koocanusa, formed by the damming of the Kootenay River, is in B.C. and the U.S. state of Montana. (Shutterstock)

In May, Teck reported selenium levels in Koocanusa exceeded both human health and aquatic life guidelines.

"High selenium concentrations are resulting in deformities and reproductive failure in trout and increasing fish mortality of up to 50 per cent in some portions of the Elk and Fording watersheds,'' the letter says.

Things are getting worse, said Erin Sexton, a researcher at the University of Montana. Elk River stations near the mines are reporting levels 50 times what's recommended for aquatic health. Near the city of Fernie, B.C., readings are 10 times that level.

> "Nobody's happy that there's selenium in excess of water quality guidelines."
>
> *- Douglas Hill, B.C.'s Environment Department*

"The levels of selenium in the Elk are astronomical,'' said Sexton.

- **Harmful chemicals found in water near Cache Creek landfill**

Commission spokeswoman Sarah Lobrichon said the report is still being reviewed by commissioners on both sides.

Until all agree, the report won't go to either government, Lobrichon said.

Canadians prefer 'weak' report, Americans say

The Americans say the delay is deliberate.

"Our Canadian colleagues prefer an earlier version of the report that is weak on addressing the recently defined impacts of selenium,'' the letter says.

Teck built a water treatment plant in 2014, but its operation has been intermittent and it is currently closed. It was converting selenium into a form more easily absorbed by plants and animals.

The Line Creek operation is one of five Teck coal operations in B.C.'s Elk Valley. (Teck Resources handout/Canadian Press)

Teck Resources said in a statement that it does extensive water testing. It said selenium levels "are appropriate and protective of aquatic life'' and that fish populations haven't been affected.

The company said it's following a water quality plan and will spend up to $900 million over the next five years on new treatment plants.

The mines employ 4,000 workers.

New rules incoming

An Environment Canada spokesman said new coal mine regulations are coming for toxins such as selenium.

Mark Johnson said Teck was fined $1.4 million in 2017 over selenium discharges. The company is being investigated for further violations.

- **Teck Resources fined $1.4M for contaminating B.C. waterway**

"Nobody's happy that there's selenium in excess of water quality guidelines,'' said Douglas Hill of B.C.'s Environment Department. "But we're reasonably satisfied that Teck's making best efforts to address the problem.''

Hill said Teck is obliged to stabilize selenium levels by the end of the decade. After that, levels are to start dropping.

Sexton said selenium in some fish from the Koocanusa increased 20 to 70 per cent between 2008 and 2013. Montana officials surveyed fish in March for a five-year update.

"Most people anticipate there's going to be another jump," Sexton said.

HEALTH

Pollution found in U.S. river downstream of Canadian mines

Matthew Brown
The Associated Press

Published Monday, September 23, 2019 7:50PM EDT
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In this file photo, a coal mining operation in Sparwood, B.C., is shown on Wednesday, Nov. 30, 2016. THE CANADIAN PRESS/Jeff McIntosh

BILLINGS, Mont. -- U.S. government scientists found high levels of pollution that can be toxic to fish, aquatic insects and the birds that feed on them in a river that flows into Montana and Idaho from a coal mining region of Canada, officials said Monday.

Elevated levels of selenium were found in fish and fish eggs from the Kootenai River downstream of Lake Koocanusa.

The lake straddles the Canada border in northwestern Montana and southern British Columbia, and feeds into the Kootenai before the water flows downstream to Idaho.

Related Stories

- 50M gallons of polluted water pours daily from U.S. mine sites
- U.S. senators say Canadian pollution putting cross-border rivers in danger
- Australia approves vast coal mine near Great Barrier Reef

Selenium is a naturally occurring mineral that can be released into rivers and streams during surface mining. It was absent from water samples taken from tributaries of the Kootenai downstream of the lake, indicating it's coming from mining-related sources upstream, Environmental Protection Agency hydrologist Jason Gildea said.

No human health impacts were expected from the levels detected in the Kootenai.

High levels of selenium can kill animals and cause them reproductive problems. Animals that lay eggs are most at risk because the pollution accumulates in eggs.

Kent Karemaker, a spokesman for British Columbia's mining agency, said he had not seen the pollution study and could not immediately offer a response. Regulators from the province participate in a cross-border monitoring group with their counterparts from Montana.

Concern about pollution from mines in British Columbia has been building for years.

U.S. senators from Alaska, Montana, Idaho and Washington state said in a June letter to British Columbia's leader that Canadian regulators need to do more to prevent mining waste from fouling downstream U.S. waterways.

In July, representatives of towns and tribes in the region said the pollution threatens the livelihoods of those who depend on fishing and other forms of recreation.

Selenium concentrations in water entering Lake Koocanusa have been increasing for decades, but the pollution had not previously been found at high levels in the Kootenai River.

"We weren't expecting to find elevated levels" in the river's fish, Gildea said. "To see this result indicates that something is going on and we're a little concerned about it."

Earlier studies showed the pollution in Lake Koocanusa comes coal mining in the Elk Valley of British Columbia.

The latest findings come from a joint study by researchers from the U.S. Geological Survey, EPA, Kootenai Tribe of Idaho and wildlife agencies in the Montana and Idaho. More than 140 fish were evaluated, and high levels of selenium were found in six mountain whitefish and one redside shiner.

Elevated levels of mercury were found in three fish sampled, but Gildea said that most likely was deposited by air pollution and not mining.

Further studies are needed but whether they happen will depend on funding, said Ayn Schmit, an EPA water policy adviser.

Crown Reporting Project

Crossing the Line: The struggle to protect international waters from mining contamination

By Celia Talbot Tobin

Montana's Lake Koocanusa sits at the end of a river system that drains Canada's most productive coal country. Today, the waters of the massive lake contain a mineral called selenium, a poorly understood byproduct of mine waste. This summer, the U.S. federal government will be in a position to declare that the selenium in the lake puts Canada in violation of its international treaty with the U.S. The Montana government, however, is preparing to argue otherwise through its own analysis of the lake.

A group of top U.S. ecologists are frustrated with the state's position and say they won't practice science that is slave to a preordained policy outcome. At a meeting in early May, the group affirmed they would break from the state's goals of focusing sharply on selenium sensitivity in the U.S. end of the lake and move forward on a separate track, pursuing science at an ecosystem level, irrespective of national borders.

Opening the meeting, Ric Hauer, an ecologist and limnologist with the University of Montana, welcomed gathered scientists, regulators and stakeholders to the meeting on Flathead Lake. He laid out the day's primary goal: to open up dialogue on an ecosystem under threat.

"The purpose is not to directly control policy. But it becomes a problem whenever policy is driving the science," said Hauer. "Science has to operate in an effort in seeking the truth. Period."

While the state pursues an analysis of Koocanusa's water quality, Hauer plans to extend the scope of any parallel research upstream into the Kootenai and Elk Rivers in British Columbia, where five massive coal mines supply a third of the world's steel-making coal. The list of unknowns is far greater when the rivers are taken into consideration. It's a project he joked they might call "Ecosystems Without Borders."

"What they're doing is highly prescriptive. It is very controlled, and it's very tidy. This -- " Hauer said, pointing to a white board overflowing with scribbled unknowns and research questions, "This is going to get very, very messy."

Selenium is a naturally occurring mineral that animals, including humans, need in tiny amounts to support healthy metabolism. But mining and other industrial practices can cause selenium to accumulate to dangerously high levels in the environment. The widespread effect of selenium concentration in an ecosystem is poorly understood. But it's grotesque and deadly, capable of derailing reproduction in fish, aquatic birds, amphibians and insects.

Fish are considered the most sensitive and are a point of concern in Koocanusa. As the mineral accumulates in their bodies, fish become so malformed they cannot survive; their eggs so contaminated their offspring die. Waterfowl that eat the fish are similarly affected. Some plants also take up selenium, and herbivores that eat such plants may be poisoned. Scientists argue the ecosystem-wide reverberations of selenium contamination are so poorly understood that tight, preemptive regulation and continued thorough research are vitally important.

Clint Muhlfeld, an aquatic ecologist with the U.S. Geological Survey who often works with Hauer, said among the many unknowns is how selenium might affect human health through consumption.

"These kind of complex questions, there is no data on this stuff," Muhlfeld said. "And that's what we need, we need a more comprehensive evaluation of this problem."

If all goes as expected, the U.S. Environmental Protection Agency will greatly reduce the allowable limit for selenium in American waterways sometime this summer. But states are not required to strictly meet that standard, and Montana has indicated it will not until a further evaluation is done to determine what Lake Koocanusa specifically can absorb.

The fight over selenium levels in Lake Koocanusa is more than just another power struggle between state and federal regulators. The lake spans the U.S.-Canadian border, which brings treaty obligations into the mix. The lake also connects the state of Montana to the province of British Columbia, both of which are traditional seats of influence for the currently beleaguered coal industry.

As the U.S. federal government takes steps toward tighter pollution controls, British Columbia has granted permits to expand four out of the five coal mines in the Elk Valley, setting the stage for more waste rock and more selenium.

In May, the British Columbia Auditor General called out provincial mine regulators for failing to comply with environmental regulations over the past decade, supporting scientists' assertion that the watershed north of Koocanusa is severely in peril. The two-year report states that neither British Columbia's Ministry of Energy and Mines, nor the Ministry of Environment, have effectively evaluated or enforced their own mine regulations.

Usually, when rivers and lakes cross the 49th parallel north, a joint U.S.-Canadian group – the International Joint Commission -- is invited by both countries to help negotiate how the waterways will be used and regulated. One goal of the negotiations is to prevent pollution from the upstream country from contaminating the water in the downstream country, a requirement of a 1909 boundary treaty between the countries.

But in the case of Lake Koocanusa, the Canadian government has deferred to British Columbia and refused to join a request to involve the International Joint Commission. Instead, British Columbia and Montana have set up their own working group, one that gives Canada's largest coal producer -- Teck Resources Ltd -- a seat at the table. They've also agreed to focus solely on regulating selenium in Lake Koocanusa, not the river that feeds into it, nor the mine waste that all agree is the source of much of the mineral.

Scientists say this gives coal too much say in setting the standard for a pollutant they have long struggled to control.

Erin Sexton, a senior scientist and research colleague of Hauer's, said allowing Teck to have a voice in setting levels is a distortion of the regulatory process, something that is also occurring in BC's own water management discussions north of the border.

"We're having two separate meetings to talk about the same water," she said. "And the only people who are dually represented at those tables is Teck Coal and the province of BC. Which is completely suspicious."

It is a plan that Muhlfeld said will doom Canada's watersheds and the lake it feeds.

"The Elk and Kootenay might be a sacrificial lamb," he said, acknowledging the messy political road ahead and the powerful grip of the coal industry.

Eric Urban, chief of the Water Quality Planning Bureau at Montana's Department of Environmental Quality, said the state is one of the national leaders on reducing nutrient pollution.

"So there's little to no chance that we would ignore the subject," he said. It is unfortunate, he said, that scientists have criticized the state for taking too narrow an approach, "Because really, nothing's off the table."

Early research by Hauer revealed tremendously elevated nitrogen and sulfate levels in the waters below the mines as well.

Urban said that through monitoring and treating for selenium as necessary, any other pollutants would likely also be covered by the process.

"So the question is, is it of value to invest in nutrient research if you're going to inform the end product without it?" he said.

Scientists believe it is, and insist that limiting studies to Koocanusa and not looking at the entire ecosystem upstream is unsound science.

"You read anything about evaluating watershed health, and that's just what you do," Muhlfeld said. "It's a system of systems. It's like the human body, everything is interconnected."

Earlier, Urban explained that the state was at the table because there are obvious concerns for water quality. "But we're not at the table because there *is* an issue," he said. "We don't know if there is or isn't at this point."

The newly released audit report makes clear, however, that river waters just 40 miles north of the boundary are indeed considered an issue. The audit sharply criticizes the Ministry of Environment for failing to publicly disclose the risks associated with coal mines in the Elk River valley.

"Lack of sufficient and effective regulatory oversight and action by MoE to address known environmental issues has allowed degradation of water quality in the Elk Valley," the report states. "... MoE has been monitoring selenium levels in the Elk Valley and over that time has noted dramatic annual increases of selenium in the watershed's tributaries. MoE tracked this worsening trend, but took no substantive action to change it."

The political messiness of the regulator-scientist relationship on both sides of the border can make the situation seem purely bureaucratic and removed from reality. But the audit report makes clear the transboundary issue is concrete and urgent.

Like selenium itself, this sense of urgency is accumulating in the hearts and minds of the people north of the border who make a living directly from the rivers.

THE ELK VALLEY

Paul Samycia looked anything but conflicted in March as he expertly wielded the oars and coached the boat's other occupant, a college-aged angler who had never fished on moving water before. Samycia owns Elk River Guiding Company and is one of a handful of fly fishing outfitters in the small town of Fernie, British Columbia. Nearby, anglers in another drift boat also plied the water. Between the two groups, casting and catching assumed a rhythmic repetition: the line tightened and struggling westslope cutthroat trout were reeled in and unhooked. They looked healthy enough.

The eight-mile stretch of bright teal water had offered up roughly six dozen fish by the end of the last spring day of open fishing on the Elk River before it closed down for two and half months for spawning season. Its waters meander through the mountainous southeast corner of British Columbia. In the fullness of summer, the surrounding valley flaunts a cloak of deep emeralds and cloudy sapphire blues, a cool chromatic spectrum that offsets the heat. For decades, the area has been lauded as one of the continent's most fruitful ecosystems for fly fishing.

Rounding a bend in the river, a train wailed, chugging sluggishly along the river's edge. Samycia steered through a strong current with the effortlessness of someone who's been doing this for decades. He counted the train as the fourth seen or heard that day on the river. This one was filled with grain, giant wheat illustrations on the paint-chipped cars. But more often than not, they're teeming with coal.

The train recalled Samycia's musing earlier: "I'm just waiting for the day that there's the disaster along the rail line where something gets dumped in the river and it's a catastrophic instant event."

Like the vocal scientists south of the border, Samycia is disheartened by the lack of comprehensive action to address what he sees as a potentially huge problem. He rarely speaks in absolutes, preferring instead to convey his philosophies in the form of analogies. He's sympathetic toward the economic importance of the mining companies in the valley. He feels about mining the way many Canadians tend to: that the companies will "do the right thing."

The legacy industry Teck represents is single-handedly the reason the valley was settled more than a century ago. Each town along the river depends on mining. But many jobs, including Samycia's, are threatened by it.

"I have a young family, and I'm looking at ways to exit my business and not give it to my children," Samycia said. "Fishing can be their passion or pastime. But it's not an industry that I would recommend them to get into, especially here. We don't know what it's going to do."

Ten miles upstream from where Samycia had put-in is a massive crater. Sixty years ago it was a mountaintop. In 2015, more than seven million tons of coal were mined from its exposed seams. It's one of Teck's five open pit mines perched above the Elk River. Fifty miles to the south, the same water crosses the border into the U.S.

Several years ago, Hauer and Sexton conducted a study that confirmed the Elk River is more polluted than had been previously assumed, due to the chemical runoff from waste rock that's removed to access the coal below it.

After Hauer's report was published in 2013, Teck began speaking openly about the state of the river, saying the company had known the condition of the water quality for a while. Some believe the paper's publication essentially forced the company to show their hand.

It can seem incongruous that below the valley's tranquil wilderness, veins of sedimentary rock stretch for miles, powering a billion-dollar industry. The Elk Valley is the largest producing coalfield in the largest coal province in Canada. In 2012, British Columbia generated 43 percent of the coal in a nation that currently ranks sixth in the world in coal production. Most of that is found here in the Elk Valley, where metallurgical coal is mined for the production of steel. As the world's second-largest exporter of steel-making coal, Teck brought in $3.05 billion in revenue in 2015 from their mines in British Columbia, (which includes one site not in the Elk Valley.) Almost all of that coking coal – which is an ingredient as well as an energy source goes directly to China, where it's made into steel.

Fording River mine is the largest and furthest upstream of the five. Its processing plant hovers on the bank of a river of the same name, one of the Elk's bigger tributaries. The Fording is closed to fishing, now, but many fishing guides recall with reverence and a quiet grief the days when it was an angler's heaven.

On the eve of the longest day of the year, Samycia flipped burgers on a grill behind his fly shop. Musty pink skies didn't fade until well past 10 pm. Guides, employees and family members cracked beers by a pit fire in the parking lot. They examined sunburns, swapped trophy stories and waxed nostalgic for the years "before it got bad," when it was impossible to leave the upper Fording River empty-handed.

Samycia's first experience fishing in the Elk Valley was on the Fording. He described a drinking game he and his friends used to play on the tributary when they would casually hike up the river, wives and girlfriends tagging along.

"You got a cast, and if you caught a fish, the other guys had to drink. If you missed a fish you had to drink," Samycia said. "That was my epiphany of 'The fly fishing here is just insane.' It was *that* good."

He delivered the punch line wistfully and without missing a beat: "The girls had to drive us home."

The upper Fording River closed to anglers in 2010, due to a dramatic decline in fish and selenium levels that have reached up to 30 times the allowable number in U.S. waters. With zero irony, locals sometimes casually refer to it as "the sacrifice zone."

In 2012, Environment Canada -- Canada's version of the EPA -- collected Fording River samples and hired a selenium expert to evaluate the findings. That report has since become integral both in science's understanding of selenium and an ongoing lawsuit Environment Canada has pursued against Teck Coal.

As a key witness in the lawsuit, Dr. Dennis Lemley is forbidden from speaking to the media. But his report states there is increasing evidence of fish mortality and "deformities, particularly the teratogenic skeletal and craniofacial deformities that are biomarkers of selenium poisoning."

In layman terms, the most common deformities are trout with missing gill plates. Samycia and other anglers are reeling in fish, mostly westslope cutthroat trout, with gaping holes in the side of their face where the gill cover should be. Samycia says he's found more and more of them throughout the years, and he documents most of them with his camera.

Some fish, Lemley's report states, are hatching with skull and jaw deformities so severe they can't feed.

What Lemley's report doesn't articulate is that many of these populations, especially westslope cutthroat trout, move back and forth between the Elk, where they spawn, and Lake Koocanusa. Deformed fish don't know borders.

TRANSBOUNDARY WATERS

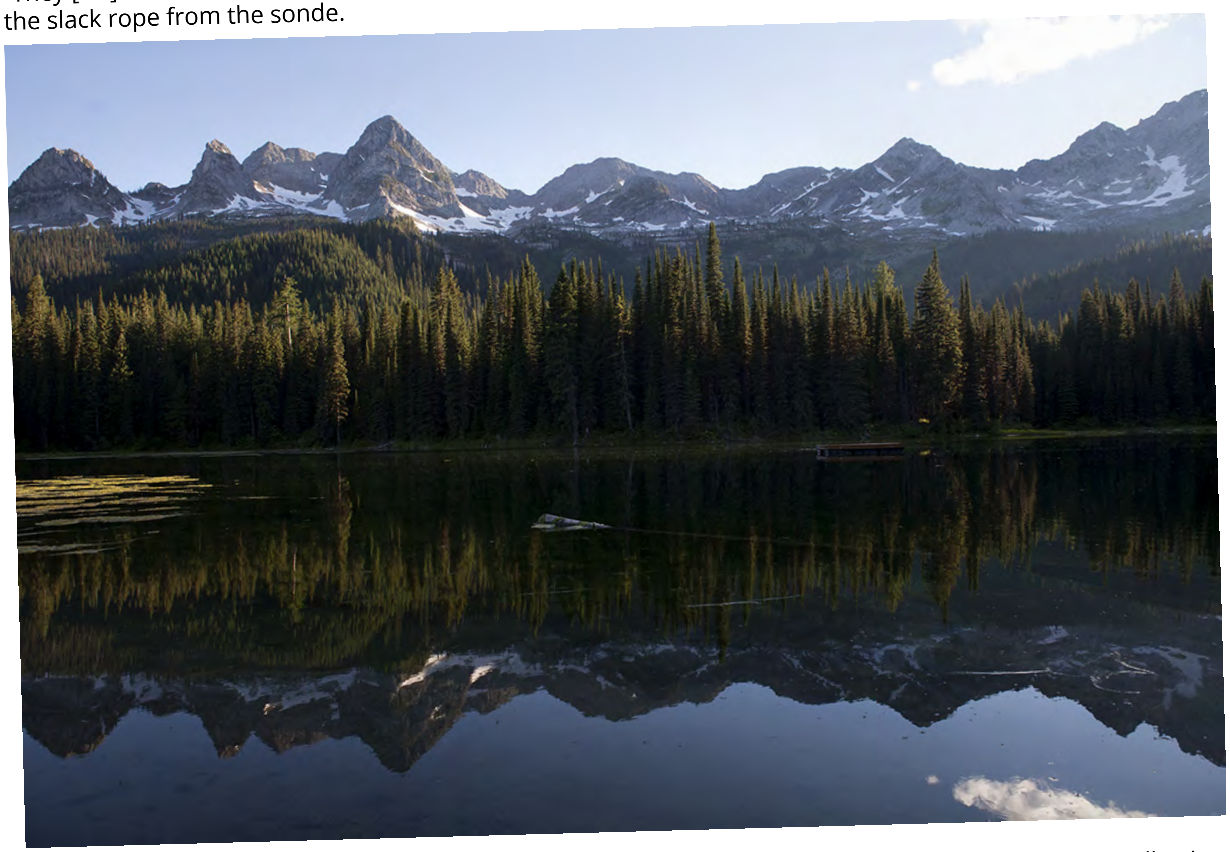
The U.S.-Canadian boundary cuts the 90-miles of Koocanusa almost in half. In July of 2015, David Naftz, a research hydrologist with the U.S. Geological Survey, steered a small aluminum skiff over the international line as if it wasn't there. There was nothing to indicate the boundary of two nations. The water ahead was the same bright teal as the water behind. Naftz slowly lowered a water quality sonde - a computerized sensor resembling an oversized relay baton to the bottom of the reservoir, more than 100 feet below. Water lapped lightly up the sides of the boat, creating echoed, tinny slurping noises.

The Elk and Kootenai waters slow down significantly when passing through Koocanusa, which was created by the construction of the Libby Dam in 1975. At the southern end, they continue downstream beyond the dam into the Kootenai River in Montana and Idaho.

Naftz was soft-spoken and wearing a loud neon orange life jacket that read "USGS." He said that Koocanusa, with its stiller waters, could be the most sensitive part of the ecosystem and its assessment was coming late in the process, for his liking.

Though Teck Resources and BC knew for years the river was polluted, the lake had rarely been mentioned throughout the years, Naftz said.

"They [BC] feel like it's outside of their area of responsibility to assess the impacts to the reservoir," he said, gathering in the slack rope from the sonde.



The water quality sensor Naftz used on the lake collects data every two seconds as it descends to the bottom, a process he repeated in three different locations. It was his fourth of six collection trips that summer on the lake. The data from the sensor, as well as sediment samples, would be passed on to both Montana DEQ and the EPA to as part of DEQ's initial assessment in working toward the creation of site-specific selenium standard for the lake.

At the same time Naftz was testing the lake, the EPA had put its new guidelines for selenium sensitivity in American waters out for public comment. The standards will lower the nationally suggested threshold for the mineral. They will also, for the first time, create a different limit for rivers than for lakes. The suggested limit for rivers in the U.S. will move from 5 micrograms per liter to 3.1. For lakes, the new limit will be 1.2. Current levels in Koocanusa hover around 1.8 micrograms and everyone expects that to rise as mining in the Elk increases.

The new lake standard very little wiggle room, given that 2 micrograms has been considered the protective number on the lake, Naftz said.

"That's just high," he said. "And when you think of the water volumes that go in here, the potential for dilution. And you're still seeing this much selenium?"

Dilution has so far been the only solution considered upstream on the Elk. After Hauer and Sexton's study was published, the British Columbian government ordered Teck to openly address water quality issues in the Elk and share its plan to do so. The eventual outcome was the Elk Valley Water Quality Plan, which was approved in November 2014. The recent audit result found the goals of the plan wanting.

"We examined the Line Creek Expansion Permit, the Area-Based Management Plan and the Area-Based Management Permit (Valley Permit) to understand how they support MoE's responsibility to minimize risks to the environment. We found that these documents do not address several risks…" the audit states.

Under the plan, Teck pledged to build six water treatment facilities, which they've since adjusted to five and built just one. The first went online in 2014. Its process is essentially one of dilution.

Naftz wasn't entirely convinced it would be an effective process in the long run. He said that while water treatment plants are built all the time, he had never heard of it being done at the scale of what Teck proposed.

Additionally, because the source of selenium is waste rock that never goes away, the plants must work in perpetuity, something the audit points out as an "economic liability."

"And when coal mining does go away in the next 50 to 100 years, where's the money going to come from to keep those plants going?" Naftz said. "We are -- the U.S., Montana -- at the receiving arm. We're going to get the shit when it comes."

Teck has also promised to meet specific short-, medium- and long-term goals to lower selenium levels in the river. The company has water monitoring stations -- in place before the plan was enacted -- that are spaced along the length of the river from the northernmost mine down to the international boundary. Each station has its own selenium goal, with the lowest number closest to the border and the highest allowance immediately downstream of the mines.

Where the U.S. and Montana governments are concerned, the most relevant part of Teck's plan is its pledge to ensure that water crossing the international border will continue to meet a target goal of 2 micrograms per liter.

Scientists like Sexton don't see how that's possible given that four out of the five mines have received permits from the British Columbia government to expand.

"They call them 'expansions,' but they're not," Sexton said. "Their footprint is equivalent to an entirely new mine."

Teck's water management plan may be a step in the right direction, Sexton said, but the 2-microgram count at the boundary doesn't go far enough, especially in light of mine expansions moving forward.

"They gave themselves permission to keep the water quality where it is, which is a kind of backwards way of doing things," Sexton said. "I just think there should be a moratorium on the mine expansions. We're continuing to exacerbate the impact in the watershed without fully knowing what the impacts are. The cart was before the horse decades ago."

British Columbia's audit supports this by not only pointing to the potential violation of the 1909 treaty in Koocanusa, but by stating that Teck's management plan fails to apply what is known in science as the precautionary principle.

"The proposed targets over the next seven years show a reduction in selenium, but are still significantly higher than current concentrations creating a high risk of further environmental impacts. The ministry has not disclosed these risks to legislators and the public," the auditor general writes.

If the site-specific data collected by the Montana DEQ over the next few years indicates that Koocanusa's standards should be near to or the same as the EPA's new suggestion of 1.2, Teck will likely be forced to re-adjust their plan. But, Sexton said, that's years away. And in the meantime, the only actionable change will be the expansion of Teck's mine operations.

CANADA'S COAL COUNTRY

The severity of the Elk Valley contamination was brought to light by a close look at an entirely different river with a very different story.

The study conducted by Hauer and Sexton that led to their selenium findings was a water quality assessment that compared the Elk to its neighbor to the east, the Flathead River. The two run roughly parallel to one another and they cross the border little more than 30 miles apart. Unlike the Elk, the Flathead's watershed flows into the protected lands of Glacier National Park and has never in its history drained nearby mining operations.

Encouraged by Montana's senators at the time and funded largely by the U.S. National Parks Service, Hauer and his team set up data collection sites up and downstream of a proposed Flathead mine, as well as up and downstream of the active Elk River mines. Because the two watersheds are so geologically and biologically similar, it's possible to look at them as something like two points in time on a single river's history; the Flathead as a pre-mining example, the Elk as the post. The study concluded that water quality in the two rivers was not only different, but that the Elk was more troubling than many people had realized.

The findings helped make a convincing argument to continue the Flathead's protection after a moratorium on mining permits had expired. In the mid 80s, prompted by a coal mine proposal in the Flathead headwaters, the International Joint Commission had been brought in to conduct an assessment. The IJC concluded that it would be nearly impossible to mine without directly impacting the health of the watershed and fisheries downstream. Their recommendation against the permit effectively killed the proposal and left British Columbia unappeased. Part of that agreement included a pledge not to propose mining projects for the next 20 years. Hauer's study was in part inspired by the expiration date of that moratorium.

People who favor IJC leadership on the Elk often point to the mine denial on the Flathead as reason British Columbia won't endorse the committee's involvement on the selenium issue on the Elk River and Lake Koocanusa.

The EPA made a push for IJC referral several years ago, but the Canadian federal government made it clear they would not support a reference if British Columbia was against it. Because both nations need to agree to involve the IJC, if one holds out, the other is left relatively powerless to force the matter.

"I think what makes this Koocanusa question pretty unique is that British Columbia is the only province that is really resisting references to the IJC," said Julie DalSoglio, director of Montana's EPA office. "In other transboundary watersheds across the rest of the continent, it's pretty much always involved."

DalSoglio said it's possible that with the grand scale of the British Columbian landscape, the province sees the Elk Valley as a drop in the bucket compared to the entirety of their resources.

"When you look at the history of B.C., they've basically been run by industry," she said.

DalSoglio has participated in every meeting Montana has held in working toward a site-specific water quality standard for Lake Koocanusa. She said that EPA supports Montana DEQ's creation of the Koocanusa Work Group, even if its direction hasn't gone completely as planned.

The group was originally intended to be led by two federal agencies -- the EPA and Environment Canada -- as well as the state and province. The four would collaborate together and pull in various groups -- such as independent scientists, local agencies and industry representatives -- to lay out a broad-term approach to addressing the watershed.

"That's really where we went off the rails last fall," DalSoglio said, several months after the group's first meeting in October 2015. "Montana and B.C. made the decision kind of on their own without dialogue with EPA or Environment Canada about really only wanting to focus on selenium standard-setting."

That decision to change course without federal consultation doesn't break any rules, because no other transboundary watershed group has completely excluded the IJC, DalSoglio said.

"We're plowing new territory here on a Canadian-U.S. international water body," DalSoglio said.

To a certain extent, the state's working group is filling the shoes of the IJC. British Columbia is a part of that group, and Montana DEQ officials emphasize that their approach is in strong partnership with the province.

But the IJC, when involved in watershed assessments, looks at the entire ecosystem on both sides of the border, something the state has said it won't do. Nor does the IJC invite the industry to have a seat at the table, as has been the case with Teck in the Koocanusa Work Group, Sexton said. The one thing that is conspicuously missing from the current work group is exactly what the IJC provides: a third party mediator with authority.

Sexton said she found the coziness of state and the province unsettling. She said she is frustrated by hearing repeatedly that the Montana DEQ will not point the finger directly at British Columbia's mining as a source of the problem, which it emphatically says is beyond the state's jurisdiction. This is also, on a technical level, true.

"Which is just fine," Sexton said. "But it is the International Joint Commission's jurisdiction, and it is the EPA's jurisdiction. Which is why the rest of us are saying, "Fine, you don't lead the process. Turn it over to the feds. Let them lead the process, let them be the 'bad guys.'"

Even with the parallel track that Hauer and other scientists have said they will take -- in essence, filling in the remaining gaps that IJC absence has left -- Sexton feels it all amounts to re-inventing the wheel.

"I think it's good to have the important science-based conversation," Sexton said after Hauer's science-first meeting in May. "I just think it's a shame that we have to build this structure from the ground up when we have an entity that could facilitate this for us."

The scientist-led meeting in May included representatives from the University of Montana, USGS, U.S. Fish and Wildlife Service, Montana Fish Wildlife and Parks, Army Corps of Engineers, as well as tribal and First Nation representatives and state, federal, and provincial regulators. Initiating a parallel track to Montana's process throughout the day seemed, to some extent, to quell the most immediate frustrations and fears of scientists and tribal leaders. Hauer said by the end of the day he felt like most of the scientists were slightly soothed by seeing an alternative path.

Sexton remains a long way off from putting her faith in the state, however.

"I think DEQ has their own ideas about what they'd like to see. And honestly I don't care as long as it's a transparent process," she said.

Sexton said she'd be suspicious of any plan the state comes out with unless it has the broad support of federal agencies.

"I want to hear that the US Fish and Wildlife service supports it, the U.S. EPA supports it, and the Army Corps of Engineers supports it, and that Montana Fish Wildlife and Parks supports it," Sexton said. "Because if DEQ puts forth the site-specific standard, I won't trust what they propose."

At the heart of Sexton's distrust is the relationship between Montana and British Columbia, something government regulators take pride in.

"Generally, we have an excellent working relationship with British Columbia," said Urban from Montana DEQ. "I hope to continue that." He repeated that several times.

Muhlfeld feels otherwise.

"In my opinion, this is an international issue and it should require the federal government to get involved and take the lead on this," he said. "Because clearly the state is belittling the situation."

Urban doesn't see it that way, and is proud of what the state has accomplished so far, saying when everyone's at the table, nationalities don't exist.

"I really believe that Canada will put the right requirements on the right sources, new or existing," Urban said. "I'm an optimist."

FINGERS CROSSED FOR THE FUTURE

The May 2015 auditor general's report is the first time the province criticized its own regulatory and enforcements efforts in the Elk Valle in clear, unmistakable language.

A month before the audit's publication, Paul Samycia sat on a red cooler on the wide, rocky shore of the Elk River. It rushed past with the faintest hint of the winter runoff that was about to descend in the next few weeks.

"All the baselines and all the targets seem to be: What is the level of selenium crossing the border? As opposed to, say, What is the level of selenium coming out of the Fording River?" Samycia said. He adjusted his sunglasses, and looked out over the water. "Why are we not concerned about that? Why aren't we concerned about the levels of selenium in the river right here, flowing by my house or by my business or through my town?"

Samycia, who plans to run his outfitter in Fernie for as long as the fish are biting, finds the audit somewhat hopeful. If nothing else, it shows it's possible that in the embittered arguments between agencies and governments, held in sterile conference rooms far from the river's banks, the rich valley he calls home might not be completely forgotten.

High Country News published Celia Talbot Tobin's story as an online photo essay on April 27, 2017, under the title Photos: Canada's coal flows into Montana's streams (http://www.hcn.org/articles/fishing-in-selenium-polluted-river).

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Crown Reporting Project

School of Journalism

University of Montana

Missoula, MT 59812

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Grassy Mountain Coal Project
IAAC No. 80101 September 21, 2020
Benga Mining Ltd
Donkersgoed Feeders Ltd/ Larry Donkersgoed

Joint Review Panel

Submissions of Donkersgoed Feeders Ltd. and Berdina Farms Ltd.

Donkersgoed Feeders Ltd and Berdina Farms Ltd are the owners of lands legally described as SW 19-08-03-W5M (the "Lands"). Larry Donkersgoed and Barb Donkersgoed are the shareholders of Donkersgoed Feeders Ltd. Larry Donkersgoed is the sole director of Donkersgoed Feeders Ltd. Edward Donkersgoed and Shannon Donkersgoed are the shareholders of Berdina Farms Ltd. Edward Donkersgoed is the sole director of Berdina Farms Ltd.

Description of the Lands

The Lands are within the Mine Permit boundary. Figure A.1.0-2 of Benga's application shows the Lands as being directly east of and adjacent to the central rock disposal area and the south rock disposal area.

We have a cabin on our Lands that we often make use of. We find that this land is a great place to truly be "one with nature." The Gold Creek, with its fresh mountain water, runs directly through our little piece of heaven. More often than not, we encounter wildlife while relaxing at the cabin. In the past we used the cabin many times a year. Now with construction and locked gates, we find it very difficult to access our property for relaxation and enjoyment.

We have owned the Lands for 15 years now.

Nature of our concerns with the Project

(a) Noise, dust and traffic concerns

We are concerned that the peace and tranquility which we enjoy on our Lands will be destroyed by Benga's proposed mine project. All of the beauty of the Gold Creek and surrounding streams and nature (wildlife and vegetation) will cease to be if this project is allowed to proceed. The noise, dust, excessive traffic and pollution which the project will bring will definitely destroy the beauty, peace, and tranquility of our lands. We will be exposed to constant noise, dust, and traffic all through the operational life of the mine, which Benga projects to be 24 years, as well as during its decommissioning stage. We are concerned about the effect on our health from being exposed to the noise and dust from the project.

(b) Water concerns

We are also concerned about Benga's proposal to discharge "treated" waste water into Gold Creek. We get our drinking water from Gold Creek, which runs right through our Lands. We are concerned that any discharge of "treated" waste water into Gold Creek will affect the quality of the water that Gold Creek provides to us and may possibly affect our health and the continued existence of westslope cutthroat trout that spawns in Gold Creek.

(c) Access Concerns

We note that Figure A.1.0-2 of Benga's Application shows that the access road that we take to access our Lands will be blocked, possibly, permanently by Benga's coal handling and processing plant and infrastructure that is projected to occur on Section 24-8-4-W5M ("Section 24").

We have always had this access road to our property. The access road is a registered easement on title to Section 24 (Land Title Registration No. 921280727). See **Tab 1** for a copy of the registered easement on Section 24 title. The easement affects NW 31, S ½ 31, Section 30, S ½ 19 and NW 19 in Townships 8, 5 and 3 W5M and NE 24-8-4-W5M. The same easement is evident on title to our property (Registration No. 921280727). See **Tab 2** for a copy of our title.

Without this access road, we will not have direct access to our property and to Blairmore road. Currently, there are locked gates and construction activities going on within the project area that we have to deal with, which have restricted our access to our lands. Basically, we have been pushed away from our own lands.

(d) Property Devaluation

We are concerned about the effect of the mine and its associated infrastructure on the value of our Lands. With our road access cut off and a coal mine in our back yard, we feel that our property will greatly depreciate and become almost unsaleable if the project is allowed to proceed.

We feel that it would be a shame to lose our little piece of heaven. As our children have grown into adults, we look upon this place as one for them to also enjoy with their families and our grandchildren. What better experience for a child to learn to respect nature, than by having the opportunity to "live in it."

Grassy Mountain Coal Project
IAAC No. 80101 September 21, 2020
Benga Mining Ltd
Donkersgoed Feeders Ltd/ Larry Donkersgoed

Contact Details

Donkersgoed Feeders Ltd.
<contact information removed>

Berdina Farms Ltd.
<contact information removed>

Requested Disposition

We request the Joint Review Panel to deny Benga Mining's applications. This is not a good location for this project. The effect on our families, our lands, on Gold Creek and the aquatic ecosystem that rely on it justify denying the applications.

Respectfully submitted,

Larry Donkersgoed and Ed Donkersgoed
On behalf of
Donkersgoed Feeders Ltd. and Berdina Farms Ltd.

ALBERTA GOVERNMENT SERVICES
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AG 1844

Alberta
ATTORNEY GENERAL

Document Registration Request

4628137

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Name
NORTH PETERSEN LINT ANDREACHUK

Account or Party Code # [redacted]

Cheque Cash

Amount Enclosed

Address (cash customers only) #600, 220 - 4th Street South
Lethbridge Alta. T1J 3Y5

Client's File # 15844.1 DRL

Return By Call Box # Mail Courier
330

Date DD MM YY
02 11 92

Signature
<Signature removed>

Customer's Special Instructions /Advice
Register regardless of prior registrations on title
320-8958 Register subject to last registered interest being #

Phone #
328-7781

Other instructions

Registration Priority | Documents – List in order of registration priority | Subsequent Services Requested
1 Easement Agreement, in dup. ② 10 Dup. REg. Easement
15
2 1 copy of each title # 8
3
4
5
6
7
8

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CALGARY L.T.O.
SE

Fax 1 copy of each title and charge to account (limit - 5 titles)

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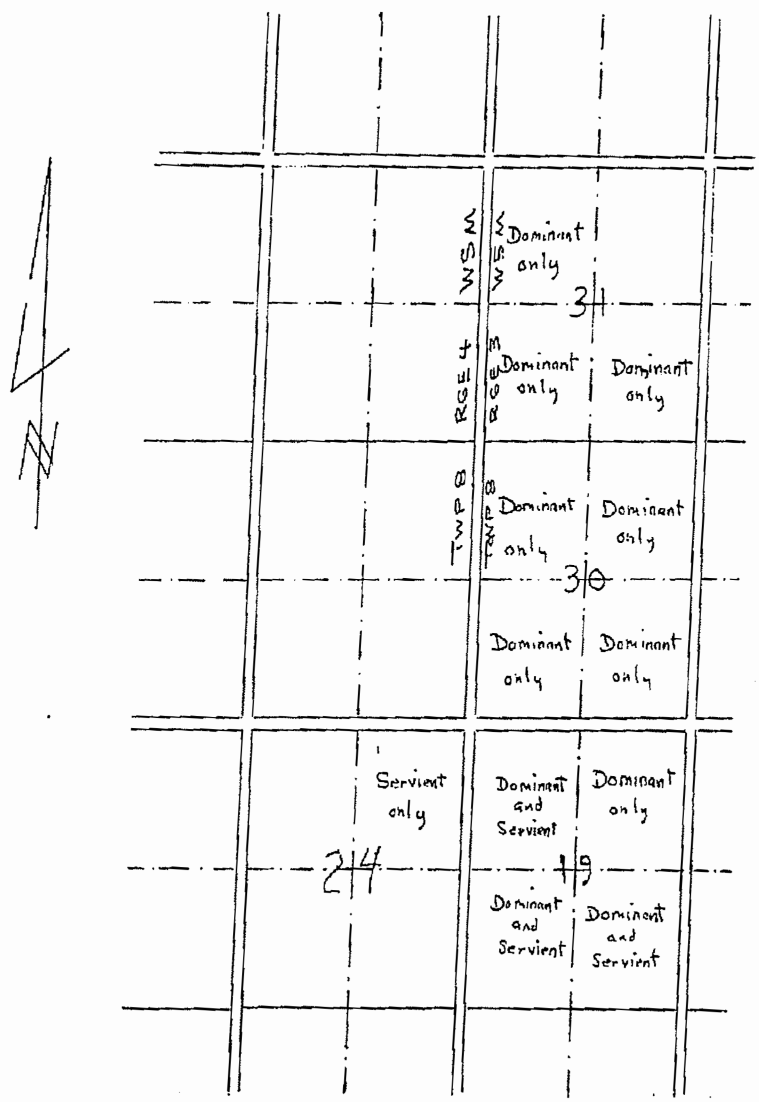


TWP 8 RGE 4 WSM
Dominant only
34
Dominant only
Dominant only
Dominant only
Dominant only
30
Dominant only
Dominant only
Servient only
Dominant and Servient
Dominant only
24
19
Dominant and Servient
Dominant and Servient

EASE OVER S½ and NW¼ 19-8-3-W5 and NE¼ 24-8-4-W5
FOR BENEFIT OF Section 19-8-3-W5, Section 30-8-3-W5 and S½ and NW¼ 31-8-3-W5.

THIS AGREEMENT made the 30 day of OCTOBER, A.D., 1992.

B E T W E E N:

KOOTENAY WOOD PRESERVERS LTD.
of P.O. Box 3338
Spruce Grove, Alberta
(hereinafter called "KWP")

OF THE FIRST PART

- and -

KOOTENAY WOOD PRESERVERS LTD.
of P.O. Box 3338
Spruce Grove, Alberta
(hereinafter called "KWP")

OF THE SECOND PART

Blanket Easement

WHEREAS KWP is registered as the owner of the lands described on Schedule "A" to this Agreement and has as owner, agreed to grant to itself the Easements hereinafter described, it being noted for the sake of clarity and agreed that:

(a) Easements are to be granted hereunder over the lands in order to permit the owner of adjoining or neighboring lands access to and egress from the adjoining or neighboring lands;

(b) All of the lands over which an Easement is being granted will, with respect to such Easement, constitute and be sometimes termed in this Agreement, a "Servient Tenement" as described in Column 1 of Schedule "B" to this Agreement. The adjoining or neighboring lands for the benefit of which each such Easement is being granted will constitute and be sometimes termed in this Agreement, a "Dominant Tenement" as described in Column 2 of Schedule "B".

(c) The Parcel numbers set out in Column 1 and Column 2 of Schedule "B" shall refer to the Parcel number of the lands as described on Schedule "A" hereto.

NOW THEREFORE this Agreement witnesseth that:

1. KWP being registered as owner of the lands described in Schedule "A" to this Agreement, in consideration of the sum of $1.00 and other good and valuable consideration, the receipt of which is hereby acknowledged, does hereby grant and convey in respect of the lands described in Column 1 of Schedule "B", each of which is described as and shall constitute the Servient Tenement of the lands described in Column 2 thereof unto KWP as registered owner of each of the parcels of land in the sequence of lands described in Column 2 of Schedule "B", each of which is described as and shall constitute the Dominant Tenement of the particular lands described in Column 1, the right, privilege and easement thereover as is hereinafter described.

2. The right, privilege and easement hereby granted shall be and is the perpetual right, privilege and easement of access to and passage to and over the lands described in Column 1 of Schedule "B" for the purposes of the owners of the Dominant Tenement and their invitees ingress to and egress from the lands described in Column 2 of Schedule "B", and for the purpose of the owner of the Dominant Tenement maintaining, repairing and rebuilding the existing roadways or other existing means of access across and over the Servient Tenement. The right, privilege and easement as aforesaid is hereafter referred to as the "Easement".

3. KWP, as owner of the lands which are the Servient Tenement of each Easement hereby granted, covenants and agrees on behalf of itself as such owner and on behalf of each of its successors in title to such lands with itself as owner of the respective lands which are the Dominant Tenement of such Easement and with the successors in title of the Dominant Tenement that:

(a) Upon execution of these presents and at all times thereafter, the owners of the Dominant Tenement and their successors in title or any person, firm or corporation acting on their behalf may enter upon and occupy the Easement with their agents, servants, workmen and contractors and with or without vehicles, machinery and equipment for the purposes as aforesaid;

(b) The owner of the Servient Tenement and their successors in title will not erect any buildings or structures upon, over or under, the Easement without the prior written consent of the owners of the Dominant Tenements;

(c) The owners of the Dominant Tenements performing and observing the covenants and conditions herein contained, shall peaceably hold and enjoy all the rights, privileges, liberties and covenants hereby granted without any hindrance or interruption from the owners of the Servient Tenements or any person or persons claiming by, through, under or in trust for them or any person or persons whatsoever.

4. KWP as owner of the lands which are the Dominant Tenement of each Easement hereby granted, covenants and agrees on behalf of itself as owner and on behalf of each of its successors in title to such land, with itself as owner of the respective lands which are the Servient Tenement of such Easement and with the successors in title of the Servient Tenement that:

(a) The owners of the lands which are the Dominant Tenement shall share equally the costs of repairing, rebuilding and maintaining the existing roadway on the Easement on the respective lands which are the Servient Tenement;

(b) Each owner of the lands which are the Dominant Tenement from time to time will separately indemnify and save harmless the owner from time to time, of the lands which are the Servient Tenement in respect of each such Easement from and against all claims, damages, debts, suits, dues, actions, liabilities and causes of action, costs or sums of money whatsoever that the owner of the Servient Tenement may suffer or be put to by reason of anything done by that owner of the Dominant Tenement in the exercise of any one or more of the rights and privileges hereby granted;

(c) The Easements hereby granted shall not be extinguished in the event that title to or ownership of any of the lands which shall adjoin each other shall be vested in the same person; and

(d) The owner of the Servient Tenement shall have the right to use the Easement and shall have a right of ingress and egress over the same but not so as to interfere in any manner with the use and occupation thereof by the owners of the Dominant Tenement.

5. This Easement and the covenants herein contained are and shall be and shall be deemed to be covenants running with the lands and shall be binding upon and enure to the benefit of KWP and its respective successors in title to all of the lands and in respect thereof, only while and to the extent that each such party remains registered as owner thereof from time to time.

6. Where required by the content or context hereof, the singular shall include the plural and the masculine gender or neuter gender shall include either feminine gender or the masculine gender as the case may be and vice versa. Should the Grantor or Grantee of the rights of Easement hereby conferred at any time and from time to time, comprise two or more persons, each such person and not one for the other or others, shall be jointly and severally bound with the other or others for the due performance of the obligations of the Grantor or Grantee of such rights.

IN WITNESS WHEREOF KOOTENAY WOOD PRESERVERS LTD. has caused its corporate seal to be affixed hereto duly attested by the hand of its proper Officer duly authorized in that behalf, all as of the day and year first above written.

KOOTENAY WOOD PRESERVERS LTD.
<Signature removed>

KOOTENAY WOOD PRESERVERS LTD.
<Signature removed>

SCHEDULE "A" to the Agreement made between
KOOTENAY WOOD PRESERVERS LTD. and KOOTENAY WOOD PRESERVERS LTD.
dated the 5 day of October A.D., 1992

PARCEL I	MERIDIAN 5 RANGE 3 TOWNSHIP 8 SECTION 31 QUARTER NORTH WEST EXCEPTING THEREOUT ALL MINES AND MINERALS
PARCEL II	MERIDIAN 5 RANGE 3 TOWNSHIP 8 SECTION 31 QUARTER SOUTH WEST EXCEPTING THEREOUT ALL MINES AND MINERALS
PARCEL III	MERIDIAN 5 RANGE 3 TOWNSHIP 8 SECTION 31 QUARTER SOUTH EAST EXCEPTING THEREOUT ALL MINES AND MINERALS
PARCEL IV	MERIDIAN 5 RANGE 3 TOWNSHIP 8 SECTION 30 QUARTER NORTH WEST EXCEPTING THEREOUT ALL MINES AND MINERALS
PARCEL V	MERIDIAN 5 RANGE 3 TOWNSHIP 8 SECTION 30 QUARTER NORTH EAST EXCEPTING THEREOUT ALL MINES AND MINERALS
PARCEL VI	MERIDIAN 5 RANGE 3 TOWNSHIP 8 SECTION 30 QUARTER SOUTH EAST EXCEPTING THEREOUT ALL MINES AND MINERALS
PARCEL VII	MERIDIAN 5 RANGE 3 TOWNSHIP 8 SECTION 30 QUARTER SOUTH WEST EXCEPTING THEREOUT ALL MINES AND MINERALS

PARCEL VIII	MERIDIAN 5 RANGE 3 TOWNSHIP 8 SECTION 19 QUARTER NORTH EAST EXCEPTING THEREOUT ALL MINES AND MINERALS
PARCEL IX	MERIDIAN 5 RANGE 3 TOWNSHIP 8 SECTION 19 QUARTER SOUTH EAST EXCEPTING THEREOUT ALL MINES AND MINERALS
PARCEL X	MERIDIAN 5 RANGE 3 TOWNSHIP 8 SECTION 19 QUARTER SOUTH WEST EXCEPTING THEREOUT ALL MINES AND MINERALS
PARCEL XI	MERIDIAN 5 RANGE 3 TOWNSHIP 8 SECTION 19 QUARTER NORTH WEST EXCEPTING THEREOUT ALL MINES AND MINERALS
PARCEL XII	MERIDIAN 5 RANGE 4 TOWNSHIP 8 SECTION 24 QUARTER NORTH EAST EXCEPTING THEREOUT ALL MINES AND MINERALS

SCHEDULE "B" to the Agreement made between

KOOTENAY WOOD PRESERVERS LTD. and KOOTENAY WOOD PRESERVERS LTD.

dated the 30th day of OCTOBER, A.D., 1992

Column 1 (Servient Tenement)	Column 2 (Dominant Tenement)
An Easement over each of the lands shown below:	Is granted under the annexed grant of Easement in favor of the respective lands shown below:
PARCEL XII	PARCEL I THROUGH PARCEL XI INCLUSIVE
PARCEL XI	PARCEL I THROUGH PARCEL X INCLUSIVE
PARCEL X	PARCEL I THROUGH PARCEL IX INCLUSIVE
PARCEL IX	PARCEL I THROUGH PARCEL VIII INCLUSIVE

LAND TITLE CERTIFICATE

S

LINC	SHORT LEGAL	TITLE NUMBER
0017 855 066	5;3;8;19;SW	051 223 917

LEGAL DESCRIPTION
MERIDIAN 5 RANGE 3 TOWNSHIP 8
SECTION 19
QUARTER SOUTH WEST
EXCEPTING THEREOUT ALL MINES AND MINERALS
AREA: 64.7 HECTARES (160 ACRES) MORE OR LESS

ESTATE: FEE SIMPLE

MUNICIPALITY: MUNICIPAL DISTRICT OF RANCHLAND NO. 66

REFERENCE NUMBER: 041 255 358

REGISTERED OWNER(S)

REGISTRATION	DATE(DMY)	DOCUMENT TYPE	VALUE	CONSIDERATION
051 223 917	23/06/2005	TRANSFER OF LAND	$435,000	$435,000

OWNERS

DONKERSGOED FEEDERS LTD.
OF BOX 449
COALDALE
ALBERTA T1M 1M4
AS TO AN UNDIVIDED 1/2 INTEREST

BERDINA FARMS LTD.
OF BOX 1493
COALDALE
ALBERTA T1M 1N3
AS TO AN UNDIVIDED 1/2 INTEREST

ENCUMBRANCES, LIENS & INTERESTS

REGISTRATION NUMBER	DATE (D/M/Y)	PARTICULARS
841 025 754	13/02/1984	UTILITY RIGHT OF WAY GRANTEE - ALTALINK MANAGEMENT LTD.

(CONTINUED)

REGISTRATION NUMBER	DATE (D/M/Y)	PARTICULARS
		2611 - 3 AVE SE CALGARY ALBERTA T2A7W7 AS TO PORTION OR PLAN:8510780 "DATA UPDATED BY: PARTIAL DISCHARGE 851201130" (DATA UPDATED BY: TRANSFER OF UTILITY RIGHT OF WAY 021200683) (DATA UPDATED BY: CHANGE OF ADDRESS 091107755)
921 280 727	06/11/1992	EASEMENT OVER S1/2 AND NW1/4 19-8-3-W5 AND NE1/4 24-8-4-W5 FOR BENEFIT OF SECTION 19-8-3-W5, SECTION 30-8-3-W5 AND S1/2 AND NW1/4 31-8-3-W5
951 154 345	11/07/1995	UTILITY RIGHT OF WAY GRANTEE - FORTISALBERTA INC. 320 - 17 AVENUE S.W. CALGARY ALBERTA T2S2Y1 (DATA UPDATED BY: TRANSFER OF UTILITY RIGHT OF WAY 001295181) (DATA UPDATED BY: CHANGE OF NAME 051028926)
971 320 737	27/10/1997	CAVEAT RE : EASEMENT CAVEATOR - ALTALINK MANAGEMENT LTD. 2611 - 3 AVE SE CALGARY ALBERTA T2A7W7 (DATA UPDATED BY: TRANSFER OF CAVEAT 021197975) (DATA UPDATED BY: CHANGE OF ADDRESS 091068270)

TOTAL INSTRUMENTS: 004

THE REGISTRAR OF TITLES CERTIFIES THIS TO BE AN ACCURATE REPRODUCTION OF THE CERTIFICATE OF TITLE REPRESENTED HEREIN THIS 2 DAY OF SEPTEMBER, 2015 AT 03:41 P.M.

ORDER NUMBER: 29197650

CUSTOMER FILE NUMBER: 154436RCS

END OF CERTIFICATE

(CONTINUED)

Joint Review Panel September 21, 2020
Benga Mining Ltd
Grassy Mountain Coal Mining Project Project ID 80101
Submissions of David Rothlin and Kari Lehr

Submissions of Kari Lehr

My husband, Dave and I have lived in Valley Ridge Estates since July 2004. We have three children, one of whom still lives at home with us while pursuing her University degree online. Our other two children are in Calgary and visit regularly to hike and bike the area.

Like so many others, we moved to Crowsnest Pass in order to be in the natural mountain environment we've always loved and camped in on our holidays away from the city. Moving to this mountain environment was a dream which eventually became reality when Dave was able to transition to the wind turbine industry by accepting a position with Vestas in Pincher Creek. We both enjoy hiking, biking and fly fishing (Dave) in Gold Creek below our home.

We were very dismayed when the proposed Grassy Mountain mine first came to our attention. During the past few years we couldn't really imagine that it would take off, as the ongoing EIA's seemed to be forever incomplete, leading us to feel that Benga wasn't really serious, and that our provincial government at the time would continue to demand strict adherence to environmental protection standards within the mining industry. However, with the current provincial government's anti-environmental agenda, we have lost faith that Benga will be held to account as it moves forward.

There is a long and dismal record of mining companies polluting waterways and degrading natural landscapes - new strip-mining projects in this day and age seems unfathomable to me in the climate crisis we are all facing. I do not have any faith whatsoever that Benga is looking out for the health and wellbeing of the residents of Crowsnest Pass. In Valley Ridge Estates where we live, we rely on well water, and it is terrifying to me that the purity of our groundwater is at risk by a company who hasn't bothered to show any consistent and serious effort to abide by the requirements which have been outlined time and time again in the environmental regulations. Our greater community is at risk as well - we don't have to look far to see what has been happening in Sparwood, with the concerns raised in Canada and the US over toxic selenium levels in the Elk river. We are very concerned that contamination of water in our area could also leave us with a beautiful home which would have no commercial value, should we be forced to move.

I believe that there is a huge risk imposed to our water, our health, our environment which is fundamentally not worth the shortsighted “gain” perceived by some in the development of Grassy Mountain coal mine.

In view of all the risks that this project poses, I request the Joint Review Panel to recommend a denial of this project.

Sincerely,
Kari Lehr
Valley Ridge Estates

Submissions of David Rothlin

Along with my wife Kari, I am opposed to the development of the Grassy Mountain coal mine and have been from the beginning. As someone who is interested in renewable energy and worked for many years as a wind turbine technician and supervisor, I believe that the province opening doors to strip mining development in the Crowsnest Pass is a huge step backward for our community and for our environment.

I am very concerned about the quality of our well water, the rivers, streams and headwaters in our area as well as dust and noise pollution, and the negative impact this mine will have on our continued attempts to brand this community as a recreational destination for visitors from far and wide. I think this municipal government has been short-sighted in its inability to move forward with any kind of progressive vision, preferring to hang on to the idea of coal mining as the only economic engine that can move this community forward. Looking at progressive countries like Sweden who are working towards replacing coking coal with hydrogen in the steel-making process, I am also dismayed at the anti-environmental agenda and lack of vision in our current provincial government.

I strongly oppose the Grassy Mountain coal mining project, as well as all other proposed strip mining projects in the Crowsnest Pass and believe they are a threat to our health and wellbeing, and will bring short-term, limited prosperity only to very few local residents.

I request the Joint Review Panel to recommend a denial of Benga Mining Limited's applications for this project.

Sincerely,
Dave Rothlin
Valley Ridge Estates

JOINT REVIEW PANEL

Submissions of Fran Gilmar

I am the registered owner of SW 30-8-3-W5M ("SW 30"). SW 30 is within the mine boundary as Benga Mining Limited ("Benga") indicates at page A-7 of its August 2016 application. SW 30 is close to the mine pit boundary and the proposed north disposal areas.

I have owned SW 30 for 28 years (since 1992). My late husband and I used to operate a ranch (Grassy Mountain Ranch) on SW 30. We have a residence, barns and corrals on SW 30. I still operate the Grassy Mountain Ranch. As often as I can, I go up to stay in the residence and enjoy the beauty that Grassy Mountain offers.

I am concerned about Benga's proposals to construct and operate a surface metallurgical coal mine, a coal handling and preparation plant with associated infrastructure, an overland conveyor system and a new rail track (the "Project").

I am also concerned about Benga's application for a licence to divert surface and groundwater for use in the Project. I am further concerned about Benga's proposal to construct two external overburden dumps adjacent to the pit.

Details of my concerns are stated below.

1. Geographic Location of the Project and past actions of Benga

The Project will affect 1,582.4 hectares of land. SW 30 is within the Project's boundary. Locating the Project in the proposed location with its attendant noise, dust, and clearing of vegetation will affect the value of SW 30 and the Grassy Mountain area. This will ultimately destroy my enjoyment and use of my property both for my personal enjoyment and for grazing my livestock.

The Project will be located near some water bodies and environmentally significant areas and will impact these water bodies. For instance, the Blairmore Creek and the Gold Creek flow in a north to south direction along the western and eastern margin of the proposed mine permit boundary. Spring run-offs flow from the top of the mountain down south along the east and west slopes of the mountain. All the spring run-offs flow into Gold Creek and Blairmore Creek. Locating the Project at the proposed location will cause a pollution of the Blairmore Creek and Gold Creek as a result of tailings/slags and coal debris being washed off during spring runoffs or heavy rain. A typical example occurred sometime in July 2015 when coal plumes and debris from Benga's exploration activities pursuant to AER approvals received under Applications CEP130011 and 140011 were washed off of the exploratory sites into watercourses below. This incident

(Reference No. 2015-020) was investigated by the Alberta Energy Regulator ("the Regulator"). The fact that an infraction occurred during the exploratory phase of this project should be sufficient reason for this Panel to deny Benga's application for approval of the Project at this location.

2. Quality of Coal

Benga states at page A-1 (A.1 Background) of its Project application that the intention of the Project is to re-establish a historical coal mine on Grassy Mountain, to ship "high quality steelmaking coal" to overseas steel producing markets. Benga further states at page A-2 that at full production, the Project will be one of the largest single site sources of steelmaking coal to have been developed in the past few decades using the most modern mining technology.

I have considerable concerns about the quality of the coal that Benga is projecting will be realized from this Project. There is no high-quality coal in Grassy Mountain. Benga's statements are speculative. Similar claims were made by the previous owners of the legacy Grassy Mountain mine prior to production. One of the miners was West Canadian Colleries Ltd. who mined coal on Ranges 3 and 4, which are the current proposed locations of the coal mine. Western Canadian Colleries Ltd. ("Western Canadian" made similar claims as Benga but the quality of coal retrieved did not match up to expectation. Western Canadian abandoned its first attempt of mining Grassy Mountain. After many years of abandonment, Western Canadian re-opened the mine. The so called "steel making coal" that was mined was shipped to Japan through Canadian Pacific Railway (CPR)'s rail lines. Japan rejected the coal. Legal battles and coal protests ensued resulting in the closure of the mine in 1960. See **Tab 1** for supporting information regarding the previous coal exploration and mining of Grassy Mountain.

I note that there are different grades of coking coal which is based on the ash content. See Tab 1, pdf 5 for more information regarding the different grades of coking and non-coking coal. According to the grading of coking coal, steel grade-1 coking coal must not have ash content exceeding 15%. Steel grade-II coking coal's ash content can exceed 15% but not exceed 18%. I took photos of coal recovered by Benga during its coal exploration program that commenced in December 2013. See **Tab 2**, pdf 45 to 50. As can be seen, the coal is mostly ash. Benga quickly buried this coal samples at SW ¼ Section 14 to avoid detection. I have attached at Tab 2, pdf 51, a map showing the approximate location of the place where Benga buried the coal samples extracted during its exploration program. If these coal samples had shown good quality coking coal as Benga proposes, Benga would not have been too quick to bury them. They would have showcased them as evidence of the coal quality that they have retrieved from the Grassy Mountain.

Volcanoes are a frequent occurrence on Grassy Mountain. The volcanoes have affected the quality of coal, if any, remaining present on Grassy Mountain. As can be seen from the photos at Tab I, pdf 17, 22-23, 26 to 31 there are rocks left after the lava from the volcano has cooled. Again, this casts serious doubt on Benga's claim that the quality of coal on Grassy Mountain is high quality coking coal.

In my view, any high coking coal present on Grassy Mountain are intermittent and sparse. There is a reason why Grassy Mountain is referred to as a Land of Sulphur, Salt, Shale and Silt.

Benga/Riversdale has made similar claims in its other coal mine projects such as the Mozambique coal projects. See **Tab 3**. A review of these claims after the projects became operational by an independent body revealed that Benga/Riversdale's African assets held less coal than previously thought and were insufficient to support its own rail infrastructure. See Tab 3, pdf 54. This is likely to happen in this case if the Panel permits this project!

3. Socio-Economic Impacts and Project Need

Benga claims that the project will bring economic development to the Grassy Mountain area and its environs. This claim of economic development does not consider the environmental damage that will result from the so-called economic development. It is possible that the coal that will be produced from this mine site if the project is allowed to proceed will turn out to be similar to the coal produced in the previous years that were rejected. The economic benefit is not really a benefit as it is not clear how much of the so-called benefit will actually benefit the local community.

4. Water Concerns

I am concerned about Benga's proposal to discharge "treated" waste water into the environment and into Gold Creek. I have water well on SW 30 that is fed by a stream that runs into Gold Creek. Any discharge of the "treated" waste into the environment will affect the quality of my drinking water and will likely affect my health.

I am also concerned about potential pollution of my water source by leaching of selenium from mining wastes dumped in the north rock disposal areas. Benga identifies at page A-25, paragraph A.6.4 that "leaching of selenium out of the rock disposal areas is a possibility". The east boundaries of the central rock disposal areas border the west boundary of SW 30 and the southeast sedimentation pond is close to the south boundary of my land. A leaching of selenium from the rock disposal areas and the sedimentation ponds will affect my water source and Gold Creek.

Furthermore, any discharge of “treated” waste water into Gold Creek will affect the quality of the water in Gold Creek and possibly affect the continued existence of Westslope Cutthroat Trout that spawns in Gold Creek. In fact, the Westslope Cutthroat Trout has its nursery in the Gold Creek running through the southwest corner of SW 30. The Westslope Cutthroat Trout habitat on SW 30 has been there for many years.

There are also pristine water bodies such as Daisy Creek that will be affected by Benga’s Project and the proposal to discharge “treated” waste water into the environment.

It is important to note that coal produced contain some common trace elements such as arsenic, lead, manganese and titanium. See Tab 1, pdf 7. These elements when released into the environment are dangerous to human health and to the health of fish. Some of these elements are likely to be introduced into the environment of Grassy Mountain including the Gold Creek and Blairmore Creek. Coupled with the natural existence of these metals in the environment, the project will intensify their quantity thereby impacting human health.

Benga anticipates that there will be diversion of water for mining activities. A diversion of water will cause a loss of flow and have significant impacts on downstream fish habitat and affect the quantity of water available to me. The flow of water will be cut off.

5. Noise and dust

I am concerned about the noise and dust that will arise from the mining operations. I will experience a large amount of dust from the mining operation due to the direction of winds. The Project area is in a strong wind zone. Strong prevailing winds come from the west to the east and SW 30 is directly east of the mine location.

The noise from the blasting operations will increase the noise levels in SW 30 and destroy my peaceful enjoyment of my land. This will also have effect on my health.

In addition, the dust from the blasting operations of Benga will settle on the Gold Creek and our water source thereby polluting them.

6. Access concerns

Figure A.1.0-2 of Benga’s Application shows that the access road (a registered easement on SW 30) which we use to access SW 30 will be blocked, possibly, permanently by Benga’s rock disposal areas and coal handling and processing plant and infrastructure that is projected to occur on Section 24-8-4-W4M (“Section 24”). This access road is also a registered easement on title to Section 24 (Land Title Registration No. 921280727). A copy of this easement has been produced as part of the submissions of Larry and Ed

Donkersgoed who are also affected by this easement. Without this access road, I will not have direct access to SW 30 and to Blairmore road.

7. Property Devaluation

I am concerned that the proximity of the mine and its associated facilities to SW 30 will devalue SW 30. No one will want to live near a mine and a mining plant. The presence of the mine will discourage potential purchasers from buying my land.

8. Air Pollution and health concerns

I am concerned that the existence of the mine pits and the rock disposal areas in close proximity to SW 30 will affect the quality of air on SW 30. I will be exposed to compounds such as sulphur dioxide, nitrogen oxides, and other substances that are released from mining activities.

9. Environmental Concerns

I am concerned about the effects of this Project on the wildlife, fauna, and fishery in the area. SW 30 has a moose yard where moose often rests. I have seen grizzly bear and black bear pass through SW 30. Sometime ago, a grizzly bear killed a moose on the corner of SW 30 and NW 30. Golden eagles used to nest on the ledge of Grassy Mountain. The golden eagles disappeared when Benga started its exploration activities in the area. Approving the Project in this location will destroy the habitats of the grizzly bears, black bears, moose, cougars and other wildlife that call Grassy Mountain home, just as the exploration activities destroyed the nesting grounds of golden eagles.

There is evidence of garter snake hibernacula on SE 25-8-4-W5M. See Tab 1, pdf 10 - 11. SE 25 is within the coal mine pit.

Requested Disposition

I request the Joint Review Panel to deny Benga's applications.

Yours truly,

Fran Gilmar

Lille-Grassy Mountain Prospect

Interrupted Coalification Process

The faulting (emerging) of the Livingstone Ridge - Cutting off water flow and movement of water needed for producing oxygen supply in the coalification process.

Less Oxygen, Lower Coal Grade.

The subsequent volcanic activity

The mineral intrusion entering the not-complete coalification process.

Weak macerals of the Lille-Grassy Mountain

Coal location - inland ocean edge - vegetation - massive Magnolia trees - red seaweed mats approximately 6 meters thick "Salt Water" Magnolia Swamp.

Second Closure of West-Canadian Collieries Ltd.
Grassy Mountain Prospect Coal Mine
Post World War II Japan Rejects

coal shipments from Canada, the coal shipments originate in Alberta, Canada. The mine location is Grassy Mountain in Prospect, West-Canadian Ltd. located in Crowsnest Pass, shipping agent is Canadian Pacific Railway, C.P.R. Ocean going freight shipping line owned by Canadian Pacific Railway, Registry (Flagged) permit from the Canadian Ocean Shipping Maritime Registry - Illegally Mined Coal - (a closed relocated mine, 1904 - 1913, West-Canadian Colleries Ltd., Grassy Mountain Prospect). Shipped by Canadian Pacific Railway, C.P.R. Coal loaded onto Canadian Pacific Ocean freighters, destination Japan - Japan Rejects - Coal Protests for approximately 12-15 years, FINALLY. The incident on Grassy Mountain Prospect Dec. 1958. The result is the closure of Grassy Mountain Prospect. Final coal shipment is jettisoned into internationale waters of the Pacific Ocean. The second closure of Grassy Mountain Prospect.

Coordinates: 49°39′5.5″N 114°23′48″W

WIKIPEDIA

Lille, Alberta

Lille is a ghost town in the Crowsnest Pass region of southwestern Alberta, Canada. It was a company-built coal mining town that, between 1901 and 1912, hosted a population that grew to nearly 400. The mines at Lille closed in 1912, due primarily to weak coal prices, increasing production costs, and the increasingly poor quality (high ash content) of the coal. The town was then dismantled and most of its structures were moved elsewhere. Today the site is an Alberta Provincial Historic Resource and is known for the elegant ruins of a set of Bernard-style coke ovens that was imported from Belgium.[1]

Ruins of coke ovens at Lille, Alberta

History

Lille was founded as a coal mining town in 1901 by two representatives of a French company, United Gold Fields Ltd., that was re-established as Western Canadian Collieries in 1903. The company representatives, J. J. Fleutot and C. Remy, were prospecting in the Crowsnest Pass area when they happened upon a coal seam near the future site of Lille. Initially called 'French Camp', [2] the town was renamed Lille after the French town of the same name where the mining venture's financial backers were located.[3][4]

The town was built mostly by the mining company. It had electricity and a water works, and grew to a population of nearly 400. It included approximately 80 structures. There were miners' residences, a large residence for the superintendent, a doctor's residence, a 15-bed hospital, a 4-room school house, a post office, and a North West Mounted Police detachment, as well as a coal washery, the mine stable and corral, and 50 Bernard-style coke ovens. Businesses included a hotel, a general store, a bakery, a butcher shop, barber shops, and a liquor store. [1][3][4]

Bituminous coal was produced from seams in the Mist Mountain Formation at three mines near Lille by underground room-and-pillar mining methods. Total production over the town's 11-year history was some 901,000 metric tons (993,000 short tons).[4] A rail spur called the Frank and Grassy Mountain Railway was built by the company to transport coal and coke from Lille to the Canadian Pacific Railway mainline at Frank, Alberta. With a length of 11 kilometres (6.8 mi), the rail spur was an expensive undertaking that required construction of 23 trestle bridges to traverse the rough terrain along the steep, narrow valley of Gold Creek.[3][4]

The Frank Slide in 1903 was a significant setback for the company. It obliterated the southern portion of the rail spur, including many trestles, and mining operations had to be suspended during the rebuilding. Further, the coke ovens that were originally planned for Frank were set up at Lille instead. The ovens, which were used to convert fine coal (slack) into coke, were imported from Belgium, with each brick numbered for ease of reassembly. [3][4]

Other setbacks for the company included a forest fire that destroyed the railway trestles, difficulties clearing snow from the rail tracks, labour unrest, weak coal prices, increasing production costs, and the increasingly poor quality

of coal

Pickeringite $MgAl_2(SO_4)_4 \cdot 22H_2O$

Crystal Data: Monoclinic. *Point Group:* 2. Acicular to hairlike crystals, with many forms measured although terminated crystals are very rare; in radial or matted aggregates; typically as incrustations and efflorescences.

Physical Properties: *Cleavage:* Poor on {010}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 1.5 D(meas.) = 1.73–1.79 D(calc.) = 1.84 Soluble in H_2O, astringent taste.

Optical Properties: Semitransparent. *Color:* Colorless, white; may be pale shades of yellow, green, or red from metallic impurities; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $Z \wedge a = 36°$. $\alpha = 1.475$ $\beta = 1.480$ $\gamma = 1.483$
2V(meas.) = 60°

Cell Data: *Space Group:* $P2_1/c$. $a = 6.1844(2)$ $b = 24.2715(9)$ $c = 21.2265(7)$
$\beta = 100.326(4)°$ Z = 4

X-ray Powder Pattern: Tucumcari, New Mexico, USA. (ICDD 12-299).
4.82 (100), 3.510 (90), 4.32 (35), 4.122 (30), 3.791 (30), 6.08 (20), 4.97 (20)

Chemistry:

	(1)	(2)
SO_3	37.84	37.29
Al_2O_3	12.30	11.87
MgO	4.35	4.69
CaO	0.09	
H_2O	44.66	46.15
insol.	0.50	
Total	99.74	100.00

(1) Quetena, Chile. (2) $MgAl_2(SO_4)_4 \cdot 22H_2O$.

Polymorphism & Series: Forms a series with halotrichite.

Mineral Group: Halotrichite group.

Occurrence: A common secondary mineral formed by alteration of pyrite in aluminous rocks or in coal seams; in the oxidized zone of pyritic hydrothermal mineral deposits, typically in arid regions, typically post-mining; a fumarolic product; formed in caves.

Association: Kalinite, alunogen, epsomite, melanterite, copiapite, gypsum.

Distribution: Widespread, so only a few localities are listed. In Chile, abundant from Cerros Pintados, 80 km southeast of Iquique, Tarapacá; at Quetena, west of Calama, and Chuquicamata, Antofagasta. In the USA, in New Mexico, from near Tucumcari, Quay Co.; at The Geysers, Sonoma Co., California; from Alum Point, Salt Lake Co., Utah. In Canada, at Newport, Nova Scotia, and from the junction of the two main branches of the Smoky River, Alberta. In Germany, at Wetzelstein, near Saalfeld, and from near Lehesten, Thuringia. On Valachov Hill, near Skřivaň, Czech Republic. At Cervenica (Opálbánya), Slovakia. In Italy, from Baia di Levante, Vulcano, Lipari Islands; on Mt. Etna, Sicily; and on Elba. At volcanoes on the Kamchatka Peninsula, Russia.

Name: To honor John Pickering (1777–1846), American lawyer and philologist of Boston, Massachusetts, USA.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 523–526. (2) Quartieri, S., M. Triscari, and A. Viani (2000) Crystal structure of the hydrated sulphate pickeringite $MgAl_2(SO_4)_4.22H_2O$: X-ray powder diffraction study. Eur. J. Mineral., 12, 1131–1138.

GRADES

The gradation of non-coking coal is based on Useful Heat Value (UHV), the gradation of coking coal is based on ash content and for semi coking / weakly coking coal it is based on ash plus moisture content , as in vogue as per notification.

Grades of Coking Coal

Grade	Ash Content
Steel Grade -I	Not exceeding 15%
Steel Grade -II	Exceeding 15% but not exceeding 18%
Washery Grade -I	Exceeding 18% but not exceeding 21%
Washery Grade -II	Exceeding 21% but not exceeding 24%
Washery Grade -III	Exceeding 24% but not exceeding 28%
Washery Grade -IV	Exceeding 28% but not exceeding 35%

Grades of Non-coking Coal

Grade	Useful Heat Value (UHV) (Kcal/Kg) UHV= 8900-138(A+M)	Corresponding Ash% + Moisture % at (60% RH & 40^{O} C)	Gross Calorific Value GCV (Kcal/ Kg) (at 5% moisture level)
A	Exceeding 6200	Not exceeding 19.5	Exceeding 6454
B	Exceeding 5600 but not exceeding 6200	19.6 to 23.8	Exceeding 6049 but not exceeding 6454
C	Exceeding 4940 but not exceeding 5600	23.9 to 28.6	Exceeding 5597 but not exceeding. 6049
D	Exceeding 4200 but not exceeding 4940	28.7 to 34.0	Exceeding 5089 but not Exceeding 5597
E	Exceeding 3360 but not exceeding 4200	34.1 to 40.0	Exceeding 4324 but not exceeding 5089
F	Exceeding 2400 but not exceeding 3360	40.1 to 47.0	Exceeding 3865 but not exceeding. 4324
G	Exceeding 1300 but not exceeding 2400	47.1 to 55.0	Exceeding 3113 but not exceeding 3865

Grades of Semi-coking and Weakly Coking Coal

Grade	Ash + Moisture Content
Semi coking grade -I	Not exceeding 19%
Semi coking grade -II	Exceeding 19% but not exceeding 24%

Grades of NEC Coal :

Grades	UHV (Kcal/Kg)	Corresponding Ash% + Moisture %age
A	6200-6299	18.85 - 19.57
B	5600 - 6199	19.58 - 23.91

There exists a genetic relationship among peats, brown coals, lignites, bituminous coals, and anthracites. This does not mean that brown coal necessarily is an intermediate stage in coal formation; there are indications that brown coals and some lignites are end products of a special genesis. As a whole, however, the process of coal formation, or coalification, proceeds as a continuous transformation of plant material, each phase being characterized by a degree of coalification, or rank. As a measure of this rank the carbon content or some related parameter can be used.

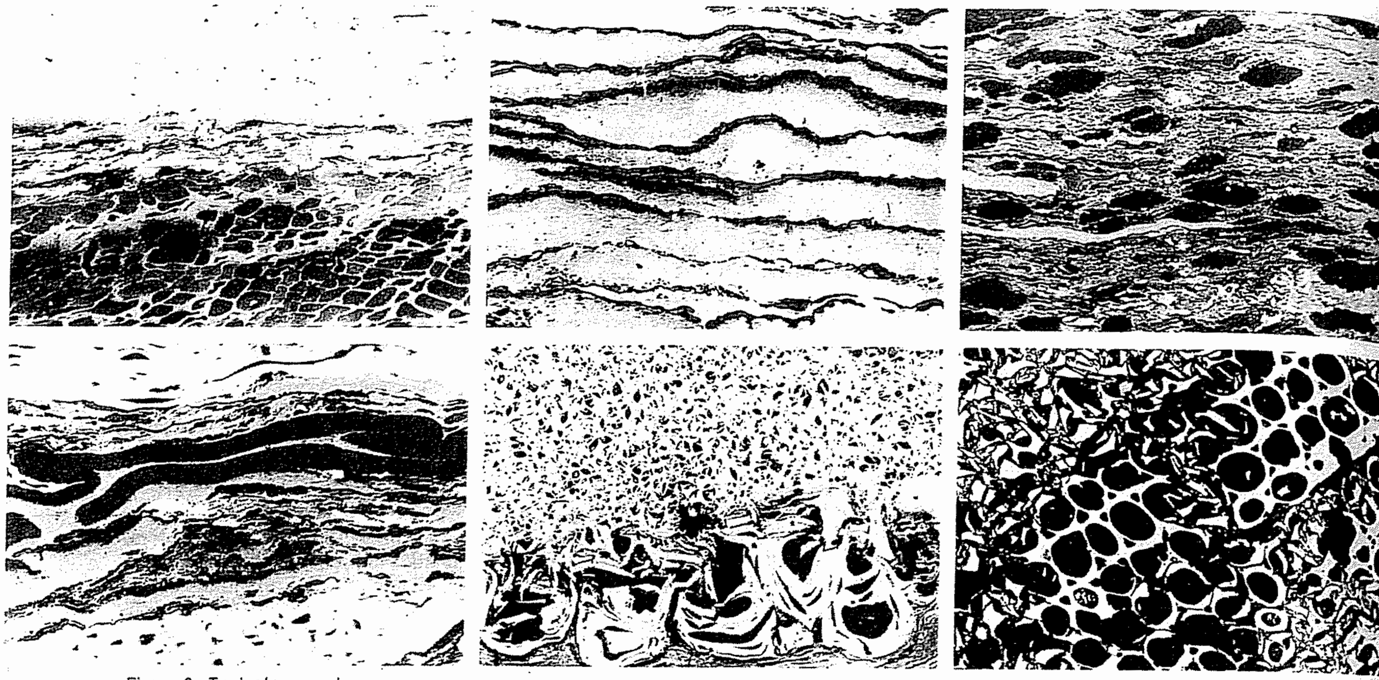


Figure 2: *Typical macerals.*
(Top left) Collinite (upper part) and telinite (lower) with resinite inclusions. (Top centre) Cutinite embedded in collinite. (Top right) Boghead-cannel coal with alginite. (Bottom left) Sporinite (macrospores and microspores) embedded in collinite (gray) and surrounded by micrinite (white). (Bottom centre) Semifusinite (upper part) and sclerotinite (lower). (Bottom right) Fusinite. Photomicrographs in reflected light (oil-immersion); magnified about 144 X.
By courtesy of M.Th. Mackowsky, Bergbauforschung, Essen, Germany

from coal-forming plants and partly are added to the deposits after the death of the plants. Nearly all the inorganic matter of the mineral coals consists of clays, sulfides, and chlorides. Selected vitrains may contain less than 1 percent of mineral matter; for an arbitrary coal sample the ash content is much higher. Many investigations have been made of the occurrence of minor elements in coal and coal ash. The common trace elements in parts per million in coal are arsenic (100), lead (100), manganese (100), and titanium (700). The development of transistors by the electronic industry has promoted an intensive search for germanium. Although certain coalified logs contain unusually high concentrations (up to 9 percent germanium in the ash), the normal average content of coals is only ten parts per million. Appreciable quantities of uranium are present in certain low-rank coals and lignites (up to 0.1 percent), but high-rank coals are practically nonradioactive.

Trace elements

From D.W. van Krevelen in I.A. Breger, *Organic Geochemistry* (copyright 1963); reprinted with permission of Pergamon Press

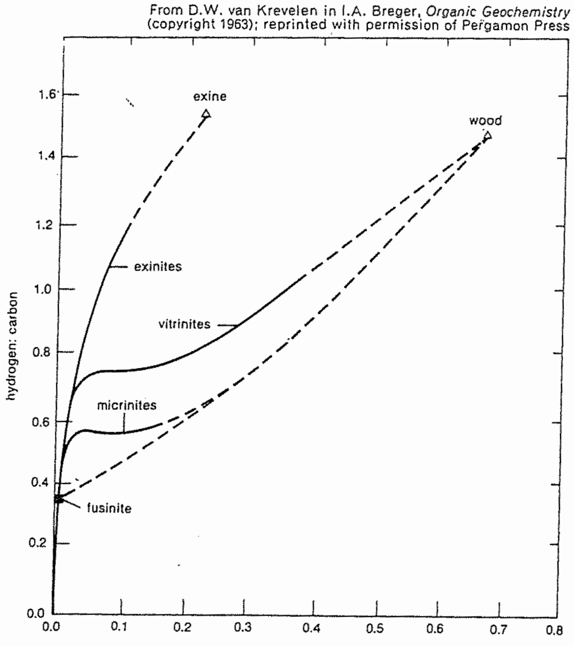


Figure 3: Development lines of macerals in terms of their carbon, hydrogen, and oxygen content.

Coal structure. The structural aspect of the coal matrix (vitrinite) may briefly be summarized as follows: Coal possesses a composition that is similar in some respects to that of such substances as pitch and bitumen. It is made up of a large number of chemical units that are identical in type but very different in molecular fine structure and molecular weight. All these units, however, have one feature in common; namely, a more or less flat lamellar shape. The dimensions of the condensed (aromatic) nuclei of the lamellae, as well as the number and character of the functional groups in the molecular periphery, can be derived by means of modern structural analysis.

Coal rank and structural change

When coalification starts, the aromatic clusters are still relatively small and probably are connected by nonaromatic bridges. This explains why the lowest rank coals possess a pronounced polymeric (*i.e.*, chainlike) character and more or less open structure. From a chemical point of view, coalification must be considered as a process in which the degree of condensation of the material increases continuously; the bridge structures become unstable as the interaction forces between the aromatic nuclei grow stronger. On continued coalification, the structure is modified into what has become known as the liquid, or glassy, structure revealed in X-ray studies. This structure is typical of coking coal. Subsequently, the structure stiffens again (anthracitization), and the lamellae display a growing tendency for orientation parallel to the bedding plane. The tendency of the flat lamellae to coalesce into small stacks can be observed in all terms of the coalification series; and this phenomenon becomes more marked as coalification advances. The interlamellar (and intralamellar) holes constitute the ultramicropore system. In a qualitative respect this explanation also holds for the other macerals, with the understanding that as far as ring condensation and cluster dimensions are concerned, exinites always lag behind vitrinites of the same rank and that micrinites have advanced further. The physical and chemical properties of coal can be interpreted in the light of this structural picture.

Volatile-matter content

Petrologic Components (Macerals) in Coal and Their Groupings

maceral grouping in Europe	macerals or components: name in Europe*	macerals or components: name in the U.S.†	maceral grouping (constituents) in the U.S.
Vitrinite	telinite	megascopic anthraxylon	anthraxylon
		attrital anthraxylon	
	collinite	subanthraxylon	translucent attritus
		humic matter	
		light-brown matter	
Exinite	resinite	red resins	
		yellow resins	
	cerinite	amorphous wax	
	sporinite (exinite)	spore coats	
	cutinite	cuticles	
	suberinite	suberin	
	alginite	algal bodies	
Inertinite	massive micrinite	dark-brown matter	opaque attritus
		amorphous opaque matter	
	granular micrinite	granular opaque matter	
	sclerotinite	fusinized fungal matter	petrologic fusain
	semifusinite	dark semifusain	
	fusinite	attrital fusain	
		megascopic fusain	

*The majority of these names originated with M.C. Stopes (1935) and were adopted by the International Stratigraphical Congresses (1935 and 1951) at Heerlen. †These names are mainly from R. Thiessen.

transition between the two modifications is called semifusinite.

In the course of the coalification process woody tissue may, however, completely lose its structure. The col-

By courtesy of Marlies Teichmuller, Geologisches Landesamt, Krefeld, Germany

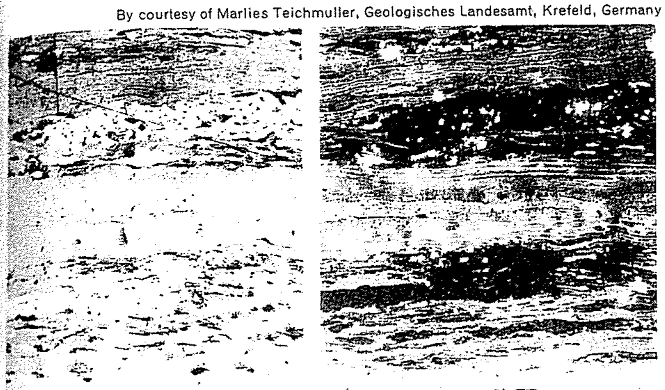


Figure 1: Polished thin section from Pond Creek Seam, Kentucky, with a blend of vitrinite or anthraxylon (gray) and fusinite in reflected light (left) and in transmitted light (right); magnified about 127 X.

loidal modification, which is translucent in thin sections, is called collinite. This term corresponds with the term humic matter (partly with brown matter) in the American nomenclature.

The other form, completely opaque under transmitted light, is known by the name micrinite (granular or massive), which is identical with opaque matter in the American nomenclature. As to the other plant constituents, the resins and waxes (resinite and cerinite), spore coats (sporinite), cuticles (cutinite), fungal sclerotia (sclerotinite), and algal bodies (alginite) can be clearly distinguished. The macerals and components have been compiled in the accompanying Table, in which the maceral groupings used in Europe and the United States are given.

Preservation of woody tissue

In Europe, the macerals are classified according to their technological properties: vitrinite includes the technologically identical substances telinite and collinite. On heating, these macerals normally leave a fused coke button as their main product; exinite includes the remainders of waxy and corky products that, on heating, are largely transformed into gas and tar; inertinite includes all chemical, practically inert, macerals that do not soften or cake on heating and cannot be hydrogenated. In the United States, the macerals (except anthraxylon) are classified mainly according to their morphological and optical properties into the following categories: translucent attritus, opaque attritus, and fusain.

On the basis of the components or macerals (see Figure 2), coal is classified into various rock types. Coal with more than 95 percent vitrinite is called vitrain; coal containing both vitrinite and exinite is known as clarain. Vitrain and clarain form the group of the bright coals. If the coal contains micrinite and exinite (besides smaller additions of other constituents), it is called durain or dull coal. Finally, coal composed mainly of a mixture of fusinite and semifusinite is called fusain. This nomenclature is based on the original macroscopic (appearance in hand specimen) classification of coals.

Vitrain, clarain, and fusain

The above list of normal coal types may be extended. Others, formed under special conditions, include cannel coal (micrinite with many microspores), pseudocannel coal (mainly composed of micrinite and mineral matter), and boghead coal, or torbanite (alginite and micrinite).

PHYSICAL AND CHEMICAL CHARACTERISTICS

All properties of coal and its components vary with its elemental composition and hence with rank. The rank can best be expressed in terms of the carbon content of the pure vitrinite that occurs, among other macerals, in the coal sample or in the coal seam.

Density and porosity. The true density of coal increases with increasing rank. Exinites have a lower density and micrinites a higher density than vitrinites of the same rank; the differences gradually decrease with increasing rank and disappear when the carbon content reaches 92 percent. Coals contain two pore systems, one with a mean-pore diameter of 500 Å (one angstrom unit equals 10^{-8} millimetre) and a second system of pores measuring five to 15 Å in diameter. The latter pores have a small volume but a large internal surface (about 200 m^2/g). The coarser pores of 500 Å have an internal surface of no more than about one m^2/g. In the early phases of coalification, coal possesses many polar groups and an extended, coarse-pore system. Hence the absorptive capacity for moisture is high. With increasing coalification the polar groups and the coarse pores disappear gradually. During the final stages of coalification a new pore system is formed; on its surface methane (CH_4), which is formed during coalification, can be absorbed. Low-volatile bituminous coals have a high sorption capacity for methane and a low rate of diffusion in the undamaged coal. This is associated with the frequent occurrence of outbursts of methane in low-volatile coal mines when cracks are formed that allow rapid desorption.

Optical, electrical, and magnetic properties. The reflecting power of coal surfaces is one of its principal optical properties. Reflectance increases sharply with increasing rank, and a measuring technique of rank is based on this property. Electrical properties are of interest because coal becomes a semiconductor with increasing rank. The magnetic properties are even more interesting. Measurements show that free radicals (molecules in which one of the atoms exhibits a valence one unit less than normal—*e.g.*, C^{3+} rather than C^{4+}) are present in coal. Their maximum concentration occurs at a carbon content of 92 percent (one free radical per 1,000 carbon atoms).

Hardness. Hardness increases with rank, passes through a maximum at 84 percent carbon, decreases again, passes through a minimum at 90 percent carbon, and increases again. The reverse is true with respect to the grindability of coals.

Hydrogen, oxygen, and carbon content. The hydrogen (H) and oxygen (O) contents of the macerals are generally plotted as functions of the carbon (C) content, and points of equal rank are connected by broken lines. At equal rank, exinites are always richer and micrinites (and semifusinites) are always poorer in hydrogen than vitrinites; the reverse applies for oxygen. Differences between the macerals disappear progressively with increasing rank, so that in anthracite all macerals have become chemically identical. The same conclusion can be drawn from Figure 3, which shows the development lines of the macerals in terms of the atomic ratio H/C, which is plotted against O/C.

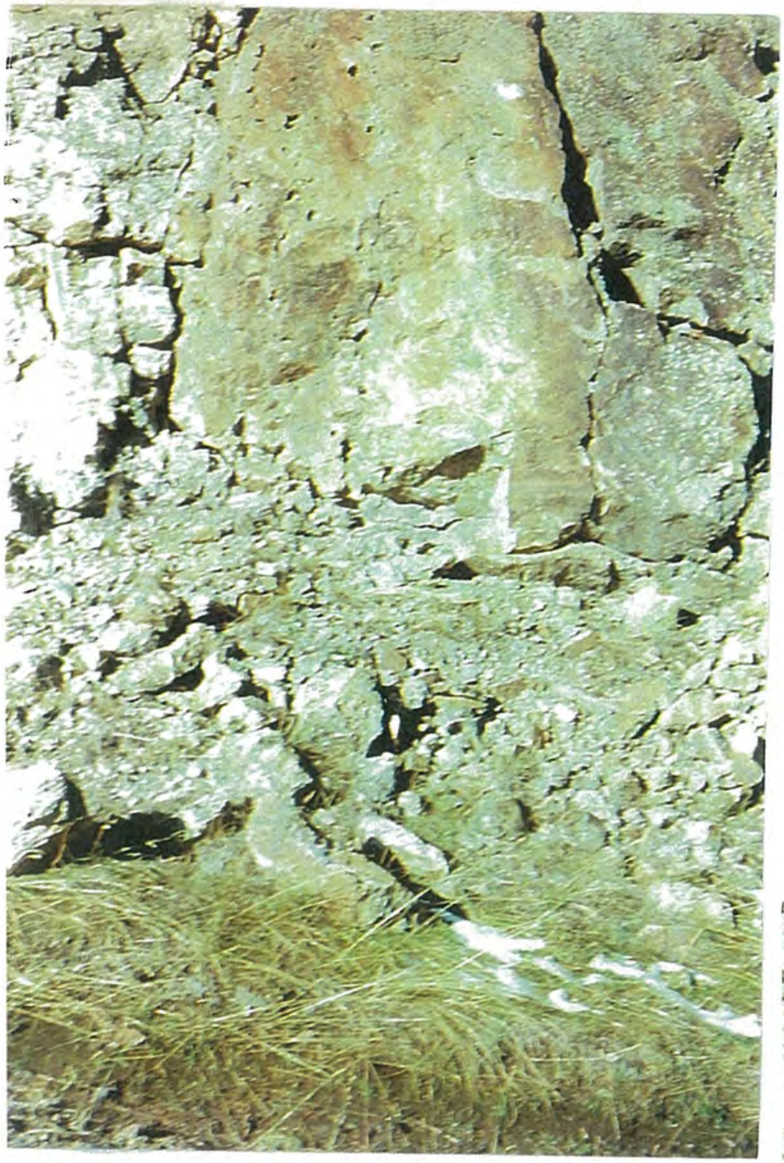
Other chemical constituents. All coals contain mineral matter or inorganic constituents that partly originate

pick·er·ing·ite \ˈpik(ə)riŋ,īt\ *n* -s [John *Pickering* †1846 Am. scientist + E *-ite*] : a mineral $MgAl_2(SO_4)_4.22H_2O$ composed of a hydrous magnesium aluminum sulfate occurring in white to faintly colored fibrous masses

Pre-CAMBIAN CORAL REEF SE$\frac{1}{4}$.Sec.25.Twp.8.Rge.4.W5M

GARTER SNAKE HIBERNACULUM--Entrance Heat Vent Snakes seek

HEAT & MOISTURE



WITNESSED GARTER SNAKE (Thamnophis)
entering Hibernaculum in late SUMMER
Entrance indicated on PHOTOS

$SE\frac{1}{4}$, Sec.25, Twp.8, Rge.4, W5M.

SW¼, Sec. 30, Twp. 8, Rge. 3, W5M.   Photo Volcanic Rubble

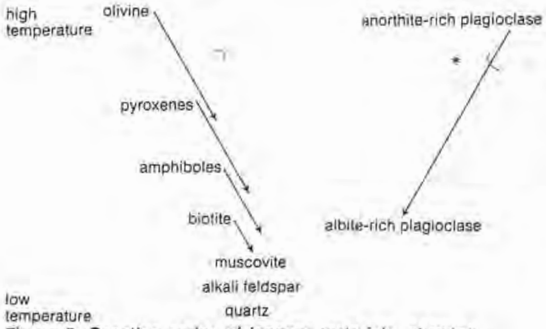


Figure 5: Reaction series of igneous materials, showing the sequence of crystallization with falling temperature. The mafic mineral series (left) and the plagioclase series (right) converge at low temperature.

yield 80 parts of gabbro, ten parts of diorite, five parts of granodiorite, and five parts of granite. These proportions may hold in some differentiated intrusions, but crustal abundances of the rock types on a global scale do not support the hypothesis that most igneous rocks evolve by differentiation of "primary" gabbroic magma.

At depth, magma is hot and highly charged with chemically reactive volatile constituents (*e.g.*, water, hydrogen fluoride, hydrochloric acid, carbon dioxide, hydrogen sulfide) that can react with and dissolve country rock. Assimilation of country rock can change the composition of magma, the degree of change depending on the relative amount of country rock that the magma assimilates and on the compositional contrasts between magma and country rock. To dissolve rock requires heat from the magma; to liberate this heat, the magma must partly crystallize. The amount of material assimilated is therefore limited by the temperature and composition of the magma compared with those of the country rock. Under ordinary conditions, no more than about ten parts of country rock can be assimilated into 100 parts of magma, and the change in magmatic composition is correspondingly small.

Emplacement of magma. Magma can make room for itself in several ways as it invades the crust. By means of the process called stoping, magma can detach fragments of country rock, which may sink or become assimilated. Piecemeal stoping is an inefficient mechanism of intrusion and usually occurs on a minor scale, serving only to modify contacts of intrusions that were emplaced in other ways.

On a much larger scale, magma can break loose portions of the overlying crust, extending all the way to the Earth's surface. Such blocks may founder in a pool of magma (Figure 6), resulting in large-scale subsidence

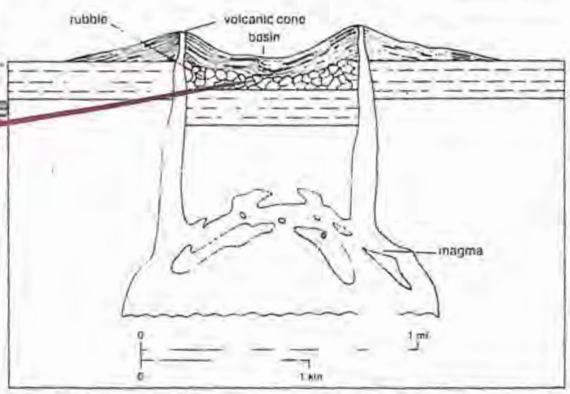


Figure 6: Caldron subsidence in cross-section. A central block of crust has sunk into magma. The surface expression is a basin (caldera) floored by rubble (breccia) and ringed by volcanic cones. The subsidence may be repeated.

(called caldron subsidence) at the surface and catastrophic eruption of volcanic rocks. Shallow intrusive bodies thus formed have the outlines of crude rings. Successive intrusions, generally younger toward the centre, build up forms that are termed ring complexes.

Instead of breaking and swallowing its wall rock, magma can shoulder it aside by forcible intrusion. Diapirism, the rise of a vertical columnar plug (diapir) of less dense rock or magma piercing through more dense rock, forms igneous as well as non-igneous intrusions; among the latter, salt domes (*q.v.*) are the most common. Rather than forcing its way upward in a vertical pipe, magma may find it less effort to follow fractures or other surfaces of weakness in the country rocks, prying them apart.

Forms of intrusive bodies

The forms of intrusive igneous bodies (Figure 7) are controlled by several factors: the stress field in that particular volume of crust (in turn related to depth and to tectonic

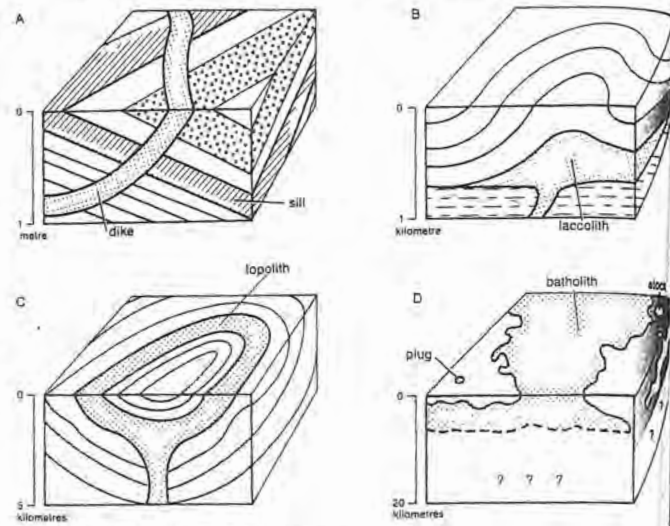


Figure 7: Forms of intrusive igneous rock bodies in hypothetical sections of Earth strata. Note the change of scale from A through D.

setting); the behaviour of the country rock (whether it is homogeneous or layered, brittle or plastic); the viscosity and density of the magma; and the rate of intrusion.

Volcanic necks, such as Devil's Tower, Wyoming, and Ship Rock, New Mexico, are the intrusive fillings of the central conduits of volcanoes (Figure 1).

Dikes are magma-filled fractures that cut across the structure of the country rock. Sills form when magma congeals in fractures that are parallel to layering of the country rock. Horizontal or gently dipping sills, such as the Palisades Sill along the west bank of the Hudson River, must have formed at shallow depths in order to have permitted the magma to lift its roof of overlying rocks.

Laccoliths are sills with updomed roofs; lopoliths sag in the centre. Lopoliths are considerably larger than laccoliths and, as a general rule, are composed of more mafic rocks. Lopoliths are apparently fed by dikes that form narrow keels at the bases of the intrusions.

Larger intrusive bodies are usually irregular in form and are classified arbitrarily according to the size of their area presently exposed. Plugs, stocks, and batholiths, in increasing order of size, complete the roster of intrusive forms. Batholiths are defined as intrusive bodies that crop out over areas greater than 100 square kilometres (40 square miles), were not intruded as one pulse of magma but grew by successive intrusions, and consist of more than one rock type (usually ranging from quartz diorite to granite). Intrusive bodies of unknown or unspecified shape are called plutons, a general term for all such bodies except dikes, sills, and volcanic necks.

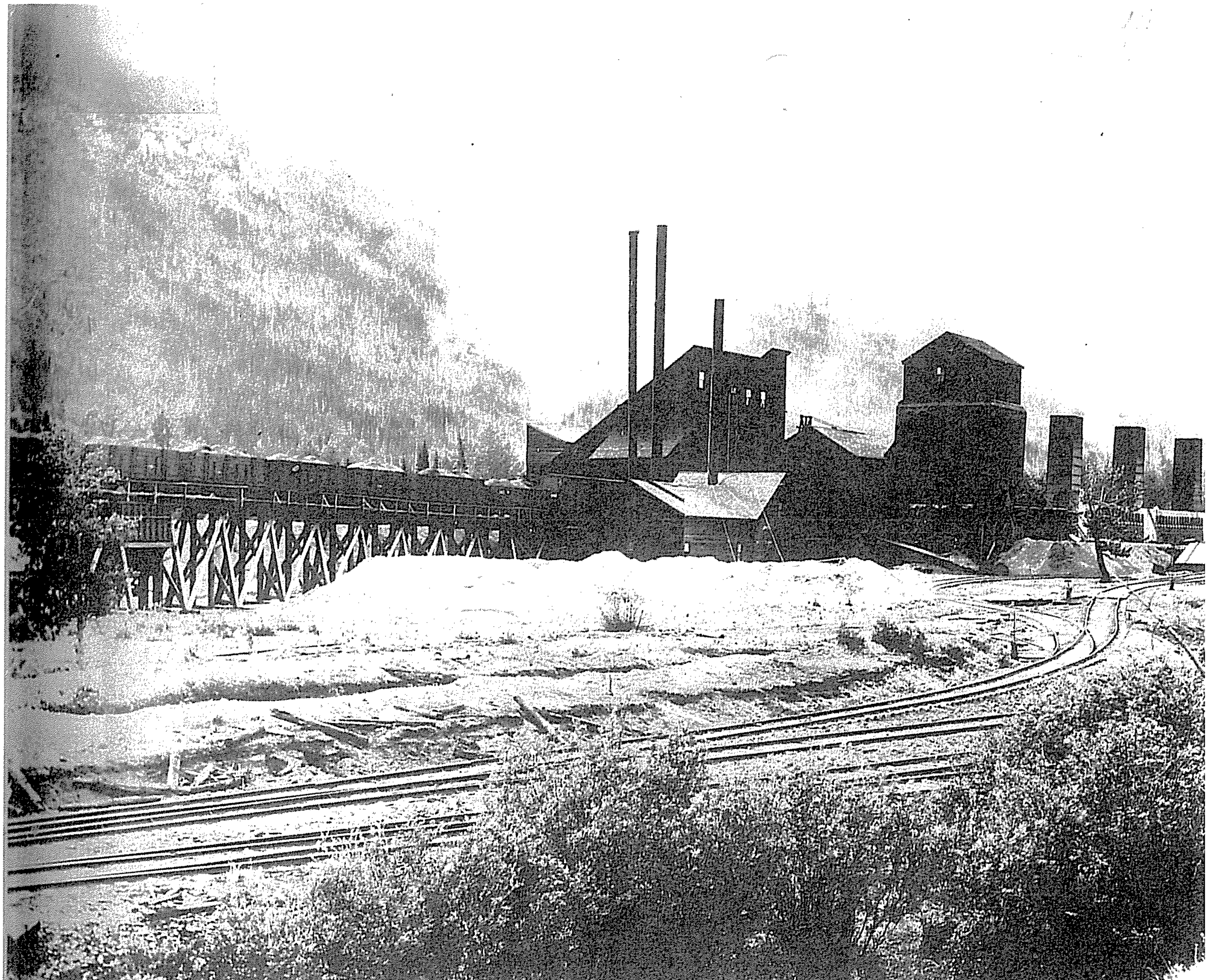
Post-orthomagmatic processes. The orthomagmatic stage embraces the process of crystallization of minerals from a melt. Because most abundant igneous minerals are anhydrous (that is, they contain no water in their chemical formulas), water becomes progressively concentrated in the liquid as crystallization proceeds. The increasing water content may cause the liquid to boil—

Lille-Grassy Mountain Coal

Land of

Sulphur, Salt

Shale, Silt



Lille Tipple and Coke Ovens.

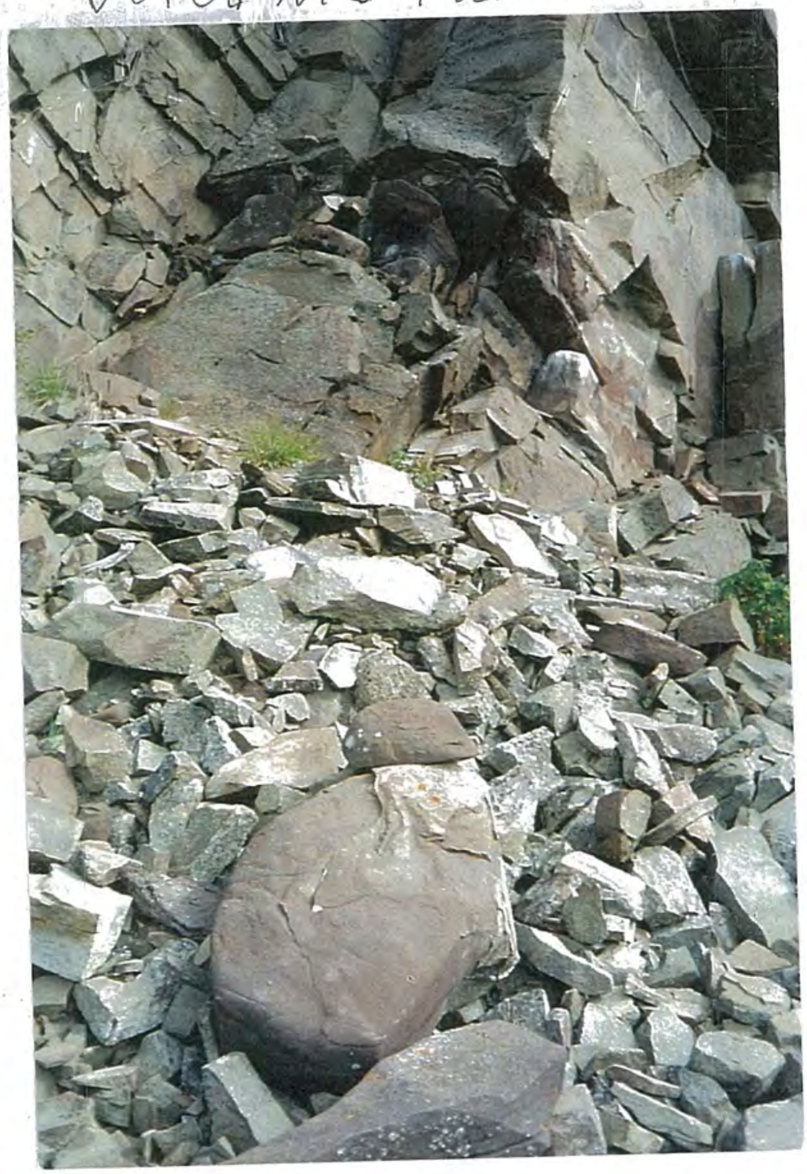
Lille business section (1907-08). Far right: Thompson General Store and Post Office. To the left: P. Burns Meat Market.

Lille 1904.

Volcanic Fumeroles

SW¼, Sec.31, Twp. 8, Rge. 3, W5M.

Volcanic Fumeroles



SW 1/4, Sec. 31, Twp. 8, Rge. 3, W5M

A Coal Without Merit

Lille-Grassy Mountain

Coal Mining - Japan Rejects

GRASSY MOUNTAIN , Reservoir of Water

Photo Marguerite Gilman 1927

Grassy Mountain Reservoir

The Water is forced to the Top, subterranean , exits from a large spring near crown. stream flows down

Coal Shipment 1958 - 1960

Insufficient - Coal Quality - Grassy-Mountain Surface Strip-Mine Closes 1958-1960

Grassy Mountain

1958 - 1960

Volcanic Fumeroles

SW¼, Sec. 31, Twp. 8, Rge. 3, W5M

A Volcano Bomb SW¼, Sec. 30. Twp. 8, W5M. Rge. 3

Quickly Cooled Piece of Lava

SW¼, Sec. 30, Twp. 8 Rge. 3, W5M

Mineral Intrusion Sw¼, Sec. 30, Twp. 8, Rge. 3, W5M.

SW¼, Sec. 30, Twp. 8 Rge 3, W5M

Volcanic Rubble

a volcanic Bomb

Volcanic air Fall Deposits
SW 1/4, sec.30, Twp.8, Rge.3, W5M

Fumeroles SW¼, Sec. 30, Twp 8, Rge. 3, W5M.

Fumeroles SW¼, Sec. 30, Twp. 8, Rge. 3, W5M.

Lille-Grassy Mountain Coal

Land of Sulphur, Salt Shale, Silt

LILLE

In Western Canada the quality of Coal increases from East to West

Lille - Booklet - Page 6 Paragraph 7
Page 7 Figure 3

halotrichite, a sulfate mineral containing aluminum and iron [$FeAl_2(SO_4)_2 \cdot 22H_2O$]. Magnesium replaces iron in the molecule; when more than 50 percent of the iron has been replaced, the mineral is called pickeringite. These minerals are usually weathering products of sedimentary rocks that contain aluminum and metallic sulfides, and usually occur as efflorescences. They also occur in volcanic fumarole deposits, in the gossan (weathered capping) of sulfide ore veins, and, recently deposited, in lignite and coal seams. They are sometimes grouped in older literature with other salts having a hairlike habit as *haarsalz* ("hair salts"). For detailed physical properties, *see* sulfate minerals.

pick·er·ing \ˈpik(ə)riŋ\ *n* -s [alter. (prob. influenced by *herring*) of *pickerel*] **1 :** PICKEREL **2 :** SAUGER

pick·er·ing governor \ˈpik(ə)riŋ-\ *n, usu cap P* [after Thomas R. *Pickering* Am. engineer] **:** a governor in which the revolving balls act against curved flat springs

pick·er·ing·ite \ˈpik(ə)riŋ,īt\ *n* -s [John *Pickering* †1846 Am. scientist + E *-ite*] **:** a mineral $MgAl_2(SO_4)_4.22H_2O$ composed of a hydrous magnesium aluminum sulfate occurring in white to faintly colored fibrous masses

pickering's tree frog *n, usu cap P* [after Charles *Pickering* †1878 Am. naturalist] **:** SPRING PEEPER

picker stick *n* [²*picker*] **:** a lever that transmits the crank ac-

The sulfur content of much of the Mid-Continental coals is high. When the coal is burned, sulfur is put into the air and forms one of the irritants in air pollution. Sulfur is believed to have been deposited with the coal, pointing to the fact that most of the coal swamps were brackish rather than completely fresh. Sulfur is not common in freshwater but sulfate is one of the common constituents of sea salt. The coals of Nova Scotia and New Brunswick and of eastern Pennsylvania are low in sulfur; this is an indication that the swamps in those particular regions were probably fresh.

visions. According to origin, fragments are juvenile (essential) if derived from fresh fluid magma, accessory (cognate) if derived from rocks of earlier related eruptions of the same volcano, and accidental if derived from basement rocks penetrated by the vent (see Table 2).

Table 2: Size Classification of Pyroclastic Fragments and Their Consolidated Rock Equivalents

fragment name	fragment size (mm)	pyroclastic rock name*	origin of fragment
Bombs and blocks	> 64	pyroclastic breccia; agglomerate	*juvenile:* from fresh magma
Lapilli	2–64	lapillistone	*accessory:* from co-magmatic rocks in vent or cone
Ash†	<2	tuff	*accidental:* from basement rocks penetrated by vent

*Rocks composed of mixtures are named according to predominating sizes, such as tuff-breccia and lapilli-tuff. †Fine ash is also called volcanic dust, or dust, and the corresponding rock is called fine tuff. The size boundary is 1/16 mm.

Scoria, cinders, and pumice, which have vesicular structures, are named without reference to size. Scoria and cinders, nearly synonymous terms, are irregular fragments usually with rough or spiny surfaces formed by gas-rich basaltic to andesitic eruptions. Pumice is a lightweight glass foam; common varieties readily float in water.

Bombs solidify from clots of fresh lava during ejection and flight, their final shapes determined by flight velocity, viscosity, and initial size. Fresh lava may be shaped by frictional air resistance into oval-shaped spindle bombs: some have twisted ends caused by in-flight differential rotation between a rigid exterior and fluid centre. Highly fluid basalt may eject large filaments that freeze as ribbon bombs; spheroidal globs may be flattened into cow-dung or pancake bombs. Partially solidified outer surfaces may crack from internal expansion of vesicles and produce bread-crust bombs. A deposit composed primarily of bombs is known as agglomerate. Agglutinate forms by accumulations of liquid or slightly tacky bombs that stick together upon impact.

Blocks may be essential or accidental in origin, and therefore vary widely in shape and composition, depending upon type of rock beneath the volcano. Broken angular shapes are common, but vents may penetrate and eject water-worn gravels, as at Menan Buttes, Idaho.

Breccias, composed mainly of blocks in a matrix of finer grained debris, originate in diverse ways: aerial ejection, eruptions through crater lakes, crumbling of volcanic spines, flows of cooling lava, and others. If fine-grained debris is abundant in the matrix, the rock is called tuff-breccia.

Lapilli include fragments of juvenile, accessory, or accidental origin. Lapillistone is the rock equivalent; lapilli-tuff is a mixture of ash and lapilli-size ejecta. Accretionary lapilli are volcanic hailstones that form in eruption clouds by the accretion of ash around moist particles. Recurring turbulent updrafts may repeat the accretionary process many times, resulting in lapilli that show concentric, onion-ring structures, and with diameters of up to ten centimetres (four inches). If they are present in sufficient quantity, the rock is called accretionary-lapilli tuff, and suggests an origin by airborne dispersal; although it is suspected that accretionary lapilli also form within horizontally moving steam-rich base surges derived from phreatic volcanic eruptions. Phreatic eruptions also give rise to armoured lapilli whereby solid particles become coated with moist, sticky, fine-grained ash.

"Fire fountains" and Pele's tears

The rapid evolution and streaming of gases through highly fluid basalt produces spectacular "fire fountains" typical of Hawaiian eruptions. The fountaining magma produces drops of spray that rapidly freeze in a wide variety of shapes. Some are drawn into fine glass threads known as Pele's hair that may drift downwind like strands from spider webs. Others form glass beads called Pele's tears, variously shaped as spheres, ovoids, pendants, or dumbbells.

Ash refers to unconsolidated pyroclastic accumulations consisting of juvenile, accessory, or accidential particles less than two millimetres in diameter; tuff is consolidated ash. Coarse ash particles are 1/16 to 2 millimetres in size; particles of fine ash (volcanic dust) have diameters less than 1/16 millimetre. According to the relative abundance of rock (lithic) particles, crystals, or glass (vitric) fragments, such names as crystal ash, vitric ash, or lithic ash, or equivalent rock terms may be applied.

Glass particles and pyrogenic minerals. Bombs, lapilli, glass fragments, and crystals derived from fresh magma reflect the pre-eruptive chemical composition of magma. The composition of bombs and juvenile lapilli is closest to that of the original magma, whereas glass is the rapidly cooled product of the liquid phase; crystals represent the solid phase prior to disruption.

Gas-rich magmas, rapidly expanding, may produce pumice—a highly inflated foam with bubbles enclosed by thin glass walls—as well as glass shards formed by shattering of bubble walls (Figure 1). Glassy particles include mafic (iron-magnesium) as well as silicic varieties, but silicic glass is most common.

By courtesy of R.V. Fisher

Figure 1: Photomicrograph of silicic glass shards formed from broken bubbles. White zones within some shards are microvesicular frothy areas (magnified 60 x).

In its greatest expanded state, the porosity values of silicic pumice may attain 90 percent or more; density values are less than water. Vesicles, ranging in size from less than .003 millimetre (.0001 inch) to cavities larger than 10 centimetres (4 inches), are typically distorted by impinging bubbles, but because viscosity values of silicic magma increase very rapidly as it cools, cavities are rarely connected (Figure 2).

Varieties of pumice and scoria

The shapes of vesicles in some varieties of pumice are roughly circular, whereas in others they are tubular and impart a strong fibrous structure to the pumice. During an initial gas-rich eruptive phase, rapid expansion and extrusion may produce pumice characterized by roughly circular vesicles, but, with a progressive loss of volatile gases, vesicles may be drawn out into tubular shapes during flowage up the vent. Thus, within pumice accumulations produced by different eruptive phases, a progressive loss of volatiles for each phase may be recorded: basal layers containing relatively high amounts of nonfibrous pumice will be succeeded upward by layers containing abundant fibrous pumice. This has been noted for each of ten eruptive cycles in New Zealand that produced a relatively thick accumulation of pumice layers (the Younger Taupo Pumice).

Scoria, another highly vesicular rock, commonly develops in the early gas-rich phases of basaltic eruptions. In some instances, such as at Kilauea Iki, Hawaii, during the 1959–60 eruption, highly vesicular glassy lapilli and bombs are produced that may properly be called mafic visions. According to origin, fragments are juvenile (essential) if derived from fresh fluid magma, accessory (cognate) if derived from rocks of earlier related eruptions of the same volcano, and accidental if derived from basement rocks penetrated by the vent (see Table 2).

Table 2: Size Classification of Pyroclastic Fragments and Their Consolidated Rock Equivalents

fragment		pyroclastic rock name*	origin of fragment
name	size (mm)		
Bombs and blocks	>64	pyroclastic breccia; agglomerate	*Juvenile:* from fresh magma
Lapilli	2–64	lapillistone	*accessory:* from co-magmatic rocks in vent or cone
Ash†	<2	tuff	*accidental:* from basement rocks penetrated by vent

*Rocks composed of mixtures are named according to predominating sizes, such as tuff-breccia and lapilli-tuff. †Fine ash is also called volcanic dust, or dust, and the corresponding rock is called fine tuff. The size boundary is 1/16 mm.

Scoria, cinders, and pumice, which have vesicular structures, are named without reference to size. Scoria and cinders, nearly synonymous terms, are irregular fragments usually with rough or spiny surfaces formed by gas-rich basaltic to andesitic eruptions. Pumice is a lightweight glass foam; common varieties readily float in water.

Bombs solidify from clots of fresh lava during ejection and flight, their final shapes determined by flight velocity, viscosity, and initial size. Fresh lava may be shaped by frictional air resistance into oval-shaped spindle bombs: some have twisted ends caused by in-flight differential rotation between a rigid exterior and fluid centre. Highly fluid basalt may eject large filaments that freeze as ribbon bombs; spheroidal globs may be flattened into cow-dung or pancake bombs. Partially solidified outer surfaces may crack from internal expansion of vesicles and produce bread-crust bombs. A deposit composed primarily of bombs is known as agglomerate. Agglutinate forms by accumulations of liquid or slightly tacky bombs that stick together upon impact.

Blocks may be essential or accidental in origin, and therefore vary widely in shape and composition, depending upon type of rock beneath the volcano. Broken angular shapes are common, but vents may penetrate and eject water-worn gravels, as at Menan Buttes, Idaho.

Breccias, composed mainly of blocks in a matrix of finer grained debris, originate in diverse ways: aerial ejection, eruptions through crater lakes, crumbling of volcanic spines, flows of cooling lava, and others. If fine-grained debris is abundant in the matrix, the rock is called tuff-breccia.

Lapilli include fragments of juvenile, accessory, or accidental origin. Lapillistone is the rock equivalent; lapilli-tuff is a mixture of ash and lapilli-size ejecta. Accretionary lapilli are volcanic hailstones that form in eruption clouds by the accretion of ash around moist particles. Recurring turbulent updrafts may repeat the accretionary process many times, resulting in lapilli that show concentric, onion-ring structures, and with diameters of up to ten centimetres (four inches). If they are present in sufficient quantity, the rock is called accretionary-lapilli tuff, and suggests an origin by airborne dispersal; although it is suspected that accretionary lapilli also form within horizontally moving steam-rich base surges derived from phreatic volcanic eruptions. Phreatic eruptions also give rise to armoured lapilli whereby solid particles become coated with moist, sticky, fine-grained ash.

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Pickeringite $MgAl_2(SO_4)_4 \cdot 22H_2O$

Crystal Data: Monoclinic. *Point Group:* 2. Acicular to hairlike crystals, with many forms measured although terminated crystals are very rare; in radial or matted aggregates; typically as incrustations and efflorescences.

Physical Properties: *Cleavage:* Poor on {010}. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 1.5 D(meas.) = 1.73–1.79 D(calc.) = 1.84 Soluble in H_2O, astringent taste.

Optical Properties: Semitransparent. *Color:* Colorless, white; may be pale shades of yellow, green, or red from metallic impurities; colorless in transmitted light. *Luster:* Vitreous.
Optical Class: Biaxial (–). *Orientation:* $Y = b$; $Z \wedge a = 36°$. $\alpha = 1.475$ $\beta = 1.480$ $\gamma = 1.483$
2V(meas.) = 60°

Cell Data: *Space Group:* $P2_1/c$. $a = 6.1844(2)$ $b = 24.2715(9)$ $c = 21.2265(7)$
$\beta = 100.326(4)°$ Z = 4

X-ray Powder Pattern: Tucumcari, New Mexico, USA. (ICDD 12-299).
4.82 (100), 3.510 (90), 4.32 (35), 4.122 (30), 3.791 (30), 6.08 (20), 4.97 (20)

Chemistry:

	(1)	(2)
SO_3	37.84	37.29
Al_2O_3	12.30	11.87
MgO	4.35	4.69
CaO	0.09	
H_2O	44.66	46.15
insol.	0.50	
Total	99.74	100.00

(1) Quetena, Chile. (2) $MgAl_2(SO_4)_4 \cdot 22H_2O$.

Polymorphism & Series: Forms a series with halotrichite.

Mineral Group: Halotrichite group.

Occurrence: A common secondary mineral formed by alteration of pyrite in aluminous rocks or in coal seams; in the oxidized zone of pyritic hydrothermal mineral deposits, typically in arid regions, typically post-mining; a fumarolic product; formed in caves.

Association: Kalinite, alunogen, epsomite, melanterite, copiapite, gypsum.

Distribution: Widespread, so only a few localities are listed. In Chile, abundant from Cerros Pintados, 80 km southeast of Iquique, Tarapacá; at Quetena, west of Calama, and Chuquicamata, Antofagasta. In the USA, in New Mexico, from near Tucumcari, Quay Co.; at The Geysers, Sonoma Co., California; from Alum Point, Salt Lake Co., Utah. In Canada, at Newport, Nova Scotia, and from the junction of the two main branches of the Smoky River, Alberta. In Germany, at Wetzelstein, near Saalfeld, and from near Lehesten, Thuringia. On Valachov Hill, near Skřivaň, Czech Republic. At Cervenica (Opálbánya), Slovakia. In Italy, from Baia di Levante, Vulcano, Lipari Islands; on Mt. Etna, Sicily; and on Elba. At volcanoes on the Kamchatka Peninsula, Russia.

Name: To honor John Pickering (1777–1846), American lawyer and philologist of Boston, Massachusetts, USA.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 523–526. (2) Quartieri, S., M. Triscari, and A. Viani (2000) Crystal structure of the hydrated sulphate pickeringite $MgAl_2(SO_4)_4.22H_2O$: X-ray powder diffraction study. Eur. J. Mineral., 12, 1131–1138.

Operational Infrastructure

In the fall of 2014, a variety of options on the rail line and associated facilities were presented to the public. Riversdale is responding to community and stakeholder discussions and is working on a final layout and design that considers concerns expressed during public consultations. We have undertaken considerable revisions to the operational facilities and are in discussions with Alberta Transportation to review impacts on highway right of ways .

Riversdale is committed to ensuring the final operational structures and layout work to have minimal potential impacts on neighbouring communities.

Visual representations of the rail line locations and applicable structures including storage and load-out facilities will be presented at the next open house in early 2015.

Exploration Program

Riversdale began the exploration program in December 2013 with ongoing drilling to delineate the resource and to conduct initial coal quality testing. All preliminary tests have indicated a high quality metallurgical coal, most of which will be sold to Asian markets. Several bulk samples have been sent for analysis and results from the latest samples are pending.

Drilling has been conducted to evaluate the stability and understand strengths of the subsurfaces as well as to determine the depths and locations of coal deposits and the surface formations. This season's drilling program is expected to be completed by mid-December. Permitting for next year's exploration program is underway which will continue drilling on both private and Crown land in the Grassy Mountain Project area. Riversdale is also working to develop an understanding of the extent of the water contained in the underground mine workings to determine if it could be used for possible future mine operations.

The majority of the roads used to manage Riversdale's exploration program are legacy trails that existed from previous coal mining operations.

Environmental Studies

In mid-2013, Riversdale began collecting four-season baseline data in the project area including surface and ground water, air, wildlife, soils and vegetation.

Seven hydrometric stations are situated on Grassy Mountain that continuously capture water flow while surface water samples are collected from Blairmore Creek, Gold Creek and Crowsnest River. Monitoring wells have been installed to gain an understanding of the groundwater volume and chemistry. Wildlife crews have conducted surveys on a variety of amphibians, birds and mammals and have deployed 15 motion sensitive cameras throughout the project area. Two climate stations monitor and capture data on weather conditions such as wind speed and patterns, precipitation and temperature. Vegetation studies have been completed for the 2014 season to understand what species of vegetation are present in the area. As well, soil surveys were conducted in 2014 to examine the soil profiles of Grassy Mountain.

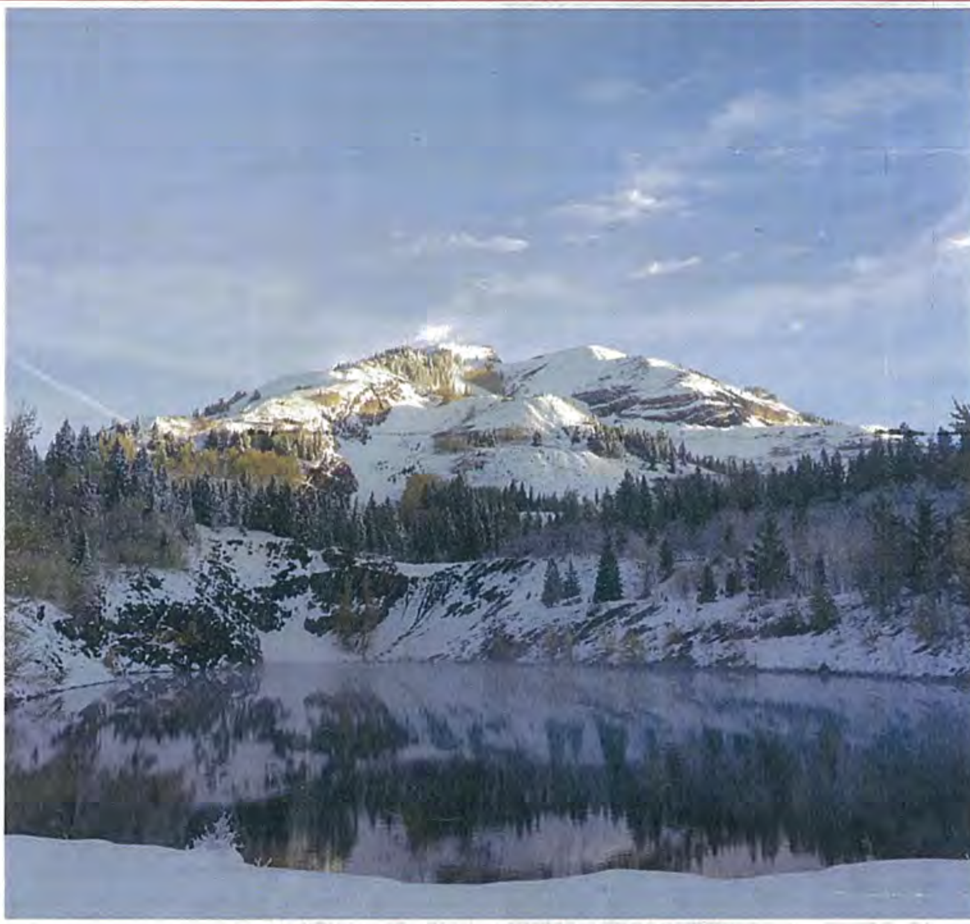
All data collected will be assessed and will become part of the Environmental Impact Assessment (EIA) which allows government, aboriginal groups, landowners and other stakeholders to have a better understanding of the potential impacts of the Grassy Mountain Coal Project. Riversdale is looking to file the EIA by mid-2015.

Riversdale is committed to the continued protection and enhancement of the environment and is currently discussing the project with the Canadian Environmental Assessment Agency and the Alberta Energy Regulator as well as conducting ongoing consultations with local representatives from Alberta Environment & Sustainable Resource Development.

December, 2014

RIVERSDALE RESOURCES

Grassy Mountain Coal Project



The Grassy Mountain Project in Crowsnest Pass proposed by Riversdale Resources is an open-cut mine design with a target of 2 to 4 million tonnes per year of metallurgical coal to be used in the international steel industry. The overall project will include surface coal mining from three main seams along with associated infrastructure including an electrical power system, haul roads, a conveyor system, a coal preparation plant, a rail load-out facility, maintenance shops and other necessary facilities.

Located in southwest Alberta, the project will provide economic benefits to the local and regional economy as well as a long-term positive effect on the provincial economy. Riversdale continues advanced exploratory work, environmental monitoring and on-going consultations with First Nations. As well, they are proceeding with the regulatory permit process with a goal to begin production in late 2018.

Community Engagement

Riversdale continues to engage with the Municipality of Crowsnest Pass, MD of Ranchlands and Pincher Creek and the Town of Pincher Creek as well as local land owners, community and business organizations and recreational groups. Riversdale continues to operate its community office in Crowsnest Pass to provide a physical location where area stakeholders can go to ask questions and find information about the project. A full time Community Liaison is dedicated to the role of addressing community questions and concerns.

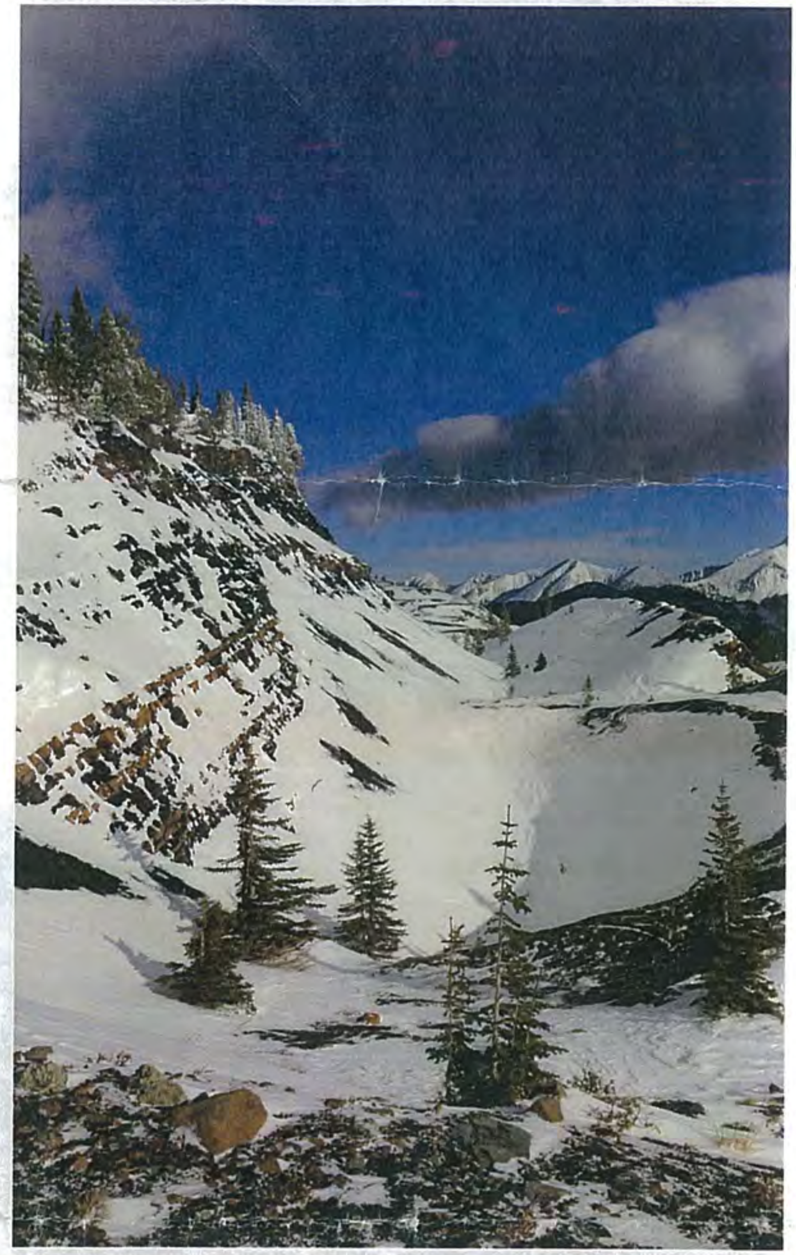
At the two open house events held in the fall of 2014, Riversdale spoke with over 150 people including business and property owners, recreation users, and area residents. During these meetings, Riversdale provided a forum for the public to ask questions about the project and to actively solicit and record comments or concerns.

Specific areas of information provided were the status of the project including technical and environmental considerations that will be made in preparation of the Environmental Impact Assessment (EIA); geographic information including the layout of the proposed mine and facilities; the company's history and corporate philosophies; and the top three rail load-out options under consideration.

Several areas of concern were identified during public consultations and Riversdale is committed to addressing these as the EIA and mine applications are being prepared.

Another open house will be held in early 2015 to provide more details on identified issues as well as to continue to engage in discussions with community members and other interested stakeholders.

Message from CEO



Riversdale enjoyed our second year in Crowsnest Pass with tremendous progress on the Grassy Mountain Project. During 2014 we completed a significant coal quality and reserve delineation and exploration program and extracted bulk samples for testing. The team were delighted to learn that the samples confirmed a hard coking coal, comparable with some of the high quality metallurgical coals from Canada, USA and Australia. We completed key environmental work in air quality, water quality, flora and fauna studies and large mammal population and habitat recording.

Riversdale is planning to complete feasibility study work by mid-2015 and, as we have done this year, we will hold more open house meetings to inform the community of our project activities.

We have appreciated the support and frank feedback and the warm welcome extended to the Aussies in the team. On behalf of Riversdale, I would like to offer our best wishes to your families over the Christmas season and we look forward to an exciting 2015.

Steve Mallyon
Managing Director

Contact information

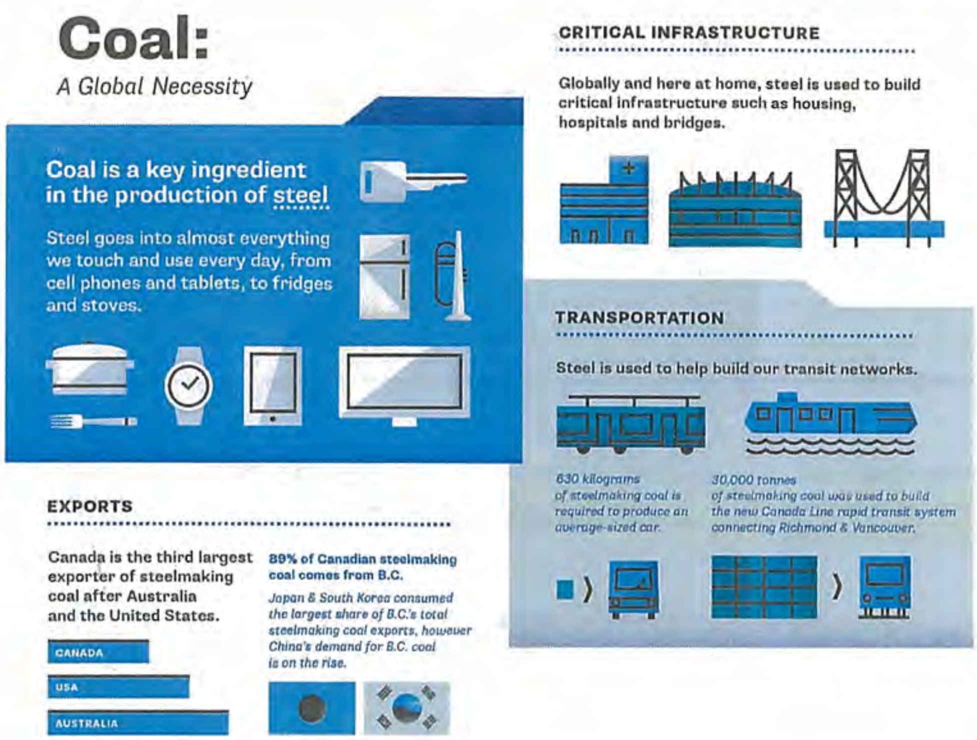
Community Liaison
Keith Bott
<contact information removed>

12331 20th Avenue
P.O. Box 660
Blairmore, Alberta T0K 0E0
Tel: (403) 753-5160

About Riversdale Resources

Riversdale Resources Limited, established in 2011, is an unlisted Australian public company with headquarters in Sydney, Australia. Benga Mining Limited, is a wholly owned subsidiary of Riversdale Resources Limited.

RIVERSDALE
RESOURCES



Courtesy of Coal Assoc. of Canada

Aboriginal Engagement

Riversdale has been actively engaged with First Nations as it is necessary to mitigate and accommodate all impacts the proposed project may have on Aboriginal Rights. All seven Nations belonging to Treaty No. 7: Piikani Nation, Kainai Nation, Siksika Nation, Tsuu T'ina Nation and Stoney Nation (Bearspaw First Nation, Chiniki First Nation and Wesley First Nation) are actively engaged in these discussions.

Over the summer and early fall, the First Nations participated in planning and field work for Environmental Assessment related studies. Piikani Nation formally blessed the site during the summer 2014 to ensure the success of the project and the safety of all workers on Grassy Mountain. Reports and consultation activities for the Environmental Assessment will continue into the spring of 2015.

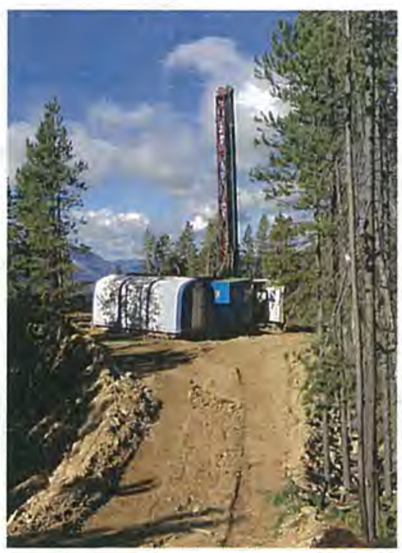
Riversdale participated in several First Nation community and cultural events that were held both in First Nation communities and at the Grassy Mountain project site. These events provide valuable opportunities for Riversdale staff and consultants to learn about the First Nations, and for First Nation community members to learn more about the Grassy Mountain project.

As results of the technical feasibility study become clear, Riversdale will initiate dialogue about employment and contracting opportunities with First Nations in addition to the municipal centres in proximity to the project.

Safety & Access Management

To ensure the safety of the public, contractors and others working in the area, Riversdale asks that signs, gates and other access restrictions be respected. Recreational users are advised that no hunting is allowed in the area and only authorized personnel are permitted where signage is posted. As exploration work and environmental testing continues, it is vital the project area be avoided.

If you would like to gain access, please contact Keith Bott at the local office (see back page) to discuss your request.

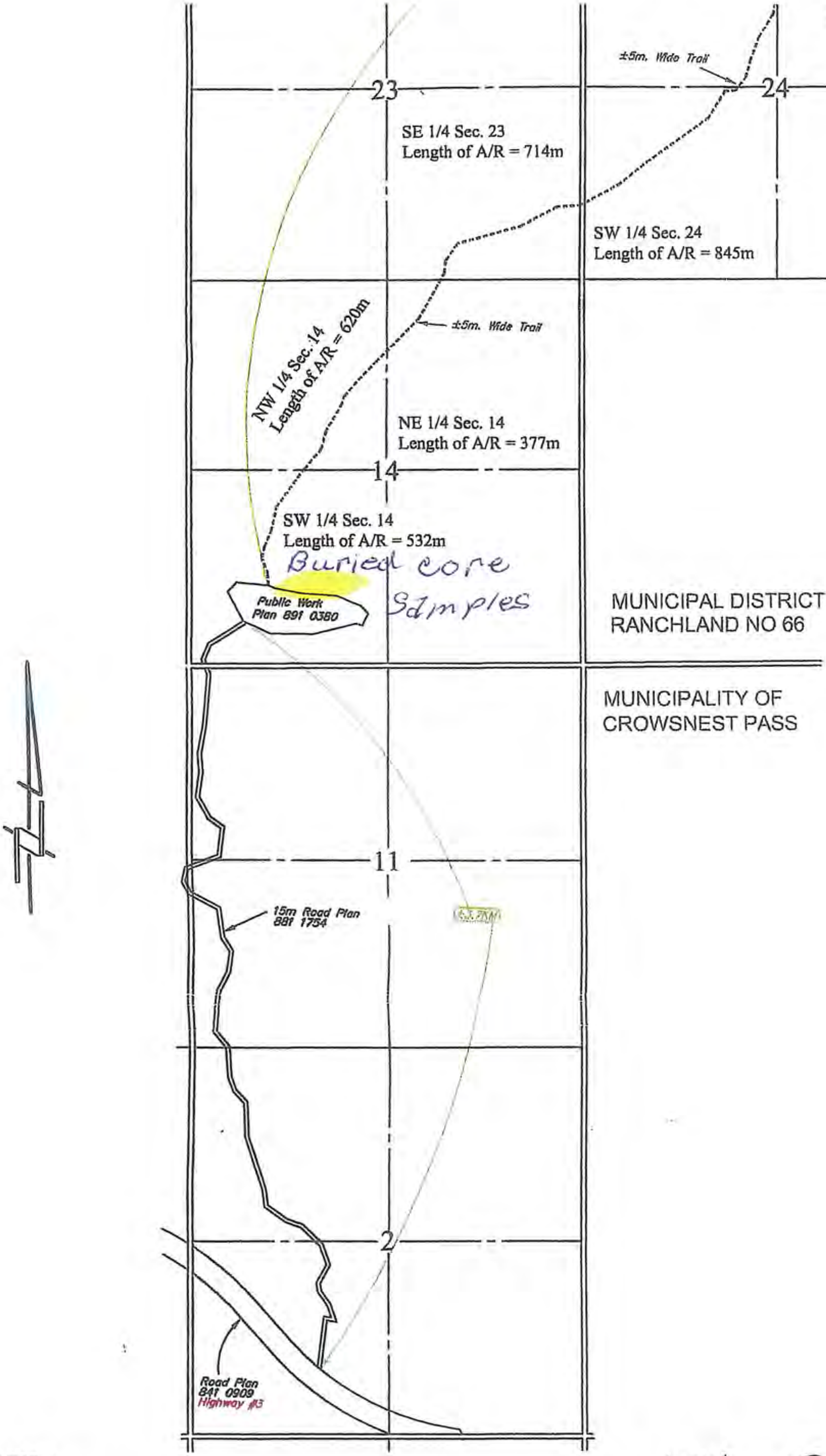


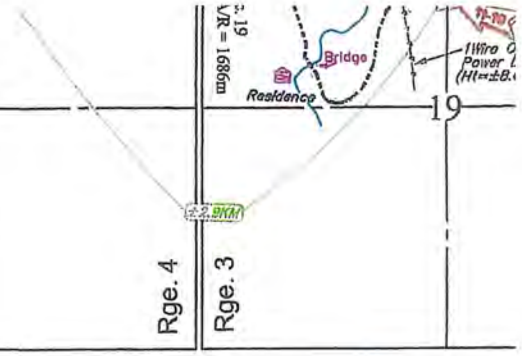
Next Steps

Environmental, engineering and construction related applications are expected to be completed and filed in mid-2015. Pending regulatory approval, Riversdale hoped to begin construction in 2017 with production following in late 2018.

A Holiday Open House will be held at the local Riversdale office as part of Christmas in the Mountains. Please join us on Friday, December 5 from 5 p.m. to 8 p.m. to celebrate the festive season. In addition, Riversdale will hold another community open house in the new year to present visual representations of the rail line and associated load-out structures.

Riversdale is currently working to file the project description and proposed terms of reference with the Alberta Energy Regulator. Watch for advertisements describing where the public can access this information. As Riversdale continues working towards environmental and regulatory approvals, we value feedback from the community and encourage you to share your concerns and ideas with us. Please contact Keith Bott at the local office (see below) if you have any questions or would like more information on any aspect of the proposed project.





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Alberta Land Surveyor

Witness (Ryan Palmer)

ALL WEST SURVEYS

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1-800-465-623.
E-Mail: allwest

CALGARY
(403) 234-7599

now Altus Geomatics (Altus Group)

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2	DATE: May 3, 2

ERATOR :

EVON CANADA CORPORATION

GRADES

The gradation of non-coking coal is based on Useful Heat Value (UHV), the gradation of coking coal is based on ash content and for semi coking / weakly coking coal it is based on ash plus moisture content, as in vogue as per notification.

Grades of Coking Coal

Grade	Ash Content
Steel Grade -I	Not exceeding 15%
Steel Grade -II	Exceeding 15% but not exceeding 18%
Washery Grade -I	Exceeding 18% but not exceeding 21%
Washery Grade -II	Exceeding 21% but not exceeding 24%
Washery Grade -III	Exceeding 24% but not exceeding 28%
Washery Grade -IV	Exceeding 28% but not exceeding 35%

Grades of Non-coking Coal

Grade	Useful Heat Value (UHV) (Kcal/Kg) UHV= 8900-138(A+M)	Corresponding Ash% + Moisture % at (60% RH & 40^{0} C)	Gross Calorific Value GCV (Kcal/ Kg) (at 5% moisture level)
A	Exceeding 6200	Not exceeding 19.5	Exceeding 6454
B	Exceeding 5600 but not exceeding 6200	19.6 to 23.8	Exceeding 6049 but not exceeding 6454
C	Exceeding 4940 but not exceeding 5600	23.9 to 28.6	Exceeding 5597 but not exceeding. 6049
D	Exceeding 4200 but not exceeding 4940	28.7 to 34.0	Exceeding 5089 but not Exceeding 5597
E	Exceeding 3360 but not exceeding 4200	34.1 to 40.0	Exceeding 4324 but not exceeding 5089
F	Exceeding 2400 but not exceeding 3360	40.1 to 47.0	Exceeding 3865 but not exceeding. 4324
G	Exceeding 1300 but not exceeding 2400	47.1 to 55.0	Exceeding 3113 but not exceeding 3865

Grades of Semi-coking and Weakly Coking Coal

Grade	Ash + Moisture Content
Semi coking grade -I	Not exceeding 19%
Semi coking grade -II	Exceeding 19% but not exceeding 24%

Grades of NEC Coal :

Grades	UHV (Kcal/Kg)	Corresponding Ash% + Moisture %age
A	6200-6299	18.85 - 19.57
B	5600 - 6199	19.58 - 23.91

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Environmental Disaster

Insight to Gold Creek, Blairmore Creek, Daisy Creek, Racehorse Creek

http://www.trademarksa.org/sites/default/files/publications/Report%20|%20Mozambique%20Mineral%20Scan.pdf

November 2011 Mozambique Mineral Scan Report

6.5.3.1. Benga Total Speculation

Total conjecture

Riversdale has been operating in Mozambique since 2006. It has a 25 year mining lease and has already had environmental approval (mining and power) and in April 2010 Benga mine (owned by Riversdale - 65% and Tata Steel - 35%) was officially opened. Mallyon (2010) has compared the quality of the coking coal at Benga to that at Bowen Basin in Australia, which is considered amongst the best in the world. The resource is given in Table 9. Riversdale had a 40% life of mine (LOM) offtake agreement with Tata steel, and a 10% LOM offtake agreement pending with WISCO in 2010 (Mallyon, 2010) and therefore this material is essentially sterilised to local beneficiation. Not International Standards – Leon Fanoe, Riversdale's Benga general manager has indicated that the company aims to export its first coking coal as soon as its processing plant is completed and plans its first shipment from Beira in September 2011 (MacDonald, 2011). Did Not Happen

6.5.3.4. Zambeze

Riversdale's Zambeze coal project lies adjacent to the Benga project, which will allow possible production and administration synergies. Riversdale had a 40% life of mine (LOM) offtake agreement pending with WISCO in 2010 (Mallyon, 2010). The resource is given in Table 9. Like Benga it plans to produce export quality coking and thermal coal. The principal geologist is reported to have indicated that there are currently 26 geologists and a total exploration staff of 60 together with 10 drilling rigs on the property at the moment (March, 2011) and that the feasibility study is expected to be completed in 2012 (MacDonald, 2011). The deposit occurs in a Precambrian aged downfaulted basin, and includes a total of 22 coal seams. It is envisaged that the Zambese project will be developed together with Chinese steelmaker Wuhan Iron and Steel Corporation (WISCO), which has a non-binding memorandum of understanding with Riversdale Mining to obtain 40% of the project for an investment of $800M (Mining-Technology, 2011a).

This Cost Rio Tinto 3.9 Aus.

http://articles.chicagotribune.com/2013-01-21/news/sns-rt-digest-australia-businessl4n0aq4sd-20130121_1_metal-recycler-australian-infrastructure-fund-future-fund

--Global miner Rio Tinto has announced it will accelerate negotiations with coal miners in Mozambique after reviewing its A$3.9 billion takeover of Riversdale Mining 18 months ago. The assessment discovered that Riversdale's African assets held less coal than previously thought and were insufficient to support its own rail infrastructure. Analysts from Commonwealth Bank of Australia called on Rio chief executive Sam Walsh to divest non-core assets, including its Australian uranium mines, diamonds and its holding in the Indonesian Grasberg copper venture. Page 17.

Total speculation

Total conjecture

No Certain Project Completion

http://articles.chicagotribune.com/2013-01-21/news/sns-rt-digest-australia-businessl4n0aq4sd-20130121_1_metal-recycler-australian-infrastructure-fund-future-fund

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http://www.trademarksa.org/sites/default/files/publications/Report%20|%20Mozambique%20Mineral%20Scan.pdf

6.5.3.1. Benga

Riversdale has been operating in Mozambique since 2006. It has a 25 year mining lease and has already had environmental approval (mining and power) and in April 2010 Benga mine (owned by Riversdale - 65% and Tata Steel - 35%) was officially opened. Mallyon (2010) has compared the quality of the coking coal at Benga to that at Bowen Basin in Australia, which is considered amongst the best in the world. The resource is given in Table 9. Riversdale had a 40% life of mine (LOM) offtake agreement with Tata steel, and a 10% LOM offtake agreement pending with WISCO in 2010 (Mallyon, 2010) and therefore this material is essentially sterilised to local beneficiation.

Leon Fanoe, Riversdale's Benga general manager has indicated that the company aims to export its first coking coal as soon as its processing plant is completed and plans its first shipment from Beira in September 2011 (MacDonald, 2011)

6.5.3.4. Zambeze

Riversdale's Zambeze coal project lies adjacent to the Benga project, which will allow possible production and administration synergies. Riversdale had a 40% life of mine (LOM) offtake agreement pending with WISCO in 2010 (Mallyon, 2010). The resource is given in Table 9. Like Benga it plans to produce export quality coking and thermal coal. The principal geologist is reported to have indicated that there are currently 26 geologists and a total exploration staff of 60 together with 10 drilling rigs on the property at the moment (March, 2011) and that the feasibility study is expected to be completed in 2012 (MacDonald, 2011). The deposit occurs in a Precambrian aged downfaulted basin, and includes a total of 22 coal

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Message from CEO

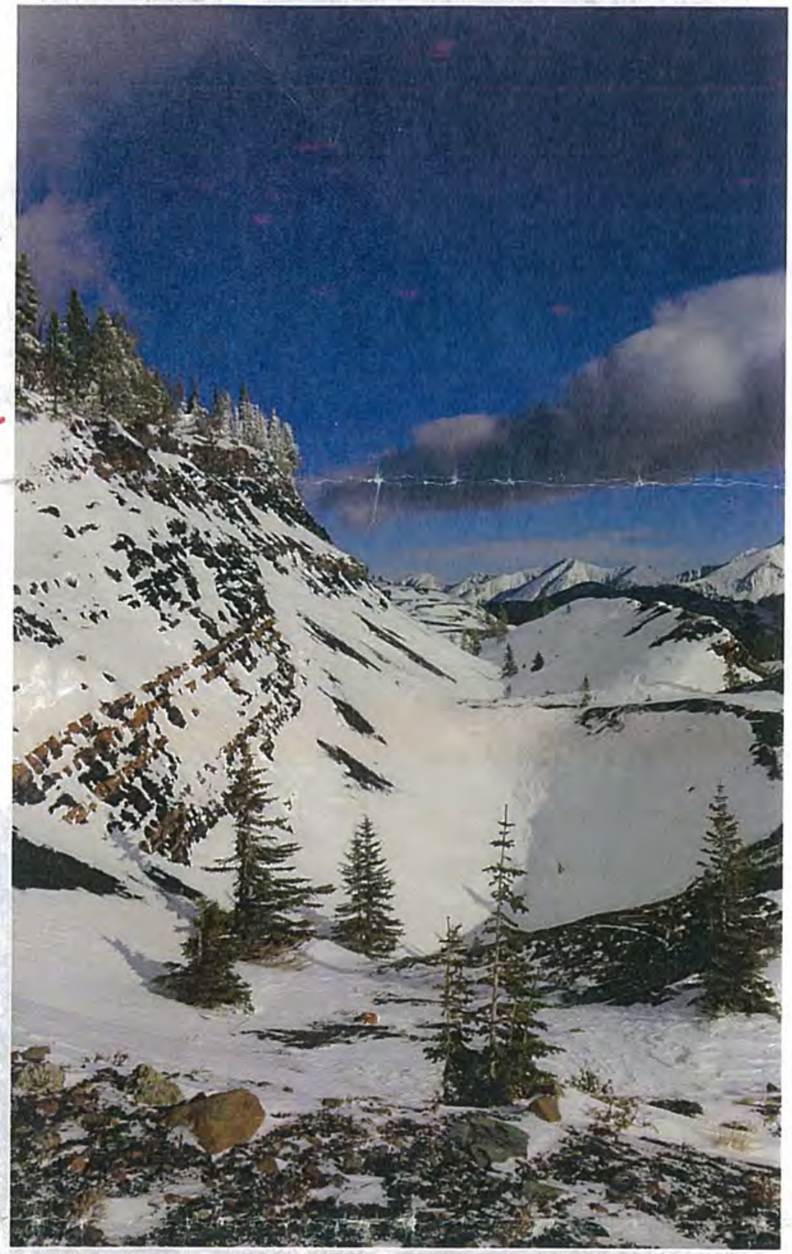
Riversdale enjoyed our second year in Crowsnest Pass with tremendous progress on the Grassy Mountain Project. During 2014 we completed a significant coal quality and reserve delineation and exploration program and extracted bulk samples for testing. The team were delighted to learn that the samples confirmed a hard coking coal, comparable with some of the high quality metallurgical coals from Canada, USA and Australia. We completed key environmental work in air quality, water quality, flora and fauna studies and large mammal population and habitat recording.

Comparable to Elk Valley Coal

Riversdale is planning to complete feasibility study work by mid-2015 and, as we have done this year, we will hold more open house meetings to inform the community of our project activities.

We have appreciated the support and frank feedback and the warm welcome extended to the Aussies in the team. On behalf of Riversdale, I would like to offer our best wishes to your families over the Christmas season and we look forward to an exciting 2015.

Steve Mallyon
Managing Director



Contact information

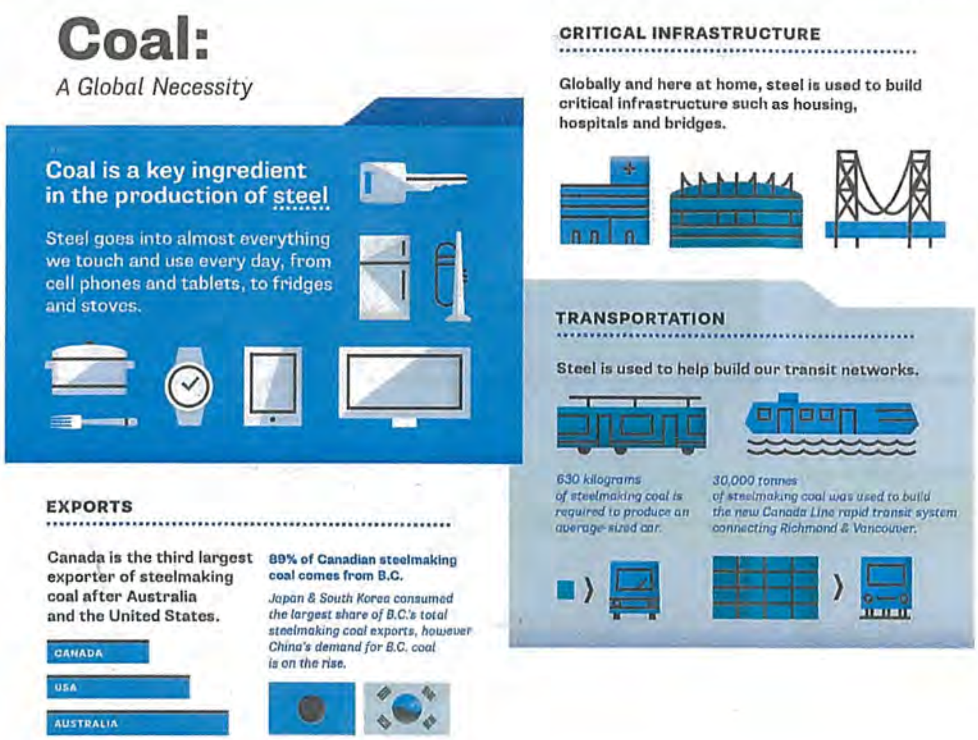
Community Liaison
Keith Bott
(403) 753-5160
keith.bott@rivresources.com

12331 20th Avenue
P.O. Box 660
Blairmore, Alberta T0K 0E0
Tel: (403) 753-5160

About Riversdale Resources

Riversdale Resources Limited, established in 2011, is an unlisted Australian public company with headquarters in Sydney, Australia. Benga Mining Limited, is a wholly owned subsidiary of Riversdale Resources Limited.

RIVERSDALE RESOURCES



Courtesy of Coal Assoc. of Canada

Aboriginal Engagement

Riversdale has been actively engaged with First Nations as it is necessary to mitigate and accommodate all impacts the proposed project may have on Aboriginal Rights. All seven Nations belonging to Treaty No. 7: Piikani Nation, Kainai Nation, Siksika Nation, Tsuu T'ina Nation and Stoney Nation (Bearspaw First Nation, Chiniki First Nation and Wesley First Nation) are actively engaged in these discussions.

Over the summer and early fall, the First Nations participated in planning and field work for Environmental Assessment related studies. Piikani Nation formally blessed the site during the summer 2014 to ensure the success of the project and the safety of all workers on Grassy Mountain. Reports and consultation activities for the Environmental Assessment will continue into the spring of 2015.

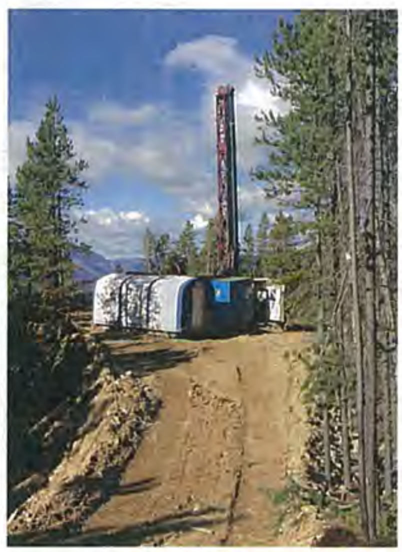
Riversdale participated in several First Nation community and cultural events that were held both in First Nation communities and at the Grassy Mountain project site. These events provide valuable opportunities for Riversdale staff and consultants to learn about the First Nations, and for First Nation community members to learn more about the Grassy Mountain project.

As results of the technical feasibility study become clear, Riversdale will initiate dialogue about employment and contracting opportunities with First Nations in addition to the municipal centres in proximity to the project.

Safety & Access Management

To ensure the safety of the public, contractors and others working in the area, Riversdale asks that signs, gates and other access restrictions be respected. Recreational users are advised that no hunting is allowed in the area and only authorized personnel are permitted where signage is posted. As exploration work and environmental testing continues, it is vital the project area be avoided.

If you would like to gain access, please contact Keith Bott at the local office (see back page) to discuss your request.



Next Steps

Environmental, engineering and construction related applications are expected to be completed and filed in mid-2015. Pending regulatory approval, Riversdale hoped to begin construction in 2017 with production following in late 2018.

A Holiday Open House will be held at the local Riversdale office as part of Christmas in the Mountains. Please join us on Friday, December 5 from 5 p.m. to 8 p.m. to celebrate the festive season. In addition, Riversdale will hold another community open house in the new year to present visual representations of the rail line and associated load-out structures.

Riversdale is currently working to file the project description and proposed terms of reference with the Alberta Energy Regulator. Watch for advertisements describing where the public can access this information. As Riversdale continues working towards environmental and regulatory approvals, we value feedback from the community and encourage you to share your concerns and ideas with us. Please contact Keith Bott at the local office (see below) if you have any questions or would like more information on any aspect of the proposed project.

Operational Infrastructure

In the fall of 2014, a variety of options on the rail line and associated facilities were presented to the public. Riversdale is responding to community and stakeholder discussions and is working on a final layout and design that considers concerns expressed during public consultations. We have undertaken considerable revisions to the operational facilities and are in discussions with Alberta Transportation to review impacts on highway right of ways .

Riversdale is committed to ensuring the final operational structures and layout work to have minimal potential impacts on neighbouring communities.

Visual representations of the rail line locations and applicable structures including storage and load-out facilities will be presented at the next open house in early 2015.

Exploration Program

Riversdale began the exploration program in December 2013 with ongoing drilling to delineate the resource and to conduct initial coal quality testing. All preliminary tests have indicated a high quality metallurgical coal, most of which will be sold to Asian markets. Several bulk samples have been sent for analysis and results from the latest samples are pending.

Drilling has been conducted to evaluate the stability and understand strengths of the subsurfaces as well as to determine the depths and locations of coal deposits and the surface formations. This season's drilling program is expected to be completed by mid-December. Permitting for next year's exploration program is underway which will continue drilling on both private and Crown land in the Grassy Mountain Project area. Riversdale is also working to develop an understanding of the extent of the water contained in the underground mine workings to determine if it could be used for possible future mine operations.

The majority of the roads used to manage Riversdale's exploration program are legacy trails that existed from previous coal mining operations.

Environmental Studies

In mid-2013, Riversdale began collecting four-season baseline data in the project area including surface and ground water, air, wildlife, soils and vegetation.

Seven hydrometric stations are situated on Grassy Mountain that continuously capture water flow while surface water samples are collected from Blairmore Creek, Gold Creek and Crowsnest River. Monitoring wells have been installed to gain an understanding of the groundwater volume and chemistry. Wildlife crews have conducted surveys on a variety of amphibians, birds and mammals and have deployed 15 motion sensitive cameras throughout the project area. Two climate stations monitor and capture data on weather conditions such as wind speed and patterns, precipitation and temperature. Vegetation studies have been completed for the 2014 season to understand what species of vegetation are present in the area. As well, soil surveys were conducted in 2014 to examine the soil profiles of Grassy Mountain.

All data collected will be assessed and will become part of the Environmental Impact Assessment (EIA) which allows government, aboriginal groups, landowners and other stakeholders to have a better understanding of the potential impacts of the Grassy Mountain Coal Project. Riversdale is looking to file the EIA by mid-2015.

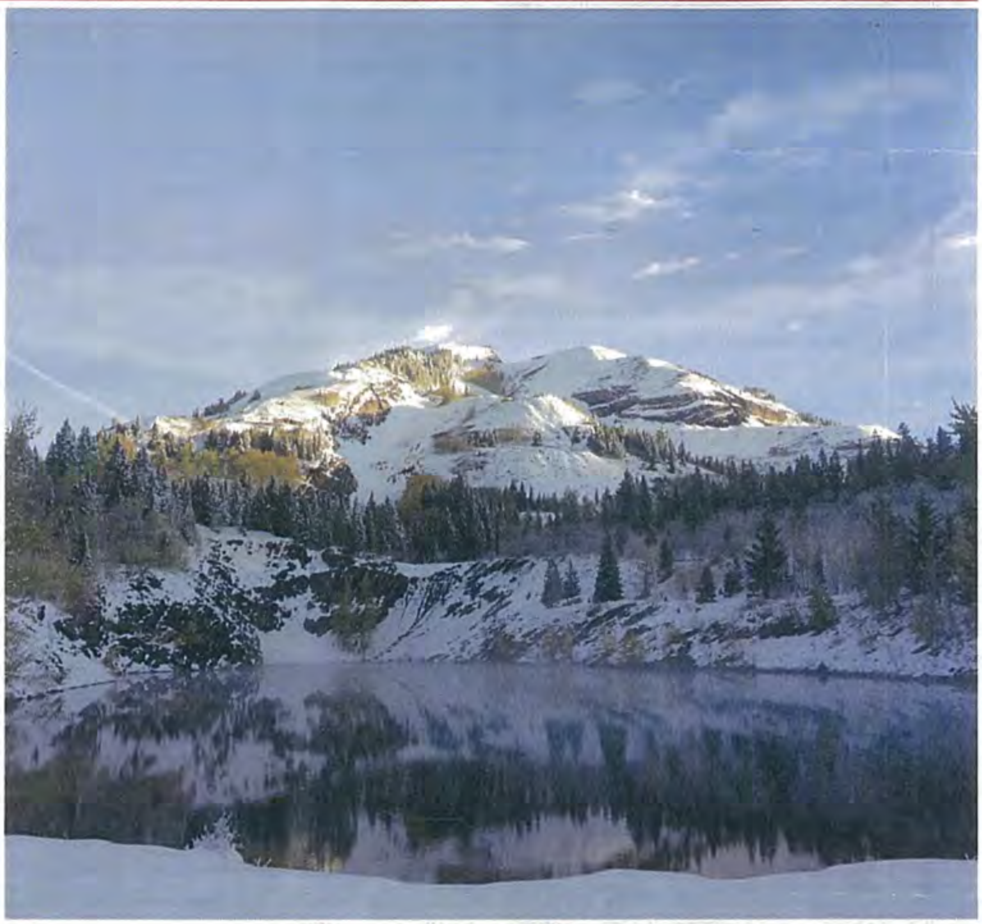
Riversdale is committed to the continued protection and enhancement of the environment and is currently discussing the project with the Canadian Environmental Assessment Agency and the Alberta Energy Regulator as well as conducting ongoing consultations with local representatives from Alberta Environment & Sustainable Resource Development.

Note Read Back Page

December, 2014

RIVERSDALE RESOURCES

Grassy Mountain Coal Project



The Grassy Mountain Project in Crowsnest Pass proposed by Riversdale Resources is an open-cut mine design with a target of 2 to 4 million tonnes per year of metallurgical coal to be used in the international steel industry. The overall project will include surface coal mining from three main seams along with associated infrastructure including an electrical power system, haul roads, a conveyor system, a coal preparation plant, a rail load-out facility, maintenance shops and other necessary facilities.

Located in southwest Alberta, the project will provide economic benefits to the local and regional economy as well as a long-term positive effect on the provincial economy. Riversdale continues advanced exploratory work, environmental monitoring and on-going consultations with First Nations. As well, they are proceeding with the regulatory permit process with a goal to begin production in late 2018.

Community Engagement

Riversdale continues to engage with the Municipality of Crowsnest Pass, MD of Ranchlands and Pincher Creek and the Town of Pincher Creek as well as local land owners, community and business organizations and recreational groups. Riversdale continues to operate its community office in Crowsnest Pass to provide a physical location where area stakeholders can go to ask questions and find information about the project. A full time Community Liaison is dedicated to the role of addressing community questions and concerns.

At the two open house events held in the fall of 2014, Riversdale spoke with over 150 people including business and property owners, recreation users, and area residents. During these meetings, Riversdale provided a forum for the public to ask questions about the project and to actively solicit and record comments or concerns.

Specific areas of information provided were the status of the project including technical and environmental considerations that will be made in preparation of the Environmental Impact Assessment (EIA); geographic information including the layout of the proposed mine and facilities; the company's history and corporate philosophies; and the top three rail load-out options under consideration.

Several areas of concern were identified during public consultations and Riversdale is committed to addressing these as the EIA and mine applications are being prepared.

Another open house will be held in early 2015 to provide more details on identified issues as well as to continue to engage in discussions with community members and other interested stakeholders.

John and Rae Redekopp
<personal information removed>

November 26, 2017

Richard Secord
Ifeoma Okoya
Ackroyd LLP
10665 Jasper Ave, Suite 1500
Edmonton, AB T3J 3S9

Re: Notice of Concern : Application, CCA1844520 and 190273 EPEA No. 001-403427 WA 001-00403428,001-00403429 , 001-00403430 and 001-00403431 PLA MSL160757 MSL160758 , LOC160841 LOC 160842 and LOC970943

Further to the letters we sent in April, June and December 2015 to both the Canadian Environmental Agency and the Alberta Department of Environment, we wish to express our concerns regarding the above mentioned proposed Riversdale/Benga coal mine on Grassy Mountain. Below is the letter expressing our initial concerns and an outline of our current concerns.

Currently our concern is with the following from Benga Mining: 'The temporary transfer of an existing License 00045622-00-00, held by the Municipality of Crowsnest Pass on York Creek, to Benga Mining Ltd. of 250,400 m3 (203 acre feet).is a partial transfer of the License currently allows of 308,280 m3 (250 acre feet). The water license dated September 5, 1911, that Benga Mining has submitted to the AER states in clause #4 'the rights and privileges hereby granted are subject to periodic review and to modification to ensure the most beneficial use of the water in the public interest and more particularly to ENSURE PRESERVATION OF THE RIGHTS OF OTHER WATER USERS'. Therefore, we do not see how a transfer of this license to Benga Mining is in the best interest of the public due to the fact that Benga Mining is a private corporation. Further, this Benga Mining project is in the MD of Ranchlands, not the Municipality of Crowsnest Pass. The summer of 2017 was one of the driest that we've encountered since we have resided here. With substantial water shortages and the forest fires that threatened our community this past summer we feel the Municipal counsellors and their staff are not acting in the best interests of their citizens by allowing this license transfer.

Further, Benga Mining has placed a so called 'air monitoring station' on our property which consists of a jar with water in it. Is this an acceptable means to provide the baseline ambient air quality test required for the project?

We live in an area called Valley Ridge Estates that shares the same valley as the proposed coal mine. When we bought this land and built our retirement home, we were not anticipating being neighbours of the Riversdale strip mine. We chose this location specifically for its peacefulness clean air and water.

After reviewing Riversdale/Benga's application to the Alberta Energy Regulator, we are concerned about the following issues. Per clause 5.7.2 in their application titled "Blasting Noise and Vibration Mitigation", Riversdale states that 'the noise and vibration levels associated with blasting can have a potential impact on nearby residents and can cause sensory disturbance to wildlife. There are not specific noise or vibration level limits for blasting in the AER Directive 038, nor are there any specific other provincial or federal criteria.' This is very disconcerting to us. In their application, Riversdale has included models for the impact of noise and/or vibration from every piece of machinery and nothing to mitigate the noise from the blasting other than to say that they will do their best to minimize the impact from blasting and noise and vibration. We feel we are at risk of seeing our property devalued due to the above and Riversdale has not addressed this issue. We are concerned about the risk of further rock slides that we have observed on Bluff Mountain (our property is located directly below it) as a result of the vibration from the mine.

The Crowsnest Pass is infamous for its wind. Our acreage development is downwind from the Grassy Mountain and the dust and air quality from the project is of great concern. Should there be baseline air quality tests carried out prior to mine development? Further, Riversdale claims they are not anticipating any impact on our water wells within Valley Ridge Estates. Riversdale is also proposing a load out facility adjacent to the Crowsnest River which is a world class trout stream. We fly fish along Gold Creek which feeds the Crowsnest River. Contamination of Gold Creek would be disastrous. What will become of the precious fish habitat when it is contaminated.

The established mines throughout the Elk Valley produce more than enough coal to meet the demand.

We believe Alberta's future depends on water NOT coal.

Sincerely,

John and Rae Redekopp
<personal information removed>

AUGUST 28, 2020

Richard Secord

Ifeoma Okoya

Ackroyd LLP

10665 Jasper Avenue, Suite 1500

Edmonton, AB T3J 3S9

POSTSCRIPT TO LETTER DATED November 26, 2017

Further to our numerous letters sent to the Federal Government and AER we'd like to add the following:

We approached Benga/Riversdale in August 2018 to address our concerns regarding the Grassy Mountain Coal Project and our residential home location which is 2-3 KM south of the proposed project. We are concerned with:

Devaluation of our property (I've attached their letter to us dated August 13, 2018 in which they determined that the mine will have no impact on our property value and gave no reason for this determination.

Water – this is a huge issue. It's a well known fact that waste rock from mining releases Selenium. Teck, in BC, has spent billions of dollars trying to rectify their toxic mess to no avail. The difference between Grassy Mountain and the Teck mines is that we have ONE headwater (Oldman). No other rivers or water to fall back on should they make a mess of our limited water supply. We want Riversdale/Benga to give us specifics on how they will deal with our well should it become contaminated. We would expect that they would pay for a water line from the town's supply if by some miracle that too isn't contaminated.

Their toxic sediment will remain in the Oldman Reservoir for decades.

Sincerely,

Rae and John Redekopp

<personal information removed>

Rae and John Redekopp

<personal information removed>

June 10, 2018

Gary Houston

VP, External Affairs

Riversdale Resources

Dear Gary,

Thank you for responding to our letter re our concerns with the Grassy Mountain Coal Project.

What we specifically want to know is what Riversdale/Benga Mining will do to mitigate the devaluation of our property resulting from any Grassy Mountain Mining activities.   This includes:

1. Hearing/feeling any affects of the blasting
2. Air quality issues which include the visual affects (black snow) from coal dust
3. Water quality – any disruption to our well with regards to flow and contamination

In no way, shape or form will the Grassy Mountain Coal Project enhance our quality of life.

Sincerely,

John and Rae Redekopp

<personal information removed>

RIVERSDALE
RESOURCES

Benga Mining Limited Operating as Riversdale Resources

Rae and John Redekopp
<personal information removed>

August 13, 2018

Dear Rae and John,

Thank you for your letter of June 10, 2018 and for joining us on a tour of Grassy Mountain on July 19. We understand that you are concerned about the potential devaluation of your home as a result of blasting and potential air quality and water quality issues.

As outlined in our response to your statement of concern #30111, should Riversdale Resources successfully obtain a mine permit, there will be a multitude of actions taken to mitigate potential impacts on air and water quality as a result of the Grassy Mountain Coal Project. According to the analysis done in each of these areas, we do not expect there to be a significant impact to your property.

Should you experience negative effects at your property during operations, you are encouraged to contact the community relations team who will facilitate an investigation process. Geotechnical instruments, and other monitoring equipment similar to that used in acquiring the project's baseline information, would be utilized to help identify issues and determine appropriate mitigations.

For further information on the topic areas noted above, please refer to the following sections in our Environmental Impact Assessment which can be found here.

Air Quality and Climate: Consultant Report #1
Noise: Consultant Report #2
Water Quality: Consultant Report #5

Sincerely,

<Original signed by>

Claire Rogers
Manager, Public Relations

Joint Review Panel
Benga Mining Ltd
Grassy Mountain Coal Mining Project
Submissions of Vern Emard

September 21, 2020

Project ID 80101

Submissions of Vern Emard and Family

I own Southeast ¼ of Section 30 Township 8 Range 3, West of the 5th Meridian (the "Land"). I have owned and lived on the Land for 30 years. I am retired now and I plan on living my last 25 years here on this Land. I have a large family that come, visit and stay with me on the Land.

My family has enjoyed the environment of living in the subalpine furtively. My children were babies on a horse ranch with abundant grass field. We have hosted hundreds of gatherings of many family, friends and new acquaintances. Socially, these lands are awe inspiring giving gratitude for our lives. There is no depression or societal stress, the air is fresh, clean and deep.

The children of which there have been hundreds, have learned valued skills of outdoors, forest and fauna. We had led groups of girl guides, beavers, cubs and scouts on adventures they will recall as magical, for many years, bringing many skills to all levels of learning and welcoming many guests into our forest life of mixed ranching; even buffaloes have grazed our grass. This may have been called a second home or vacation retreat, but no, this was a lifestyle of every weekend extended to three or four days. We worked and played, dreaming of the day we no longer had to return to the (city).

This Land is a flowerpot of art recreation, wonder, amazement, swimming, hiking, hunting, quadding, snowmobiling, pondering, teaching, gathering, educating, socializing and grieving. Our fathers and grandfather made this possible, as the trees grow from their ashes.

Our retirement is here. The last eight years of this application has been very stressful on this family and even if this application is denied we fear Benga will re-apply and continue this stress.

Nature of our Concerns with the Project

We have a lot of concerns which we have expressed in our submission. Our biggest concern is our access to our property.

(a) Land Use and Access Concerns

The access to our property is through an easement registered on title to Section 24-8-4-W5M (Registration No. 921280727). A copy of this easement is attached to the submissions of Larry and Ed Donkersgoed which we have reviewed. We rely on this easement. This easement is also reflected on title to our property. We have always had this access to our property.

Our review of Benga's application shows that this access road will be blocked either permanently or temporarily by Project components such as the Coal Handling and Processing Plant and associated infrastructure. When Benga was asked how they were going to address landowners access concerns, Benga indicated that they would tell landowners to find alternate route through the bush. This is unacceptable. Our Land was bought and sold with access guaranteed through Alberta Land Registry. At the very least, Benga should respect our rights to our access road and provide us with alternate and comparable access.

As a 3rd generation retired road builder, I (Vern) believe that alternate routes could be developed to alleviate all land owner concerns at a reasonable financial cost to Benga. We believe that approximately 5 miles of road can be built through the Gold Creek access at a minimal cost to Benga considering the scope of this project. There is existing road along Gold Creek now that may be easy for Benga to improve upon. There may be environmental considerations in this, but this whole application is based on environmental considerations. We should not be made to bear the cost of Benga's operation that does not benefit us.

Presently Benga has restricted access to our property by installing locked gates on the access road. Although we have been provided with two keys to the locked gates, access by medical or fire emergency operators such as EMS or the Fire Service will be hindered when unrestricted and unhindered access to the property is needed to provide critical health services to us and other residents impacted by the restriction. It is not right to lock residents, family and friends in without an emergency response plan. In our view, if Benga's project must be approved, Benga must be required to provide us with full, uninterrupted and unrestricted access similar to what we have now.

(b) Impacts to Air Quality, Water and Noise Pollution

We want to know how our air quality and quality of our drinking water as well as noise pollution and how living within the scope of Benga's mine boundaries will be addressed. We drink water from our local well. Any impacts to our water well and the air that we breathe will impact our quality of life. Having lived here for 30 years, we have seen 2 flood events that changed the course of the river. As the river valley is flat there is overwhelming evidence of reoccurring flooding and river course changes. Having seen these rise and fall of water firsthand, we do not believe Benga can contain the water in the sedimentation ponds and other ponds they plan to contain water. It is easy for water to overcome its containment and pollute other water sources. What becomes of us and our livelihood then?

As we will be living close to the mine boundary, we are concerned about the noise and dust that the Project will generate and its impacts on our quality of life. The mine will make outdoor living and enjoyment difficult for us and non-existent.

(c) Environmental Impacts

We are concerned that this Project will contaminate Gold Creek and Blairmore Creek and impact the aquatic resources that rely on the water quality and quantity within these creeks. While we are not opposed to a mine with proper mining practices with viable and confirmed benefits to the economy of our province and our country, we find Benga's proposals on environmental impacts and mitigation dubious and unsustainable. For instance, this project has not assessed the cumulative environmental impacts of other projects within the vicinity of the Project.

Since this project started, there has been a snowball effect of further coal exploration into the back country. We have reported a number of these activities which have resulted in some unethical pollution of the watershed on Grassy Mountain. We have also seen many kilometers of wildlife corridors adversely affected by coal exploration in this area. If this project is approved, there will be a doubling of the damages to the Oldman river watershed as another watershed is presently being explored aggressively by potential miners.

Considering all the environmental impacts that this Project will raise, this Project should not be approved. If this one mine grassy mountain mine is approved, this will provide justification for other companies to seek approval to further the devastate the whole of the Oldman river watershed. If the Panel feels that they have to approve this project, the Panel should set up a forum of stewardship monitoring or a stewardship program to monitor Benga's activities on this Project as well as the actions of other miners given authorization to explore for coal on public lands and ensure that environmental policies and legislation are being adhered to. This stewardship program should be paid for and solely funded by Benga and other miners seeking to mine on Grassy Mountain.

The roles and responsibilities of this stewardship monitoring forum or program should include:

(i) monitoring compliance with the terms and conditions of any approval granted including monitoring impacts to adjacent landowners' water sources and any access road impacts;

(ii) monitoring compliance with any approved dust suppression policies, emergency response plan, noise reduction/abatement policies

Benga should be required to develop an emergency response plan in case an emergency arises that impacts residents.

In our view, it is important that the Panel considers the cumulative impacts of this Project with other projects in the area. Also, all disturbances on public lands related to coal mining in the Oldman river watershed should be ceased until the Panel has fully considered the impacts of this Project and a decision made.

(d) Reclamation

We are concerned about the reclamation of this area in the event that Benga goes out of business. What is the amount of money or bonding set aside at the beginning of this Project in reserve for the reclamation of this mine at any stage if Benga goes out of business? Let us be clear, this is a money business project, first and foremost, it is not about anything else. At the very least, Benga should be required to post a bond to cover its reclamation costs.

(e) Economic Impacts/Benefits and Project Need

As landowners on Gold Creek adjacent to the mine site for 27 years, we are exhausted with keeping up with the whole application process. A lot of very smart people have asked and stated concerns regarding Benga application to mine coal in Southern Alberta in the headwaters of the Old Man River water shed. This in itself sounds very disturbing.

In the beginning, we had thought it was their lands to do as they would. After reading the ninth and tenth amendment and responses I see the agenda as not being in the public best interest. Some points in the original application stated 25 years of mining, 2 years reclamation. some where I have read the application includes the wording of 100 years. Unacceptable.

Also, wordings of taxes paid to our government of 100 million dollars. Is this broken down to 1 million dollars a year? Also provided by the miners were cost break downs and assumptions. As an ARHCA member for 40 years I disagree with their cost break downs. We do not want for the public and government money to bail a faltering business profile based on assumptions. Benga, Riversdale and Hancock responses have a lot of assumptions, and wording leaving more questions. Data from other sources and well worded responses. A lot of assumptions relied on a selected split regarding people's choices in deciding where they want to live when working in these mines. Benga says that about 40% of the workers will live in BC and commute to Alberta to work and about 60% will reside in Alberta. It is not clear to us how Benga arrived at this split. A lot of the mine workers in BC currently reside in Crowsnest Pass and commute to BC to work.

At the same time, we question the need for this project and the so called socio-economic benefits that it will present. To also consider the act of climate change and our part as humans, what makes it right to mine this mountain and send it to the other side of the world where it will be processed all the same?
Is there an expert that can tell us what 4.5 million tons of coal will give us to benefit us as humans? Will it build more machinery to mine the land? Is this not ludicrous?
Are we not in a position to say NO at this point? There is more than enough product to supply the exciting market by other companies in near neighborhoods (B.C. Elk Valley)
The crux seems to be it is needed for new and gregarious untapped markets. Do we need to feed the world at this time?

The reasons this Project should be declined are many. They are relevant and they are real. The false sense of we need this for our economy, jobs, people, maybe valid; we are not experts on this. But mining of coal is proven to be detrimental to communities, environment, land and tourism. Of profit orientated business, this project is no more than a play to make money at a cost to us far larger than we can calculate.

We request the Panel to deny the approval of this Project.

Respectfully Submitted,

Vern Emard and Family.

Shirley Kirby
<personal information removed>

September 21, 2020

Submission of Shirley Kirby

I object to the Grassy Mountain Coal Mine Project because I am likely to be directly and negatively affected by its mining activities. I am specifically concerned with acid rain and fine particulate matter. The leading medical research shows that the impact of fine dust to our health is actually more problematic than previously believed. A recent publication finds a significant impact on healthy populations where before only those with compromised immune systems were thought to be affected http://www.sciencedirect.com/science/article/pii/S1352231015304568. My home is located 7 km south-east of the proposed mine.

I argue that Section E, Environmental Assessment, **E.1 Air Quality & Climate** of Benga/Riversdale Resources' Environmental Impact Assessment (EIA) is unreliable, ethically questionable, incomplete and inadequate. It lacks commitment to the environment and the people of Crowsnest Pass (CNP).

Unreliable

Millennium EMS Solutions (MEMS) prepared an Air Quality & Climate Assessment for the proposed Project https://iaac-aeic.gc.ca/050/documents/p80101/115592E.pdf. MEMS' consultants selected values from sites such as:

i. Nelson, BC, 225km away, a residential community,
ii. Lethbridge, AB, 100km away with food and agricultural facilities, and
iii. Castlegar BC Zinio Place, 195 km away, influenced by two pulp mills.

These regional background sites were used for air quality forecasting, mapping, modelling, and remote sensing applications. The consultants recognized that SO_2 exceedances in Castlegar are due to industrial emissions; that they are 10 times higher than measurements at Lethbridge and Devon Coleman. O_3 values in Lethbridge are higher than the other two Alberta stations. The Lethbridge air quality station was chosen based on its proximity to the project and because it measures most parameters of interest. Other locations lacked some of the parameters. The Nelson station represented rural concentrations of $PM_{2.5}$ and PM_{10} distant from the mine location. It is utterly contrary to common sense to consider reliable the outcomes of models based on this data as representative of CNP air.

Also unreliable were the dust jars that the consultants set up in several locations in the Municipality to measure air quality. They were inexpensive and ineffective tools for measuring $PM_{2.5,}$ $PM_{10,}$ $O_{2,}$ and $NO_{2.}$ Despite several requests for results from the dust jars, none came.

Diesel emissions, a complex mixture of solid, liquid and gaseous components, are too complex to separate diesel exhaust from other combustion sources. Volatile Organic Compounds (VOC) and Polycyclic Aromatic Hydrocarbons (PAH) estimated on the basis of diesel combustion emission factors are also unreliable measurements https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4118891/.

Statements within the heading 2.5.4 Representative Model Predictions in Consultant' Report #1 (p. 23) are contradictory. "Representative model predictions for the Project were performed on the basis of expected maximum emission rates" … dispersion models are generally designed to accurately but conservatively predict concentration and deposition so that practitioners can apply model results with the understanding that effects are likely to be underestimated https://iaac-aeic.gc.ca/050/documents/p80101/115607E.pdf. What do the models predict?

Ethically Questionable

Millennium EMS Solutions' (MEMS') website promotes their ability to reduce monitoring requirements for a different Alberta mine: https://www.mems.ca/coalspur-vista-mine-dust-assessment. In Consultant Report #1 (p.21) the contractor augments Grassy Mountain data with "recent and current assessments undertaken in Alberta" (p. 21) https://iaac-aeic.gc.ca/050/documents/p80101/115607E.pdf. The Vista Coal mine, near Hinton, AB, whose numbers were tweaked so that it did not have to do an impact assessment, now faces a federal review https://thenarwhal.ca/vista-coal-mine-alberta-federal-review-announced/.

The benefits to MEMS' client, Benga/Riversdale Resources, are the reduction of expensive monitoring requirements and implementable mitigation approaches. This promotion specifically works against local air quality monitoring, building a local baseline air quality data bank and acting responsibly on the data that is collected. It raises the question: Are they seriously considering local issues and working to resolve them? Are these consultants working in the interest of the public or the interest of Company that has hired them?

A MEMO for Benga's Air Quality Monitoring Reports (attached) shows MEMS are inappropriately using the AAAQOs in comparing the background air quality levels to those objectives. As the government document they provide says itself, objectives are used to determine adequacy of facility design, to establish required stack heights and other release conditions, and to assess compliance and evaluate facility performance. The AAAQOs are not inherently 'safe' levels of exposure and are not "pollute-up-to limits". (They are not the equivalent of how speed limits work).

The AAAQOs that MEMS uses show exceedances of PM10 and ozone in their background monitoring data. So, if Benga thought they can pollute up to those AAAQOs, this shows that they are already being exceeded. Why are the AAAQOs being exceeded?

Incomplete

My confidence in Benga/Riversdale Resources/MEMS' ability to monitor and mitigate air quality is further eroded when I notice that the headings for the Table of Contents of Section E - Environmental Assessment Summary, **E.1** Air Quality & Climate in the Updated Environmental Impact Assessment and links to Addenda do **not** match.

Under **E.1** Air Quality & Climate Page E-ii, 18 headings are listed from **E.1.1** Air Quality and Climate Page E-4 to Air Quality Impacts **E.1.5.3** https://iaac-aeic.gc.ca/050/documents/p80101/115592E.pdf.

In the actual assessment, **E.1.1** Introduction and Terms of Reference on Page E-4 is immediately followed with the heading **3.2.5** Air Emissions Management and an outline in italics on Page E-5. The numerical order restarts with **E.1.2** Baseline Conditions and 3 subheadings, **E.1.3** Potential Impact and 5 subheadings, **E.1.4** Cumulative Effects Assessment and 2 subheadings and **E.1.5** Summary and 3 subheadings on Page E-7.

The two pages of italics are cut and paste from CEAA Guidelines (below). They include: **3.2.5** Air Emissions Management, **4.1**, Air Quality**,** Climate and Noise, **4.1.1,** Baseline Information, **4.1.2** Impact Assessment, **6.1.1** Atmospheric environment and **6.2.1** Changes to the Atmospheric Environment. This anomaly occurs in the 2016 update, the 2020 update and the 10th addendum. Do MEMS have experience with rigorous air quality assessment? Why have they ignored these two pages?

These same two pages also reappear as Terms of Reference (p. 1) https://iaac-aeic.gc.ca/050/documents/p80101/115607E.pdf The provincial Terms of Reference (ToR) are linked to Appendix 1 where the corresponding cells are blacked out. Considerable improvements are needed to make this section readable and understandable.

Inadequate

Finally, on page 10 of the Benga/Riversdale Resources' response to Information Request 1.3 in the 10th Addendum is inadequate https://iaac-aeic.gc.ca/050/documents/p80101/132604E.pdf.

Provide a draft air quality mitigation and monitoring plan.

The draft plan is found in Appendix 1.3-1. Goals and objectives are found in Tables 3.0-1; the Mitigation Program in Table 5.0-1 and Monitoring Program in Table 6.0-1; and the Adaptive Management Program in Table 7.2-1 https://iaac-aeic.gc.ca/050/documents/p80101/132604E.pdf.

The air quality monitoring mitigation plan is inadequate. It is characterized by a clinical generic methodology that is vague at best. Reviewing, quantifying and implementing are self-generating mechanisms. There is not a hint of how to prevent their previous dust problems at Bengalla in Australia. There are no references to Crowsnest Pass features, unique activities or places that may be affected and how.

a) A description of the potential effects of the Project on air quality that require mitigation.

There is no description of the potential effects of the Project on air quality that require mitigation other than naming: fugitive dust emissions, NOx emissions, $PM_{2.5}$ emissions in Table 6.0 (p.10). At Crowsnest Pass there have been no consultations on the risks to the environment and to health that Grassy Mountain Coal Mine poses. Many citizens do not suspect the risks to their environment and health. The example in Brayton Point Towers, Massachusetts where residents woke up to a persistent rain of coal dust that coated patios and cars is a reminder. https://www.ecori.org/renewable-energy/2019/4/27/brayton-cooling-tower-come-down-to-delight-of-neighbors

Also, at Pioneer Mine in Stellarton, Nova Scotia, Dr. Ian Spooner from the Earth and Environmental Science Department at Acadia University states: "The presence of significant coal dust on properties located close to the mine must be considered as both a nuisance and a health risk… Human disease associated with coal mining primarily results from breathing in particulate matter during the mining process…. Coal dust already generated by the mine could be contributing to health problems with the students at the school, and with the surrounding residents https://www.ecori.org/renewable-energy/2019/4/27/brayton-cooling-tower-come-down-to-delight-of-neighbors.

b) A clear statement of the mitigation objective being pursued and identification of indicators that will be used to determine whether mitigation measures are effective.

Mitigation objectives are vague: reduce emissions, establish baseline ambient air quality, quantify changes to ambient air quality, review monitoring results periodically or when complaints are received and implement mitigation measures when opportunities to improve ambient air quality are identified or if set targets are not being met. Benga/Riversdale Resources has not provided the residents with an adequate explanation as to how the escape of particulate matter (coal dust from the mine site) will be reduced.

For over a year I made repeated requests for information from a recently installed air quality monitor on the Old Golf Course. I was met with the excuse that such a gesture was not possible, followed by delays. It is an already-established practice that periodic monitoring and the receipt of complaints will not move Benga/Riversdale Resources to act. It is more likely that monitoring will not be shared, if done at all, and complaints will be heard when Benga/Riversdale Resources gets around to it.

c) Details of the proposed monitoring and how the monitoring will measure for Project effects.

Generic terms with few local details characterize the proposed monitoring and how the monitoring will measure for Project effect in Tables 3.0-1, 5.0-1, and

6.0-1 https://iaac-aeic.gc.ca/050/documents/p80101/132604E.pdf. No pertinent evidence or specific measurements is available.

d) Thresholds to which monitoring results will be compared to that will trigger the implementation of alternative management actions or mitigation measures.

The Benga/Riversdale Resources EIA must provide specific local measurements that indicate air quality health in the CNP. The responsibility for this critical threshold must not be left to self-triggering long-standing mitigation methods in engineering.

e) A description of the technically and economically feasible management actions or mitigation measures that Benga will implement if thresholds are exceeded.

Technically and economically feasible management actions during construction would include: use of a water truck to control 80% of the dust on roads in summer months. Twenty percent of the diesel emissions, fugitive dust and critical case contaminants in Year 19 are enough to cover the whole 373.1 kg^2 of Crowsnest Pass with a layer of diesel, fugitive emissions and critical contaminants! (CR#1, Section 4.2, Appendix A Table A-10-1). Eighty percent control of the dust is not enough! The lives of grass, trees, shrubs, other plants, animals and people are at stake.

On a road trip to BC, the sight of homes and hills covered with coal dust is not easy to forget. My mother exclaimed how hard it must be for the women to wash clothes and hang them on the line, just to have them get black again. Black lung disease took the lives of many men who worked in the mines, but no one knew then the number in the community who were also affected by the fine dust lodged in their lungs. Sixty years later, hardy grasses grow over the coal slack and homes are renovated copies of their former selves with bright colours and trims. Tourists are attracted by the history, the small town atmosphere, the clean air and the mountain terrain. (My story)

f) A general description of whether, or how, Benga would propose to consider traditional knowledge in the mitigation and monitoring plan.

Benga's proposal to let air quality management and monitoring actions evolve and be finalized with affected Aboriginal groups is nebulous, at best.

When I express my fears about the lack of real baseline air quality data, Keith Bott, Community Relations Officer for Riversdale Resources, assures me that there is no risk. I am not reassured. Bengalla Mining Company in Australia, a sister company of Benga/Riversdale Resources, was warned once and fined twice in 2012 and 2018 after it “allegedly did not have proper measures in place to reduce dust from its operations” https://www.gem.wiki/Bengalla_mine.

Local evidence which shows the reality of air quality gathered over a minimum of five years and improvements to the current EIA with a commitment to the environment and people of Crowsnest Pass are required. A Benga/Riversdale Resources funded satellite faculty of the University of Lethbridge Department of Health and Science to study the effects of coal dust on age groups in mountain communities is also an important social and cultural contribution to consider. It would provide the much-needed tax base and attract employers and employees who would stay long after the mine leaves.

Section E.1 Air Quality and Climate of Benga/Riversdale Resources/MEMS’ Environmental Impact Assessment does not inspire me with confidence. The document is unreliable, ethically questionable, incomplete, inadequate and lacking in commitment to the Crowsnest Pass environment and people. IAAC approval of Grassy Mountain Coal Mine Project would put the protection and maintenance of our quality of life for me and the citizens of my community in jeopardy. An approval would be contrary to federal climate commitments; Grassy Mountain’s metallurgical coal is destined to be burned in China. I ask that you reject the Benga/Riversdale Grassy Mountain Coal Mine Project EIA.

Respectfully submitted,

Shirley Kirby

EXTERNAL MEMO

To: Keith Bott **Company: Benga Mining Limited** **Date: 7/8/2020**

Re: Benga's Air Quality Monitoring Reports

Benga's Air Quality Monitoring Station is installed in proximity to the proposed train loop, which is currently the lower portion of the Crowsnest Pass Town and Country Club golf course. As shown in the picture, the station (indicated with a blue dot) is located north of Highway 3, approximately 400 meters east of Crowsnest Pass Health Centre in the community of Blairmore. The Legal Description of the monitoring site is 08-03-008-04 W5M with the coordinates of 49.6164 N and -114.4529 W.

Air Quality Monitoring Station Location

The Benga Air Quality Monitoring Station sensors were set up to monitor the concentrations and relative changes in ambient air concentration of fine particulate matter - 2.5 micros or less ($PM_{2.5}$), fine particulate matter - 10 micros or less (PM_{10}), carbon monoxide (CO), nitrogen dioxide (NO_2) and ozone (O_3). The $PM_{2.5}$ and PM_{10}, are the parameters within 'dust', that are important to monitor as it relates to human health. Benga's Air Quality Monitoring Station is also collecting air temperature, humidity, pressure and wind speed.

Benga is comparing the collected air quality data against the provincial Alberta Ambient Air Quality Objectives and Guidelines Summary (AAAQO), which is provided in Appendix 1 (of this summary). Below in Table 1 is a list of the thresholds for the applicable industrial facility substances.

Table 1 Alberta Ambient Air Quality Objectives and Guidelines Summary		
Substance	**Period**	**Alberta Objectives ($\mu g/m^3$)**
Nitrogen Dioxide (NO_2)	Annual	45
	1-hour	300
Particulate Matter Smaller than 2.5 Microns ($PM_{2.5}$)	Annual	-
	24-hour	29
	1-hour	80
Carbon Monoxide (CO)	8-hour	6,000
	1-hour	15,000

The monitoring data summaries (Appendices 2-9) present the daily and hourly concentrations of the substances monitored. The concentrations are then compared to the thresholds, as provided in AAAQO, to check if any exceedance occurs. The threshold are referred as "Guideline Value" or "Hourly Guideline" in the reports. The wind rose diagram presents the distribution of $PM_{2.5}$ or PM_{10} concentration with the wind directions. See Table 2 for the list of Appendices.

Table 2 List of Appendices	
Appendix 1	Alberta Ambient Air Quality Objectives and Guidelines Summary
Appendix 2	Daily Average Concentration Report $PM_{2.5}$
Appendix 3	Daily Average Concentration Report PM_{10}
Appendix 4	Hourly Average Concentration Report $PM_{2.5}$
Appendix 5	Hourly Average Concentration Report CO
Appendix 6	Hourly Average Concentration Report NO_2
Appendix 7	Hourly Average Concentration Report O_3
Appendix 8	$PM_{2.5}$ Windrose
Appendix 9	PM_{10} Windrose

We thank you for the opportunity to be of assistance. Should you have any questions, please contact he undersigned at 403.270.5008.

Yours truly,

Millennium EMS Solutions Ltd.

Title:	Alberta Ambient Air Quality Objectives and Guidelines Summary
Number:	AEP, Air Policy, 2016, No. 2
Program Name:	Air Policy
Effective Date:	Differential effective dates for each objective or guideline
This document was updated on:	January, 2019

Alberta's ambient air quality objectives and guidelines are developed under the Alberta Environmental Protection and Enhancement Act (*EPEA*). Objectives are developed to protect Alberta's air quality.

Air quality objectives are generally established for one-hour, 24-hour, and annual averaging periods. Occasionally, the underlying information or ambient monitoring method requires that other averaging periods be used. For example, a three-day objective was set for ethylene as experimental evidence indicated that this was a more appropriate averaging period than 24-hours.

Objectives and guidelines are based on an evaluation of scientific, social, technical, and economic factors.

Consultation

Alberta Environment and Parks works with a variety of stakeholders, including other government departments, the scientific community, environmental organizations, industry and the general public to prioritize substances and to develop and review objectives and guidelines.

Reporting Air Quality

The Ambient Air Quality Objectives are compared to actual air quality measurements to report on:

- special ambient air quality surveys; and
- current air quality through the Air Quality Health Index.

Reporting Exceedances

Exceedances of ambient air quality objectives must be reported as outlined in the Air Monitoring Directive (refer to the definition for "AAAQO").

Industrial Facilities

All industrial facilities must be designed and operated such that the ambient air quality remains below Ambient Air Quality Objectives.

Use of Objectives (Table 1)

Objectives are used:

- to determine adequacy of facility design
- to establish required stack heights and other release conditions
- to assess compliance and evaluate facility performance

Table 1 Alberta Ambient Air Quality Objectives

Substance/ CAS	Averaging Period	µg m^{-3} †	ppbv *	Basis	Effective Date**	Last Review**
Acetaldehyde						
75-07-0	1-hour	90	50	Adopted from Texas	1999	
Acetic acid						
64-19-7	1-hour	250	102	Adopted from Texas	1999	
Acetone						
67-64-1	1-hour	5,900	2,400	Adopted from Texas	1999	2005
Acrolein						
107-02-8	1-hour	4.5	1.9	Adopted from Ontario (development of irritation)	Oct 1, 2013	
	24-hour	0.40	0.17	Adopted from Ontario (development of lesions in upper airways)		
Acrylic acid						
79-10-7	1-hour	60	20	Adopted from Texas	Jan 1, 2004	
	Annual	1.0	0.34	Adopted from California		
Acrylonitrile						
107-13-1	1-hour	43	19	Adopted from Texas	Jan 1, 2004	
	Annual	2	0.9	Adopted from California		
Ammonia						
7664-41-7	1-hour	1,400	2,000	Odour perception	1976	2005
Arsenic						
7440-38-2	1-hour	0.1	-	Respiratory effects	May 1, 2005	2013
	Annual	0.01	-	Carcinogenic effects		
Benzene						
71-43-2	1-hour	30	9.0	Haematological effects	1999	2012
	Annual	3	0.9	Carcinogenic effects		
Benzo[a]pyrene						
50-32-8	Annual	0.30 ng m^{-3}	2.9 $x10^{-5}$	Chronic and carcinogenic human health effects	June 1, 2009	
Carbon disulphide						
75-15-0	1-hour	30	10	Odour threshold	1999	2006

Substance/ CAS	Averaging Period	µg m-3 †	ppbv *	Basis	Effective Date**	Last Review**
Carbon monoxide						
630-08-0	1-hour	15,000	13,000	Oxygen carrying capacity of blood	1975	
	8-hour	6,000	5,000	--		
Chlorine						
7782-50-5	1-hour	15	5.0	Adopted from Texas	1999	
Chlorine dioxide						
10049-04-4	1-hour	2.8	1.0	Adopted from Texas	1999	
Chromium						
7440-47-3	1-hour	1	-	Adopted from Texas	1999	
Cumene						
98-82-8	1-hour	500	100	Adopted from Texas	May 1, 2005	
Dimethyl ether						
115-10-6	1-hour	19,100	10,100	Adopted from Texas	1999	
2-Ethylhexanol						
104-76-7	1-hour	600	110	Adopted from Ontario	May 1, 2005	
Ethylbenzene						
100-41-4	1-hour	2000	460	Adopted from Texas	May 1, 2005	
Ethyl chloroformate						
541-41-3	1-hour	0.57	0.13	Stack emission limits	1999	
Ethylene						
74-85-1	1-hour	1,200	1,050	Crop yield	Jan 1, 2004	
	3-day	45	40	Crop yield		
	Annual mean	30	26	Conifers and perennials		
Ethylene oxide						
75-21-8	1-hour	15	8.0	Adopted from Ontario	1999	
Formaldehyde						
50-00-0	1-hour	65	53	Adopted from Texas	1999	2007
n-Hexane						
110-54.3	1-hour	21,000	5,960	Derived from 24-hr California objective	Aug 1, 2008	
	24-hour	7,000	1,990	Adopted from California		
Hydrogen chloride						
7647-01-0	1-hour	75	50	Adopted from Texas	1999	
Hydrogen fluoride						
7664-39-3	1-hour	4.9	6.0	Adopted from Texas	1999	2009

Substance/ CAS	Averaging Period	µg m^{-3} †	ppbv *	Basis	Effective Date**	Last Review**
Fluoride content in forage – dry wt basis				Adopted from Ontario	2009	
	30-day avg.	35 µg g^{-1}		April 1 to October 31		
	Avg. for any single 30-day period	80 µg g^{-1}		April 1 to October 31		
	Avg. for 2 consecutive months	60 µg g^{-1}		April 1 to October 31		
Hydrogen sulphide						
7783-06-4	1-hour	14	10	Odour perception	1975	
	24-hour	4	3	Health effects		
Isopropanol						
67-63-0	1-hour	7,850	3,190	Adopted from Texas	Aug 1, 2005	
Lead						
7439-92-1	1-hour	1.5	-	Adopted from Texas	1999	
Manganese						
7439-96-5	1-hour	2	-	Adopted from Texas	May 1, 2005	
	Annual	0.2	-	Adopted from Texas and California		
Methanol						
67-56-1	1-hour	2,600	2,000	Adopted from Texas	1999	
Methylene bisphenyl diisocyanate						
101-68-8	1-hour	0.51	0.050	Adopted from Texas	1999	
Monoethylamine						
75-04-7	1-hour	1.19	0.645	Stack emission limits	1999	
Naphthalene						
91-20-3	Annual	3	-	Health effects	Sept 1, 2016	
Nickel						
7440-02-0	1-hour	6	-	Adopted from California	May 1, 2005	
	Annual	0.05	-	Adopted from California		
Nitrogen dioxide						
10102-44-0	1-hour	300	159	Respiratory effects	1975	2009
	Annual	45	24	Vegetation		
Ozone (ground level)						
10028-15-6	1-hour daily maximum	150	76	Pulmonary function	1975	2019
Particulate Matter						
Fine - 2.5 microns or less	24-hour	29	-	Health effects	2007	2018

Substance/ CAS	Averaging Period	µg m-3 †	ppbv *	Basis	Effective Date**	Last Review**
Total suspended particulate matter	24-hour	100	-	Pulmonary effects	1975	
	Annual geometric mean	60	-			
Pentachlorophenol						
87-86-5	1-hour	5.0	0.44	Adopted from Texas	Nov 1, 2004	
	Annual	0.5	0.04	Adopted from Texas		
Phenol						
108-95-2	1-hour	100	26.0	Adopted from Ontario	1999	
Phosgene						
75-44-5	1-hour	4	1	Adopted from Texas	1999	
Propylene oxide						
75-56-9	1-hour	480	200	Adopted from Oklahoma	Jan 1, 2004	
	Annual	30	13	Adopted from California		
Styrene						
100-42-5	1-hour	215	52.0	Adopted from Texas	1999	
Sulphur dioxide						
7446-09-5	1-hour	450	172	Pulmonary function	1975	2008
	24-hour	125	48.0	Adopted from European Union – human health		
	30-day	30	11			
	Annual	20	8.0	Adopted from European Union - ecosystems		
Sulphuric acid						
7664-93-9	1-hour	10	2.5	Adopted from Texas	1999	
Toluene						
108-88-3	1-hour	1,880	499	Adopted from Texas	May 1, 2005	
	24-hour	400	106	Adopted from Michigan and Washington		
Vinyl Chloride						
75-01-4	1-hour	130	51	Adopted from Texas	1999	
Xylenes						
1330-20-7	1-hour	2,300	530	Adopted from Ontario	May 1, 2005	
	24-hour	700	161	Adopted from California		

† µg m-3 is the weight, in micrograms, of the substance in one cubic meter of air.

* Standard conditions of 25°C and 101.325 kPa are used as the basis for conversion from µg m-3 to ppbv (parts per billion by volume) or from mg m-3 to ppmv (parts per million by volume).

** The Effective Date column indicates when the objective/guideline was initially effective in Alberta. A date in the Last Review column indicates the last date the objective/guideline was reviewed.

Note: Underscore indicates this digit is the last significant figure in the number e.g. 100 has two significant figures.

Note: The least significant figure is underlined to indicate calculation accuracy when converting from one unit to the other (e.g. µg m-3 to ppbv). These numbers **do not** indicate reporting accuracy or precision. Refer to the Air Monitoring Directive for the Reporting Policy on significant figures for comparison to the ambient air quality objectives.

Use of Guidelines (Table 2)

Guidelines may be used:

- for airshed planning and management
- as a general performance indicator
- to assess local concerns

Table 2 Alberta Ambient Air Quality Guidelines

Parameter	Guideline		Effective Date**	Last Review**
Dustfall				
30 days	53 mg 100 cm^{-2}	In residential and recreation areas	1975	
30 days	158 mg 100 cm^{-2}	In commercial and industrial areas		
Particulate Matter Fine - 2.5 microns or less				
1-hour	80 µg m^{-3}	Derived from the Canada Wide Standard	2007	2018
Static fluorides				
30 days	40 µg 100 cm^{-2}	Water soluble fluorides	Pre 1976	

For More Information

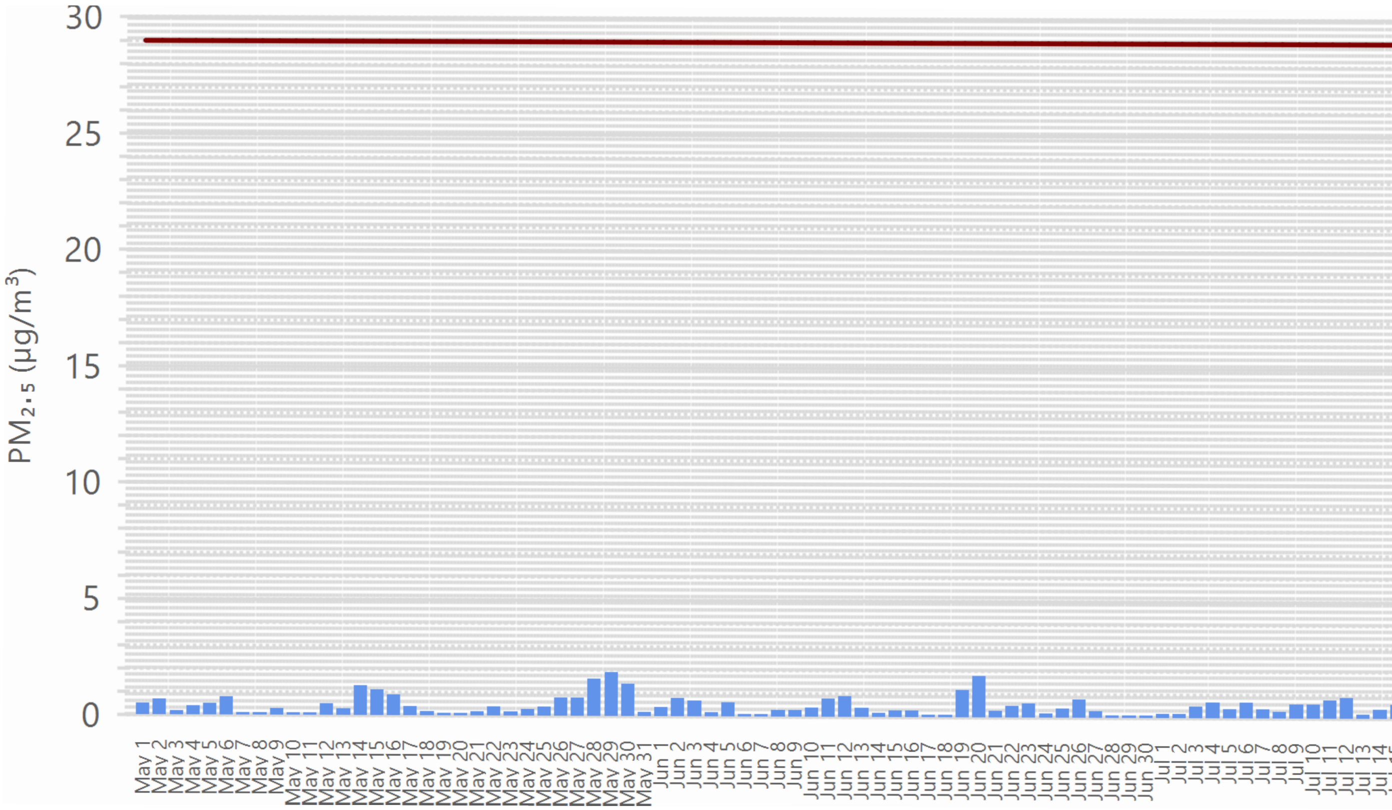
For more information on Alberta's Ambient Air Quality Objectives, contact:

Alberta Environment and Parks
Air Policy
Email: AirQuality.Comments@gov.ab.ca
Phone: **(780) 427-4979**

Original signed by:
Marilea Pattison Perry
Executive Director
Air, Biodiversity and Policy Integration Branch

Date: January 31, 2019

Further information is available online at
www.alberta.ca/air-quality



Date	Average Daily Value	Guideline Value	Exceedance	Unit
2020-05-01	0.5	29	0.0	µg/m
2020-05-02	0.7	29	0.0	µg/m
2020-05-03	0.2	29	0.0	µg/m
2020-05-04	0.4	29	0.0	µg/m
2020-05-05	0.5	29	0.0	µg/m
2020-05-06	0.8	29	0.0	µg/m
2020-05-07	0.1	29	0.0	µg/m
2020-05-08	0.1	29	0.0	µg/m
2020-05-09	0.3	29	0.0	µg/m
2020-05-10	0.1	29	0.0	µg/m
2020-05-11	0.1	29	0.0	µg/m
2020-05-12	0.5	29	0.0	µg/m
2020-05-13	0.3	29	0.0	µg/m
2020-05-14	1.3	29	0.0	µg/m

Grassy Mountain - AQ-001 - Proposed Loadout

DAILY AVERAGE CONCENTRATION REPORT - BY GUIDELINE

May 1, 2020 - July 29, 2020

Guideline: Alberta Ambient Air Quality Objectives and Guidelines

Guideline Revision Date: January 31, 2019

Parameter: $PM_{2.5}$

Date	Average Daily Value	Guideline Value	Exceedance	Unit	Exceedance %
2020-05-15	1.1	29	0.0	µg/m³	0.0%
2020-05-16	0.9	29	0.0	µg/m³	0.0%
2020-05-17	0.4	29	0.0	µg/m³	0.0%
2020-05-18	0.2	29	0.0	µg/m³	0.0%
2020-05-19	0.1	29	0.0	µg/m³	0.0%
2020-05-20	0.1	29	0.0	µg/m³	0.0%
2020-05-21	0.2	29	0.0	µg/m³	0.0%
2020-05-22	0.4	29	0.0	µg/m³	0.0%
2020-05-23	0.2	29	0.0	µg/m³	0.0%
2020-05-24	0.3	29	0.0	µg/m³	0.0%
2020-05-25	0.4	29	0.0	µg/m³	0.0%
2020-05-26	0.8	29	0.0	µg/m³	0.0%
2020-05-27	0.8	29	0.0	µg/m³	0.0%
2020-05-28	1.6	29	0.0	µg/m³	0.0%
2020-05-29	1.9	29	0.0	µg/m³	0.0%
2020-05-30	1.4	29	0.0	µg/m³	0.0%
2020-05-31	0.2	29	0.0	µg/m³	0.0%
2020-06-01	0.4	29	0.0	µg/m³	0.0%
2020-06-02	0.8	29	0.0	µg/m³	0.0%
2020-06-03	0.7	29	0.0	µg/m³	0.0%
2020-06-04	0.2	29	0.0	µg/m³	0.0%
2020-06-05	0.6	29	0.0	µg/m³	0.0%
2020-06-06	0.1	29	0.0	µg/m³	0.0%
2020-06-07	0.1	29	0.0	µg/m³	0.0%
2020-06-08	0.3	29	0.0	µg/m³	0.0%
2020-06-09	0.3	29	0.0	µg/m³	0.0%
2020-06-10	0.4	29	0.0	µg/m³	0.0%
2020-06-11	0.8	29	0.0	µg/m³	0.0%
2020-06-12	0.9	29	0.0	µg/m³	0.0%
2020-06-13	0.4	29	0.0	µg/m³	0.0%

Grassy Mountain - AQ-001 - Proposed Loadout

DAILY AVERAGE CONCENTRATION REPORT - BY GUIDELINE

May 1, 2020 - July 29, 2020

Guideline: Alberta Ambient Air Quality Objectives and Guidelines

Guideline Revision Date: January 31, 2019

Parameter: $PM_{2.5}$

Date	Average Daily Value	Guideline Value	Exceedance	Unit	Exceedance %
2020-06-14	0.2	29	0.0	µg/m³	0.0%
2020-06-15	0.3	29	0.0	µg/m³	0.0%
2020-06-16	0.3	29	0.0	µg/m³	0.0%
2020-06-17	0.1	29	0.0	µg/m³	0.0%
2020-06-18	0.1	29	0.0	µg/m³	0.0%
2020-06-19	1.2	29	0.0	µg/m³	0.0%
2020-06-20	1.8	29	0.0	µg/m³	0.0%
2020-06-21	0.3	29	0.0	µg/m³	0.0%
2020-06-22	0.5	29	0.0	µg/m³	0.0%
2020-06-23	0.6	29	0.0	µg/m³	0.0%
2020-06-24	0.2	29	0.0	µg/m³	0.0%
2020-06-25	0.4	29	0.0	µg/m³	0.0%
2020-06-26	0.8	29	0.0	µg/m³	0.0%
2020-06-27	0.3	29	0.0	µg/m³	0.0%
2020-06-28	0.1	29	0.0	µg/m³	0.0%
2020-06-29	0.1	29	0.0	µg/m³	0.0%
2020-06-30	0.1	29	0.0	µg/m³	0.0%
2020-07-01	0.2	29	0.0	µg/m³	0.0%
2020-07-02	0.2	29	0.0	µg/m³	0.0%
2020-07-03	0.5	29	0.0	µg/m³	0.0%
2020-07-04	0.7	29	0.0	µg/m³	0.0%
2020-07-05	0.4	29	0.0	µg/m³	0.0%
2020-07-06	0.7	29	0.0	µg/m³	0.0%
2020-07-07	0.4	29	0.0	µg/m³	0.0%
2020-07-08	0.3	29	0.0	µg/m³	0.0%
2020-07-09	0.6	29	0.0	µg/m³	0.0%
2020-07-10	0.6	29	0.0	µg/m³	0.0%
2020-07-11	0.8	29	0.0	µg/m³	0.0%
2020-07-12	0.9	29	0.0	µg/m³	0.0%
2020-07-13	0.2	29	0.0	µg/m³	0.0%

Grassy Mountain - AQ-001 - Proposed Loadout

DAILY AVERAGE CONCENTRATION REPORT - BY GUIDELINE

May 1, 2020 - July 29, 2020

Guideline: Alberta Ambient Air Quality Objectives and Guidelines

Guideline Revision Date: January 31, 2019

Parameter: $PM_{2.5}$

Date	Average Daily Value	Guideline Value	Exceedance	Unit	Exceedance %
2020-07-14	0.4	29	0.0	µg/m³	0.0%
2020-07-15	0.6	29	0.0	µg/m³	0.0%
2020-07-16	0.7	29	0.0	µg/m³	0.0%
2020-07-17	0.3	29	0.0	µg/m³	0.0%
2020-07-18	0.4	29	0.0	µg/m³	0.0%
2020-07-19	0.5	29	0.0	µg/m³	0.0%
2020-07-20	0.4	29	0.0	µg/m³	0.0%
2020-07-21	0.8	29	0.0	µg/m³	0.0%
2020-07-22	1.1	29	0.0	µg/m³	0.0%
2020-07-23	1.1	29	0.0	µg/m³	0.0%
2020-07-24	1.2	29	0.0	µg/m³	0.0%
2020-07-25	0.5	29	0.0	µg/m³	0.0%
2020-07-26	1.2	29	0.0	µg/m³	0.0%
2020-07-27	1.9	29	0.0	µg/m³	0.0%
2020-07-28	1.3	29	0.0	µg/m³	0.0%
2020-07-29	1.9	29	0.0	µg/m³	0.0%

The number of days with exceedance of the guideline: 0

Grassy Mountain - AQ-001 - Proposed Loadout

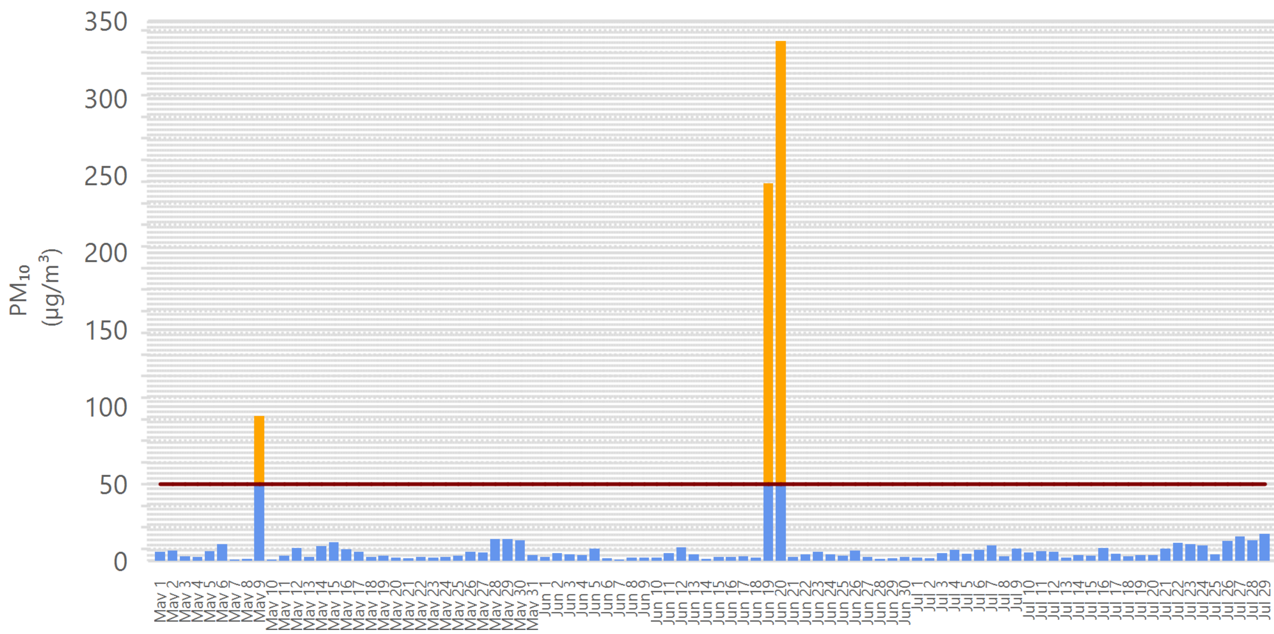
DAILY AVERAGE CONCENTRATION REPORT - BY GUIDELINE

May 1, 2020 - July 29, 2020

Guideline: Alberta Ambient Air Quality Objectives and Guidelines

Guideline Revision Date: January 31, 2019

Parameter: PM_{10}



Date	Average Daily Value	Guideline Value	Exceedance	Unit	Exceedance %
2020-05-01	5.7	50	0.0	µg/m^3	0.0%
2020-05-02	6.8	50	0.0	µg/m^3	0.0%
2020-05-03	2.9	50	0.0	µg/m^3	0.0%
2020-05-04	2.7	50	0.0	µg/m^3	0.0%
2020-05-05	6.3	50	0.0	µg/m^3	0.0%
2020-05-06	10.8	50	0.0	µg/m^3	0.0%
2020-05-07	0.8	50	0.0	µg/m^3	0.0%
2020-05-08	1.2	50	0.0	µg/m^3	0.0%
2020-05-09	94	50	44.0	µg/m^3	88.0%
2020-05-10	1	50	0.0	µg/m^3	0.0%
2020-05-11	3.5	50	0.0	µg/m^3	0.0%
2020-05-12	8.3	50	0.0	µg/m^3	0.0%
2020-05-13	2.7	50	0.0	µg/m^3	0.0%
2020-05-14	9.6	50	0.0	µg/m^3	0.0%

Grassy Mountain - AQ-001 - Proposed Loadout

DAILY AVERAGE CONCENTRATION REPORT - BY GUIDELINE

May 1, 2020 - July 29, 2020

Guideline: Alberta Ambient Air Quality Objectives and Guidelines

Guideline Revision Date: January 31, 2019

Parameter: PM_{10}

Date	Average Daily Value	Guideline Value	Exceedance	Unit	Exceedance %
2020-05-15	12.2	50	0.0	µg/m³	0.0%
2020-05-16	7.6	50	0.0	µg/m³	0.0%
2020-05-17	6	50	0.0	µg/m³	0.0%
2020-05-18	2.5	50	0.0	µg/m³	0.0%
2020-05-19	3.6	50	0.0	µg/m³	0.0%
2020-05-20	2	50	0.0	µg/m³	0.0%
2020-05-21	1.9	50	0.0	µg/m³	0.0%
2020-05-22	2.7	50	0.0	µg/m³	0.0%
2020-05-23	2.2	50	0.0	µg/m³	0.0%
2020-05-24	2.6	50	0.0	µg/m³	0.0%
2020-05-25	3.5	50	0.0	µg/m³	0.0%
2020-05-26	6.1	50	0.0	µg/m³	0.0%
2020-05-27	5.6	50	0.0	µg/m³	0.0%
2020-05-28	14.3	50	0.0	µg/m³	0.0%
2020-05-29	14.4	50	0.0	µg/m³	0.0%
2020-05-30	13.5	50	0.0	µg/m³	0.0%
2020-05-31	4	50	0.0	µg/m³	0.0%
2020-06-01	2.4	50	0.0	µg/m³	0.0%
2020-06-02	4.9	50	0.0	µg/m³	0.0%
2020-06-03	4.1	50	0.0	µg/m³	0.0%
2020-06-04	3.8	50	0.0	µg/m³	0.0%
2020-06-05	8.1	50	0.0	µg/m³	0.0%
2020-06-06	1.6	50	0.0	µg/m³	0.0%
2020-06-07	0.9	50	0.0	µg/m³	0.0%
2020-06-08	2	50	0.0	µg/m³	0.0%
2020-06-09	2.1	50	0.0	µg/m³	0.0%
2020-06-10	2.3	50	0.0	µg/m³	0.0%
2020-06-11	5.1	50	0.0	µg/m³	0.0%
2020-06-12	9	50	0.0	µg/m³	0.0%
2020-06-13	4.3	50	0.0	µg/m³	0.0%

Grassy Mountain - AQ-001 - Proposed Loadout

DAILY AVERAGE CONCENTRATION REPORT - BY GUIDELINE

May 1, 2020 - July 29, 2020

Guideline: Alberta Ambient Air Quality Objectives and Guidelines

Guideline Revision Date: January 31, 2019

Parameter: PM_{10}

Date	Average Daily Value	Guideline Value	Exceedance	Unit	Exceedance %
2020-06-14	1.5	50	0.0	µg/m³	0.0%
2020-06-15	2.4	50	0.0	µg/m³	0.0%
2020-06-16	2.6	50	0.0	µg/m³	0.0%
2020-06-17	3.1	50	0.0	µg/m³	0.0%
2020-06-18	2	50	0.0	µg/m³	0.0%
2020-06-19	244.8	50	194.8	µg/m³	389.6%
2020-06-20	336.9	50	286.9	µg/m³	573.8%
2020-06-21	2.6	50	0.0	µg/m³	0.0%
2020-06-22	4.1	50	0.0	µg/m³	0.0%
2020-06-23	5.7	50	0.0	µg/m³	0.0%
2020-06-24	4.3	50	0.0	µg/m³	0.0%
2020-06-25	3.5	50	0.0	µg/m³	0.0%
2020-06-26	6.7	50	0.0	µg/m³	0.0%
2020-06-27	2.5	50	0.0	µg/m³	0.0%
2020-06-28	1.3	50	0.0	µg/m³	0.0%
2020-06-29	1.6	50	0.0	µg/m³	0.0%
2020-06-30	2.5	50	0.0	µg/m³	0.0%
2020-07-01	2.3	50	0.0	µg/m³	0.0%
2020-07-02	1.9	50	0.0	µg/m³	0.0%
2020-07-03	5	50	0.0	µg/m³	0.0%
2020-07-04	7.2	50	0.0	µg/m³	0.0%
2020-07-05	4.5	50	0.0	µg/m³	0.0%
2020-07-06	7	50	0.0	µg/m³	0.0%
2020-07-07	9.9	50	0.0	µg/m³	0.0%
2020-07-08	2.8	50	0.0	µg/m³	0.0%
2020-07-09	8.1	50	0.0	µg/m³	0.0%
2020-07-10	5.6	50	0.0	µg/m³	0.0%
2020-07-11	6.4	50	0.0	µg/m³	0.0%
2020-07-12	6.1	50	0.0	µg/m³	0.0%
2020-07-13	2	50	0.0	µg/m³	0.0%

Grassy Mountain - AQ-001 - Proposed Loadout

DAILY AVERAGE CONCENTRATION REPORT - BY GUIDELINE

May 1, 2020 - July 29, 2020

Guideline: Alberta Ambient Air Quality Objectives and Guidelines

Guideline Revision Date: January 31, 2019

Parameter: PM_{10}

Date	Average Daily Value	Guideline Value	Exceedance	Unit	Exceedance %
2020-07-14	3.8	50	0.0	µg/m³	0.0%
2020-07-15	3.6	50	0.0	µg/m³	0.0%
2020-07-16	8.5	50	0.0	µg/m³	0.0%
2020-07-17	4.5	50	0.0	µg/m³	0.0%
2020-07-18	3	50	0.0	µg/m³	0.0%
2020-07-19	4	50	0.0	µg/m³	0.0%
2020-07-20	3.8	50	0.0	µg/m³	0.0%
2020-07-21	8	50	0.0	µg/m³	0.0%
2020-07-22	11.6	50	0.0	µg/m³	0.0%
2020-07-23	10.7	50	0.0	µg/m³	0.0%
2020-07-24	10.2	50	0.0	µg/m³	0.0%
2020-07-25	4.4	50	0.0	µg/m³	0.0%
2020-07-26	12.8	50	0.0	µg/m³	0.0%
2020-07-27	16	50	0.0	µg/m³	0.0%
2020-07-28	13.2	50	0.0	µg/m³	0.0%
2020-07-29	17.7	50	0.0	µg/m³	0.0%

The number of days with exceedance of the guideline: 3

Grassy Mountain - AQ-001 - Proposed Loadout

HOURLY AVERAGE CONCENTRATION REPORT

May 1, 2020 - July 29, 2020

Guideline: Alberta Ambient Air Quality Objectives and Guidelines

Guideline Revision Date: January 31, 2019

Parameter: $PM_{2.5}$

Hourly Guideline: 80 μg/m^3

Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Daily Average	Daily Maximum
2020-05-01	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.5	1.2	1	0.9	0.9	1	1.2	0.9	0.8	0.6	0.7	0.5	0.6	0.6	0.5	0.2	**0.5**	**1.2**
2020-05-02	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4	0.7	0.7	0.7	1.2	1	2.4	1.6	1.1	1.1	1.4	1.5	0.9	0.9	1.2	**0.7**	**2.4**
2020-05-03	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.7	0.8	0.2	0.5	0.3	0.2	0.5	0.5	0.2	0.2	0.1	0.2	**0.2**	**0.8**
2020-05-04	0.1	0.1	0.1	0.2	0.1	0.2	0.1	0.1	0.2	0.6	0.5	0.5	0.7	0.9	1.1	0.9	0.9	0.7	0.4	0.4	0.6	0.2	0.4	0.4	**0.4**	**1.1**
2020-05-05	0.7	0.3	0.1	0.1	0.1	0.1	0.1	0.2	0.9	0.8	0.5	0.8	0.5	0.6	0.6	0.5	0.7	0.8	0.8	0.7	0.7	0.6	0.4	0.7	**0.5**	**0.9**
2020-05-06	0.5	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	1	3.2	3.7	3.1	3.2	2.2	1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	**0.8**	**3.7**
2020-05-07	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	**0.1**	**0.1**
2020-05-08	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	**0.1**	**0.1**
2020-05-09	0.1	0.1	0.1	0.1	0.1	0.9	2.2	1.2	0.1	0.1	0.3	0.5	0.4	0.3	0.2	0.4	0.5	0.2	0.1	0.1	0.1	0.1	0.1	0.1	**0.3**	**2.2**
2020-05-10	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	**0.1**	**0.1**
2020-05-11	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4	0.6	0.4	0.1	0.1	0.1	**0.1**	**0.6**
2020-05-12	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.3	0.4	1.6	1.4	1.5	1.4	1	0.8	1.2	1.1	0.9	0.2	0.1	**0.5**	**1.6**
2020-05-13	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1	0.1	0.1	0.1	0.1	0.1	0.3	0.4	0.6	0.5	0.6	0.5	0.5	0.5	0.3	0.1	0.1	**0.3**	**1**
2020-05-14	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	0.5	0.6	0.5	0.4	0.5	0.4	0.4	1.2	3.1	5.4	5.4	4.5	3.9	2.9	**1.3**	**5.4**
2020-05-15	2.4	2.5	1.8	0.8	0.2	0.1	0.1	0.1	0.3	2.3	2.8	2.8	3	1.6	0.8	1.2	1.1	0.7	1.1	0.6	0.8	0.3	0.1	0.1	**1.2**	**3**
2020-05-16	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	0.5	0.5	0.8	1.4	0.8	2	1.5	1	1.5	0.9	1.4	7.4	1.4	**0.9**	**7.4**
2020-05-17	0.7	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	0.4	0.5	0.5	0.4	0.5	0.5	1.3	0.7	0.7	0.1	0.1	0.1	**0.3**	**1.3**
2020-05-18	0.1	0.2	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	0.5	0.8	0.7	0.7	0.4	0.1	0.1	0.1	0.1	0.1	**0.2**	**0.8**
2020-05-19	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	**0.1**	**0.1**
2020-05-20	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	**0.1**	**0.1**
2020-05-21	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.4	0.4	0.2	0.1	0.1	0.2	0.2	0.2	**0.2**	**0.4**
2020-05-22	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	0.3	0.4	0.5	0.5	0.5	1	0.7	2.4	0.3	0.2	0.2	0.1	0.1	0.1	**0.4**	**2.4**
2020-05-23	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.5	0.4	0.2	0.4	0.6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	**0.2**	**0.6**
2020-05-24	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.5	0.8	1.7	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.2	0.1	0.1	**0.3**	**1.7**
2020-05-25	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.5	0.5	0.5	0.8	1	0.8	0.7	1.1	0.9	0.3	0.3	0.1	0.1	0.1	0.1	**0.4**	**1.1**
2020-05-26	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	2.1	1.7	0.9	0.7	1.4	2.7	1	2.3	1.3	1.1	0.8	0.9	0.7	0.1	0.1	**0.8**	**2.7**
2020-05-27	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.6	0.7	1.1	1	1.1	0.8	0.7	0.7	1.6	1.2	1.8	1.6	1.3	1.7	1.4	**0.8**	**1.8**
2020-05-28	0.8	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.5	1.8	1.3	1.4	1.5	1.4	2.1	3	3.2	4.1	3	2.6	5.1	4.4	1.5	0.9	**1.6**	**5.1**

Grassy Mountain - AQ-001 - Proposed Loadout

HOURLY AVERAGE CONCENTRATION REPORT

May 1, 2020 - July 29, 2020

Guideline: Alberta Ambient Air Quality Objectives and Guidelines

Guideline Revision Date: January 31, 2019

Parameter: $PM_{2.5}$

Hourly Guideline: 80 µg/m^3

Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Daily Average	Daily Maximum
2020-05-29	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1	2.2	3.2	3	2.9	2.9	4.1	3.7	3.9	3.4	3.3	3.4	3.9	2.6	0.3	**1.9**	**4.1**
2020-05-30	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5	3	3	2.7	3.1	2.9	2.4	2.5	2.2	2.3	2	2.5	1.6	1.6	0.5	0.1	**1.4**	**3.1**
2020-05-31	0.1	0.1	0.1	0.1	0.1	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.3	0.2	0.6	0.2	0.2	0.2	0.1	0.2	0.1	0.1	**0.2**	**0.6**
2020-06-01	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.4	0.8	0.7	0.8	0.7	0.7	0.9	0.8	0.9	0.6	0.5	0.5	**0.4**	**0.9**
2020-06-02	0.4	0.3	0.3	0.2	0.1	0.3	0.4	0.6	0.8	0.9	1	0.9	1.1	1.1	1.6	2.3	1.2	1	0.9	0.7	1.1	0.9	1.1	0.6	**0.8**	**2.3**
2020-06-03	0.5	0.5	1.6	0.5	0.5	0.4	0.3	0.4	0.5	0.7	1.3	0.7	0.6	1.3	1.3	0.8	1.1	1.1	0.6	0.5	0.4	0.4	0.4	0.4	**0.7**	**1.6**
2020-06-04	0.4	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4	0.7	0.5	0.6	0.4	0.1	0.1	0.1	0.1	0.1	0.1	**0.2**	**0.7**
2020-06-05	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.2	0.7	1	1.2	1.1	1.5	1.8	1.8	1.9	1.7	0.2	0.1	0.1	0.1	**0.6**	**1.9**
2020-06-06	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.2	0.2	0.2	0.3	0.2	0.2	0.1	0.1	0.1	**0.1**	**0.3**
2020-06-07	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	**0.1**	**0.1**
2020-06-08	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.3	0.4	0.7	0.4	0.3	0.3	0.9	0.3	0.5	0.5	0.1	0.1	0.1	**0.3**	**0.9**
2020-06-09	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.4	0.6	0.8	0.8	0.8	0.9	0.9	0.5	0.3	0.3	0.2	0.1	0.1	**0.3**	**0.9**
2020-06-10	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4	0.2	0.4	0.6	0.8	0.4	0.5	0.6	0.7	0.5	0.5	0.7	0.6	0.4	0.4	**0.4**	**0.8**
2020-06-11	0.3	0.4	0.3	0.3	0.3	0.3	0.2	0.3	0.4	0.4	0.4	0.6	0.8	0.7	0.7	1.1	0.9	1	0.8	1	2.3	2.4	2.4	1.3	**0.8**	**2.4**
2020-06-12	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	1	1.1	1.9	1.6	1.6	1.8	1.8	2.1	2.1	1.5	1.3	1.1	1.2	0.8	0.5	**0.9**	**2.1**
2020-06-13	0.1	0.4	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.7	0.9	0.8	1	1	1.1	0.8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	**0.4**	**1.1**
2020-06-14	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.3	0.5	0.3	0.3	0.3	0.3	0.3	0.5	0.3	0.3	0.2	0.1	**0.2**	**0.5**
2020-06-15	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	0.4	0.5	0.6	0.7	0.5	0.5	0.7	0.4	0.5	0.6	0.4	0.3	0.1	0.2	0.1	0.1	**0.3**	**0.7**
2020-06-16	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.6	0.6	0.6	0.6	1	0.9	0.4	0.1	0.2	0.1	0.1	0.1	**0.3**	**1**
2020-06-17	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	**0.1**	**0.3**
2020-06-18	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	**0.1**	**0.1**
2020-06-19	0.1	0.1	2	12.4	9.9	1.3	0.1	0.1	0.1	0.1	0.1	0.2	0.4	0.5	0.5	0.5	0.4	0.2	0.1	0.1	0.1	0.1	0.1	0.2	**1.2**	**12.4**
2020-06-20	0.1	3.4	5.6	7.5	8.4	9.8	2.3	0.4	0.2	0.2	0.6	0.6	0.7	0.9	1	0.7	0.4	0.3	0.3	0.3	0.1	0.1	0.1	0.1	**1.8**	**9.8**
2020-06-21	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.5	0.4	1	0.5	0.4	0.3	0.3	0.5	0.6	0.4	0.2	0.2	0.1	**0.3**	**1**
2020-06-22	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.4	2	0.8	0.7	0.7	0.7	0.6	0.7	0.7	0.5	0.7	0.7	0.7	0.2	**0.5**	**2**
2020-06-23	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.5	0.6	0.8	0.7	1	1.2	1	0.8	0.9	0.8	1	0.9	1	1.7	0.5	**0.6**	**1.7**
2020-06-24	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5	0.6	0.7	0.7	1	0.3	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	**0.2**	**1**
2020-06-25	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.2	0.4	0.3	0.4	0.4	0.6	0.6	0.8	0.5	0.5	0.7	0.7	0.9	0.6	0.4	**0.4**	**0.9**
2020-06-26	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	1	0.9	2.2	1.5	1.7	0.9	0.8	1	1.1	1.1	1	1.7	1.3	0.8	0.1	**0.8**	**2.2**

Grassy Mountain - AQ-001 - Proposed Loadout

HOURLY AVERAGE CONCENTRATION REPORT

May 1, 2020 - July 29, 2020

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Parameter: $PM_{2.5}$

Hourly Guideline: 80 µg/m^3

Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Daily Average	Daily Maximum
2020-06-27	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.4	0.5	0.4	0.5	0.4	0.4	0.5	0.5	0.6	0.4	0.5	0.2	0.7	0.3	**0.3**	**0.7**
2020-06-28	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	**0.1**	**0.2**
2020-06-29	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.2	0.1	0.1	0.1	**0.1**	**0.3**
2020-06-30	0.1	0.1	0.1	0.1	0.1	0.7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	**0.1**	**0.7**
2020-07-01	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.4	0.3	0.2	0.2	0.1	0.3	0.2	0.2	0.1	0.1	**0.2**	**0.4**
2020-07-02	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.3	0.3	0.2	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.2	0.5	0.3	0.2	0.2	0.2	**0.2**	**0.5**
2020-07-03	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.8	0.9	0.7	0.6	0.7	0.6	0.6	0.8	1	1.1	1.1	0.9	1.1	0.8	0.1	**0.5**	**1.1**
2020-07-04	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5	1.8	1.3	1.4	1	1.3	1.2	1.4	1.6	1	0.7	1	0.6	0.6	0.6	0.9	**0.7**	**1.8**
2020-07-05	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.5	0.4	0.5	0.5	0.5	0.5	0.8	0.5	0.6	0.6	0.6	0.9	0.5	0.2	0.1	**0.4**	**0.9**
2020-07-06	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.7	1.1	0.8	0.7	0.6	1.1	0.9	1	0.9	1.9	0.9	1.5	2.1	1	0.2	**0.7**	**2.1**
2020-07-07	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.3	0.7	1.1	1.4	1.2	1.8	0.5	0.4	0.2	0.1	0.1	0.1	**0.4**	**1.8**
2020-07-08	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5	0.5	1	0.5	0.6	0.5	0.5	0.4	0.4	0.5	0.5	0.3	0.1	0.1	**0.3**	**1**
2020-07-09	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.2	0.4	0.5	0.6	1	0.6	1	1.1	1	1.1	0.8	0.8	0.5	1.3	1.1	0.9	**0.6**	**1.3**
2020-07-10	0.9	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4	1	1.1	1	2.6	1	1.4	0.9	0.5	0.6	1	0.7	0.5	0.5	0.3	**0.6**	**2.6**
2020-07-11	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.9	1.6	0.9	1.4	1.8	1.9	1.3	1.3	1.4	0.9	0.7	1.1	1	0.9	1	**0.8**	**1.9**
2020-07-12	0.8	1.1	1.4	1.4	1.5	1.1	0.9	1.3	1	0.8	0.8	0.8	0.8	2.2	1.3	1.3	1	0.5	0.2	0.1	0.1	0.1	0.1	0.1	**0.9**	**2.2**
2020-07-13	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	0.6	0.5	0.3	0.4	0.3	0.4	0.4	0.3	0.2	0.1	0.1	0.1	0.1	**0.2**	**0.6**
2020-07-14	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.6	0.5	0.8	0.6	0.4	0.6	0.5	0.4	0.5	0.7	0.8	0.7	0.5	0.5	0.3	**0.4**	**0.8**
2020-07-15	0.4	0.7	0.8	0.6	0.5	0.4	0.3	0.4	0.3	0.5	0.5	0.6	0.7	0.7	0.5	0.9	0.8	0.8	1	0.8	0.9	0.7	0.4	0.1	**0.6**	**1**
2020-07-16	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.3	1	0.9	0.8	2	1.7	1.5	1.4	1.7	1.4	1.1	1.1	1	0.1	0.1	0.1	**0.7**	**2**
2020-07-17	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.8	0.8	0.7	0.5	0.8	0.7	0.5	0.3	0.5	0.6	0.3	0.1	**0.3**	**0.8**
2020-07-18	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.5	0.6	0.6	0.6	0.6	0.6	0.5	0.6	0.6	0.6	0.6	0.8	0.8	0.6	**0.4**	**0.8**
2020-07-19	0.7	0.9	0.6	0.4	0.2	0.1	0.1	0.1	0.6	1.4	0.9	0.8	0.7	0.6	0.6	0.3	0.3	0.4	0.4	0.4	0.7	0.4	0.1	0.1	**0.5**	**1.4**
2020-07-20	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.5	0.3	0.4	0.3	0.5	0.9	1.1	1.3	1	0.9	0.8	0.4	0.1	0.1	**0.4**	**1.3**
2020-07-21	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1	1.7	1.6	0.8	1.2	1.8	1.6	1.8	1.2	1.4	1.2	1.3	1.4	0.7	**0.8**	**1.8**
2020-07-22	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	3.1	2.6	1.9	1.8	1.8	1.7	2	1.8	1.5	1.2	0.9	0.9	2.1	1.9	1.1	**1.2**	**3.1**
2020-07-23	0.6	0.3	0.1	0.1	0.1	0.1	0.2	0.1	1.3	3	1.8	1.6	1.4	1.5	1.5	2.3	1.4	1.6	1.2	1.3	1.7	1.3	1.5	1.4	**1.1**	**3**
2020-07-24	0.5	0.5	0.2	0.1	0.1	0.1	0.1	0.1	1.6	1.6	1.2	1.7	1.8	1.9	2.6	1.5	3.8	3.6	1.2	1.6	0.8	0.7	0.6	0.4	**1.2**	**3.8**
2020-07-25	0.5	0.5	0.4	0.4	0.2	0.1	0.1	0.1	0.6	0.6	0.4	0.5	0.5	0.8	0.7	0.4	0.4	1	0.5	0.7	0.7	1.3	1.1	0.8	**0.6**	**1.3**

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Parameter: $PM_{2.5}$

Hourly Guideline: 80 $\mu g/m^3$

Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Daily Average	Daily Maximum
2020-07-26	0.2	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.3	1.5	1.7	0.9	1.1	1.5	1.2	1.6	0.8	2.5	3.4	3	2.6	2.3	2.4	1.8	**1.2**	**3.4**
2020-07-27	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	1.3	2.4	2	1.9	1.8	2.5	4.2	4.8	5.2	4.4	3.9	4	4.1	1.9	0.2	**1.9**	**5.2**
2020-07-28	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.5	3.5	2.4	1.9	2.4	2.2	1.7	1.6	1.8	1.7	1.6	1.6	1.8	1.7	1.8	2.1	**1.3**	**3.5**
2020-07-29	1.4	1.1	0.7	0.1	0.1	0.1	0.1	0.3	4.4	5.4	3.5	2.1	2.2	3	3.8	2	2.1	2.1	2.3	1.4	1.3	1.4	1.6	2	**1.9**	**5.4**
Diurnal Average:	**0.2**	**0.2**	**0.3**	**0.4**	**0.3**	**0.3**	**0.2**	**0.2**	**0.3**	**0.6**	**0.7**	**0.7**	**0.8**	**0.9**	**0.9**	**0.9**	**0.9**	**0.9**	**0.8**	**0.8**	**0.8**	**0.7**	**0.6**	**0.4**		
Diurnal Maximum:	**2.4**	**3.4**	**5.6**	**12.4**	**9.9**	**9.8**	**2.3**	**1.3**	**4.4**	**5.4**	**3.5**	**3.7**	**3.1**	**3.2**	**3.8**	**4.2**	**4.8**	**5.2**	**4.4**	**5.4**	**5.4**	**4.5**	**7.4**	**2.9**		

Grassy Mountain - AQ-001 - Proposed Loadout

HOURLY AVERAGE CONCENTRATION REPORT

May 1, 2020 - July 29, 2020

Guideline: Alberta Ambient Air Quality Objectives and Guidelines

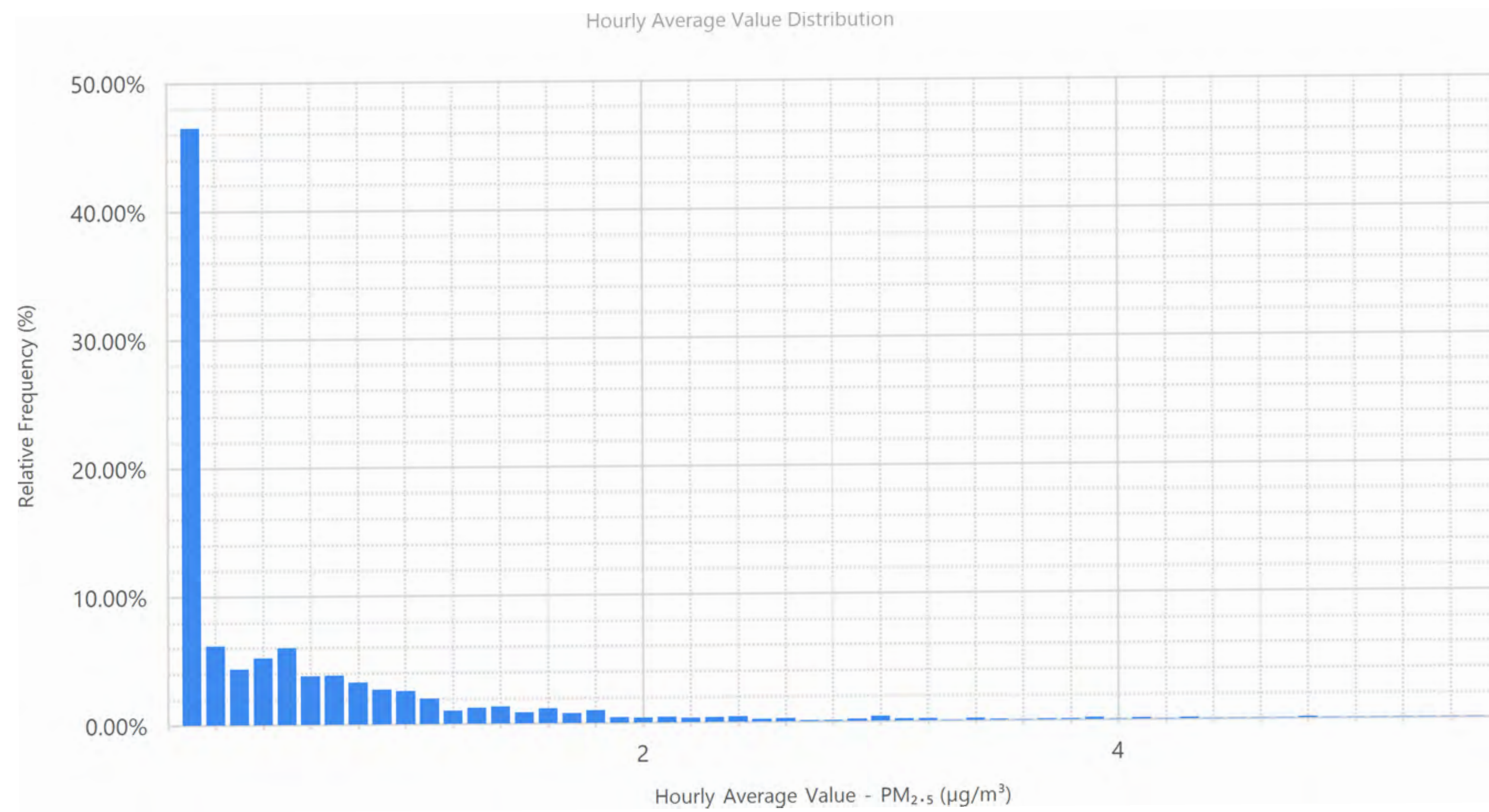
Guideline Revision Date: January 31, 2019

Parameter: $PM_{2.5}$

Hourly Guideline: 80 µg/m^3

Number of Exceedances:	0
Maximum Value:	12.4 µg/m^3 on June 19 at hour 4
Mean Value:	0.6 µg/m^3
Variance (S^2):	0.8
Standard Deviation (S):	0.9
Mode:	0.1 µg/m^3. Number Count = 1004
Percentiles:	
P_1:	0.0
P_{10}:	0.0
Q_1:	0.0
Median:	0.0
Q_3:	1.0
P_{90}:	1.0
P_{99}:	4.0

The Total Number of Hours in the Reported Period:	2160
Hours of Data:	2160
Hours of Missing Data:	0
Percent Operational Time:	100.0%



Grassy Mountain - AQ-001 - Proposed Loadout

HOURLY AVERAGE CONCENTRATION REPORT

May 1, 2020 - July 29, 2020

Guideline: Alberta Ambient Air Quality Objectives and Guidelines

Guideline Revision Date: January 31, 2019

Parameter: CO

Hourly Guideline: 13000 ppb

Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Daily Average	Daily Maximum
2020-05-01	69.3	54.8	49.8	47.3	50.8	49.2	44.7	70.7	96.8	78	81.8	82.8	76.2	86.8	86.8	96.7	93	99.2	93	101.3	93.5	92.3	71.7	54.5	**75.9**	**101.3**
2020-05-02	45.3	47.7	46.8	48.5	53.3	53.3	69.7	65.5	104.8	113.5	109.7	86.7	82.7	88.7	97	97.2	105	103.7	107.7	119.7	124.3	116	97.7	84.3	**86.2**	**124.3**
2020-05-03	70.3	68.8	81.7	64.5	55.8	59.2	69	77.8	54.8	58.8	55.2	50.8	84.5	86.2	59	77	58	79	69.7	79.8	77.7	69.7	70.2	66.2	**68.5**	**86.2**
2020-05-04	64.3	65.3	60.7	63.5	59	59.5	59.5	63.2	72.8	86	87	89.5	82.5	87.8	93	89.8	87.5	91.7	95.2	90.8	91.5	84.7	78.5	64.5	**77.8**	**95.2**
2020-05-05	65.2	53.8	35.3	37.8	44.2	45.5	51.8	75.8	108	108.8	101.2	90	88.3	90.3	95.3	100.8	106.7	108.3	111.2	113.7	115.3	94.7	86.3	89.2	**84.1**	**115.3**
2020-05-06	72.2	52.8	49.7	46.2	48	51.2	60.3	66	87.5	115.3	107.3	90.2	95.8	89.8	83	64.3	72.5	83.3	83.7	67.7	51.5	46.3	46.5	47.2	**69.9**	**115.3**
2020-05-07	47.5	47.2	47.5	46.2	44.8	48.5	54.2	66.8	62.2	67.3	71.3	84.3	72	66.2	58.7	58.3	54.7	54.8	56.3	53.5	54.5	53.8	50	47.2	**57**	**84.3**
2020-05-08	44.5	47.8	48.8	50.8	53.8	52.5	55	68	80.5	91.8	84.5	84.5	71.3	55	52.7	57.5	57.8	64.7	56.7	54.5	44.5	47	48.8	57.2	**59.6**	**91.8**
2020-05-09	46.2	63.3	35.7	28.2	32	42.5	60.5	77.2	82.2	76	76.8	67.2	71.7	59.5	60	72.7	74	46.8	49.3	57	45.3	42.5	47.7	54.8	**57**	**82.2**
2020-05-10	46.3	38.3	36.7	37.5	31.8	29.8	29.5	29.8	32.7	33.8	27.7	31.5	30.5	32	30.5	33.8	36.3	40.8	37.2	35.2	30.5	28	24.3	29	**33.1**	**46.3**
2020-05-11	24.5	24.2	26	26.2	24	25.2	34	57.8	38.7	39.2	35.7	32	36	34	35.7	39.3	32.2	37.8	42.3	45.3	33.2	24.5	35.2	47.2	**34.6**	**57.8**
2020-05-12	34.3	29.3	27	28	34.3	34.3	53.2	67.2	55.7	35.3	37.8	46.7	52.7	56.8	61.7	68.7	73.7	67.5	68.8	66.5	64.8	50.7	57.2	40.8	**50.5**	**73.7**
2020-05-13	33.8	33.7	38	36	35.3	45.3	74.7	72	69.7	73.2	51.8	49.2	51.8	68.3	66.2	76.7	69	77.3	77.8	79	79.8	60.8	45.3	48	**58.9**	**79.8**
2020-05-14	49.8	49.3	54.5	46.7	42.3	43.3	54	60.8	75.5	79.8	84.8	88.2	88.2	84.8	85.8	80	84.7	86.8	106.8	93.7	93.3	99.7	92	82.3	**75.3**	**106.8**
2020-05-15	80.2	82.5	67.8	52.5	39.3	32.7	39.2	57.3	81.3	114.7	101.8	91.2	85.8	82.8	95.2	85.2	101.8	80.2	120.8	108.5	99.8	68.2	61.3	67.8	**79.1**	**120.8**
2020-05-16	52.5	49.8	49.8	47	42.3	43.7	50.7	67.3	96.2	83.7	83.8	86.5	87.5	91.2	95.7	92.3	91	98.2	98.7	103.2	104.3	99.2	84.3	78	**78.2**	**104.3**
2020-05-17	89.8	83.2	64.3	54.7	55.3	48.3	59.3	91.2	87.3	108.3	85.5	92	83.2	85.8	83.8	83	83.8	88.8	80.5	81.8	72.3	50	66	62.2	**76.7**	**108.3**
2020-05-18	63.2	78.2	54	49.2	50.2	52	46.3	60.8	51.2	48.7	43.7	53.2	73	63.3	72.3	70.7	71	74.5	56.7	75	67.5	44.3	44.3	41.2	**58.5**	**78.2**
2020-05-19	43.2	42.5	41.7	38	43	40.8	45	71.7	84.8	89	96.8	84.5	101.5	107	100.5	82.7	67.8	70.7	69.3	75	78	75.8	79.3	78.3	**71.1**	**107**
2020-05-20	75.2	62	56.8	63.3	63.5	59.8	70.2	82.8	90.8	74.5	78.2	104.8	94	82.5	77.8	89.3	101.8	90.8	75.7	75.7	95.7	97.5	73.2	71.8	**79.5**	**104.8**
2020-05-21	68.5	67.3	77.2	70.7	71.5	68.5	65.5	67.3	55.8	46.7	47.8	51.7	58.5	50	44.7	50	51.5	50	51.5	39	45.7	53	51.7	51.3	**56.5**	**77.2**
2020-05-22	48	41.2	39.2	40.3	43	43	38.5	37.8	61.5	70.5	74	78.3	82.5	84.5	80.8	78.5	89.8	86.5	76.7	76.8	72	60	54.5	53	**63**	**89.8**
2020-05-23	51.2	48	41	44	53.7	43.7	52	61.2	72.2	79.3	84	93.2	93.2	76.3	77	66.8	74.7	75.5	67.2	70	63.3	57.3	48.8	45.7	**64.1**	**93.2**
2020-05-24	45.3	49.8	58.2	55.2	51.2	51.3	62.8	53.3	78.5	72	80.2	80.8	82.3	78.3	84.8	88.8	96.3	98.3	99.8	99.8	95.8	64.2	60	64.3	**73**	**99.8**
2020-05-25	63	54.3	52.2	69.5	52	38.2	52.3	78.2	98.2	89.3	86.5	88.8	94.2	85.3	83.5	96	104.8	95.7	97	81	77.3	73.7	71.5	68	**77.1**	**104.8**
2020-05-26	67.7	66.2	58	54.3	45	56	63.8	65.5	88	75.8	80.2	96.8	83.2	86.2	88.7	93.7	94.7	95.2	106.7	109.8	110.8	99	80.5	90.8	**81.5**	**110.8**
2020-05-27	85	71.8	47.3	39.2	40.8	37.7	50.3	96.3	99.3	97.2	85.7	82	79.7	82.7	85.7	89	94.2	99.5	103	104.5	119.3	117.5	108.5	92.8	**83.7**	**119.3**
2020-05-28	75.8	54	52.2	50.8	49.2	47.3	60	97.8	115.7	116.3	93.7	92.8	90.3	92.2	96	100.5	103.8	110.8	112.8	114.3	110.7	122.8	118.8	100.3	**90.8**	**122.8**

Grassy Mountain - AQ-001 - Proposed Loadout

HOURLY AVERAGE CONCENTRATION REPORT

May 1, 2020 - July 29, 2020

Guideline: Alberta Ambient Air Quality Objectives and Guidelines

Guideline Revision Date: January 31, 2019

Parameter: CO

Hourly Guideline: 13000 ppb

Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Daily Average	Daily Maximum
2020-05-29	77.5	71.3	63.8	58.3	50.3	49	95.3	92.3	105	100.3	104.3	104.2	91.5	97.3	102.8	117	124.7	122.2	124	126.3	117	117.5	105.7	72.3	**95.4**	**126.3**
2020-05-30	74.5	72.5	69.7	69.3	59.3	57.3	102.5	117	128.2	113.3	94.2	98	104.8	111.5	121.5	119	104.8	101.3	111.7	120.2	122	118.3	105.5	105.7	**100.1**	**128.2**
2020-05-31	114.2	126	91.2	88.8	73.7	60.5	86.8	86.3	95.7	92.2	38.7	53.5	55.5	56.3	53.5	53.2	64.2	61.7	61.3	45.3	57.5	63.7	58.8	53	**70.5**	**126**
2020-06-01	48	47.8	49.3	48	49.7	46	62	57.8	79.5	77.3	86.3	88.7	92.3	90.5	87.2	97	89	107	101.8	101.7	105.3	101.3	95.3	95.7	**79.4**	**107**
2020-06-02	88.5	82	77.8	67.5	61.7	69.2	76.2	84.2	84.7	93.5	83.8	83	81.7	99.5	100.3	99.3	91.5	94.7	101.3	109	111.5	114.5	104.2	109.2	**90.4**	**114.5**
2020-06-03	111.5	101.2	93	82.2	78.2	76.7	87.3	86.8	89.5	95.2	91.7	95.3	98.2	97.3	100.2	99.7	102	105.8	107.2	111.5	112.3	112.7	106	93.3	**97.3**	**112.7**
2020-06-04	89.5	71.5	64.2	65.7	69.2	65.7	90.8	109.7	86.3	72.2	69.2	71	71.5	95.7	76	80.3	80.7	63.5	58.7	81	66.7	56	45	34.2	**72.3**	**109.7**
2020-06-05	34.5	35.8	34.3	33.7	30.5	31.3	50	65.2	60	67.8	75.2	83.8	69.7	69	67.5	72.7	69.8	74.8	78	81.2	56.5	65.7	64.2	64	**59.8**	**83.8**
2020-06-06	79.5	74	69.7	63.3	59.7	61.3	98.5	76.2	73	67.7	58.8	55.7	59.7	69.5	66	70.2	69.5	74.2	77.2	66.5	61.5	47.5	51.3	52	**66.8**	**98.5**
2020-06-07	46.5	48	45.8	43.8	43.3	50.8	57.7	56.7	54.7	50.8	55	53.8	52.5	42.8	43.5	48.2	46.8	51.8	49.2	53.3	39.5	49.5	52.5	51.5	**49.5**	**57.7**
2020-06-08	49.3	41.7	44.3	40.2	35	41.5	59.3	61.7	74.8	68.3	72.5	66.3	69.7	69	76.5	71.3	83.3	60.5	74.5	82	69.8	35.7	41.3	58.8	**60.3**	**83.3**
2020-06-09	45.3	39.2	32.2	26	26	22.5	36.2	32.8	52.7	63.5	61.5	63.7	66.7	67.7	76.7	76.2	84.8	82.3	78.3	76.8	80.2	74.7	67.2	70.2	**58.5**	**84.8**
2020-06-10	60.3	54	51.8	46.8	48	47.7	52	55.7	76	76.7	78.5	81.2	79.5	74	74.3	86	82.5	83	84	91.1	94	93.8	93	94	**73.2**	**94**
2020-06-11	91.5	87.3	85.3	81.3	77.3	73.7	81.3	86.5	94.5	89.3	82.3	81.2	83.3	81.5	71.3	71.7	89.3	92.8	89.7	100.2	117.8	124.5	128.8	101.3	**90.2**	**128.8**
2020-06-12	78.3	72.5	78	85	71.5	61.7	120	88.2	111.8	100.3	83.3	64.3	81.3	81	74.7	85.7	111.7	124	86.8	93.7	108	107.7	103.7	89	**90.1**	**124**
2020-06-13	78.7	112.5	79.2	45.8	48.7	51.8	124.5	91.7	89	106.2	115.7	86.7	78.7	70.5	77.2	87.7	108	126.5	127.3	106.8	74.5	56.7	52.7	42.7	**85**	**127.3**
2020-06-14	33.2	29.5	26	23.5	23.2	25.5	35.2	38	47.7	53	47.2	58.3	74	73.3	69.7	71.3	76	68.2	70.2	72.7	69.5	72.3	67.8	63.3	**53.7**	**76**
2020-06-15	71.5	60	69.2	64.5	51	56.2	71.5	69	69.5	72	73.8	75.5	68.7	72.3	81.3	85.3	87.2	81.7	76.5	78	71.2	71.5	64.2	60	**70.9**	**87.2**
2020-06-16	58.5	43.3	36	36.7	28.2	22.2	45.3	106.8	103.8	73.3	71.2	60	64.7	70.3	67.8	86.5	81.8	82.7	84.2	83	84.8	72.7	63.7	54.3	**65.9**	**106.8**
2020-06-17	55.3	48.2	36.7	32.3	28.8	28	58.2	70.3	78.5	81.2	100.2	66	54.8	63.3	74	53.8	43.7	67.7	63	62.8	67	64	53.8	50.5	**58.4**	**100.2**
2020-06-18	47.7	49.3	48	46	48.8	48.7	37.8	47.7	44.8	41.3	58.5	60	64.2	60.3	53.3	61.2	56.8	63.7	60.8	58.7	74.2	78.5	81.8	64.5	**56.5**	**81.8**
2020-06-19	63	59.5	49	43.2	36.3	41.8	56.2	61	68.7	92.5	90.7	72	66.2	69.8	85.7	77	89.7	81.3	84.3	88	94.8	63.8	68	61.2	**69.3**	**94.8**
2020-06-20	58	60.7	64.5	74.7	60	61.7	197.8	164	175.7	136.8	71.3	69.5	78.8	79.8	78.7	76	84.2	92.7	83.5	74.2	72.8	66.3	58	50.8	**87.1**	**197.8**
2020-06-21	51.5	48.7	45.8	40.7	41	37.3	78.5	91.3	83	56.7	64.2	74.2	65	78.3	71.2	55.2	108.3	92	78.2	76.2	85.8	87.8	84.5	80.7	**69.8**	**108.3**
2020-06-22	74.5	67.3	61	56.3	53.7	49.2	83.5	106.8	131	87.8	78.2	75.7	76.2	79.7	82.5	83.2	89.7	89.3	101.5	98.2	107.3	117.2	108.8	95.5	**85.6**	**131**
2020-06-23	89.2	89	79.5	74.2	72.5	73.2	91.3	129.2	104.5	81.5	80.2	99	80	60.8	63.7	62.8	54.8	62.8	62.5	76.2	106.7	128.5	141	117.3	**86.7**	**141**
2020-06-24	103.5	88.5	72.2	63.7	63.5	51.8	110.3	118	100.5	80.7	90	56	50.3	81.3	68.7	67.2	96.8	117	92.2	62.2	58.5	74.2	76.7	63.3	**79.5**	**118**
2020-06-25	64.5	62.2	49	53.2	47.5	41.5	64.5	67	80.2	68.7	63	47.8	57.2	63.3	66.3	68.3	71.3	72.5	80.5	91.2	112.7	141.3	122	122.3	**74.1**	**141.3**
2020-06-26	95	91.5	90.3	84.8	80.2	80	83	101.8	103.2	109.8	100.8	75.5	78.7	79	85.2	100.3	108	112.7	118.3	119.3	127	130.7	109.7	115.5	**99.2**	**130.7**

Grassy Mountain - AQ-001 - Proposed Loadout

HOURLY AVERAGE CONCENTRATION REPORT

May 1, 2020 - July 29, 2020

Guideline: Alberta Ambient Air Quality Objectives and Guidelines

Guideline Revision Date: January 31, 2019

Parameter: CO

Hourly Guideline: 13000 ppb

Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Daily Average	Daily Maximum
2020-06-27	112.2	101.5	100.3	81.7	78.7	70.8	63.2	66	58	67	60.5	64.8	60.7	71.8	81	90.7	85.7	88.3	90.3	91.8	94	92.5	96.7	71.3	**80.8**	**112.2**
2020-06-28	66.2	62.7	69.7	58.8	56	55.7	90	86	75.2	54.3	59	54.7	55.2	52.3	38	48.5	43.5	41.6	64.8	61.3	31.8	35.8	37.5	43	**55.9**	**90**
2020-06-29	42.5	44	40	44.7	47	46.3	49.7	64	63.8	84.5	56.2	42.2	42.5	37.3	44	45	64.5	63.8	74	75.7	71.8	61.7	68.2	70.7	**56**	**84.5**
2020-06-30	62	66	62.3	62	63	57.8	77.8	92.8	77.7	72.3	83.8	75.8	84.8	60	53.8	40.3	36.3	35.2	36.5	39.2	43.3	40	39.2	43.2	**58.5**	**92.8**
2020-07-01	47.3	61.8	49.5	46.5	47.3	43.8	51	41.2	38	31.7	30.8	55.7	58.5	60	65.5	66.8	65	61.5	67.8	62.7	61	53.7	45.7	43.3	**52.3**	**67.8**
2020-07-02	44.3	38.8	44	31.2	36.3	46.8	49	49.7	55.7	60.5	54.8	59.7	63.2	63.7	61.8	75.8	77.5	63.3	77.2	65.7	67.2	61.7	64.8	55.3	**57**	**77.5**
2020-07-03	47.7	45.2	44	44.7	35.7	33.8	88.5	107.3	97.2	101	77	75.7	78.2	87.5	84	83.2	75.8	96.3	106.2	117.3	124.7	142.7	125.7	98.3	**84.1**	**142.7**
2020-07-04	102.8	97.3	85	85	79.7	67.7	102	130.8	162.3	132.8	71.5	85.2	79.5	78.3	77.8	80.2	94.2	103.5	112.3	118.8	115.7	126.3	121	132	**101.7**	**162.3**
2020-07-05	107.3	78.3	74.8	66.3	59.7	53.8	105.3	117.8	128.7	124.3	97.2	79.5	87.5	84.7	100	93.8	92.7	91.5	114.2	116.8	126.8	130.3	104.2	92.5	**97**	**130.3**
2020-07-06	83.3	79.8	74.5	68.8	61.2	61.5	98.3	96.8	110.8	113.8	96.8	74.2	62.3	76	89.3	92	86.5	87.7	113.5	101.3	110.2	143.3	134.8	103	**92.5**	**143.3**
2020-07-07	100.2	97.5	89	76.3	67.8	63.2	83.5	98.2	118.3	142	161.2	89.5	81.5	78.7	70.2	64.5	76.3	80.3	78.5	96.2	72.8	60.7	54.8	52.8	**85.6**	**161.2**
2020-07-08	45.5	37.5	34.8	34.5	34.3	32.5	37.5	40	46.5	53.3	69	84.3	73.2	77.8	83.7	87.2	89.5	84	104.7	100	100.7	78.3	60.5	68.8	**64.9**	**104.7**
2020-07-09	74.7	57.5	51	47.7	45.2	58.3	100.3	150.3	150.7	92.3	73.8	70.7	69	74.8	71.7	70	83.7	100.5	105.7	86.2	94.5	107.3	109.5	109.7	**85.6**	**150.7**
2020-07-10	106	75.5	65.7	58	63	65.2	106.5	92.3	63.3	76.8	71.7	63.7	64.3	68.5	73.5	76.7	88.5	90.7	93.7	104.3	117.8	118	100.8	83	**82.8**	**118**
2020-07-11	74.3	80.2	66	54.5	48.8	49.7	95	110.7	99	100.3	74.5	71.5	68.7	63.2	61.3	57.8	64.5	88.5	93.3	92.7	117.3	135.8	148.7	139.7	**85.7**	**148.7**
2020-07-12	144.7	113	92.3	96.5	99	95.2	114.2	103.2	96	100.3	107.7	112.8	111.5	109.7	108.2	109.7	112.5	106.8	115.8	115.7	92.3	93.8	92.2	80.7	**105.2**	**144.7**
2020-07-13	67	57.3	54.3	43.5	40.8	36.5	74	64.2	86.8	81.7	74.3	74.5	71.8	78.3	78.3	82.5	81.2	93.8	97.8	80.3	111.2	84	69	61.8	**72.7**	**111.2**
2020-07-14	55.8	53	45.5	45	40	38.8	62	76.2	172.2	115.2	73.5	62.8	62.3	66.2	73	71.5	70.5	74	84.3	94	99.2	97.3	98.7	103.2	**76.4**	**172.2**
2020-07-15	105.2	96.7	94.3	97	102.3	78	109.2	114.5	113	106.2	100.8	97.5	92.2	98.7	90.5	81.3	83.2	104.5	99.3	110.8	123	198.7	162.3	93.2	**106.3**	**198.7**
2020-07-16	79.8	97	72.3	73.7	74.2	68.5	94.3	123.7	133	124.5	73	62.8	77.8	64	88.3	101.8	93.2	77.3	60.2	86.2	111.3	131.2	128.5	124	**92.5**	**133**
2020-07-17	106.7	89.8	69.2	56.7	43.8	45.8	89.5	80.2	104.5	88.7	81	87.2	64.5	41.7	47.7	38.2	40.2	59.3	71.7	95.8	96.8	97.2	83.3	103	**74.3**	**106.7**
2020-07-18	87	81.5	63.3	79.7	57.8	43.3	49	159.5	117.5	69.3	65.2	55	44.2	53.3	59.7	62.8	57.3	80.7	96	107.8	116.5	126.7	115.8	112	**81.7**	**159.5**
2020-07-19	111.3	96.7	88	92.2	75.3	54.3	69.8	114	139	116.7	70.5	58	74	63.7	76.7	100.2	88.5	94.8	90.2	83.3	91.3	119.8	112.8	81.5	**90.1**	**139**
2020-07-20	75.2	72	64	47.3	36.8	33.8	173.5	147.8	94.7	93.2	75	53.7	55.5	56.3	63	67	82	85.5	94.2	105.3	106	88.2	78.5	68.7	**79.9**	**173.5**
2020-07-21	51.3	48.7	48.7	48.3	43.8	47.7	68.8	94.2	110.3	112.7	105	44.5	14.7	29.8	36.8	36.8	35.3	66.5	89.2	101.3	117.3	147.2	142.5	119.2	**73.4**	**147.2**
2020-07-22	110.7	98.5	83.8	81.8	80	85.8	104	135.8	171	155.2	58.5	2.5		5.5	32.8	56.7	62.7	60.8	54.7	67.7	99.7	142.5	141.2	137.7	**84.6**	**171**
2020-07-23	123.8	90.2	85.7	76.5	77.8	78.8	102.7	129.3	181.2	131.2	48.8	10.5	12.5	20.3	31.7	55.5	82.7	104.5	115.8	126	134.7	142.5	140.5	139.8	**93.5**	**181.2**
2020-07-24	110.8	103.3	73.7	65.7	61.3	64.2	127.8	108.7	158.2	77.3	43.8	46	44.8	65.2	66.7	85	87.8	91	104.5	120.3	153.3	140.2	124.7	104.5	**92.9**	**158.2**
2020-07-25	107	97.8	80.8	63.2	39.3	24.7	62.7	76.7	137.5	92.5	66.7	67	74.8	73.8	73.3	77.2	79.5	78.3	86.5	94.2	108.5	134.5	123.2	106.5	**84.4**	**137.5**

Grassy Mountain - AQ-001 - Proposed Loadout

HOURLY AVERAGE CONCENTRATION REPORT

May 1, 2020 - July 29, 2020

Guideline: Alberta Ambient Air Quality Objectives and Guidelines

Guideline Revision Date: January 31, 2019

Parameter: CO

Hourly Guideline: 13000 ppb

Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Daily Average	Daily Maximum
2020-07-26	87	76.2	66	67.7	60.3	73.3	88.7	91.7	172.8	122.8	94	54.7	47	53.3	33.8	26.7	38.3	85.3	157.2	168	166.5	156.8	141.8	105.3	**93.1**	**172.8**
2020-07-27	79.2	71	66	61.8	57.5	51	104	73.3	141.2	123	97.8	54.2	13.3		18	57.8	94	115.3	122.7	131.3	145.5	139.8	155.8	119	**87.2**	**155.8**
2020-07-28	117.5	99.3	87.3	76	77.5	74	116	110.5	154.3	167.5	60.3	0		0	1	5.4	0.7	8.8	39.5	86.7	124.8	165.8	173.8	180.2	**80.3**	**180.2**
2020-07-29	168.7	151.7	130.8	104.5	94.5	99	243	184.8	233.3	165.2	67.2	9	11	11.5			7	30.3	46.3	72	103.5	186	168.2	160.8	**102**	**243**
Diurnal Average:	**72.9**	**67.5**	**60.8**	**56.8**	**53.5**	**52.1**	**76.3**	**85.1**	**95.5**	**88.3**	**76.4**	**69.7**	**70.3**	**70.4**	**71.7**	**74.7**	**77.8**	**81.8**	**85.5**	**88.2**	**91**	**92**	**86.6**	**79.7**		
Diurnal Maximum:	**168.7**	**151.7**	**130.8**	**104.5**	**102.3**	**99**	**243**	**184.8**	**233.3**	**167.5**	**161.2**	**112.8**	**111.5**	**111.5**	**121.5**	**119**	**124.7**	**126.5**	**157.2**	**168**	**166.5**	**198.7**	**173.8**	**180.2**		

Grassy Mountain - AQ-001 - Proposed Loadout

HOURLY AVERAGE CONCENTRATION REPORT

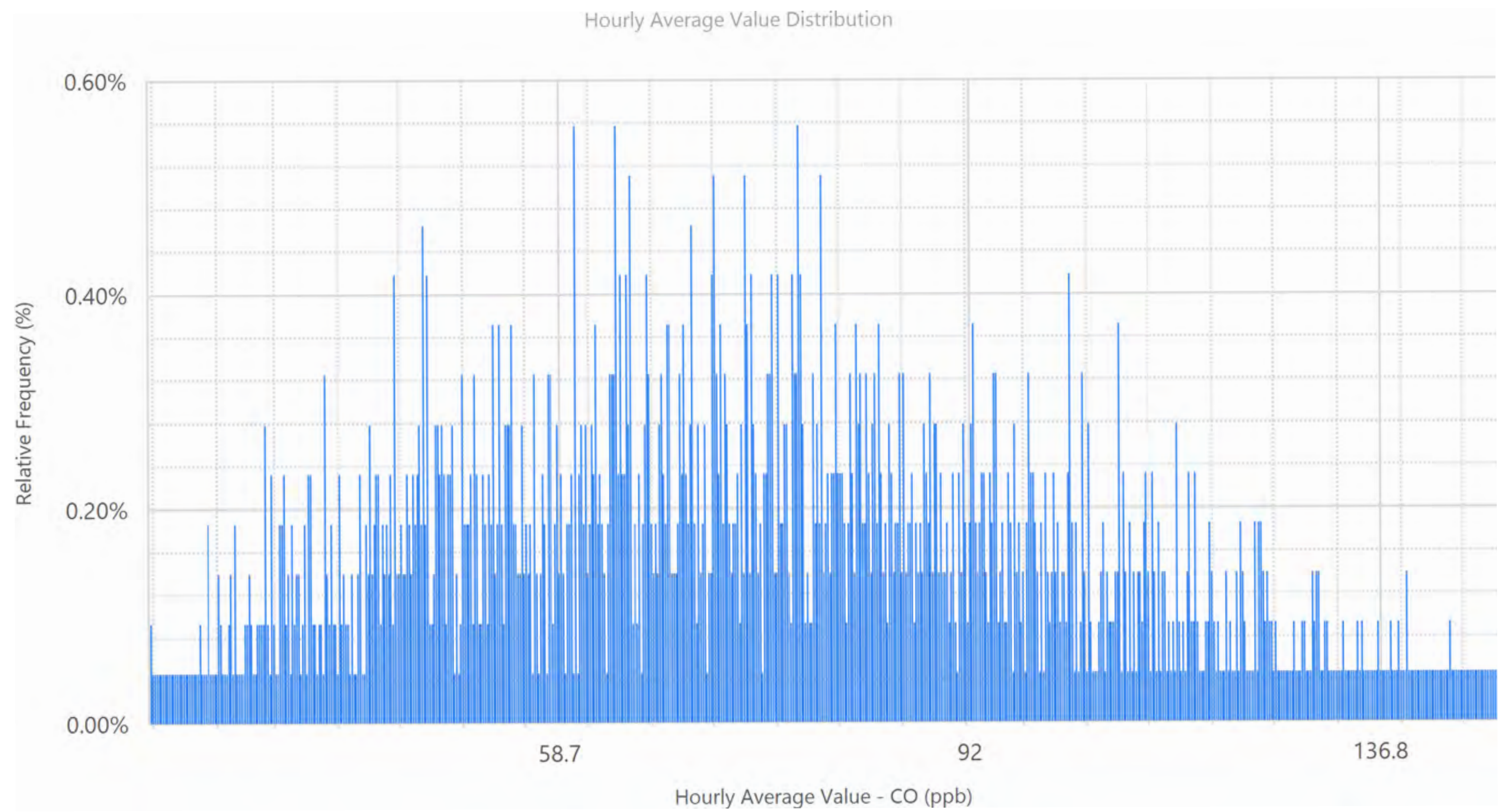
May 1, 2020 - July 29, 2020

Guideline:	Alberta Ambient Air Quality Objectives and Guidelines
Guideline Revision Date:	January 31, 2019
Parameter:	CO
Hourly Guideline:	13000 ppb

Number of Exceedances:	0
Maximum Value:	243.0 ppb on July 29 at hour 7
Mean Value:	76 ppb
Variance (S^2):	799.3
Standard Deviation (S):	28.3
Mode:	60.0 ppb. Number Count = 12
	63.3 ppb. Number Count = 12
	78.3 ppb. Number Count = 12

Percentiles:

P_1:	19.2
P_{10}:	43.0
Q_1:	56.0
Median:	74.0
Q_3:	92.0
P_{90}:	111.0
P_{99}:	162.8



The Total Number of Hours in the Reported Period:	2160
Hours of Data:	2155
Hours of Missing Data:	5
Percent Operational Time:	99.8%

Grassy Mountain - AQ-001 - Proposed Loadout

HOURLY AVERAGE CONCENTRATION REPORT

May 1, 2020 - July 29, 2020

Guideline: Alberta Ambient Air Quality Objectives and Guidelines

Guideline Revision Date: January 31, 2019

Parameter: NO_2

Hourly Guideline: 159 ppb

Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Daily Average	Daily Maximum
2020-05-01	17.7	8.3	6	1.2	2.5	6.8	1.2	4.8	14.7	7.7	12.8	12.3	11.3	16.7	15.5	17.5	15	16.8	15.8	21.3	20.3	21	13.7	7.7	**12**	**21.3**
2020-05-02	4.2	5.7	3.5	2	0.2	0.3	3.4	6	13.5	14	9.5	2.5	8.3	14.3	13.8	17	18.2	15.8	16.8	23.2	26.2	28.2	19.7	16.2	**11.8**	**28.2**
2020-05-03	7.8	6.8	9.7	1	0.4	2	4	13.2	6.7	11.8	7.5	10.3	13.3	14.5	19.2	11.8	21.2	13	17.2	18.5	16.8	18.5	16.5	16.3	**11.6**	**21.2**
2020-05-04	18.2	18.5	17.7	18.5	16.2	15.8	18	20.5	18.7	19.7	17.2	18.3	17	18.8	18.5	15.5	17.8	17.5	21	18.7	21.5	20.8	18.8	16.8	**18.3**	**21.5**
2020-05-05	17.8	12	4.8	4	4.7	4.2	5.2	11.8	22.5	16.3	14.3	10	11	14.5	15.2	16.5	15.2	17.3	21.3	25.7	20.5	17.8	19.5	18.3	**14.2**	**25.7**
2020-05-06	9.8	4.8	3.2	2.7	1.2	1.3	1.5	3.5	8.2	11.7	10.5	12.8	16	14.3	17.5	14	22	28.2	15.3	7.7	3.7	4.3	3.7	3.8	**9.2**	**28.2**
2020-05-07	3.5	3.7	4.3	4.8	8.5	7.5	4.8	3.3	6.8	8.3	7.2	6.7	2.7	2.8	2.8	3.2	4.5	8.8	8.5	9.2	6.2	2	0.5	0	**5**	**9.2**
2020-05-08	0.8	0		0	0.3	0	0.2	0.8	4.2	6.3	9.3	8.2	5.5	6.8	6.3	6.7	7.7	8	7	6.5	7.7	8	7.2	4.3	**4.7**	**9.3**
2020-05-09	1.2	0	0	0	0	1	2.5	4.5	7.8	12.7	9.4	10.5	15.7	15.8	23	22.7	19.7	20.5	25.3	22	15.7	17.7	15.5	16.2	**11.6**	**25.3**
2020-05-10	12.5	10.2	14.3	10.5	11.7	10.7	8.8	12	12.7	12.2	9.3	13.7	11.8	13.3	12	16.2	16.3	16.8	15	14.3	11.2	12.5	14.3	15	**12.8**	**16.8**
2020-05-11	14.8	16	16.3	13.2	9.2	7.8	11.7	14.2	15.7	13.5	12.8	14.5	15	12.3	13.5	11.8	10.7	12.2	15.8	15.5	10.3	6.7	9.2	11.2	**12.7**	**16.3**
2020-05-12	6.2	6.3	4.2	4.7	5	4.8	6.5	11	11.2	7.2	11.2	13.3	18.2	20.2	19.5	25	26.5	21.7	24.8	24.7	24.3	20	19.8	17.7	**14.8**	**26.5**
2020-05-13	17.8	15.2	14.5	14	10	11	14.7	18.5	18.7	15.8	10	18.8	15.8	23.5	19	23.8	20.7	26	23.8	26	28	23.2	18	18.5	**18.6**	**28**
2020-05-14	14.7	15.7	18	6	5.7	7.3	10.8	16.3	11.8	15.7	16.2	16.2	12.8	15	14.3	14.8	23.3	27	31.8	22.5	23.8	24.8	21.2	20.8	**16.9**	**31.8**
2020-05-15	20	20	13.8	9.5	2	0	2.7	5.8	13	14.8	13.7	11.8	8.7	14.8	22.2	11.5	24.8	21.8	29.8	18.8	22	13.3	11.8	12	**14.1**	**29.8**
2020-05-16	7.2	7.2	6.3	3.3	0.8	0	2.5	13.7	13.8	8.5	9.7	12.2	14.8	14.8	13.7	14	12.2	17.8	21.2	16.8	20.7	22.3	19	17	**12.1**	**22.3**
2020-05-17	20	16.3	10.5	6.5	4.3	1.2	4.3	4.5	6.8	12.8	7.5	14	5.8	13.3	15.7	18	19.2	18.8	16.2	18.2	12.5	7	9	7.7	**11.3**	**20**
2020-05-18	10.5	8.7	2.3	0	0	0	0.2	13	5.7	6	3.8	8.7	8.3	5	15	10	11.7	15.3	22.5	24.8	12	10.3	11.2	6.8	**8.8**	**24.8**
2020-05-19	8.7	4.7	1	0.2	1.2	0.8	0.6	8	9	9.5	11.8	9.5	10.5	8.3	8.7	5.7	5.7	9.7	9.3	5.3	3.3	0.7	2	2	**5.7**	**11.8**
2020-05-20	1.3	0.3	0	0.4	0	0	2.2	4.2	5	4.8	8.8	10.3	11	10.2	10	10.5	10.8	9	9	6.8	5.2	6.2	4	4.8	**5.6**	**11**
2020-05-21	2	0.4	2.2	1.5	1.4	3	2	2.5	3.8	4.2	4.3	4.5	2.8	0		2	4.5	8	13.5	10.2	14.5	17.5	18.3	18.3	**5.9**	**18.3**
2020-05-22	16.2	13.8	12.8	13.2	12.8	13.7	12.3	12.5	19.5	19.3	18.8	19.3	20.3	20.2	17.3	17	23.8	19	18.2	23.7	18.5	16.2	12.8	11	**16.8**	**23.8**
2020-05-23	10	5.5	4.8	5.5	12.5	2.8	9	12.8	12.3	11.8	13.2	13.8	14.5	11	18.7	17	22.7	12.2	15.2	10.7	9.5	7.3	4.8	1.8	**10.8**	**22.7**
2020-05-24	1.8	2.5	0.7	1	2.2	0	2.7	11.3	17.2	7.5	10	7.2	11.3	9.3	19.8	18.8	23.5	22	20.3	24.8	19.8	14	15.8	14.7	**11.6**	**24.8**
2020-05-25	12.5	10.5	9.7	20	4.6	4	7.8	22.5	17.5	10	15.3	19	22.3	16.5	19.7	25.5	21.5	22.2	27.7	23.2	21.8	18.7	17.5	15.3	**16.9**	**27.7**
2020-05-26	14	14.3	13.2	10.7	12	12.3	10.2	14.7	15.5	8.7	13	17.3	13.7	16.5	16.5	18.7	20.3	22.5	30.3	27.7	31.2	29.8	33.3	35.3	**18.8**	**35.3**
2020-05-27	28.5	20.5	8.8	6.7	6.2	5.2	5.3	12.7	19	14.8	4.2	10	14.8	18.3	19	23	24	23.7	25.7	27	36.3	40	35	30.8	**19.1**	**40**
2020-05-28	24.7	15.5	16.3	14.5	14.3	11.8	13.2	19.3	24.3	20.2	16.7	20	21	22.7	25	24.7	23.8	26.8	29.5	31.8	30.3	32.2	25.7	20.5	**21.9**	**32.2**

Grassy Mountain - AQ-001 - Proposed Loadout

HOURLY AVERAGE CONCENTRATION REPORT

May 1, 2020 - July 29, 2020

Guideline: Alberta Ambient Air Quality Objectives and Guidelines

Guideline Revision Date: January 31, 2019

Parameter: NO_2

Hourly Guideline: 159 ppb

Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Daily Average	Daily Maximum
2020-05-29	15	11.5	11	8.8	5.7	2.8	2.8	9.7	7.8	12.2	14	12.2	7	13.7	20	27.7	28.2	27	29.7	32.8	31.7	31.3	24.3	19.2	**16.9**	**32.8**
2020-05-30	17.7	14.7	14.3	12.5	7.8	4.2	6.8	10.7	10.5	4.3	12.3	17	20.5	24	32.5	28.3	27.5	23.5	29.3	31.3	34.3	29.8	17	22.2	**18.9**	**34.3**
2020-05-31	17.7	23.5	28	24	11.8	5.3	5.3	5.5	8.3	11.5	6.2	24	7.6	3	5.8	8.8	13	14.7	11.2	8.8	12.7	13.7	13.7	10.5	**12.3**	**28**
2020-06-01	8.8	9.3	10.3	8.7	10.3	10.2	8.8	14	15.3	11.3	13.7	9.2	8.7	5.8	7.7	18.3	12.3	23.7	15.5	16	20.8	23.8	27	25.7	**14**	**27**
2020-06-02	21	16.8	19	15.3	14.3	15.3	13.5	19.2	14.2	16.7	10.5	11.7	9.2	21.2	22	16.7	14.7	20	20.2	24.2	23.2	26.2	26.3	36.5	**18.7**	**36.5**
2020-06-03	28.2	23.8	20	18.8	19.8	21.3	25	26.7	22.3	21.7	18.8	19	18.8	16.7	16.8	17.5	19.7	18.2	17.2	20	19.3	22.2	23	22	**20.7**	**28.2**
2020-06-04	21	14	9.8	6.7	4.7	1	3.3	5	3	5.2	5.7	4	8.3	10.5	9	13.3	15.7	13.5	26	21.2	10.2	6.5	2.7	0.2	**9.2**	**26**
2020-06-05	0	0	0	0.3	0	0	3.5	5	8	10	11.7	11.8	11.7	22	24.7	24.2	22	24.3	23.7	25.2	18.7	19.3	18.2	21.2	**12.7**	**25.2**
2020-06-06	24.5	17.5	15.5	11.7	11.7	10.2	10.5	11.3	9.2	11.2	9.2	9.5	14.2	10.3	14.7	17.7	18.5	21	22.5	21.3	18.2	12.3	12.7	11.7	**14.5**	**24.5**
2020-06-07	12.2	11.5	13.8	10.2	13.2	13.2	15.3	17.2	13.3	10.3	16.3	14	9.8	4.8	6.3	9.3	10.7	12	16.2	8.3	19.7	18.5	10.2	8.3	**12.3**	**19.7**
2020-06-08	6.3	1.6	3.5	0.6	0	1.4	0.2	5.2	11.3	8.3	4.7	6.7	8.3	8.6	20.8	23.2	14.8	17.2	24.5	22.7	20.2	20.2	26.3	20.7	**11.6**	**26.3**
2020-06-09	15.3	11.3	9.7	6.5	8.3	6	7	10.5	16	19.3	14	16	15.8	23	23.5	22.2	27.7	21.2	22.7	23.2	26.8	24.5	20.7	21.8	**17.2**	**27.7**
2020-06-10	17.2	15.5	14	11	9.3	7	7.5	10.5	16.7	10.3	13.8	13.3	12.2	9.7	13	23.5	16.3	16.8	18.3	21.9	22.7	24.5	31.7	29	**16.1**	**31.7**
2020-06-11	26.7	25.7	24.5	22	21.8	18.8	23	25	21.3	19.2	17.3	13.5	18.2	14.3	13.7	16.2	24.8	28	25	28.7	31.2	35	32.5	25	**23**	**35**
2020-06-12	18.8	15.3	19	15.3	11.7	11	5.8	15.5	12.3	10.5	6.4	0.8	14.7	18.3	23.3	16.8	34.2	28.8	12.8	21.2	27.3	29.2	26.8	23.7	**17.5**	**34.2**
2020-06-13	18	31.3	16.8	12.5	13.3	11.5	11	14.2	8.5	10.3	11.2	8.5	4.5	6.5	16.5	17.3	35.8	42.5	35.7	26.7	18	19.3	10	0.2	**16.7**	**42.5**
2020-06-14	2.3	1.7	1.2	0.7	0	0	1.2	2.2	1.5	3.7	1.3	8	8.8	5.8	2	7.2	7	6	12.3	13.7	12.7	12.7	14.5	16.2	**5.9**	**16.2**
2020-06-15	15	11.2	14.2	12.2	10.7	9.8	13.3	12.8	11	12.5	10.8	11.7	8.8	15.3	15.8	17.7	17.2	12.5	16.5	14.8	14	12.5	12	10.5	**13**	**17.7**
2020-06-16	9.5	4.8	3.8	5.7	1.5	0		2.8	14.5	2.8	3.3	2.5	5.7	9.7	5.7	19.8	8.2	19.8	24.5	20	15	10.8	5.5	4	**8.3**	**24.5**
2020-06-17	3	0.3	0	0	0	0	2.3	3.5	7	5.8	8.5	5.3	6.8	14.2	7	4.3	13.7	21.2	11.8	23.3	16.3	11	6.3	5.7	**7.4**	**23.3**
2020-06-18	2.8	3.5	2.2	1	1.3	3.5	7.7	8.2	7.7	6.7	8.2	7.5	8.2	3.5	5.4	8.5	8	8.5	10.2	22.3	28.3	17.3	14.7	11.2	**8.6**	**28.3**
2020-06-19	7.5	6	2.5	1.3	0.3	4.3	1.3	6.5	9.5	19.7	14.5	7.6	10.6	1.5	10	15.2	22.7	13.2	19.2	16.8	13.3	21	14.8	7.3	**10.3**	**22.7**
2020-06-20	5.7	3.5	1.3	1	0	0	2.3	8.3	23	17.8	0	6.2	16.5	17	15.5	20	27.8	28.3	25.2	21.3	22	18	15	15.5	**13**	**28.3**
2020-06-21	17.5	15	15	11.8	15.5	6.5	14	17.5	12.7	9.2	12.7	20.8	16	20.8	15	25.8	38	21.2	15.7	15.7	25	26.2	24.5	23.5	**18.2**	**38**
2020-06-22	20.7	17.8	13.7	12.5	11.3	10.8	12.3	18.8	23.8	4.7	4.5	6	13.2	19	20	22.3	25	20.8	33.3	25.7	31.5	29.7	28.3	24.2	**18.7**	**33.3**
2020-06-23	23.2	22.7	16.2	15.2	15.2	18.8	16.8	25	8.3	7.7	13.5	24.5	15.7	7.3	18.3	21.8	19.3	23.3	26.5	26.2	34.2	38.2	41.2	46.5	**21.9**	**46.5**
2020-06-24	46.2	38.5	23	17.8	16.5	10.2	10.3	13.7	19	9.7	10.6	4.4	11.2	34.2	22	45.8	45.3	39.7	21.8	20	23.2	23.2	25	27.3	**23.3**	**46.2**
2020-06-25	34.2	27	20.2	20	15.8	12.5	12.7	21.2	20.2	6.8	2.5	5	14.3	13.7	9.8	16.5	20.7	18.2	23.7	27.7	32.7	39.2	35.2	31.3	**20**	**39.2**
2020-06-26	19	18.8	17	13.7	13.2	14.3	6.8	20	10.5	15.8	19	5.7	13.8	20.7	22.2	26.5	33.2	28	34.2	32.7	34.5	34	36.3	51.5	**22.6**	**51.5**

Grassy Mountain - AQ-001 - Proposed Loadout

HOURLY AVERAGE CONCENTRATION REPORT

May 1, 2020 - July 29, 2020

Guideline: Alberta Ambient Air Quality Objectives and Guidelines

Guideline Revision Date: January 31, 2019

Parameter: NO_2

Hourly Guideline: 159 ppb

Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Daily Average	Daily Maximum
2020-06-27	38.2	29	27.7	24.5	24.7	15.8	6.7	13.2	7.5	11.3	4.5	13.2	12.5	19.7	26.8	23.7	21.3	27.5	26.2	22.7	28.3	43.7	38.8	29.7	**22.4**	**43.7**
2020-06-28	31.7	39.3	31.3	19.3	16.7	15.2	16.5	18.7	18.2	16.3	19.2	14.2	16	11.3	5.7	13.3	16	17.8	21.8	16.3	15	15.3	18	20.2	**18.5**	**39.3**
2020-06-29	16.3	15.8	16.8	18.2	17.8	16.2	16.3	16.3	16.7	20	14	8	5	3.8	7.7	7.7	14.2	14.3	19.5	19.7	18.8	17	21.5	22.8	**15.2**	**22.8**
2020-06-30	14.5	12.2	11	10.3	9.8	7.3	9.2	8.2	10.2	11.8	12.5	10	11.3	11.7	10	9.2	10.2	9.3	9.8	16.8	17.3	9.5	9	6.7	**10.7**	**17.3**
2020-07-01	8.3	10.5	7.5	6.7	5.7	6.5	5	7.3	4	1.6	2.5	9.8	8	11.2	14.5	10.8	11.3	10	19.5	19.3	20	16.3	16	13.8	**10.3**	**20**
2020-07-02	13	13.5	14.7	9.5	12.3	13.5	15.5	14.2	15	15	10.3	10.2	11.2	8.3	13	14.7	13.2	9.7	17.7	4	13.5	13.8	16.8	15	**12.8**	**17.7**
2020-07-03	12.5	10.5	9.7	10	7.5	6.8	7.7	20.3	15.8	11.7	4.3	12.2	11.8	16	18.3	20.5	12.8	20.8	29.5	35.5	34.2	32.5	27	24.3	**17.2**	**35.5**
2020-07-04	22.5	19.7	18.3	14.2	11.2	7	9.7	17.8	20.3	13.8	2.5	10	14.5	15.8	22.7	21.8	27.7	32	29.3	32.8	30.2	32.7	32.3	39	**20.7**	**39**
2020-07-05	29.3	16.5	16.2	15.8	10.8	9.5	10	16.2	22	12	6.5	10.7	17.3	17.5	25.7	21.8	24.2	25.5	33.5	30.7	34.8	36.3	32	30	**21**	**36.3**
2020-07-06	24.3	24.8	20	17.2	13	12.5	13.7	20.3	23.7	17	12.7	7.2	11.2	23	23.5	32.7	23.8	24.2	41	34.5	33.5	53.2	38	30.8	**24**	**53.2**
2020-07-07	31.3	26.8	23	19	16	13.3	17.8	22.3	20.7	19.2	17.3	16	19.2	23.8	20.3	21.3	32	30	29.7	31.7	27.5	28.5	30.2	25	**23.4**	**32**
2020-07-08	20.2	18.2	18	17.7	17.7	18.5	18	18.8	17.7	21.2	25.3	24.2	19.5	20.5	24	19.8	28	23	35.3	31.2	28.3	24.7	18.2	21.3	**22.1**	**35.3**
2020-07-09	20.3	17.8	16.2	14.2	12.3	11.5	15.3	21.8	23.5	10.6	2.3	6.5	8.2	15	14.2	12.3	24.2	30	32.2	19.5	27.5	30.8	33.5	33.7	**18.9**	**33.7**
2020-07-10	34	26.3	25.3	19.7	20	20.7	15.2	17.8	19.8	12.2	9.3	6.7	11.2	10.5	16	15.2	24	23.5	23	23.8	29	29.8	26	21	**20**	**34**
2020-07-11	19.7	16.7	13.5	9	12	9.3	9.7	14.3	16	8.2	3.5	3.5	7.2	6.2	11.2	12.3	16.8	27.2	24.2	22.5	28.2	31.3	34.5	33.5	**16.3**	**34.5**
2020-07-12	35.2	15.5	13	19.7	22.2	25.7	28.8	28.5	23.8	22.8	25.8	27.8	26.2	20.5	14.7	16.8	18.3	31	41.2	39.8	37.5	30.8	23.5	15.5	**25.2**	**41.2**
2020-07-13	11	10.2	9.7	6.3	4.5	3	1	9.3	9.7	5.5	2.7	6	7	8.3	9.7	11.8	12	11.8	22.8	35.3	28.5	11.5	14.7	8.5	**10.9**	**35.3**
2020-07-14	4	2	1.2	2	0.8	1	1.3	3.8	16.8	7.2	0.8	3.8	8.7	13.3	12.2	10.7	15.3	16.2	19.7	22.7	21.8	23.7	25.7	30.2	**11**	**30.2**
2020-07-15	28.3	26.3	29.5	25.8	25.2	18.3	23.3	23.2	20.8	21	22.2	16.3	14.5	22.7	16.7	19	17.2	28	23.3	26.5	30.3	30.8	26.8	21.5	**23.2**	**30.8**
2020-07-16	17.3	16.7	12.2	11.8	10.3	8	8.7	14.5	18.3	11.5	23.3	13	25	16.8	24.7	35.8	31	29.7	18.5	27.7	38.3	70.3	54.3	41.3	**24.1**	**70.3**
2020-07-17	33.7	25	16.5	15	11.2	9	11.2	9.2	16.2	16.5	16	14.3	8.6	4	14.3	11.8	16.3	25.2	23.8	42	36.5	33.2	28.2	27.8	**19.4**	**42**
2020-07-18	29.8	23.8	22.7	32.3	18.5	13.7	14.3	14.3	20.3	12	10.8	3	6.5	17.7	18.8	20.8	16.7	21.8	31.7	31.5	33.3	33.3	32.2	33.5	**21.4**	**33.5**
2020-07-19	32.5	27	25.3	27.5	16.5	12.5	13.3	16.2	26	17.3	4.3	11.2	22.7	15.2	28.7	38.5	26.7	32.3	30.5	24	26.8	50.3	39	28	**24.7**	**50.3**
2020-07-20	35	29.3	19.3	13.7	12	12.3	13.8	16.7	17.2	12.5	5.4	10.7	14.5	16.3	21.3	28	31.3	33.5	35.7	37.2	36.7	35.7	28.2	17.3	**22.2**	**37.2**
2020-07-21	18.3	15.5	14.2	12.3	10.7	9.3	8.8	12.3	14.7	15	9.8	2	4	8	19	19.8	22.3	27.8	36.7	36.7	38.5	41.5	40.8	32.7	**19.6**	**41.5**
2020-07-22	29.7	24.5	21	19.3	16.7	16.8	15.8	22.2	25.5	25.3	7	6.8	19.2	25.5	40.8	37.3	42.7	37.8	39.7	35.6	45.5	57.3	57.5	57	**30.3**	**57.5**
2020-07-23	50.5	40.2	39.5	36.3	36.8	31.7	33.3	36	40.2	28.3	9.3	14.3	17.2	22.8	29.3	32.8	44.8	48.8	48.8	50.5	50.3	54.7	56.2	58.7	**38**	**58.7**
2020-07-24	50.8	44.5	36.2	35	33	32	30	34.7	38	8.8	14.3	21.7	19.8	35.8	29.7	40.2	39.5	39.2	45.5	47.5	69	53.8	49.5	51.8	**37.5**	**69**
2020-07-25	53.3	44	40.3	36.2	32	26.7	26.3	30.2	41	26.8	26.2	28.7	31.7	30.7	33	37.3	35.7	36.5	38.2	40.2	43	51.2	47.8	48.2	**36.9**	**53.3**

Grassy Mountain - AQ-001 - Proposed Loadout

HOURLY AVERAGE CONCENTRATION REPORT

May 1, 2020 - July 29, 2020

Guideline: Alberta Ambient Air Quality Objectives and Guidelines

Guideline Revision Date: January 31, 2019

Parameter: NO_2

Hourly Guideline: 159 ppb

Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Daily Average	Daily Maximum
2020-07-26	37.7	33.2	32	31	25.5	22.5	24.5	26.8	32.8	25.7	18.7	8	19.3	25.3	20.2	19.2	23	36.7	59.8	58.5	56.2	56.5	52	36.3	**32.6**	**59.8**
2020-07-27	33.8	31.3	28.8	27	22.5	21	18	19.8	27	24.3	17.5	14.8	10.3	19.3	23.2	40.2	51.8	51.5	54.2	53.3	55.2	53.3	44.7	42	**32.7**	**55.2**
2020-07-28	39	33	28.8	27.7	24.8	22.2	21.2	22	27.5	24.5	4	3	6.8	13.2	22.2	22	16	16.2	20.5	29.5	34.8	46.8	49.2	53.2	**25.3**	**53.2**
2020-07-29	50.2	41.5	33.5	27.2	26.5	27.5	27.3	31.3	37.5	21.3	7.5	1.8	8.5	20.3	14	6.2	12.2	12.2	10.5	12.2	27.8	44.5	49.8	46.8	**24.9**	**50.2**
Diurnal Average:	**19.2**	**16.2**	**14.3**	**12.3**	**10.8**	**9.6**	**10.4**	**14.2**	**15.9**	**13**	**10.8**	**11.4**	**12.8**	**14.8**	**17**	**18.8**	**20.9**	**21.9**	**24.1**	**24.1**	**25**	**25.6**	**23.6**	**21.9**		
Diurnal Maximum:	**53.3**	**44.5**	**40.3**	**36.3**	**36.8**	**32**	**33.3**	**36**	**41**	**28.3**	**26.2**	**28.7**	**31.7**	**35.8**	**40.8**	**45.8**	**51.8**	**51.5**	**59.8**	**58.5**	**69**	**70.3**	**57.5**	**58.7**		

Grassy Mountain - AQ-001 - Proposed Loadout

HOURLY AVERAGE CONCENTRATION REPORT

May 1, 2020 - July 29, 2020

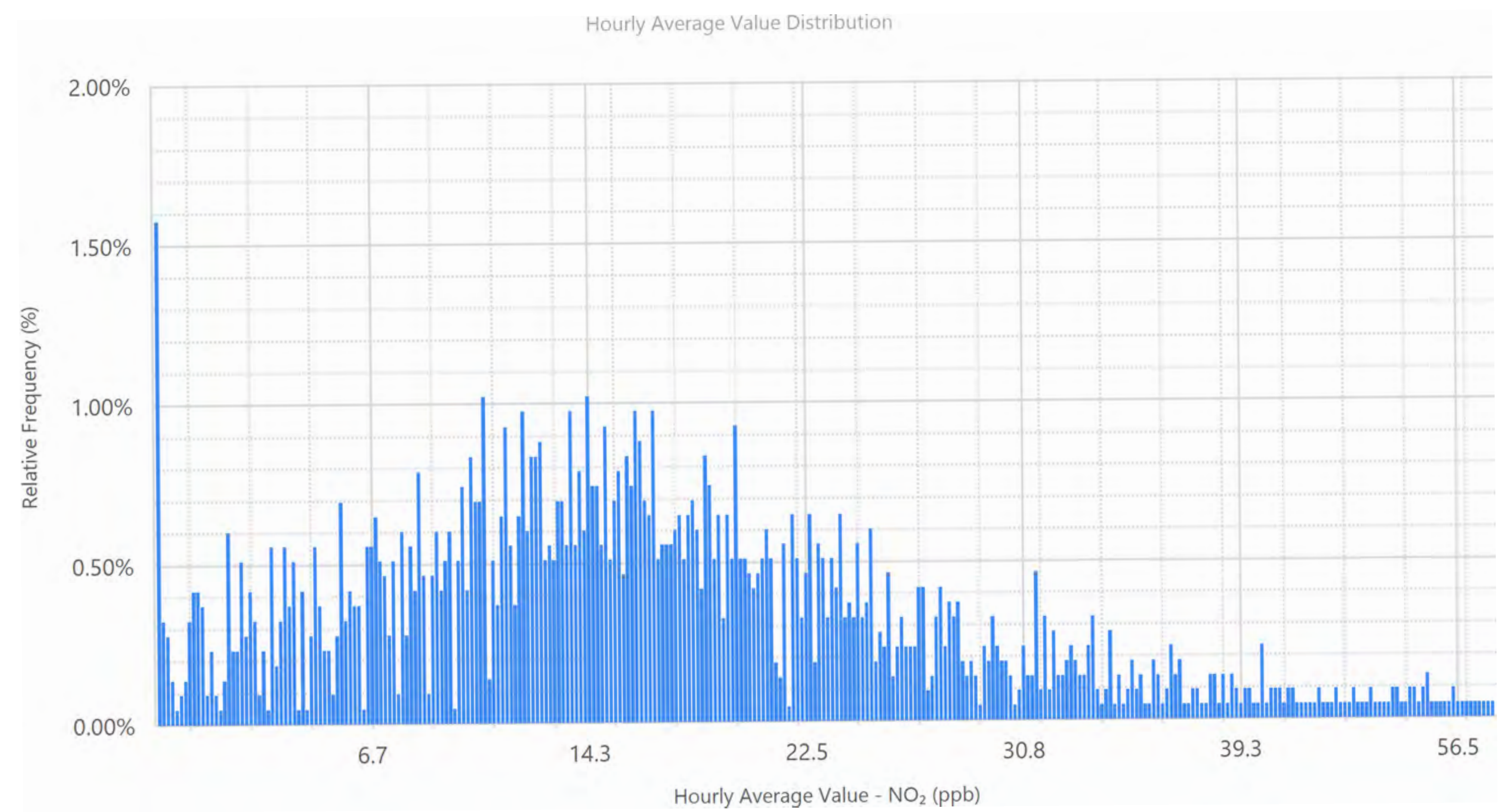
Guideline:	Alberta Ambient Air Quality Objectives and Guidelines
Guideline Revision Date:	January 31, 2019
Parameter:	NO_2
Hourly Guideline:	159 ppb

Number of Exceedances:	0
Maximum Value:	70.3 ppb on July 16 at hour 22
Mean Value:	17 ppb
Variance (S^2):	116.5
Standard Deviation (S):	10.8
Mode:	0.0 ppb. Number Count = 34

Percentiles:

P_1:	0.0
P_{10}:	4.0
Q_1:	10.0
Median:	16.0
Q_3:	23.0
P_{90}:	31.0
P_{99}:	52.0

The Total Number of Hours in the Reported Period:	2160
Hours of Data:	2157
Hours of Missing Data:	3
Percent Operational Time:	99.9%



Grassy Mountain - AQ-001 - Proposed Loadout

HOURLY AVERAGE CONCENTRATION REPORT

May 1, 2020 - July 29, 2020

Guideline: Alberta Ambient Air Quality Objectives and Guidelines

Guideline Revision Date: January 31, 2019

Parameter: O_3

Hourly Guideline: 76 ppb

Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Daily Average	Daily Maximum
2020-05-01	10.2	13.8	13.8	7.7	10.3	12	9	3.5	8.7	21	17.2	19.2	20	15.3	16.2	13.3	13.5	15.5	13.8	7.5	10.5	6.8	2.4	4.3	**11.9**	**21**
2020-05-02	2.8	1.2	0.8	2	0.8	0.5	0	0	1.2	3.5	15.8	31.7	33	24	23	19.3	17.7	19.5	18.8	14.8	15.3	13.7	3.8	1.4	**11**	**33**
2020-05-03	10.3	9.3	2.3	11	11.3	7.7	6.7	12	34.3	30.8	28.8	26.7	17.3	23.7	20.3	25.3	17.7	26.3	18.5	17.8	16.7	17.7	21.7	20.2	**18.1**	**34.3**
2020-05-04	14.7	13.2	13.8	14.2	18	16	13.8	14.5	14	11.7	12.7	10.8	10.3	9.5	12.2	13.3	13.2	11.8	10.2	12.5	7.5	2.2	0.3	0.8	**11.3**	**18**
2020-05-05	0	0.5	5.2	3.3	3.3	1.8	1.2	0	0	1.8	3.2	14.5	19.8	18.2	16	16.3	21.5	18.2	10	4.5	3.2	0	0	0	**6.8**	**21.5**
2020-05-06	0	6.7	4.2	3.2	2.2	2.2	0	0	0.3	0	9.3	9.2	4.3	7.2	7.3	15.3	2.4	1.5	15	24.5	24.5	21.8	23.2	22.8	**8.6**	**24.5**
2020-05-07	20.8	21.3	19.3	14.3	6	0.5	1	0	1	2	4.8	8.2	13.2	12.2	8.3	6.7	4.5	0.6	2.4	0.4	0	0	0	0	**6.1**	**21.3**
2020-05-08	0	0	0	0	0	0	0	0	0	0	0.3	3.8	8.5	10.3	15.7	15.3	11.3	8	7.2	9.5	9.8	9.7	9.3	4.2	**5.1**	**15.7**
2020-05-09	0	0	0	0	0	0	0	0	0	0	8.6	9.8	9.5	10	6	7.2	11	13.8	4.2	7.7	13.7	11	4.2	5.5	**5.1**	**13.8**
2020-05-10	6.3	10.5	7	8.8	15.8	16.7	14.3	7.8	14	16.8	25.2	20.8	24.5	24.8	24.5	16.3	15	14	18.2	16.2	18.8	21	16.8	17.5	**16.3**	**25.2**
2020-05-11	19	15.8	13.5	14.3	18.5	19.8	14	11.7	9	11	11.8	14.2	15.7	18.5	18.5	19.3	20.7	19.8	16.2	7.8	6.8	3.5	0.4	0	**13.3**	**20.7**
2020-05-12	1.3	0	0	0	0	0	0	0	11.5	18.7	15.5	12.3	10.3	7.8	9.3	3	3.7	9.7	6.7	5	5.2	5.5	4.3	10	**5.8**	**18.7**
2020-05-13	3.5	0.8	1.6	1.2	0	0.8	0	1	0	3.4	8.2	4.5	12.7	9.8	12.8	6	10.3	5.2	8.3	6.8	6	2	0	0	**4.4**	**12.8**
2020-05-14	0	0.4	3.3	13.2	14	12.5	12.3	16	25.2	18.8	13.8	14.8	21.5	19	17.5	28.3	21.7	22.3	14.8	18.5	21.2	14.3	13.2	9.8	**15.3**	**28.3**
2020-05-15	8	14.2	19	21	20.3	10.8	7.8	2.3	4.4	6.3	11.2	17.2	26.7	23.2	15.2	24	14.6	18.8	11.6	17.3	9.3	7.2	3.5	3.8	**13.2**	**26.7**
2020-05-16	6.8	5.7	7.7	9.5	7.2	5.7	5.8	5.8	17.8	20	20.2	17.8	14.3	14.3	19.7	18.5	19.5	16.2	13	18.7	12.5	2.5	4.2	3.6	**12**	**20.2**
2020-05-17	2.2	10	9.2	8.5	10	13.2	9.3	2.7	3.4	5	15.3	14.3	24	16.3	17.2	14	17.5	19	17.7	18.3	12.7	12.2	5.8	2.2	**11.7**	**24**
2020-05-18	3.3	0	2.5	1.3	0.8	0	0.3	6.2	23.5	16.3	18.7	16.5	18.2	24.3	13.8	19	19.8	16.7	12.2	0	13	29.3	18	5.5	**11.6**	**29.3**
2020-05-19	2.7	1.8	0.5	0	0	0	0	0	0	0	0	0.3	0	0	1.4	18.2	17	16.8	13.7	14.3	8.8	0.5	0	0	**4**	**18.2**
2020-05-20	0	0		0	0	0	0	0	0	7.3	7.2	8.8	11.8	16.2	16.5	16.5	17.2	14.3	9.8	9.7	10	6.7	13.5	16	**7.6**	**17.2**
2020-05-21	10	0	0	0	0	0	0	0.5	10.3	15.7	14.3	13.2	16	14.8	13	13.2	13.7	12.2	7	17.5	16.3	14	9.8	11.2	**9.3**	**17.5**
2020-05-22	11.8	16.2	16.7	14.8	16.5	16.3	16.3	19	8	4.7	6.2	7	8.8	3.7	6.2	8.2	0	4	3.4	0.7	2.8	6.7	8.2	8.5	**8.9**	**19**
2020-05-23	10.7	8	0.8	1	1	2.4	1.4	2	3.3	2.3	1.2	0	1.5	6.5	0.5	5.8	0.2	10.2	6.5	6.7	6.2	0.5	0	0	**3.3**	**10.7**
2020-05-24	0	0	0	0	0	0	0	0	8.3	9.3	5.8	10.8	5.5	9.2	1.2	3.5	0	0.5	1.6	0.5	1.3	0.5	0	0	**2.4**	**10.8**
2020-05-25	0	0	0.3	1.2	5.2	0.7	0	0	3.6	8.7	4.2	4	5.2	7.5	4.7	3.3	10	11.7	3.8	9.7	12.5	15.3	14.2	19.3	**6**	**19.3**
2020-05-26	18.2	15	14.8	15.3	7.8	8	0.3	0	1.8	14.7	14	12.7	21	17.3	18.7	17.2	20.7	20.7	6.6	12.3	11.2	13	10.7	0.8	**12.2**	**21**
2020-05-27	8.2	17.2	15.2	4.5	2	1	0	0	6.2	14.8	37.5	32.5	31.2	28	28	26.8	21.5	24.5	21.3	22	18.3	14.5	12.2	4.5	**16.3**	**37.5**
2020-05-28	3.3	6.5	5.2	4.5	1.2	2.2	0.8	0	0.8	10.3	26	26.5	31	30	28	28.5	30.5	28.7	26.7	21.3	20.2	3.3	1.3	4.3	**14.2**	**31**

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Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Daily Average	Daily Maximum
2020-05-29	6.2	7	5.5	3.8	5.5	7.2	6.8	2.2	10.3	3.3	5.8	17.3	36.7	31	32.8	28.7	28.3	33.3	33.8	30	26.7	25.7	23.3	12.3	**17.6**	**36.7**
2020-05-30	11.2	10.2	8	7	6.8	10.3	2.5	1.8	16	27.8	36.5	40.2	37.5	33.2	20.3	19.2	17.5	16.7	11.2	8.5	8.8	11.8	12.5	2.5	**15.8**	**40.2**
2020-05-31	1.5	4.7	13.5	11.3	8.8	6.3	1.8	0	6.8	6.5	36.7	27.5	44	43.3	29.7	27.3	25.7	23.2	20.3	26	25.8	23.8	20.7	20	**19**	**44**
2020-06-01	23.8	27.5	29.7	29.3	29.2	27.5	22.5	19.2	22	25	22.8	33	35	43	42.3	34.3	38.3	26.8	37.3	39.7	34	31.2	25.5	26.5	**30.2**	**43**
2020-06-02	31.8	35	32.7	30.7	33.3	33.5	33	32	34.8	30.3	39.2	37	41	26	27.2	36.2	42.3	36	32.7	33.7	32.2	27.7	34.2	18.8	**33**	**42.3**
2020-06-03	25.7	29.3	34.2	36.7	35	34.5	26.5	18.2	21	18.2	20.2	21.3	22.3	21.5	22.5	21	19	22.8	23	19.3	21	14.3	5.2	1.3	**22.2**	**36.7**
2020-06-04	0	0.6	2.2	0.8	0.6	2.6	1.3	0	21.3	26.8	26.5	30.5	28.3	26.5	24.2	19.2	19.2	22.5	6.8	11.2	12.2	3.7	7.8	3	**12.4**	**30.5**
2020-06-05	0	0	0	0	0	0	0	0	0	0	0	12.7	19.5	9.2	11.8	12.7	17.8	17.5	16.7	11.2	9.3	4.5	1.3	0	**6**	**19.5**
2020-06-06	0	0	0	0	0	0	0	0	0.3	7.6	15.8	17.2	22.5	28	21.5	20.8	18.7	12.2	7.2	7.2	8.3	10.3	11	11.7	**9.2**	**28**
2020-06-07	18.8	11	11.2	19.7	14	2.6	0.3	3.2	11.3	14.7	4	9.3	13.7	20	17.3	12.3	12.5	11.2	12	10.5	3.5	0.3	0	0	**9.7**	**20**
2020-06-08	0	0	0	0	0	0	0	0	3.3	9.5	9.8	8.5	12	10	6.3	10	6.2	10.8	1.3	2.2	3	8.8	0	0	**4.2**	**12**
2020-06-09	8.2	13	15	14.8	18.8	21.7	20.8	17.3	7.2	5.3	13.5	9	11	5.3	2.5	2.7	2.2	2.5	1.2	2.8	1.3	1	4.4	2	**8.5**	**21.7**
2020-06-10	4	4.8	8	9.2	12.5	13.8	12.7	9.7	2.3	3.6	2.8	5.7	4.2	10.8	11.3	3.6	15	11.2	15.3	10.3	7.2	7.7	0	1.6	**7.8**	**15.3**
2020-06-11	3	4	8.5	11.7	11	13	5.7	4.8	7.3	10.5	13.2	17.7	16.7	24.7	29.8	23.7	14.8	7.2	6.8	2.7	11.7	4.3	0	2.3	**10.6**	**29.8**
2020-06-12	1.4	0.3	2	0	0	0	0	0	2	2.6	16	25.3	16.6	9.5	2	15	4.5	3.7	22.5	19.3	15	7.2	2.7	0	**7**	**25.3**
2020-06-13	0.3	7.4	15.7	9.3	2.5	0.2	0	0	1.6	2	5.2	16	34	39.5	30.2	29.3	15.2	0.4	0	5.3	17.3	26.5	25	23.2	**12.8**	**39.5**
2020-06-14	15.3	16.8	21.5	31.8	30	25.2	23.3	22.8	30.8	23.8	26.3	18.7	11.8	17.7	24	19.8	20	18.7	13.8	12.8	17	21.2	16.5	17.5	**20.7**	**31.8**
2020-06-15	16.2	21.3	12.3	12.8	13	17.7	13.3	10.5	15	15.2	16.2	14.3	19.3	15.2	13.8	12.3	10	15.7	10.5	17	20.3	17.3	15.7	20.3	**15.2**	**21.3**
2020-06-16	21.5	24.7	22.7	19	16.2	11.3	7.7	6.2	6.8	18.8	19.7	17.5	16.2	14.3	16.7	8.7	16.3	7.2	1.8	1.2	6.7	6	5.2	1.5	**12.2**	**24.7**
2020-06-17	1.5	0	0	0	0	0	0	0	0	0	3.5	10.3	7.7	5.7	8.8	16.7	7.2	3.5	11.5	0.4	0.7	0.2	0	0	**3.2**	**16.7**
2020-06-18	0	0	0	0	0	1	11.8	12.2	14	14.3	10.5	9.7	9.8	19.3	18	12.2	19.8	18.2	16.2	5.8	0	3	1.4	1.6	**8.3**	**19.8**
2020-06-19	3.3	5.8	4.3	0	0	0	0	0	0	0	0	5.8	6.8	19.2	14.3	10.7	9	14.8	11	8.7	11.7	4.8	0	0	**5.4**	**19.2**
2020-06-20	0	0	0	0	0	0	0	0	0	14.3	19.3	23.7	11.8	16.2	21	12.8	6.6	9.8	10.2	14.2	13.8	16.3	15.8	12.2	**9.1**	**23.7**
2020-06-21	10.2	12.7	11.3	7.3	4.2	6.2	0	0	13.8	17	17.8	18.5	11.7	9.8	18.7	21.6	7.4	13.2	17.8	20.3	9	6.2	3.5	0	**10.8**	**21.6**
2020-06-22	0.2	0	0.2	0	0	0	0	0	3.4	25.8	28.7	32	20.2	14.7	10.7	12.8	6.5	13	5.2	9	5.8	2.8	1.4	2.8	**8.1**	**32**
2020-06-23	0.2	0	2.8	2	0.5	0	0	6.4	18	21.3	12.8	10.7	9	22.3	13.8	5	11	3.7	4	5	0	0	0	0	**6.2**	**22.3**
2020-06-24	0	0.3	2.3	2.2	2.2	3.2	1	0.3	1	9.8	19.2	24	21.3	11.7	16	27.5	0	0	19.2	35.7	39.8	27.8	17	12.5	**12.2**	**39.8**
2020-06-25	12.3	13.5	2.2	0	0	0	0	0	5.3	34.3	45	46	41.3	41	44.7	41.7	34.3	39.5	34.2	32	26.5	10.3	10.7	8.7	**21.8**	**46**
2020-06-26	23.2	24.5	22.5	24	21.3	26.5	28.8	16.7	38.3	26.7	28.8	46	44	37.2	34.5	31.8	21.5	25.2	20.8	27.8	26.8	32.7	40.8	21.3	**28.8**	**46**

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Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Daily Average	Daily Maximum
2020-06-27	32	30.3	15.3	33.3	24.8	36.7	45	34.7	44	42.2	45.8	43.3	46.2	44.2	37.2	38.2	44.2	41.5	42.2	44.8	42.3	27	28	40.7	**37.7**	**46.2**
2020-06-28	39.5	23.8	13.7	13.5	13.5	10.8	6	8.2	13.2	35.2	40.5	33.3	35.2	32.5	39.8	35.5	34.5	31.2	31.3	37.3	38.2	37.2	33.8	20.8	**27.4**	**40.5**
2020-06-29	24.2	28.8	30	16.2	16	13.3	14.2	12.5	12	12.8	30.2	41.3	45	45	44.3	43.5	33.7	36.2	32.5	32.7	31.3	30.7	23.8	8.5	**27.4**	**45**
2020-06-30	5.8	9.2	3.8	1.8	1.5	2.7	0.5	0	1	4.8	4.7	4.3	3	14.8	16.5	24.8	31.5	28	28.5	20.7	22.3	25.5	22.2	14.2	**12.2**	**31.5**
2020-07-01	5	0	2.2	2.7	2.5	9.7	10.3	17.2	27.8	30	28.8	17	17.7	16.3	12.7	14	18.7	21.7	7	10.9	9.2	15	18.5	23.2	**14.1**	**30**
2020-07-02	22	22.8	23	22.7	23.7	21.7	15.3	15.7	12.3	8.7	16.2	16.5	15.8	13	11.7	8.5	7.7	12.7	4.2	22.8	12.5	18.3	15.8	15	**15.8**	**23.7**
2020-07-03	22.3	23.3	23.7	21.5	10.8	6.8	6.8	0	6	13.3	29.5	23.7	34.5	36.5	26.3	17.3	26.8	25.5	12.2	1.4	4.8	2.2	0	0	**15.6**	**36.5**
2020-07-04	0	1	0.8	1.4	4	8.7	6.3	2.6	2.7	23.2	39.7	42	41	40.7	34.7	32.3	20.8	14.3	18.3	13.2	10.2	5.3	2.2	0	**15.2**	**42**
2020-07-05	0	5.3	2.8	1.5	6	7.3	1.8	0	1.6	11	21	19.2	10.5	11.5	5.5	10	8.8	10	2.2	5.2	0.2	0	0	0	**5.9**	**21**
2020-07-06	0	0	0	0	0	0	0	0	0	5	10	24.8	24	16.3	18.8	6.2	14.5	16	3	9.7	7.7	1.8	0.8	0	**6.6**	**24.8**
2020-07-07	0	0	0	0	0	0	0	0	0	0	1	28.2	38.3	33	42.3	38.5	30.3	26.8	23	22.8	27.3	21.8	18.8	23.2	**15.6**	**42.3**
2020-07-08	32.7	33.5	35.8	34.8	35	33.2	34.3	30	28.3	22	12.3	13.7	16.2	13	14.4	12	3.8	12.8	0	0.3	0.8	2	1.5	0.4	**17.6**	**35.8**
2020-07-09	0	0	0	0	0	0	0	0	0.3	20.2	37	37.5	37.3	37	37	41.8	37.8	30.7	23.7	39.3	34.5	19.7	16	16	**19.4**	**41.8**
2020-07-10	27.2	28.8	24	25.5	22	24.3	28.8	16.8	31.5	40.3	44.3	45.2	45	46.3	44.5	45.3	39.5	41.8	43.8	41.5	33.5	30.2	31.5	28.8	**34.6**	**46.3**
2020-07-11	30	33.8	37.5	36.8	24.8	23.8	21.7	15.5	28	40.8	46.8	51.7	49.8	51.3	49.2	48.7	47.5	41.8	44.5	45.5	36.7	27.2	16.3	20.7	**36.3**	**51.7**
2020-07-12	30.7	50.7	53.3	50.3	47.3	45	44.2	45	46.2	45.7	43.7	43.3	42.2	42.5	45.5	45.2	43.8	36	23.8	20	21.7	12.2	16.2	26	**38.4**	**53.3**
2020-07-13	25.3	30.7	30.8	40.7	38.7	37.3	28.3	23.2	34.8	44.8	45.5	44.7	41.8	40.7	38.2	36.2	37.7	35.8	26.3	13.8	21.2	23.7	7.5	11.5	**31.6**	**45.5**
2020-07-14	16.7	14.3	11.8	11.7	10.8	8.7	6.2	1.8	0	14.5	19.7	20.3	16.8	11.7	12.5	12.7	10.3	12	14	12.8	15.8	15.5	9.8	1.5	**11.7**	**20.3**
2020-07-15	2.3	0	0	0	0	0	0	0.8	0.2	0	1.3	8	13.2	3.4	5.3	3.7	8.5	2	3.7	1.8	0.3	0	0	0	**2.3**	**13.2**
2020-07-16	0	0	0	0	0	0	0	0	2	12.7	14.4	17.5	4.6	9.2	11.6	0.8	3.8	1.8	15.5	7.3	7.8	0	0	0	**4.5**	**17.5**
2020-07-17	0	0.8	2.2	3.8	7.7	9	4.7	6.2	2.4	8.2	12	14.7	28.7	39	33.8	40.8	35.8	26.5	39	28.8	24.5	24.8	20.2	9.8	**17.6**	**40.8**
2020-07-18	3.3	9.5	13.3	19	37.7	41.5	28.3	14.2	24.2	32.7	34	43.2	41.8	30	27	25.3	30.8	28.2	14.2	15	10.8	9.7	11.3	4.2	**22.9**	**43.2**
2020-07-19	8.2	8.3	13.5	5.3	12.7	18.8	15.2	12.3	4.7	14.3	37.5	32.5	17	28	10.8	23	18.6	23.2	15	22	20.3	4.8	11.8	25.5	**16.8**	**37.5**
2020-07-20	18.8	24.7	28.3	16.8	15	13.5	4.7	4.5	8.8	19	41.5	36.8	31.7	30.7	25.3	19.7	13.3	11.7	11.2	14.2	13.8	17.7	22.8	24.7	**19.5**	**41.5**
2020-07-21	11.5	9	11.7	8.5	5.5	4	3.5	1.8	6	15.3	26.5	28.5	39.5	38.2	29.8	32.3	34	26	11.7	9	7.3	0.3	0	0	**15**	**39.5**
2020-07-22	1.2	0.8	1.3	1.2	1.7	1.5	0	0	4.5	4	36.2	35.7	23.5	17.2	7.3	4	1.5	1.6	0.3	1.1	0	0	0	0	**6**	**36.2**
2020-07-23	0.2	1.3	0	2.8	3.7	8	2.2	0.4	0.8	22.2	48.5	47.3	49	48.5	46	46.2	35	27.5	27.3	22.8	21.5	13.2	3.5	0	**19.9**	**49**
2020-07-24	3.6	13.8	16.7	15.8	17.8	20.3	20.8	16.3	19.8	52.2	49.5	47.5	49.8	43.8	46.5	42.2	42.5	40.2	29.2	28	5.8	14	21.8	13.5	**28**	**52.2**
2020-07-25	8.3	19.2	20	20.3	16	15.7	16.2	12	10.2	27.8	30	27.8	25.5	31	27.7	17.5	18.7	18	15.2	14.8	10.2	0	0	0	**16.8**	**31**

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Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Daily Average	Daily Maximum
2020-07-26	4.4	6	3.7	1.8	5.5	7.5	3.8	2.5	4	14.7	31.8	47.7	44.7	43.7	48.8	51	49.3	37.5	4.7	8.3	14.8	14.3	19.3	21.3	**20.5**	**51**
2020-07-27	15.5	14	16	17.2	17.2	14.3	16.3	11.8	19.3	28.7	40.2	45	48.3	47.3	48.5	42.5	23.3	23.5	20.2	20.8	17.7	9.5	4.4	5.2	**23.6**	**48.5**
2020-07-28	3.7	2	8.2	5	5	9.5	7.2	8.7	12.5	22	49.7	54.8	59.5	57.2	53	53.3	59.3	60.3	55.3	48.5	45.2	28	13	7.3	**30.3**	**60.3**
2020-07-29	4	19.3	25.3	27.2	24.8	18.5	12.8	12.4	11.8	38.3	56.7	67	73	60.2	73.5	96.5	80	75	78.8	75.8	48.7	12.3	6.8	10	**42**	**96.5**
Diurnal Average:	**9**	**10.3**	**10.5**	**10.2**	**9.9**	**9.9**	**8.2**	**6.8**	**10.5**	**15.7**	**21.1**	**23.2**	**24.1**	**23.6**	**22.3**	**22**	**20**	**19.1**	**16.3**	**16.3**	**15**	**12**	**10**	**8.6**		
Diurnal Maximum:	**39.5**	**50.7**	**53.3**	**50.3**	**47.3**	**45**	**45**	**45**	**46.2**	**52.2**	**56.7**	**67**	**73**	**60.2**	**73.5**	**96.5**	**80**	**75**	**78.8**	**75.8**	**48.7**	**37.2**	**40.8**	**40.7**		

Grassy Mountain - AQ-001 - Proposed Loadout

HOURLY AVERAGE CONCENTRATION REPORT

May 1, 2020 - July 29, 2020

Guideline: Alberta Ambient Air Quality Objectives and Guidelines

Guideline Revision Date: January 31, 2019

Parameter: O_3

Hourly Guideline: 76 ppb

Number of Exceedances: 3

Maximum Value: 96.5 ppb on July 29 at hour 16

Mean Value: 14.8 ppb

Variance (S^2): 183

Standard Deviation (S): 13.5

Mode: 0.0 ppb. Number Count = 286

Percentiles:

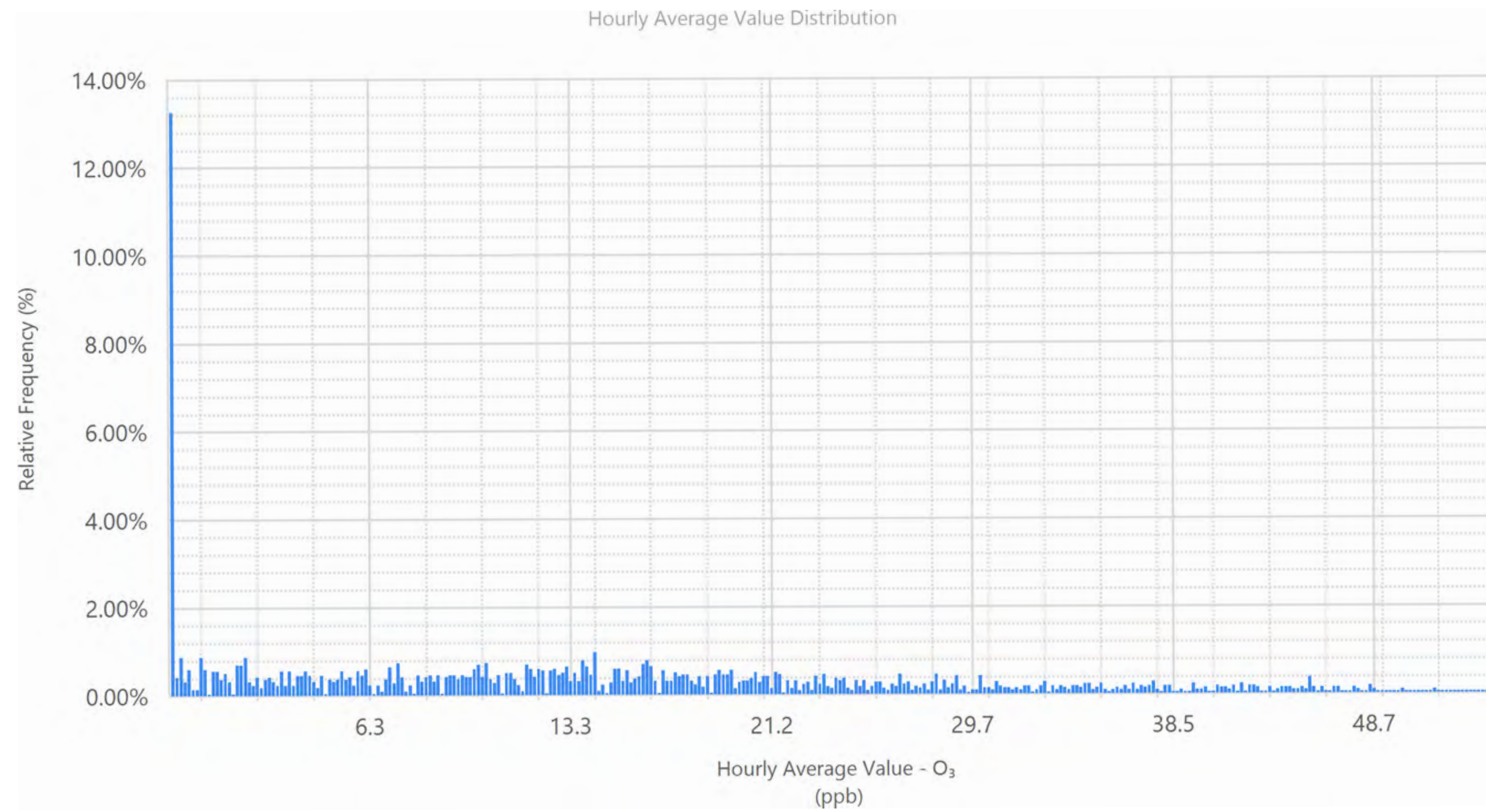
P_1:	0.0
P_{10}:	0.0
Q_1:	3.0
Median:	12.0
Q_3:	22.0
P_{90}:	34.0
P_{99}:	51.0

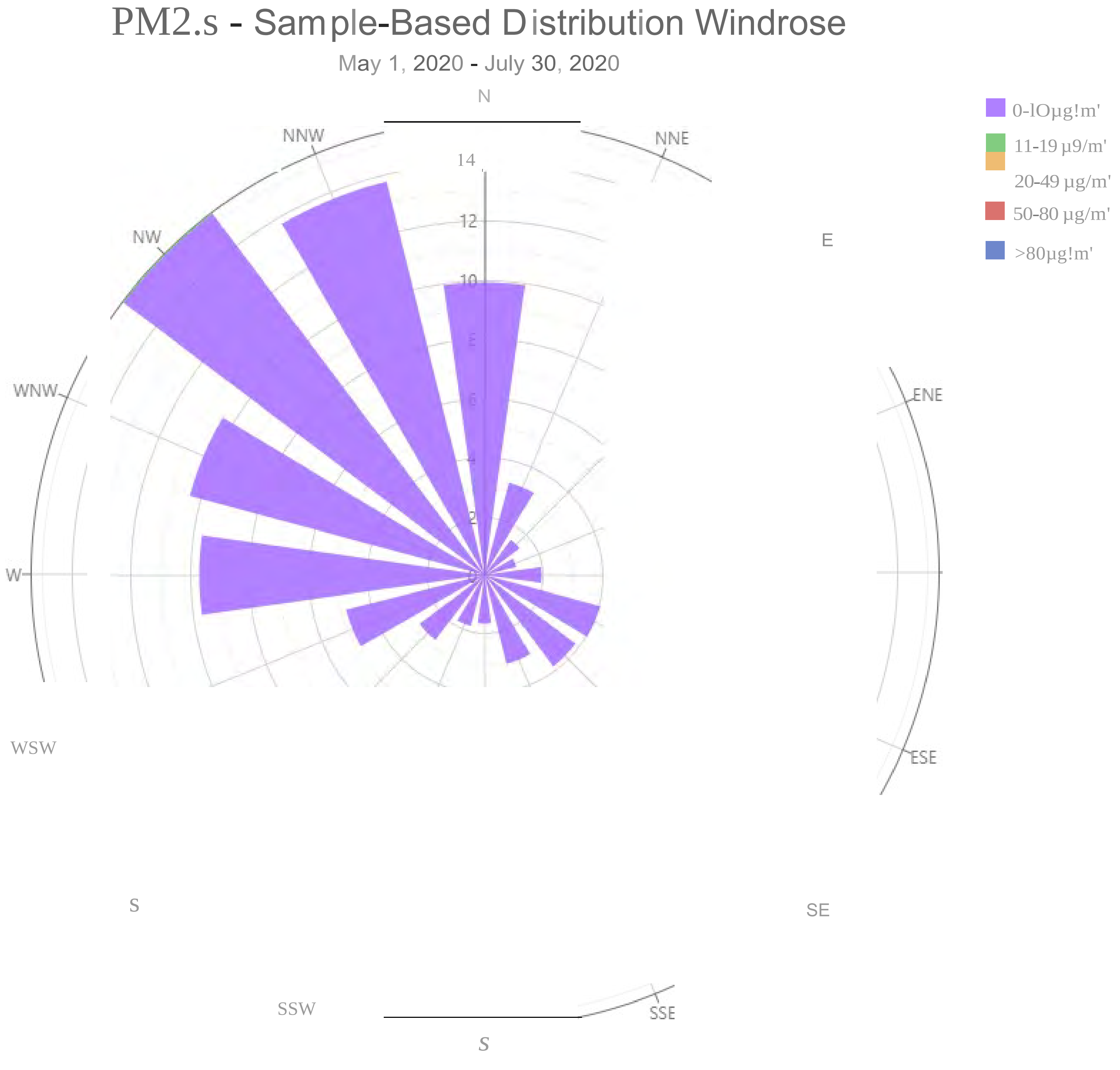
The Total Number of Hours in the Reported Period: 2160

Hours of Data: 2159

Hours of Missing Data: 1

Percent Operational Time: 100.0%

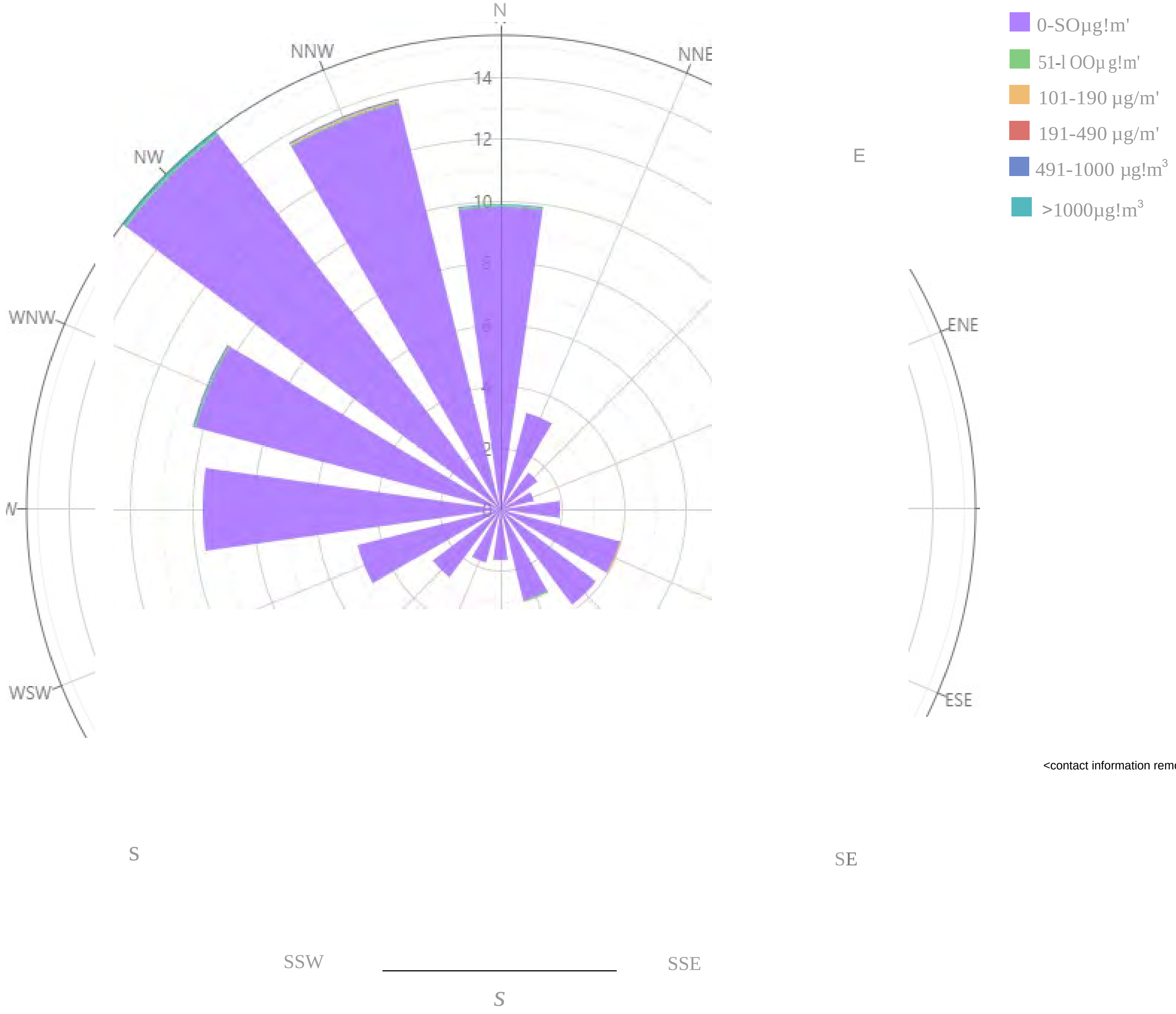




PM2.s - Sample-Based Distribution Windrose
May 1, 2020 - July 30, 2020
N
NNE
E
ENE
ESE
SE
SSE
S
SSW
S
WSW
W
WNW
NW
NNW
14
12
10
8
6
4
2
0
0-lOµg!m'
11-19 µ9/m'
20-49 µg/m'
50-80 µg/m'
>80µg!m'

PM 0 - Sample-Based Distribution Windrose

May 1, 2020 - July 30, 2020



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Title:	**Alberta Ambient Air Quality Objectives and Guidelines Summary**
Number:	**AEP, Air Policy, 2016, No. 2**
Program Name:	**Air Policy**
Effective Date:	**Differential effective dates for each objective or guideline**
This document was updated on:	**January, 2019**

Alberta's ambient air quality objectives and guidelines are developed under the Alberta Environmental Protection and Enhancement Act (*EPEA*). Objectives are developed to protect Alberta's air quality.

Air quality objectives are generally established for one-hour, 24-hour, and annual averaging periods. Occasionally, the underlying information or ambient monitoring method requires that other averaging periods be used. For example, a three-day objective was set for ethylene as experimental evidence indicated that this was a more appropriate averaging period than 24-hours.

Objectives and guidelines are based on an evaluation of scientific, social, technical, and economic factors.

Consultation

Alberta Environment and Parks works with a variety of stakeholders, including other government departments, the scientific community, environmental organizations, industry and the general public to prioritize substances and to develop and review objectives and guidelines.

Reporting Air Quality

The Ambient Air Quality Objectives are compared to actual air quality measurements to report on:

- special ambient air quality surveys; and
- current air quality through the Air Quality Health Index.

Reporting Exceedances

Exceedances of ambient air quality objectives must be reported as outlined in the Air Monitoring Directive (refer to the definition for "AAAQO").

Industrial Facilities

All industrial facilities must be designed and operated such that the ambient air quality remains below Ambient Air Quality Objectives.

Use of Objectives (Table 1)

Objectives are used:

- to determine adequacy of facility design
- to establish required stack heights and other release conditions
- to assess compliance and evaluate facility performance

Table 1 Alberta Ambient Air Quality Objectives

Substance/ CAS	Averaging Period	µg m^{-3} †	ppbv *	Basis	Effective Date**	Last Review**
Acetaldehyde						
75-07-0	1-hour	90	50	Adopted from Texas	1999	
Acetic acid						
64-19-7	1-hour	250	102	Adopted from Texas	1999	
Acetone						
67-64-1	1-hour	5,900	2,400	Adopted from Texas	1999	2005
Acrolein						
107-02-8	1-hour	4.5	1.9	Adopted from Ontario (development of irritation)	Oct 1, 2013	
	24-hour	0.40	0.17	Adopted from Ontario (development of lesions in upper airways)		
Acrylic acid						
79-10-7	1-hour	60	20	Adopted from Texas	Jan 1, 2004	
	Annual	1.0	0.34	Adopted from California		
Acrylonitrile						
107-13-1	1-hour	43	19	Adopted from Texas	Jan 1, 2004	
	Annual	2	0.9	Adopted from California		
Ammonia						
7664-41-7	1-hour	1,400	2,000	Odour perception	1976	2005
Arsenic						
7440-38-2	1-hour	0.1	-	Respiratory effects	May 1, 2005	2013
	Annual	0.01	-	Carcinogenic effects		
Benzene						
71-43-2	1-hour	30	9.0	Haematological effects	1999	2012
	Annual	3	0.9	Carcinogenic effects		
Benzo[a]pyrene						
50-32-8	Annual	0.30 ng m^{-3}	2.9 $x10^{-5}$	Chronic and carcinogenic human health effects	June 1, 2009	
Carbon disulphide						
75-15-0	1-hour	30	10	Odour threshold	1999	2006

Substance/ CAS	Averaging Period	µg m^{-3} †	ppbv *	Basis	Effective Date**	Last Review**
Carbon monoxide						
630-08-0	1-hour	15,000	13,000	Oxygen carrying capacity of blood	1975	
	8-hour	6,000	5,000	--		
Chlorine						
7782-50-5	1-hour	15	5.0	Adopted from Texas	1999	
Chlorine dioxide						
10049-04-4	1-hour	2.8	1.0	Adopted from Texas	1999	
Chromium						
7440-47-3	1-hour	1	-	Adopted from Texas	1999	
Cumene						
98-82-8	1-hour	500	100	Adopted from Texas	May 1, 2005	
Dimethyl ether						
115-10-6	1-hour	19,100	10,100	Adopted from Texas	1999	
2-Ethylhexanol						
104-76-7	1-hour	600	110	Adopted from Ontario	May 1, 2005	
Ethylbenzene						
100-41-4	1-hour	2000	460	Adopted from Texas	May 1, 2005	
Ethyl chloroformate						
541-41-3	1-hour	0.57	0.13	Stack emission limits	1999	
Ethylene						
74-85-1	1-hour	1,200	1,050	Crop yield	Jan 1, 2004	
	3-day	45	40	Crop yield		
	Annual mean	30	26	Conifers and perennials		
Ethylene oxide						
75-21-8	1-hour	15	8.0	Adopted from Ontario	1999	
Formaldehyde						
50-00-0	1-hour	65	53	Adopted from Texas	1999	2007
n-Hexane						
110-54.3	1-hour	21,000	5,960	Derived from 24-hr California objective	Aug 1, 2008	
	24-hour	7,000	1,990	Adopted from California		
Hydrogen chloride						
7647-01-0	1-hour	75	50	Adopted from Texas	1999	
Hydrogen fluoride						
7664-39-3	1-hour	4.9	6.0	Adopted from Texas	1999	2009

Substance/ CAS	Averaging Period	$\mu g\ m^{-3}$ †	ppbv *	Basis	Effective Date**	Last Review**
Fluoride content in forage – dry wt basis				Adopted from Ontario	2009	
	30-day avg.	35 $\mu g\ g^{-1}$		April 1 to October 31		
	Avg. for any single 30-day period	80 $\mu g\ g^{-1}$		April 1 to October 31		
	Avg. for 2 consecutive months	60 $\mu g\ g^{-1}$		April 1 to October 31		
Hydrogen sulphide						
7783-06-4	1-hour	14	10	Odour perception	1975	
	24-hour	4	3	Health effects		
Isopropanol						
67-63-0	1-hour	7,850	3,190	Adopted from Texas	Aug 1, 2005	
Lead						
7439-92-1	1-hour	1.5	-	Adopted from Texas	1999	
Manganese						
7439-96-5	1-hour	2	-	Adopted from Texas	May 1, 2005	
	Annual	0.2	-	Adopted from Texas and California		
Methanol						
67-56-1	1-hour	2,600	2,000	Adopted from Texas	1999	
Methylene bisphenyl diisocyanate						
101-68-8	1-hour	0.51	0.050	Adopted from Texas	1999	
Monoethylamine						
75-04-7	1-hour	1.19	0.645	Stack emission limits	1999	
Naphthalene						
91-20-3	Annual	3	-	Health effects	Sept 1, 2016	
Nickel						
7440-02-0	1-hour	6	-	Adopted from California	May 1, 2005	
	Annual	0.05	-	Adopted from California		
Nitrogen dioxide						
10102-44-0	1-hour	300	159	Respiratory effects	1975	2009
	Annual	45	24	Vegetation		
Ozone (ground level)						
10028-15-6	1-hour daily maximum	150	76	Pulmonary function	1975	2019
Particulate Matter						
Fine - 2.5 microns or less	24-hour	29	-	Health effects	2007	2018

Substance/ CAS	Averaging Period	$\mu g\ m^{-3}$ †	ppbv *	Basis	Effective Date**	Last Review**
Total suspended particulate matter	24-hour	100	-	Pulmonary effects	1975	
	Annual geometric mean	60	-			
Pentachlorophenol						
87-86-5	1-hour	5.0	0.44	Adopted from Texas	Nov 1, 2004	
	Annual	0.5	0.04	Adopted from Texas		
Phenol						
108-95-2	1-hour	100	26.0	Adopted from Ontario	1999	
Phosgene						
75-44-5	1-hour	4	1	Adopted from Texas	1999	
Propylene oxide						
75-56-9	1-hour	480	200	Adopted from Oklahoma	Jan 1, 2004	
	Annual	30	13	Adopted from California		
Styrene						
100-42-5	1-hour	215	52.0	Adopted from Texas	1999	
Sulphur dioxide						
7446-09-5	1-hour	450	172	Pulmonary function	1975	2008
	24-hour	125	48.0	Adopted from European Union – human health		
	30-day	30	11			
	Annual	20	8.0	Adopted from European Union - ecosystems		
Sulphuric acid						
7664-93-9	1-hour	10	2.5	Adopted from Texas	1999	
Toluene						
108-88-3	1-hour	1,880	499	Adopted from Texas	May 1, 2005	
	24-hour	400	106	Adopted from Michigan and Washington		
Vinyl Chloride						
75-01-4	1-hour	130	51	Adopted from Texas	1999	
Xylenes						
1330-20-7	1-hour	2,300	530	Adopted from Ontario	May 1, 2005	
	24-hour	700	161	Adopted from California		

† $\mu g\ m^{-3}$ is the weight, in micrograms, of the substance in one cubic meter of air.

* Standard conditions of 25°C and 101.325 kPa are used as the basis for conversion from $\mu g\ m^{-3}$ to ppbv (parts per billion by volume) or from $mg\ m^{-3}$ to ppmv (parts per million by volume).

** The Effective Date column indicates when the objective/guideline was initially effective in Alberta. A date in the Last Review column indicates the last date the objective/guideline was reviewed.

Note: Underscore indicates this digit is the last significant figure in the number e.g. 100 has two significant figures.

Note: The least significant figure is underlined to indicate calculation accuracy when converting from one unit to the other (e.g. $\mu g\ m^{-3}$ to ppbv). These numbers **do not** indicate reporting accuracy or precision. Refer to the Air Monitoring Directive for the Reporting Policy on significant figures for comparison to the ambient air quality objectives.

Use of Guidelines (Table 2)

Guidelines may be used:

- for airshed planning and management
- as a general performance indicator
- to assess local concerns

Table 2 Alberta Ambient Air Quality Guidelines

Parameter	Guideline		Effective Date**	Last Review**
Dustfall				
30 days	53 mg 100 cm^{-2}	In residential and recreation areas	1975	
30 days	158 mg 100 cm^{-2}	In commercial and industrial areas		
Particulate Matter Fine - 2.5 microns or less				
1-hour	80 µg m^{-3}	Derived from the Canada Wide Standard	2007	2018
Static fluorides				
30 days	40 µg 100 cm^{-2}	Water soluble fluorides	Pre 1976	

For More Information

For more information on Alberta's Ambient Air Quality Objectives, contact:

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Air Policy
Email: AirQuality.Comments@gov.ab.ca
Phone: **(780) 427-4979**

Original signed by:
Marilea Pattison Perry
Executive Director
Air, Biodiversity and Policy Integration Branch

Date: January 31, 2019

Further information is available online at
www.alberta.ca/air-quality