KUDZ ZE KAYAH PROJECT: PRELIMINARY FISHERIES OFFSETTING PLAN

BMC-15-02-2490_020_Preliminary Fisheries Offsetting Plan_Rev0_170222

February 2017

Prepared for:

BMC MINERALS (NO. 1) LTD.

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ALEXCO ENVIRONMENTAL GROUP INC. SIGNATURES

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LIST OF ACRONYMS

AEG	Alexco Environmental Group Inc.
AQRMP	Aquatic Resource Monitoring Plan
BCMOE	British Columbia Ministry of the Environment
BMC	BMC Minerals (No.1) Ltd.
CCME	Canadian Council of Ministers of the Environment
COPI	Contaminant of Potential Interest
CPUE	Catch per Unit Effort
DFO	Fisheries and Oceans Canada
EA	Effects Assessment
EBA	Tetra Tech EBA Inc.
EEM	Environmental Effects Monitoring
EMSRP	Environmental Monitoring, Surveillance and Reporting Plan
FAA	*Fisheries Act* Authorization
FHCP	Fish Habitat Compensation Plan
FOP	Fisheries Offsetting Plan
FPP	Fisheries Protection Program
KZK	Kudz Ze Kayah
MAR	Mean Annual Runoff
MIF	Mine Infrastructure Footprint
MMER	Metal Mining Effluent Regulations
MTPA	Million Tonnes Per Year
ROM	Run of Mine
VMS	Volcanogenic Massive Sulphide
WQO	Water Quality Objective
YESAA	*Yukon Environmental and Socio-Economic Assessment Act*
YG	Yukon Government

GLOSSARY

Benthic invertebrates: organisms that live in or on the bottom sediments of rivers, streams, and lakes. Benthic invertebrates are an integral component of aquatic ecosystems and provide valuable biological information to assess potential effects of metal toxicity and nutrient enrichment on a system.

Catch per unit effort (CPUE): catch of fish in numbers during a defined period of effort (indirect measure of the abundance).

Channel width: width of the wetted stream channel at the normal high water level attained during mean annual flow events (the channel defining width); also called bankfull width.

Chlorophyll α: primary photosynthetic pigment common to all algae.

Cyanobacteria: a phylum of bacteria that obtain their energy through photosynthesis.

Detritus: dead particulate organic material.

Electrofishing: common scientific survey method using direct current electricity flowing between a submerged cathode and anode. This affects the movement of the fish so that they swim towards the anode where they can be caught. Electrofishing is a common scientific survey method used to sample fish populations to determine abundance, density, and species composition. When performed correctly, electrofishing results in no permanent harm to fish, which return to their natural state in as little as two minutes after being caught.

Fork length: length of a fish measured from the tip of the snout to the end of the middle caudal fin rays.

Fry: juvenile fish life stage reached when fish are capable of feeding themselves.

Heterotrophic microbe: an organism that cannot fix carbon and uses organic carbon for growth.

Minnow trap: cylindrical device with ¼“ or ½“ mesh and a funnel opening on each end, for capturing small fish.

Overwintering habitat: area used by fish when winter conditions (cold or sub-zero temperatures, ice, snow, limited food supplies) make normal activity or even survival difficult.

Periphyton: complex mixture of algae, cyanobacteria, heterotrophic microbes, and detritus that is attached to submerged surfaces in most aquatic ecosystems. Periphytic algae are simple aquatic plants which inhabit the substrate of water bodies. As photosynthesizers, algae form the base of the aquatic food web.

Phylum: a principal taxonomic category that ranks above class and below kingdom.

Reach: continuous piece of surface water with similar hydrologic characteristics, such as a stretch of stream between two confluences or a lake, used as a unit of study.

Rearing habitat: area where fish take up residence during some stage of development and utilize the area for feeding, shelter, and growth.

Riparian vegetation: plant habitats and communities along the river margins and banks.

Spawning habitat: areas where eggs are deposited and fertilized.

Stream confinement: ratio of valley width to active channel width.

Substrate: material that rests at the bottom of a stream.

Taxonomic Richness: number of different species represented in an ecological community.

Wetted Width: width of the portion of the stream channel covered in water.

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1 INTRODUCTION

A preliminary Fisheries Offsetting Plan (FOP) has been developed for BMC Minerals (No. 1) Ltd. (BMC), Kudz Ze Kayah (KZK) Project (the Project), located in Yukon Territory, Canada (Figure 1-1). The purpose of the FOP is to accompany the request for authorization from Fisheries and Oceans Canada (DFO) under the *Federal Fisheries Act,* to undertake *work that may result in serious harm to fish*[1] in normal circumstances (e.g., non-emergency). The content of the FOP has been derived from *An Applicant's Guide to Submitting an Application for Authorization under Paragraph 35(2)(b) of the Fisheries Act* (DFO 2013b). The deliverables in this FOP describe how BMC proposes to address residual impacts to fish and fish habitat, in order to avoid serious harm to fish in the Project area and outlines BMC's proposed offsetting measures to mitigate any impacts.

The development plan for the Project includes the construction of mine infrastructure (open pit, process plant, camp, connecting roads), development of rock storage facilities (Class A, B and C Storage Facilities), tailings storage facility and water storage ponds in the upper Geona Creek watershed (Figure 1-2). Aquatic resource studies at KZK have determined the entire length of Geona Creek to be fish bearing, and is considered fish habitat. The placement of certain facilities into the upper half of Geona Creek will result in the direct loss of fish habitat and/or isolation of that habitat to fish access. Changes to the hydrology of Geona Creek (water diversion or direct storage) will also influence fish habitat in the area. BMC is required to obtain a *Fisheries Act* Authorization (FAA) prior to proceeding with development and construction of those facilities that may cause serious harm to fish that are part of a fishery. Therefore, this FOP has been developed in order to facilitate procurement of a FAA to ensure that BMC minimises and manages any potential harmful effects on the fish habitat that may be affected by the mine proposal.

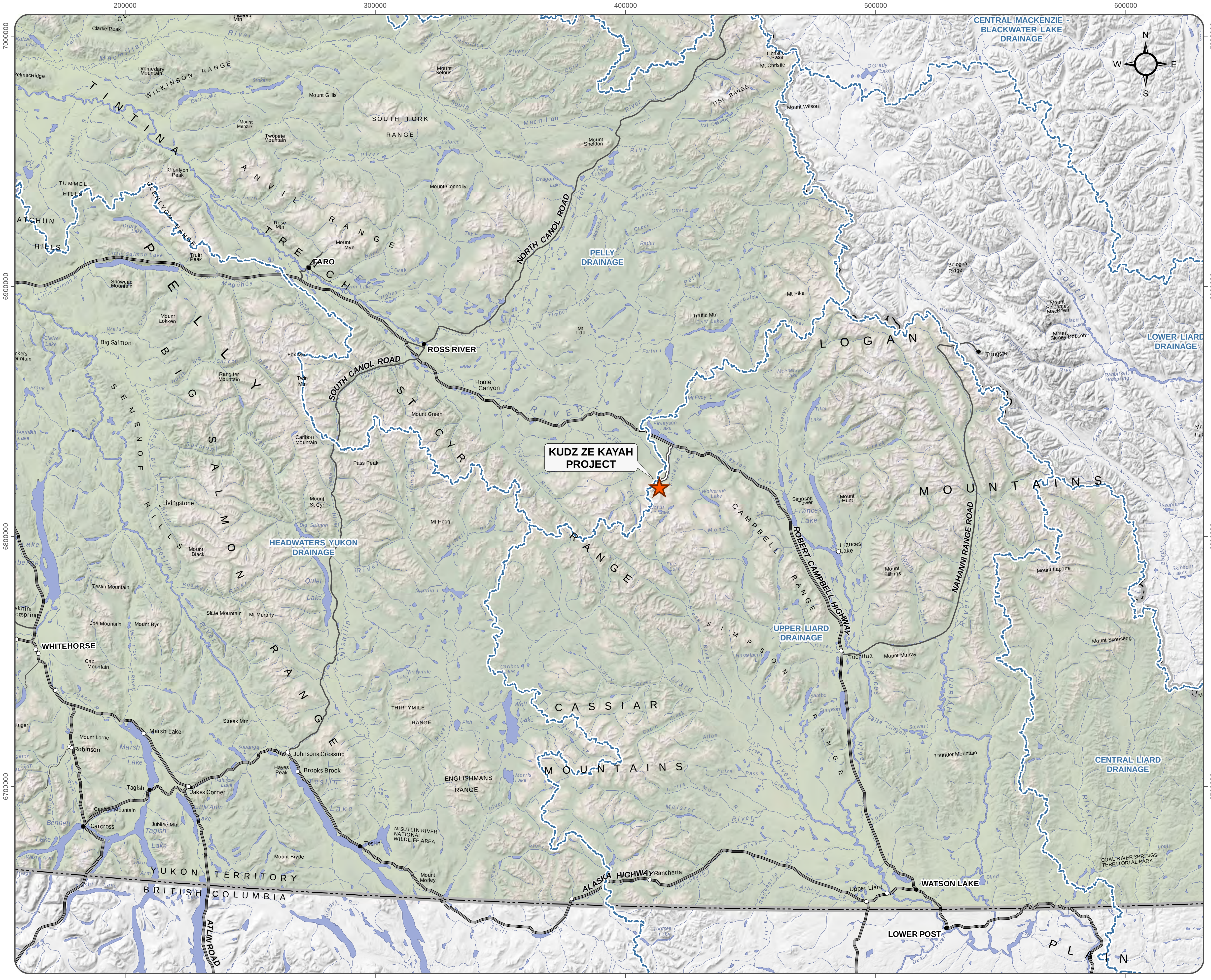
Contents of this FOP include:

- Reviewing previous plans for fish compensation;
- Summary of KZK Project activities;
- Reviewing regulatory criteria under the new Fisheries Protection Program (i.e., criteria assessment of a commercial, recreational and aboriginal fishery);
- Assessment of fish habitat within the Geona Creek watershed;
- Historical and recent assessments of fish use of Geona Creek and nearby watercourses;
- Life history of Arctic grayling (Thymallus arcticus), the primary fish species of concern;
- Measures and standards to avoid or mitigate impacts to fish and fish habitat;

[1] *"Serious harm to fish"* is defined in Subsection 2(2) of the *Fisheries Act* as "the death of fish, or any permanent alteration to, or destruction of, fish habitat."

- Direct and indirect impacts of mine development and operations to fish and fish habitat; and
- Measures to offset impacts to fish and fish habitat, and mitigations associated directly with offset developments.

Aquatic resource baseline data has been collected at KZK annually or every other year over the last twenty years. This has provided substantial background data which has been used for the development of this plan (Appendix E-3 of Project Proposal). It is understood that development of the final FOP will be an iterative process involving BMC and its engineering and environmental team and consultants, in discussion and consultation with Kaska First Nations, including the Ross River Dena Council, the Liard First Nation, and the Kaska Dena Council, DFO, Yukon Government (YG) Environment, YG Highways and Public Works, and Environment and Climate Change Canada. This preliminary Plan has been incorporated into the Kudz Ze Kayah Project Proposal to the Executive Committee of Yukon Environmental and Socio-economic Assessment Board for assessment, and will also be incorporated into the Type A Water Licence application.



KUDZ ZE KAYAH PROJECT
FISHERIES OFFSETTING PLAN

FIGURE 1 -1

LOCATION OF KUDZ ZE KAYAH PROJECT AREA

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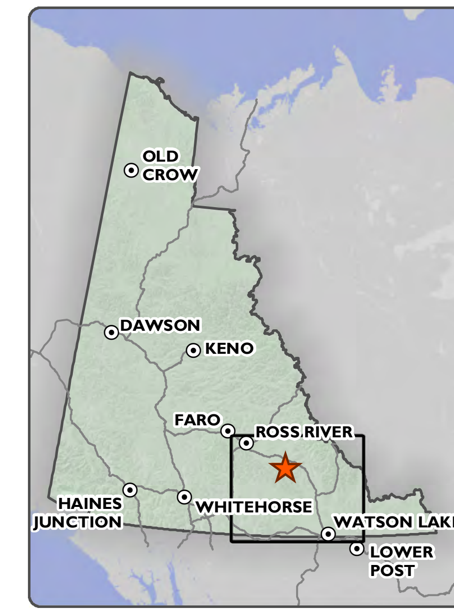

★ KUDZ ZE KAYAH PROJECT

Digital elevation model created by the Yukon Department of the Environment interpolated from the digital 1:50,000 Canadian National Topographic Database (NTDB Edition 2) contour and watercourse layers. Obtained from Geomatics Yukon.

Drainage areas obtained from National Hydrology Network 2011

Datum: NAD 83; Projection UTM Zone 9N

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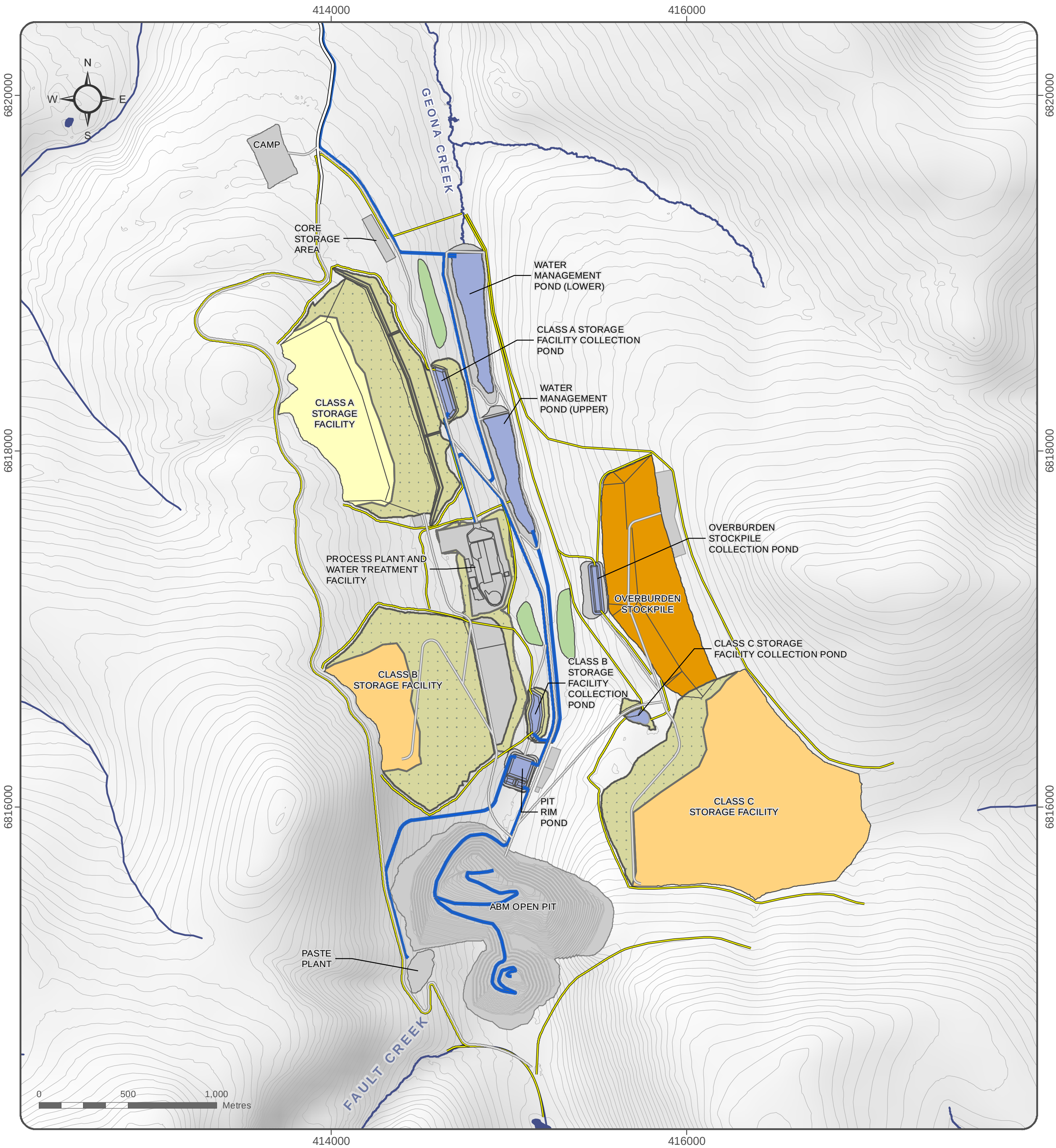

Class A Storage Facility
Class B and C Storage Facility
Overburden Stockpile
Topsoil Stockpile
Progressive Reclamation
Pond/Water
Pipeline
Diversion Ditch
Tote Road/ Proposed Access Road
Proposed Mine Road
Contour (10 m)

KUDZ ZE KAYAH PROJECT FISHERIES OFFSETTING PLAN

FIGURE 1-2

PROPOSED PROJECT SITE LAYOUT

Datum: NAD 83; Projection: UTM Zone 9N

AEG

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1.1 PLAN REQUIREMENTS

This preliminary FOP contains information requirements identified within the *Applicant's Guide to Submitting an Application for Authorization under Paragraph 35(2)(b) of the Fisheries Act* (DFO 2013b). Requirements outlined in Section 3, Schedule 1 of that guide, and their corresponding locations in this report, are identified in the table of concordance (Table 1-1).

Table 1-1: Table of Concordance

Schedule 1 Requirement	Location in FOP
Contact Information	Section 1.2
Location	Section 2.0
Description of Proposed Work, Undertaking or Activity	Section 2.1
Timeline	Section 2.2
Description of Fish and Fish Habitat	Section 4
Measures and Standards to Avoid or Mitigate Serious Harm to Fish	Section 5
Residual Serious Harm to Fish After Implementation of Avoidance and Mitigation Measures and Standards	Section 6
Offsetting Plan	Section 7

1.2 CONTACT INFORMATION

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1.3 PREVIOUS *FISHERIES ACT* COMPENSATION PLAN

The previous owners of the KZK property (i.e., Cominco Ltd) successfully obtained a FAA in 1997 under previous requirements of the *Fisheries Act* (Authorization Yukon Area 1997-03), which allowed the company to undertake harmful alteration of fish habitat in the upper Geona Creek valley. In addition to measures to mitigate/reduce harm during development of the Project, the FAA largely relied on a Fish

Habitat Compensation Plan (FHCP) to “ensure no net loss of fish production.” The plan consisted of two commitments:

1. Stocking two barren lakes in the local area primarily with Arctic grayling that were salvaged from upper Geona Creek; and

2. Creation of new habitat, including an Arctic grayling spawning area in the upper South Creek drainage, resulting from a planned diversion of Fault Creek from the Geona Creek watershed to the South Creek watershed.

This plan was never implemented, as Cominco Ltd. did not advance the Project. However, following the acquisition of the property by BMC in January 2015, advanced planning is in progress to develop a mining project similar in scope and approach to the previous plan and with a similar development footprint. The anticipated disturbance to fish and fish habitat will be less, as waste storage locations, and tailings handling methods have been modified significantly. The previous mine plan developed by Cominco Ltd. included the placement of waste facilities (waste rock and tailings) directly into the Geona Creek floodplain, behind a water filled dam. BMC has altered that plan and will now establish those facilities outside of the floodplain, however, two temporary water management ponds for operations will be established in the creek towards the downstream end of the mine development zone. At closure these ponds will be converted into a wetland passive treatment system. These structures will likely permanently prevent fish from accessing habitat upstream during mine construction, operations, closure and post-closure. The open pit that will be developed will be situated directly in Geona Creek headwaters as was proposed in the previous Project plan. Therefore, BMC has developed an updated FOP that takes into consideration changes to the mine plan (Section 2), additional fisheries information collected since the previous FAA was issued (Section 4), and changes to the Fisheries Protection Program (FPP) that were implemented in 2013 (Section 3).

2 KZK PROJECT

The Project is located within the Pelly River and Pelly Mountain ecoregions in Yukon Territory. It is located within the northern foothills of the Pelly Mountains of the Yukon Plateau, on the east side of the divide between the Pelly River and the Liard River drainage basin. Access to the Project is via a 24 km single lane gravel Tote Road that connects the Project to the Robert Campbell Highway. The Project site is located on Map Sheet 105G/7-10 and shown on Figure 1-1.

2.1 DESCRIPTION OF ACTIVITIES

The following briefly summarises the Project. A more detailed description is available in Chapter 4 (Project Description). In general, the Project encompasses the ABM Deposit, of which there are two zones the ABM Zone and the Krakatoa Zone. The open pit will be located at the upper reach of the Geona Creek watershed (Figure 1-2) and will extend up the east and west sides of the valley. The ABM Deposit is a polymetallic volcanogenic massive sulphide (VMS) deposit containing economic concentrations of copper, lead, zinc, gold and silver. Mining is planned to be conducted via both open pit and underground mining methods, with ore processed into separate copper, lead and zinc concentrates via sequential flotation through a nominal 2 million tonnes per year (Mtpa) processing plant. The mine is planned to operate for ten years, producing up to 185,000 t zinc, 60,000 t copper, and 35,000 t lead concentrates annually.

In addition to the open pit and underground mining component Project infrastructure will include the following:

- Open-pit and underground mine;
- Processing plant and associated structures;
- Dry stack tailings, waste rock storage, and associated water collection facilities;
- Overburden and topsoil storage facilities;
- Water treatment facility and Operations Water Management Ponds;
- Liquefied natural gas and diesel power generation facility;
- Paste back fill plant;
- Site roads;
- Core shack and storage; and
- Mine camp, maintenance facilities, sewage treatment, and waste disposal facilities.

Waste and water management are key components of the Project. The processed tailings and a portion of the waste rock are potentially acid generating, thus, a major program to evaluate and develop plans for the management of these materials has been undertaken (see Project Proposal Appendix D-4 Acid

Rock Drainage Metal Leaching Characterization Report for additional details). The site has a positive water balance and therefore, excess water must be discharged from the site. Water management plans have been developed to minimize the impact of controlled discharges on the receiving environment.

At closure the water management ponds to be situated in Geona Creek (Figure 1-2) will be converted into wetlands and serve as a passive water treatment system. This system is planned because water quality of Geona Creek upstream (i.e., coming from the mine footprint) is predicted to have certain parameters that will exceed the water quality objectives at closure (Appendix H-1) that can be removed by passive treatment. This system will remain in place in perpetuity.

2.2 TIMELINE / SCHEDULE

The life of the mine will occur in three phases, construction, operations and closure. Construction is anticipated to take approximately two years and will include site preparation, clearing and establishment of Project infrastructure. The operations phase will be approximately ten years and will include open pit and underground development as well as ore processing. The closure phase will consist of three years for decommissioning, reclamation and active closure, followed by a 13 year transition period during which the ABM open pit fills and a post-closure period starting when the ABM lake begins to spill to Geona Creek (year 26).

The Project Proposal will be submitted for environmental assessment and permitting in 1st quarter (Q1) of 2017 with project construction phase being initiated shortly after all required permits and authorizations (including the FAA) have been obtained. A schedule of activities with actual dates will be developed once it is understood when required permits will be issued.

3 FISHERIES PROTECTION PROGRAM (FPP) OF THE *FISHERIES ACT*

Since the previous FAA was issued in 1997 there have been updates made to the *Fisheries Act* and the FPP. The purpose of the revised *Fisheries Act* is to prevent serious harm to fish that are part of a commercial, recreational or aboriginal fishery. The changes made reflect the new provisions of the *Fisheries Act*, which came into force on November 25, 2013 (DFO, 2013a).

3.1 PURPOSE OF THE NEW FISHERIES PROTECTION PROVISIONS

The new Section 6.1 of the *Fisheries Act* sets out the purpose for decision-making under the fisheries protection provisions: "to provide for the sustainability and ongoing productivity of commercial, recreational and Aboriginal fisheries."

In this context, DFO interprets:

- Sustainability as the use of the environment and resources to meet the needs of the present, without compromising the ability of future generations to meet their needs; and
- Productivity as the sustained yield of all component populations, species, and habitats that support and contribute to a fishery in a specified area.

3.2 THE PROHIBITION AGAINST SERIOUS HARM TO FISH

The recently amended fisheries protection provisions has established prohibition 35(1) which states that "No person shall carry on any work, undertaking, or activity that results in serious harm to fish that are part of a commercial, recreational or Aboriginal fishery, or to fish that support such a fishery."

It is understood that Section 35 is not a permitting scheme but rather a prohibition against serious harm to fish. Therefore, it is BMC's responsibility to avoid serious harm through appropriate design and mitigation measures. BMC has determined that although the new design reduces impacts, the potential for serious harm to fish cannot be avoided and therefore, must apply for authorization under Section 35(2).

Definition of "Serious Harm to Fish" is defined in the *Fisheries Act* as "the death of fish or any permanent alteration to, or destruction of, fish habitat." In terms of implementing the provision, DFO interprets the prohibition as:

- The death of fish;
- The permanent alteration to fish habitat as an alteration of such duration that limits or diminishes the ability of fish to carry out one or more of their life processes; and

- The destruction of fish habitat as an elimination of habitat such that fish can no longer rely on this habitat to carry out one or more of their life processes.

Protected fish and their habitats are defined under the prohibition Section 2 of the Fisheries Act which provides definitions of commercial, recreational and Aboriginal, in relation to a fishery:

- *A **commercial Fishery** refers to fish that are harvested under the authority of a licence for sale, trade, or barter*;

- *A **recreational Fishery** refers to fish that are harvested under the authority of a licence for personal use or sport; and*

- *An **Aboriginal fishery** refers to fish that are harvested by an Aboriginal organization or any of its members for the purpose of using the fish as food, for social or ceremonial purposes, or for purposes set out in a land claims agreement entered into with the Aboriginal organization*.

The prohibition also applies to fish that are part of, or support a commercial, recreational, or Aboriginal fishery. The fish habitats of these fisheries are those that provide functions for sustaining the production of commercial, recreational or Aboriginal fishery species. These areas may occur in other water bodies outside the location of the fishery and be connected through food webs and migrations.

The four factors to be taken into account by the Minister in decision-making (e.g., issuing authorizations) or making regulations under the fisheries protection provisions are:

- Contribution of the relevant fish to the ongoing productivity of commercial, recreational or Aboriginal fisheries;
- Fisheries management objectives;
- Measures and standards to avoid, mitigate or offset serious harm to fish that are part of a commercial, recreational or Aboriginal fishery; and
- Public interest.

3.3 COMMERCIAL, RECREATIONAL AND ABORIGINAL FISHERY RELEVANCE AT KZK

3.3.1 COMMERCIAL FISHERY

Geona Creek and Finlayson Creek do not support a commercial fishery, nor is there any likelihood that it has in the past or would in future years.

3.3.2 RECREATIONAL FISHERY

Arctic grayling adults frequent the Finlayson Creek watershed (Figure 4-1) and may contribute marginally to recreational fishing opportunities in that system. No adult grayling were encountered in Geona Creek during investigations in the 1990's; however, more recent surveys have determined that a limited number of adults occur in Geona Creek and use it for spawning. Grayling are the only recreational fish that occur in Geona Creek and is the only species that has been captured or observed in the creek above its confluence with Finlayson Creek. Conversely, numerous slimy sculpin (*Cottus cognatus*) have been encountered in Finlayson Creek, but very few grayling have been encountered in Finlayson Creek above the culvert at the Robert Campbell Highway 20 km downstream of the proposed Project site. Numerous grayling have been captured immediately downstream of the culvert over eight years of sampling.

Based on sampling information collected over the last two decades, recreational fishing opportunities are limited or non-existent in the Finlayson Creek watershed above the Robert Campbell Highway due to the low numbers of grayling encountered there. There may be the potential for recreational fishing of grayling below the highway culvert. Fishery investigations have been conducted since 1995 on a bi-annual basis in order to maintain compliance with a Water Use Licence (QZ96-026), issued in 1998. These investigations have shown that grayling tend to congregate in lower Finlayson Creek on the downstream side of the Robert Campbell highway, approximately 20 km biennial basis downstream from the proposed mine site. More recent investigations on the physical attributes of the culverts and their elevated velocities exiting at the culverts indicate they probably form at least a partial barrier to fish passage and thus may account for the apparent lack of larger populations of grayling upstream. Results from these investigations are discussed in more detail in Section 7.2. Descriptions of fish and fish habitat in Geona and Finlayson Creeks are presented in Section 4.

3.3.3 ABORIGINAL FISHERY

Due to the low productivity of fish in Finlayson Creek above the Robert Campbell Highway, there is limited opportunity for the harvest of fish for Aboriginal use. Arctic grayling that rear and spawn in Geona Creek may contribute recruits to the Finlayson system, although this appears to be very minimal based on sampling data to date. Fish habitat replacement proposed in this plan (Section 7.0) has been designed to at a minimum to maintain current grayling productivity levels in Geona Creek, which in turn would continue to contribute fish to Finlayson Creek. Additionally, a plan to reconnect habitat on Finlayson Creek, isolated by the culverts at the Robert Campbell Highway (described in Section 7.2), should increase grayling productivity in the system; therefore, enhancing the system overall and increasing the opportunity for Aboriginal use of the system.

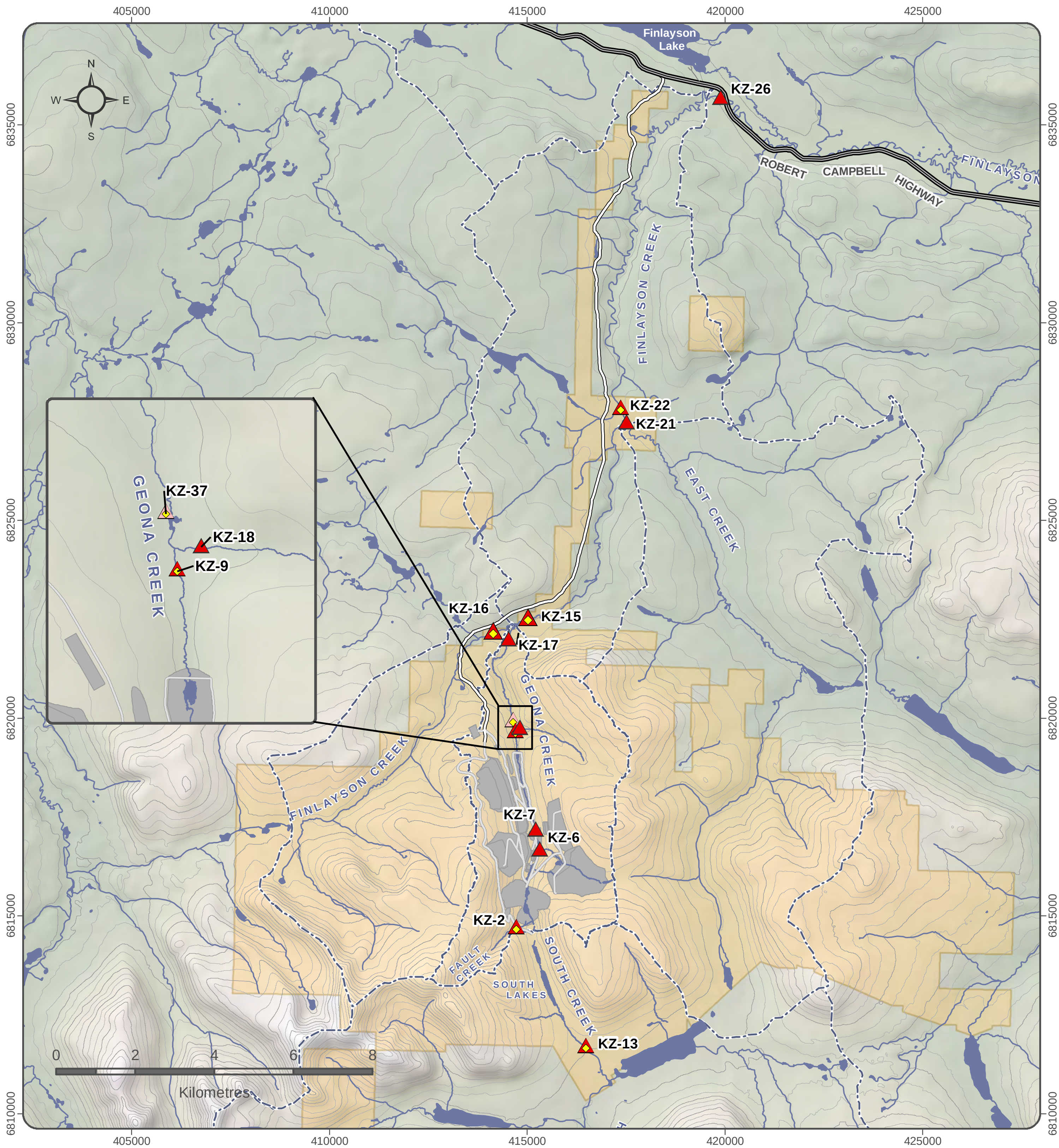
4 DESCRIPTION OF FISH AND FISH HABITAT

4.1 GEONA CREEK WATERSHED

Geona Creek is 9.1 km in length and drains an area of approximately 25.7 km^2. The creek flows generally northward where it drains into Finlayson Creek, which in turn drains into the Finlayson River (Figure 4-1). For descriptive purposes, Geona Creek has been divided into four distinct reaches (Figure 4-2). The following table summarises characteristics of each reach (Table 4-1). Additional details of the reaches (including photos) are available in the Aquatic Resource Baseline Report (Appendix E-3 of Project Proposal).

Table 4-1: Summary of Reach Characteristics

Characteristic		Reach 1	Reach 2	Reach 3	Reach 4
Reach Length (m)		4847	1312	218	2717
Total Area (m^2)		14766	25124	1703	5705
Pond/pool habitat (m^2)		430	4719	No functional pools in this reach	46670
Average Slope (%)		2.6	2.1	2.3	1.2
Channel Width (m)		5.5	29.13	13.53	4.88
Wetted Width (m)		3.2	19.2	7.81	2.1
Average Pool Depth (m)		0.75	0.3	0.2	0.32
Stream Cover	Dominant	Overhanging vegetation	Boulders	Instream vegetation	Boulders
	Sub-dominant	Small woody debris	Small and large woody debris	Overhanging vegetation and boulders	Undercut banks and overhanging vegetation
Total Cover (%)		25	8	12	12
Crown (Canopy) Closure (%)		0	0	0	0
Left Bank Shape		Undercut	Sloping	Sloping	Undercut and vertical
Right Bank Shape		Undercut	Sloping	Sloping	Undercut, vertical and sloping
Riparian Vegetation	Left Bank/Right Bank	Grass and shrubs (both banks)	Grass and shrubs (both banks)	Grass, shrub and conifer/ grass and shrub	Grass, shrub and wetland spp./grass and shrub
Bank Texture	Left Bank/Right Bank	Fines and gravels/ fines, gravel and cobble	Cobble and boulders (both banks)	Gravel/ gravel, cobble and boulder	Fines and gravel/ fines, gravel, cobble and boulder
Bed Material	Dominant	Fines	Boulders	Gravel	Cobble
	Sub-dominant	Gravel	Cobble	Cobble/Boulder	Boulders/Gravel
Stream Pattern		Irregular with some meandering	Sinuous	Sinuous	Irregular wandering
Stream Confinement		Occasionally confined	Occasionally confined	Occasionally confined	Occasionally confined



Water Quality and Hydrometric Station

Water Quality Sampling Location

Proposed Water Quality and Hydrometric Station

Selected Regional Catchments

Location of Proposed Mine Infrastructure

BMC Minerals (No. 1) Ltd. Claims

Tote Road/Proposed Access Road

Proposed Mine Road

Contour (40 m interval)

Watercourse

Waterbody

KUDZ ZE KAYAH PROJECT
FISHERIES OFFSETTING PLAN

FIGURE 4-1

REGIONAL CATCHMENTS AND WATER QUALITY AND HYDROMETRIC MONITORING STATIONS

JANUARY 2017

National topographic Data Base (NTDB) compiled by Natural Resources Canada at a scale of 1:50,000. Reproduced under license from Her Majesty the Queen, as represented by the Minister of Natural Resources Canada. All rights reserved.
Datum: NAD 83; Projection: UTM Zone 9N

AEG

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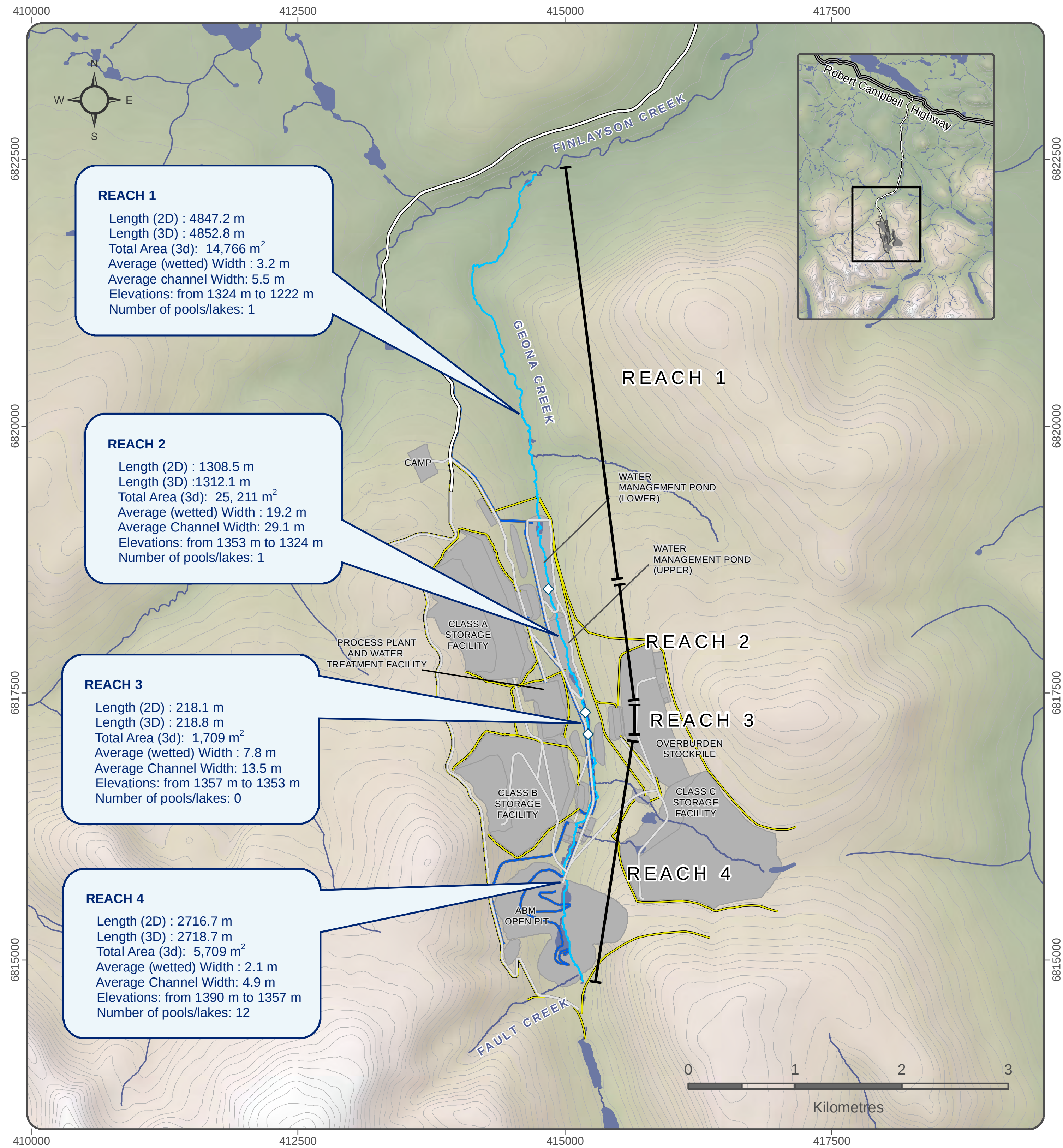

- ◇ Reach Break
- Geona Creek
- Other watercourse
- Contour (20 m interval)
- Tote Road/Proposed Access Road
- Proposed Mine Road
- Diversion Ditch
- Pipeline
- Location of Proposed Mine Infrastructure
- Waterbody

Reach characteristics from field observations or from 2015 LiDAR data analysis (with the exception of for reach 1, for which LiDAR data was not available and so lenghts and heights taken from CANVEC data (50k)
Datum: NAD 83; Projection: UTM Zone 9N

AEG

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KUDZ ZE KAYAH PROJECT
FISHERIES OFFSETTING PLAN

FIGURE 4-2

GEONA CREEK REACH CHARACTERIZATION

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Fault Creek is a small, high gradient headwater tributary of Geona Creek, approximately 2 km in length and with 2 km^2 of drainage area. Several small tributaries drain into Geona Creek contributing to its flow (Figure 4-2).

In general, Geona Creek provides pond and riffle habitat. Some of the ponds are natural morphological features, while others have developed due to beaver activity in the system. The majority of pond habitat occurs in the upper reaches of Geona Creek where mine development will be concentrated. One large, active beaver dam and accompanying pond (Plate 4-1) is situated at the downstream end of Geona Creek near the confluence with Finlayson Creek (Figure 4-2). Hydrological characteristics of Geona Creek are described in detail in Section 6.1.

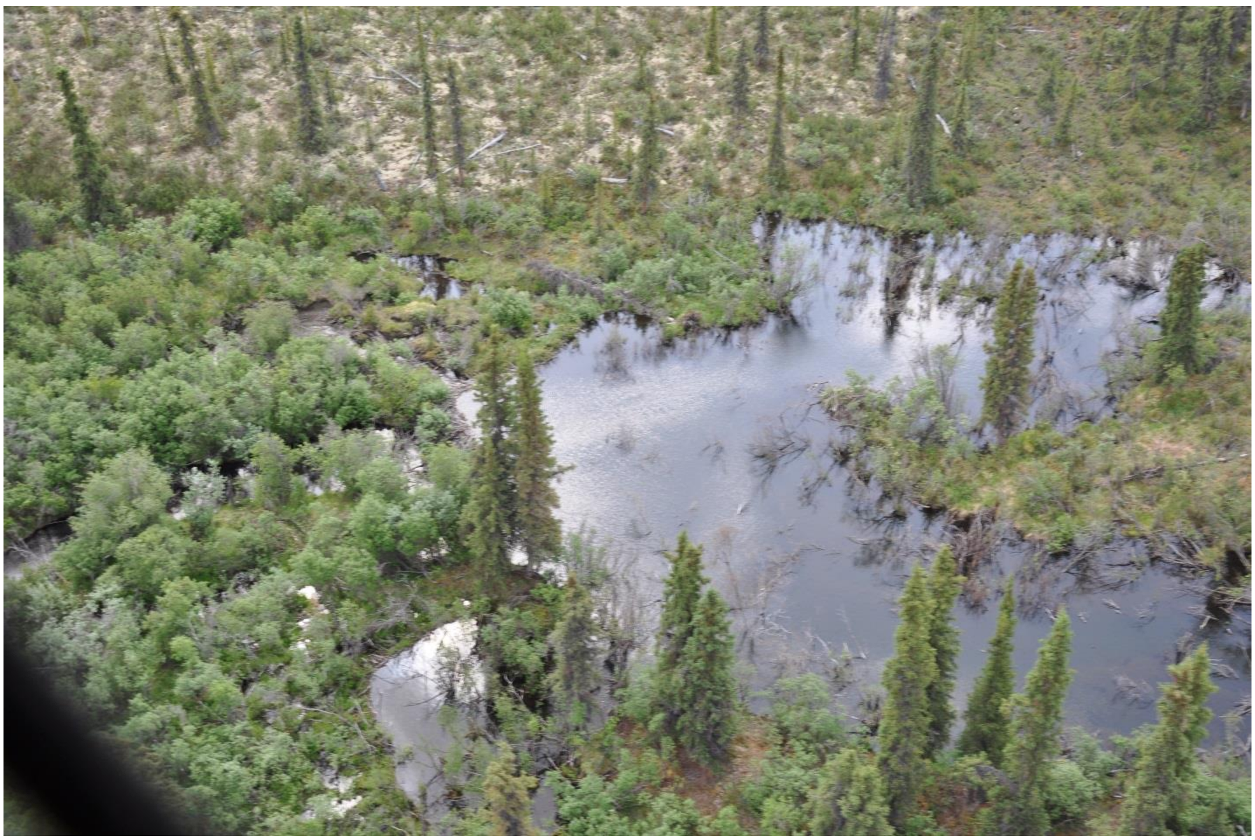


Plate 4-1: Beaver Pond Situated at the Lower End of Geona Creek[2]

[2] As of November 2016 the beaver pond has drained due to failure of the dam

4.2 FISHERY RESOURCES IN PROJECT AREA

The following section describes the fish resources of Geona Creek, lower reaches of Finlayson Creek, and South Creek. To provide further context and understanding, a description of the life history of Arctic grayling is provided in Section 4.2.2. Arctic grayling is the only species of concern with respect to mine development.

4.2.1 FISH RESOURCES IN GEONA CREEK AND SURROUNDING WATERWAYS

In general, fish investigations in Geona Creek over the last two decades indicate that Arctic grayling are the only fish found in the system, and that all stages of grayling life history (fry, juvenile and adults) occur and use the system for rearing and spawning and possibly overwintering. Population estimates for grayling in Geona Creek have not been done, but based on Catch per Unit Effort (CPUE) the numbers of grayling in the system are relatively low (Appendix E-3 of Project Proposal). No grayling (or any other species) have been encountered in the small tributaries that flow into Geona Creek. This includes Fault Creek, which is a headwater tributary of Geona Creek (Appendix E-3 of Project Proposal).

It appears there has been a small resident population of grayling in Geona Creek, partially isolated in the system by the beaver dam near the confluence with Finlayson Creek. This dam has likely prevented fish in Finlayson Creek from migrating into Geona Creek. In fact, while there are numerous slimy sculpin residing in Finlayson Creek, none have been encountered in Geona Creek above the beaver impoundment at the confluence. This beaver dam however has recently failed as observed during a site investigation in November 2016. This will likely influence fish use in the system in future months and years., Even without the beaver dam barrier on lower Geona, migration of grayling up Geona Creek may be limited due to a culvert barrier at the Robert Campbell Highway; this is discussed in more detail in Section 7.2. Overwintering habitat investigations conducted in Geona Creek during 2016 indicate very little overwintering habitat is available in the upper ponds. Therefore, overwintering fish in the system may be limited to residing in one of several beaver ponds in the system.

Fish and fish habitat investigations were conducted on Geona and other nearby creeks in the mid-1990’s as part of baseline studies to support environmental assessment for mine permitting (Norecol, Dames & Moore, 1996). These investigations determined that Arctic grayling inhabit Geona Creek but are present in low numbers. Of the grayling captured during these studies, the majority were 1^+ age class with some older fish. The report by Norecol, Dames & Moore Ltd (1996) suggested that the age of the majority of fish captured were 2^+ or older with no adults captured. Based on a review of expected growth rates for grayling in their first year in northern regions (Hubert et al., 1985), it is likely that some of the fish identified as 2 years old were likely a 1^+ age class.

Below is a summary of fish sampling results in Geona Creek and other waterways in the vicinity of the proposed mine infrastructure that supported assessment and permitting submissions in the mid-1990’s.

Further details of the work are available in the Aquatic Resource Baseline Report (Appendix E-3 of Project Proposal).

Low numbers of Arctic grayling and were found in the immediate Project area. Young grayling (2 to 3 years) inhabit the headwater lakes (beaver ponds) in Geona Creek and likely overwinter in the deepest zones. No full-sized adult grayling were captured or observed in Geona Creek after extensive electrofishing, while adults were caught in other parts of the study area. No fish were captured in Fault Creek, a small headwater tributary of Geona Creek.

Arctic grayling and burbot (*Lota lota*) were found to inhabit the headwater lakes in South Creek.

Several species of adult fish were captured in the North Lakes system. Adult grayling were also found in the Finlayson Creek system below Geona Creek in the spring of 1995. The authors concluded that the large fish are moving into the smaller watercourses from large lakes and rivers. However, the headwater areas contained fewer species, fewer adults, and low numbers of fish in general. The beaver dams likely contributed significantly to this pattern of fish distribution.

The upper East Creek drainage appeared to be devoid of fish upstream of the beaver dams based on extensive electrofishing and diver surveys in that area. Numerous large beaver dams were determined to be fish migration barriers, especially at low flows. Juvenile grayling were encountered in lower East Creek.

No bull trout (char) (Salvelinus confluentus) or Dolly Varden char (Salvelinus malma) were found in any of the creeks sampled. “It is likely that there are no resident salmonid species other than Arctic grayling in the creeks and beaver ponds within the project area. Lake trout were found in the North Lakes and are known to occur in Finlayson Lake, but none were found in the Finlayson Creek or South Creek systems.” (Norecol, Dames & Moore, 1996).

Sufficient samples of Arctic grayling and slimy sculpin were collected for metals analysis in most of the study watercourses and levels were found to be below guidelines for human consumption.

Survey results for creeks crossing the Tote Road indicated that none of the small creeks would likely support fish, except the mainstem of Finlayson Creek. One of the small tributary creeks was judged to be physically capable of supporting fish, although it provides little habitat.

Following environmental review and permitting, Cominco Ltd. was issued a Yukon Territory Water Use Licence for the proposed Project. This current licence (QZ97-026-01) includes a biennial fish monitoring requirement, of which BMC has been compliant. However, these studies only sampled fish in Finlayson Creek near the confluence with Geona Creek (KZ-15 and KZ-16), East Creek confluence (KZ-22), and the Robert Campbell Highway culvert (KZ-26) (Figure 4-1). Further detail is available in the appended Aquatic Resource Baseline Report (Appendix E-3 of Project Proposal). A summary of those sampling events is presented below:

- From 2002 to 2014, except for one burbot captured at KZ-26 in 2012, only slimy sculpin and Arctic grayling have been captured in Finlayson Creek;
- Only one grayling was captured at the upper Finlayson sites (KZ-15, KZ-16, and KZ-22) over eight years of sampling. This indicates the use of upper Finlayson Creek by grayling is limited; and
- Numerous grayling have been captured at KZ-26, most on the downstream side of the road culverts.

Aquatic resource baseline studies in the vicinity of the proposed Project infrastructure were re-initiated in spring of 2015 to update previous work to support BMC's plan to permit the site for mine development. The following summarizes fish sampling results from the most current investigations which are detailed in the Aquatic Ecosystems and Resources Baseline Report (E-3):

- Results of the 2015 fisheries investigations are generally consistent with previous findings. Fish were captured in low numbers, with the highest CPUE recorded near the headwaters of Geona Creek but below Fault Creek. The only species captured in Geona Creek was Arctic grayling, with the exception of one slimy sculpin captured at the confluence with Finlayson Creek. All of the Arctic grayling captured in Geona Creek were fry or juveniles, except for one possible sub-adult. Only three small grayling were captured during the June 2015 sampling event. Based on their fork-length size (83-86 mm) these fish were likely spawned the previous year (i.e., 1^+ age-class). During the August sampling event a number of the grayling captured had fork-length's ranging from 46-81 mm. Based on this size range, these individuals were likely recruits from 2015 spawning events. Since fish are likely prevented from migrating into Geona Creek due to the beaver dam, these fish are probably recruits from grayling spawning events in the creek. Three larger grayling were captured in Geona Creek during the August 2015 sampling event, ranging in size from 107 mm to 205 mm. Sampling in Geona Creek in October resulted in the capture of only 0^+ age class grayling, ranging in fork length size of 49 mm to 70 mm. Therefore, based on these results it was suspected that some adults over-winter and spawn in Geona Creek. Spawning surveys were therefore conducted in spring of 2016 and resulted in the observation of adult grayling spawning in the system as described in the Aquatic Resources Baseline Report.
- Overwintering habitat investigations conducted in 2016 indicates overwintering habitat in upper Geona Creek where the majority of ponds in the system are situated, may be limited or marginal at best. The ponds in upper Geona (above KZ-9) are shallow, either freezing to the bottom or have low dissolved oxygen (Appendix E-3 of Project Proposal). During these investigations it was determined that there is oxygenated flow below KZ-9, and pond habitat in lower Geona (i.e., beaver pond near Finlayson Creek) could potentially sustain fish throughout the winter. Additional overwintering investigations are in progress (winter 2016-2017) to help confirm the presence or absence of overwintering habitat in upper Geona creek. To date (December 2016) it has been determined that there is some limited overwintering potential (i.e., oxygenated water) in certain

ponds. As the winter season progresses this habitat will be monitored to determine if overwintering habitat potential is sustained throughout the season.

- It was determined in spring 2016 that a small population of adult grayling inhabit Geona Creek. Adult spawning was observed in the upper reaches, which will be impacted by mine development. It is suspected these adults remain in Geona Creek year-round and potentially over-winter somewhere in the system. Overwintering in the creek is assumed as the beaver dam structure was likely a barrier to fish passage. Therefore, it appears that grayling may have established a small resident population in the creek and are spawning successfully based on the occurrence of young grayling (young of the year and 1^+). Future fisheries monitoring programs will determine the influence the loss of the beaver structure in lower Geona Creek will have on the resident population in the system.
- Fish sampling in surrounding watercourses (South Creek, North River, East Creek) indicated the presence of Arctic grayling, slimy sculpin, and burbot. No fish were captured in Fault Creek, despite significant sampling effort applied.
- Collection of baseline information is ongoing and as that information comes forward updates will be made to the baseline report (Appendix E-3) and this FOP. This includes benthic monitoring conducted in 2016 as a requirement of the current WUL.

4.2.2 ARCTIC GRAYLING LIFE HISTORY

Arctic grayling are found across northern North America, Asia and Europe having a holarctic distribution (Scott and Crossman, 1973). They are found throughout the Yukon inhabiting lakes, rivers and streams (McPhail, 2007). Grayling will move between various systems depending on the time of year (season) and life history stage (Stewart et. al., 2007). Typically, adult grayling inhabit the main stem of rivers and lakes in late fall and winter moving to tributary streams in the spring to spawn, returning to the larger order systems following spawning. Juveniles will also move up into smaller tributaries but their movement can differ from one system to the next. In smaller tributary systems, all age classes will tend to move downstream to overwintering habitat in the fall (Hubert et al., 1985). Figure 4-3 depicts typical seasonal movement of grayling fry, juvenile, and adults throughout the open water system in creeks and streams in a northern environment. Movement is also influenced or prevented by physical factors such as variable flow-rates (too high or too low), stream gradient, winter freezing and natural barriers including cascades, waterfalls, beaver dams or by man-made barriers including culverts and habitat disruption.

Grayling typically like cold, clear-water rivers and streams avoiding highly turbid areas. Pool or pond habitat is very important. Grayling are rarely found in riffle habitat but instead tend to reside in pools (Hubert et al., 1985). Spawning typically occurs over gravel in small tributary streams. There is a preference for the transition zone between a riffle and pool (Hubert et al., 1985), but when no appropriate spawning habitat is available, "spawning occurs over gravel and rock or sometimes over muddy vegetated areas in pools of large rivers" (Scott and Crossman 1973). Eggs hatch relatively quickly (depending on water temperature) but usually between 8-32 days (Roberge et al., 2002). Young at hatching are about 8 mm in length, but grow quickly initially reaching about 40-70 mm by late August (Scott and Crossman, 1973; Hubert et al., 1985). Sexual maturity can be reached as early as 4 years of age but is typically reached between 6-9 years (Scott and Crossman, 1973).

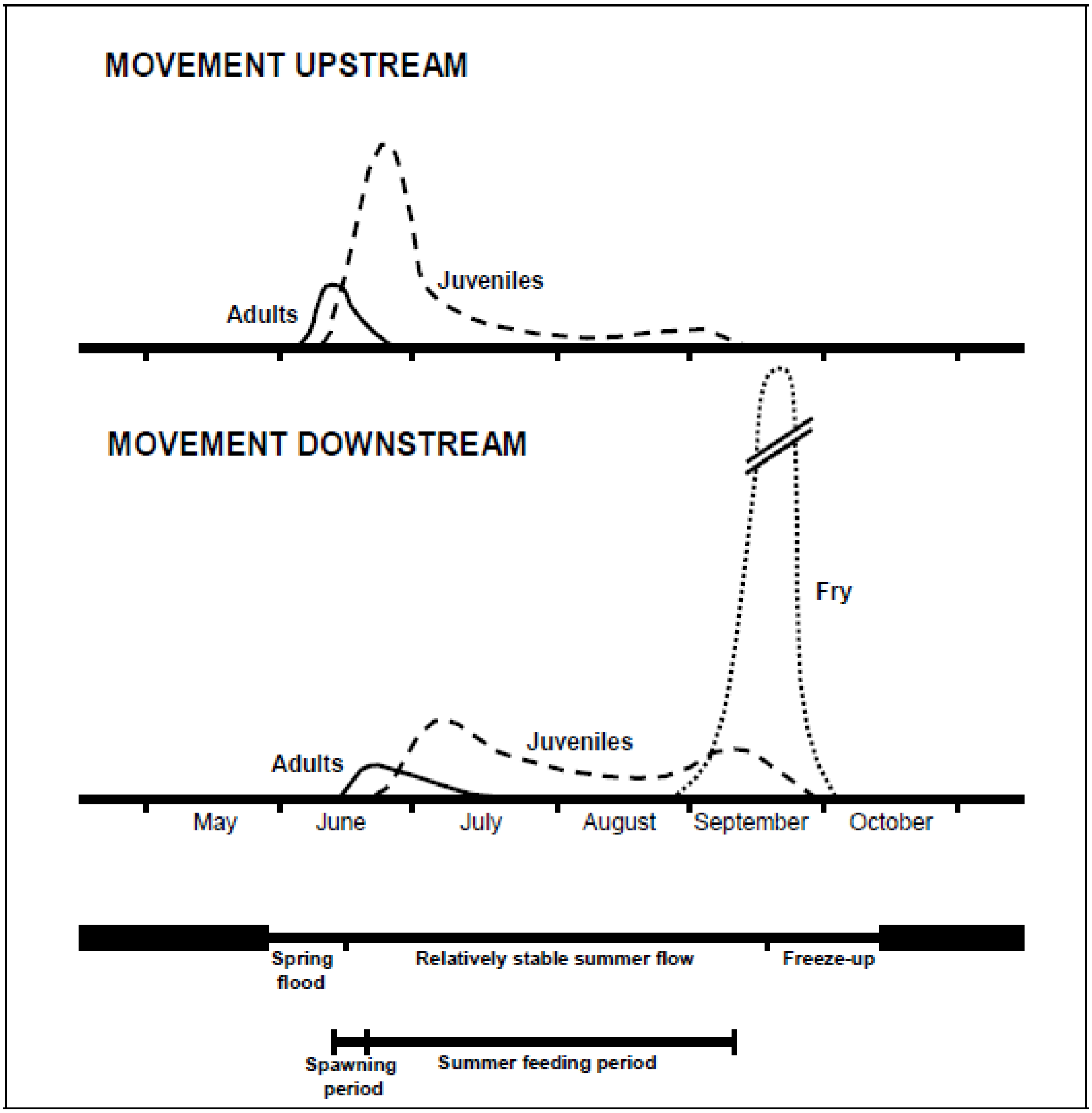


Figure 4-3: Schematic Diagram of Grayling Movements in Small Alaskan Streams (Craig and Poulin, 1975, p. 696)

Habitat requirements for all life stages of Arctic grayling are summarised in the table below (Table 4-2). Habitat criteria presented in Table 4-2 were derived from: Scott and Crossman, 1973; Roberge et al., 2002; McPhail, 2007; Stewart et al., 2007. Additional notes and discussion on habitat suitability requirements are presented in Appendix A. The criteria presented in Table 4-2 will be used to guide the design and development of proposed offsetting structures. Discussions on habitat use and movement patterns within various habitat types in these publications are not consistent. This indicates that habitat use by grayling can be highly plastic and site specific.

Table 4-2: Physical Habitat Criteria/Metrics by Life History Stage Suitable to Sustain Arctic Grayling Populations in Northern Aquatic Systems (Derived from Scott and Crossman, 1973; Roberge et al., 2002; McPhail, 2007; Stewart et al., 2007)

Life History Stage	Metric	Description	Optimal Range	Aim to not exceed these values
Spawning and Embryo Development	Water Temperature	Average maximum water temperature during warmest period of the year	7.5 to 15°C	Below 4°C and above 25°C
	Dissolved oxygen	Average minimum dissolved oxygen during the late summer period	3.5 to 12 mg/L	Below 2 mg/L
	Gravel and Rubble Substrate	Percentage of substrate composed predominately of gravel and rubble	20 to 25%	Below 20% is not ideal but still adequate for grayling survival
	Fines	Percentage of substrate composed of fines	0 to 10%	Greater than 50% fines
	Velocity	Average Water Velocity	0 to 0.15 m/s	Below 0.05 m/s and above 1 m/s
	Pools	Percentage of pool, backwater, and side channel areas with water velocity <0.15 m/s	30 to 50%	Below 20% is not ideal but still adequate for grayling survival
Fry Rearing	Water Temperature	Average maximum water temperature during warmest period of the year	7.5 to 15°C	Below 4°C and above 25°C
	Velocity	Average Water Velocity	0 to 0.15 m/s	Anything above 0.175 m/s
	Depth	Average Water Depth	0.07 to 0.65 cm	Below 0.05 cm and above 0.92 cm
	Substrate	Dominant substrate particle size	Cobble/Boulder	n/a
Juveniles and Adults	Water Temperature	Average maximum water temperature during warmest period of the year	7.5 to 15°C	Below 4°C and above 20°C
	Dissolved oxygen	Average minimum dissolved oxygen during the late summer period	3.5 to 12 mg/L	Below 3 mg/L
	Spawning Access	Annual frequency of early spring access to tributary spawning streams within 150 km of wintering areas	0 to 1 year	n/a
	Wintering Habitat	Occurrence of winter habitat (i.e., deep pools with water velocities <0.15 m/s that do not freeze solid in winter)	Overwintering Habitat Present	n/a

5 MEASURES AND STANDARDS TO AVOID OR MITIGATE SERIOUS HARM TO FISH

Under Section 3.4.3 of the FPP the Minister must consider whether measures and standards to avoid, mitigate or offset serious harm to fish that are part of, or that support, a commercial, recreational or Aboriginal fishery have been applied. In this context, DFO interprets:

- **Avoidance** as measures to completely prevent adverse effects to fish and fish habitat;
- **Mitigation** as measures to reduce the duration, intensity or extent of adverse effects to fish and fish habitat that cannot be completely avoided; the best-available measures or standards should be implemented as much as practically, technically and economically feasible; and
- **Offsetting** as measures to offset serious harm to fish by maintaining or improving the productivity in the area of the affected fishery.

> *These factors build upon a mitigation hierarchy which is internationally recognized by the Convention on Biological Diversity (1992) as best practice in reducing risks to biodiversity. According to the mitigation hierarchy, efforts should be made to prevent (avoid) impacts first, then, when avoidance is not possible minimise (mitigate) impacts, and then repair or restore adverse effects. After these steps, any significant residual impacts should then be addressed via offsetting* (DFO, 2013b).

5.1 AVOIDANCE

Due to the location of the mineral deposit (i.e., at the headwaters of Geona Creek, directly under the creek alignment), impacts to Geona Creek watershed cannot be avoided. BMC has substantially re-considered mine infrastructure design and placement of waste facilities from what was proposed and licensed by the previous owners in the 1990's in order to "reduce the duration, intensity or extent of adverse effects to fish and fish habitat that cannot be completely avoided." A description of those changes and their significance with respect to avoiding impacts on fish and fish habitat follows.

5.1.1 TAILINGS MANAGEMENT

The former design involved the development of a submerged tailings facility directly in Geona Creek. The facility was designed to receive wet tailings and required a significant dam structure to retain the material. That type of facility could require ongoing active water treatment for an extended period at closure and possibly in perpetuity. In order to avoid this situation BMC has committed to developing a "dry-stack" tailings facility that will be placed outside the creek alignment. Any surface water that comes in contact with the facility or seeps through it will be collected and directed to a collection pond where it will be treated prior to discharge (if necessary) during operations. At closure the facility will be capped and covered to minimize or avoid meteoric water from becoming contaminated.

5.1.2 ROCK MANAGEMENT

The former design involved developing waste rock storage facilities (both acid generating and non-acid generating) in or in very close proximity to Geona Creek. Those facilities will now be placed at a distance from the creek and appropriate water collection ponds will be established to ensure minimal to no contact water flows directly into Geona Creek. The collection ponds will allow for determining concentration of contaminants in the waters and for managing the treatment and discharge of this water as appropriate (see Water Management Plan Chapter 18; section 18.4 of Project Proposal). The rock storage facilities will be capped at closure to reduce the risk of contaminants originating from the storage facilities entering Geona Creek.

5.1.3 WATER MANAGEMENT FACILITIES

There will be two operations water management ponds developed within the current alignment of Geona Creek. The Upper and Lower Water Management Ponds will capture direct flow of water in the watershed that has not been re-directed or conveyed around the various facilities and water resulting from dewatering of the ABM open pit during construction and operations. These operations water management ponds will be used to store water for mine use and mill processing. Water that may need to be discharged from the facility into Geona Creek or Finlayson Creek will be treated as necessary to remain in compliance with discharge regulations (i.e., Metal Mining Effluent Regulations and *Yukon Waters Act*).

An energy dissipation structure will be situated downstream of the Lower Water Management Pond. This feature will receive clean or non-contact water that is conveyed around the waste facilities located upstream, allowing for dissipation of any gained velocity to mitigate erosion and mobilisation of sediment before the water enters Geona creek. It will also receive treated water discharged from the Lower Water Management Pond. Water discharged into this feature will flow directly to Geona Creek and/or Finlayson Creek via a pipeline.

Overall, the significant changes in the mine re-design are primarily to reduce long term impacts on fish and fish habitat in Geona Creek and the downstream receiving environment. The risk of contaminated water entering fish habitat downstream has been reduced significantly by this re-design. Additionally, at closure the water management ponds will be converted to wetlands that will serve as a passive water treatment system ensuring water discharging into the receiving environment does not present a risk to aquatic resources downstream.

5.2 MITIGATION

In addition to avoidance measures to reduce impacts to fish and fish habitat, a number of mitigative measures have been incorporated into the Project design to further reduce impacts of the mine's development and operations on fish and fish habitat. The following mitigative measures relate directly to mine development and construction. Note that additional mitigative measures as they relate directly to proposed offsetting measures are described in Section 7, following each respective offset measure description.

5.2.1 GENERAL MITIGATIONS

The following mitigations will be implemented throughout the Project area, and during all Project phases (where applicable):

- Water conveyance systems will be constructed on the up-gradient side of the various mine structures in order to convey clean (non-contact) water around them. The water will be directed to an energy dissipation structure, which will minimize sediment erosion from the clean diverted water before being discharged in downstream fish habitat;
- During closure the Fault Creek diversion will be decommissioned to redirect streamflow into the ABM open pit within the Geona Creek catchment. During closure Fault Creek will flow into the ABM open pit. Lime will be added to the ABM pit while it fills to improve water quality once ABM lake reaches an elevation of 1,380 masl, where the discharge will enter Geona Creek;
- Construction timing windows will be used to minimize downstream effects of construction activities when it is necessary to work directly in or in close proximity to the creek. For instance, activities requiring working directly in the creek bed will be scheduled during low flow periods. Creek water may also be conveyed around the construction activity by pumping and/or development of temporary bypass channels. Instream construction will be avoided, when practicable, during grayling spawning and incubation period (mid-May to late June); and
- Sediment and erosion control measures will be employed to minimize mobilization and sediment loading into fish habitat downstream. These measures are outlined in BMC's Sediment and Erosion Control Plan (Chapter 18 – Section 18.6 of Project Proposal).

5.2.2 GEONA CREEK

The following mitigations are specific to the Geona Creek catchment:

- Water management structures and treatment systems will be used to manage water flows and quality to ensure contaminants do not discharge into fish habitat, and downstream fish habitat receives adequate flow to support any individuals residing in lower Geona Creek;
- Covers will be constructed progressively during operations for the Class A, B, and C Storage Facilities to ensure geochemical stability of rock and tailings. At closure, the final covers will be revegetated to maximize the reduction of infiltration and to meet land use objectives;
- A series of wetlands will be constructed to treat water from the Class A Storage Facility, Class B Storage facility, and ABM lake outflows. As a contingency, the water treatment plant will remain

on site and functional until the covers and wetlands have proven to meet the closure design objectives including the water quality objectives being met in the receiving environment;

- At closure the water management ponds will be converted to wetlands to serve as a passive water treatment system to ensure water quality meets water quality objectives during post-closure.
- In order to preserve the fisheries resources in Geona Creek and avoid inflicting serious harm to fish as described above (FPP-Fisheries Protection Provisions – Section 2.0), the fish currently residing in Geona Creek will be isolated from upper Geona Creek where construction activities will occur. The previous FAA described a program to salvage fish from the Geona Creek watershed prior to construction initiation in the system and transferring them to barren lakes in the vicinity of the mine site (e.g., upper East Creek watershed). However, observations of the upper Geona Creek watershed, where the mine impact will occur indicates that salvaging of fish will be very difficult and not practical due to the hyper-braided and/or flat wide stream and pond structure of the creek in this location combined with the soft muddy substrate in the ponds. Therefore, the following is proposed to minimize and mitigate for the direct loss of fish during mine and habitat compensation development;
- Overwintering habitat investigations conducted during the winter of 2016 indicate that grayling may not be able to survive in upper Geona Creek due to the ponds freezing to the bottom and/or very low flow and dissolved oxygen levels in the ponds. Therefore, it is likely that most, if not all fish, using upper Geona Creek during open water retreat to lower Geona Creek for over-wintering. Thus BMC proposes to isolate these fish from the development section of the creek and avoid having to salvage fish there by constructing a barrier that would prevent any upstream migration. The fish barrier will be removed after the construction period; and
- The barrier will be placed in a section of the creek downstream of the water management ponds and where ponds will be developed as part of the offsetting strategy (discussed in section 7.0) and where the creek is incised adequately in a single channel to allow for easy construction of a temporary barrier. The barrier will consist of sandbags and vexar mesh. The sandbags will be placed on a sheet of mesh on the bottom of the creek with the mesh extending downstream an extra 2-3 metres. Sandbags will then be stacked across the creek to a height of approximately 60-75 cm, using the banks as lateral supports. Once this height is obtained the mesh will be folded up on the downstream side of the sandbag structure and lay on the top row of bags. Another row or two of sandbags will then be placed on top of the mesh. The mesh will then be folded back and secured at an approximate 45^{o} angle oriented downstream. Upstream water will be able to flow over the sandbags and through the mesh. Fish that may still be upstream when this structure is put in place will still be able to move downstream while preventing upstream movement of fish (see conceptual drawing – Figure 5-1). This will eliminate the need to do a significant salvage upstream provided the barrier is placed prior to grayling initiating upstream movement in the spring (i.e., early May).

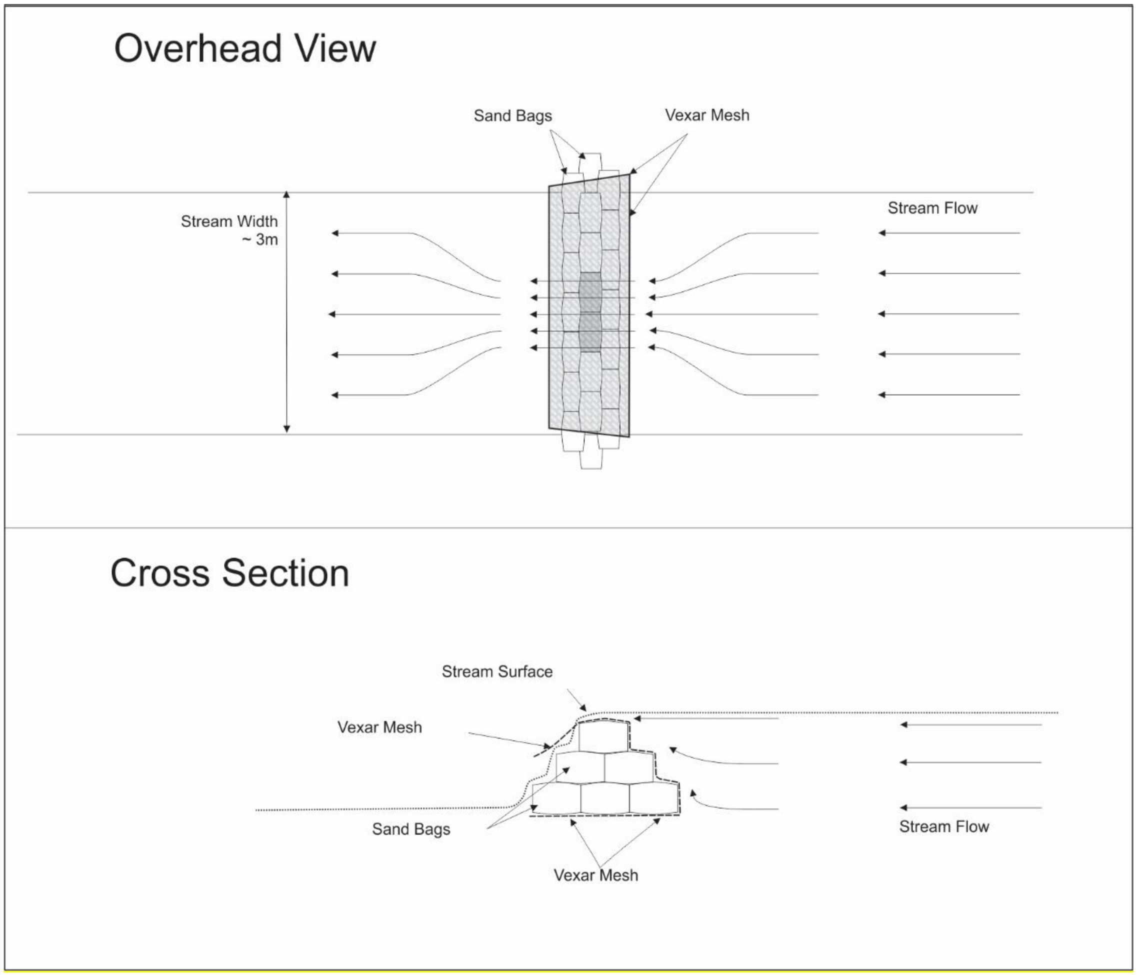


Figure 5-1: Conceptual Fish Barrier Proposed for Geona Creek to Help Avoid Having to Undertake a Large-Scale Fish Salvage Operation

- Following placement of the fish barrier some salvage effort will be undertaken upstream to test the barriers effectiveness and to determine if any fish remained upstream when the barrier was placed. Any fish captured would be re-located downstream of the barrier. Salvage would involve the use of an electro-fisher, gee-traps and seine nets to capture fish and isolate salvage sections of the creek. The barrier will be established early in spring or at freeze-up to prevent fish from accessing upstream habitat. This may impact spawning success for certain adults in the system that would not have access to their preferred habitat. However, grayling are known to spawn in less than ideal habitat conditions when other options are not available (Scott and Crossman, 1973; Hubert et al., 1995). In fact, the current available spawning habitat in Geona Creek is not considered optimal. Once in place the fish barrier will be checked regularly and especially after high rainfall events to clear any debris accumulation and to ensure it is still functioning as designed.

5.2.3 SOUTH CREEK

South Creek is a small drainage situated immediately south of the Project area (Figure 1-2). Fault Creek, a non-fish bearing headwater tributary of Geona Creek will be diverted to the South Creek watershed to prevent this water from flowing into the ABM open pit. The following presents the mitigation measures that will be implemented to reduce fish and fish habitat effects in South Creek:

- The water will be diverted down an existing dry channel; therefore, reducing erosion and sediment loading potential downstream. Sediment and erosion issues will follow standard management practices and as outlined in BMC's Sediment and Erosion Control Plan (Chapter 18 – Section 18.6 of Project Proposal);
- The dry channel will be visually inspected prior to initiating diversion work. Any obstructions and/or debris will be cleared from the channel to the extent possible to ensure diverted flow follows the channel's alignment;
- The diversion will be performed during low water conditions. Only a portion of the water will be diverted initially in order to monitor flow performance and if necessary, the channel will be modified to ensure it operates as expected and designed; and
- A fish barrier will be constructed at the bottom end of the diversion channel to prevent fish from relying on the temporary diversion as fish habitat. Gradients in the system may act as a natural barrier or a small structure will be placed at the lower end of the system creating a plunge to prevent fish from moving upstream.

6 POTENTIAL PROJECT EFFECTS TO FISH AND FISH HABITAT AFTER IMPLEMENTATION OF AVOIDANCE AND MITIGATION MEASURES

The Project development and operation will have direct and indirect impacts to fish habitat. The Project will be situated in the upper half of the Geona Creek watershed. Structures such as the open pit and water management ponds will be situated directly on the floodplain. A portion of the creek above the water management ponds will not be altered in a significant way, but will be permanently isolated from fish access as the water management ponds will have a dam structure controlling water discharge and at closure the Lower Water Management Pond will be converted to a wetland for ongoing passive treatment in perpetuity.

Geona Creek currently flows through the proposed open pit, which includes the Fault Creek watershed, a small headwater tributary of Geona Creek. Fault Creek will be re-directed to an adjacent watershed (South Creek) as was proposed in Cominco Ltd.'s original mine plan. This will result in reduced flows to Geona Creek and a corresponding increase in flows to South Creek. The reduction of flow to Geona from the diversion of Fault Creek will however be partially offset by dewatering of the ABM open pit during mine construction and operations, water that will ultimately be discharged to Geona and Finlayson Creeks. During active closure, the water management strategy also involves discharging a portion of water from the water management ponds directly into Finlayson Creek.

A comprehensive evaluation on the influence and effects mine development will have on the surface water quality and quantity within local and regional waterways (Geona, South and Finlayson Creeks) was undertaken (Chapter 8 of Project Proposal). This evaluation was used to conduct an effects assessment on the aquatic resources in the Project area (Chapter 10 of Project Proposal). The following describes the effects the development will directly have on fish habitat in each of the three waterways and summarises the effects changes in hydrology and water quality are predicted to have on the aquatic resources in the systems.

6.1 EFFECTS TO GEONA CREEK

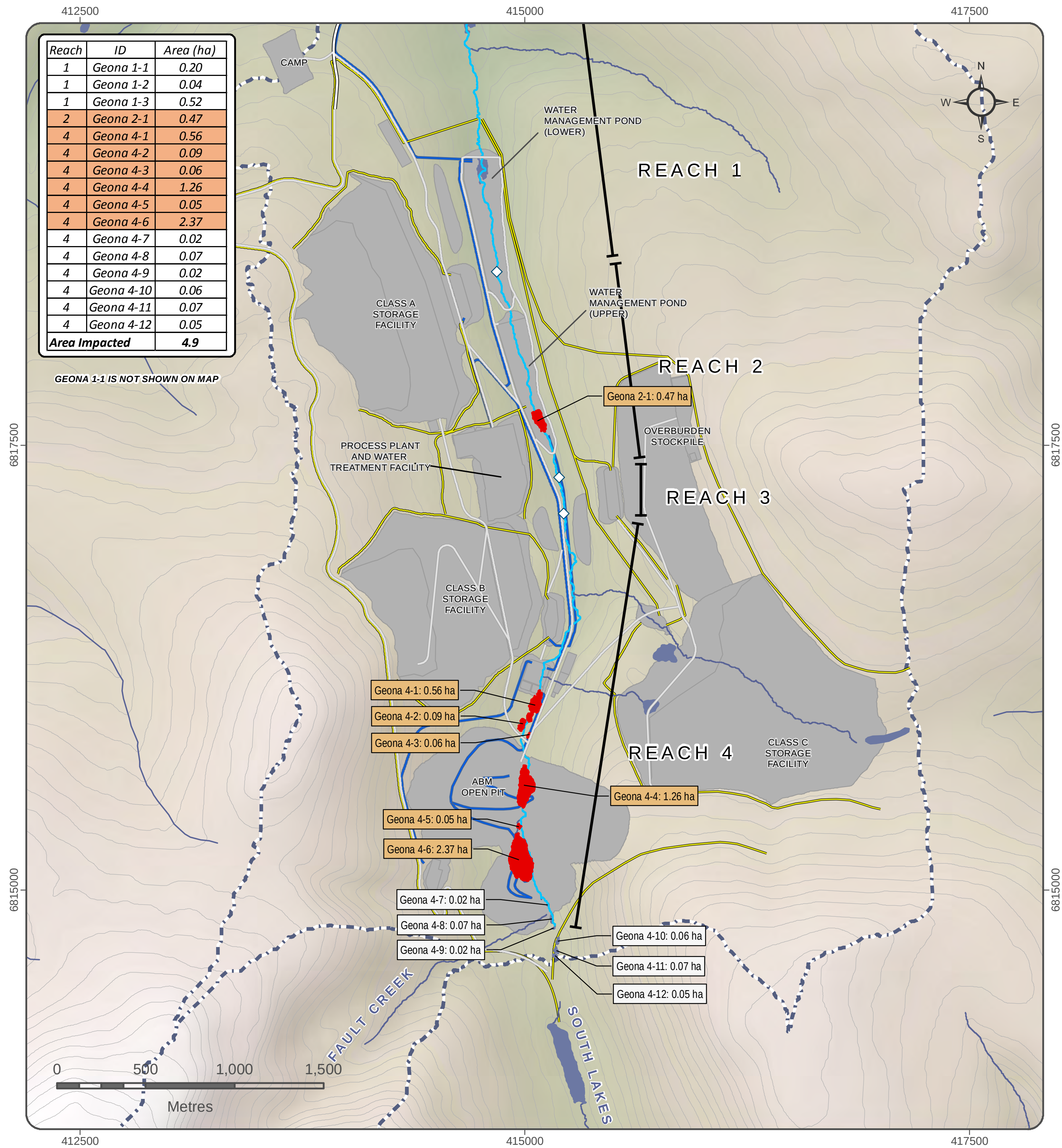
6.1.1 CHANGES IN HABITAT AVAILABILITY, DISTRIBUTION AND CONNECTIVITY

Geona Creek is approximately 9.1 km in length, not including Fault Creek. The creek does not meander significantly, and is relatively straight from its headwaters to its confluence with Finlayson Creek. There are several non-fish-bearing tributaries along its length that contribute to overall discharge. Habitat characterization work has divided the creek into four major reaches (Figure 4-2). Reach descriptions are presented in Table 4-1 and further habitat descriptions are available in the Aquatic Resource Baseline Report (Appendix E-3 of Project Proposal).

The Project will result in permanent removal or isolation of approximately 5.4 linear km of fish habitat in upper Geona Creek. This section begins in the upstream section of reach 1 near KZ-9, to the headwaters at the confluence with Fault Creek. Isolation will occur as a result of establishing water management ponds towards the downstream section of the mines development (Figure 6-1). Habitat that will be impacted includes mainly ponds and riffle habitat.

With respect to ponds, approximately 4.85 ha of pond surface area will be removed from fish use in the Geona Creek watershed. This pond habitat loss consists of seven ponds (Figure 6-1) below the Fault Creek confluence. One of those ponds is located at the south end of the proposed open pit and is approximately 2.4 ha or about 50% of the total pond area that will be isolated from fish use.

Based on what is known to date about the fish habitat and usage in Geona Creek, habitat replacement will need to be provided for all life stages (spawning, incubation and early rearing, rearing, and overwintering). Therefore, a diversity of habitat replacement is proposed as an offsetting measure (see Section 7) including riffles for spawning and ponds for rearing and potentially overwintering. In particular, pool and pond habitat is very important for grayling life history (Hubert *et al*., 1985) and overwintering habitat may be the limiting factor for grayling in Geona Creek.



Reach	*ID*	*Area (ha)*
1	*Geona 1-1*	*0.20*
1	*Geona 1-2*	*0.04*
1	*Geona 1-3*	*0.52*
2	*Geona 2-1*	*0.47*
4	*Geona 4-1*	*0.56*
4	*Geona 4-2*	*0.09*
4	*Geona 4-3*	*0.06*
4	*Geona 4-4*	*1.26*
4	*Geona 4-5*	*0.05*
4	*Geona 4-6*	*2.37*
4	*Geona 4-7*	*0.02*
4	*Geona 4-8*	*0.07*
4	*Geona 4-9*	*0.02*
4	*Geona 4-10*	*0.06*
4	*Geona 4-11*	*0.07*
4	*Geona 4-12*	*0.05*
Area Impacted		***4.9***

Lakes and Ponds In Study

- Not Impacted/Not Considered as Fish Habitat
- Directly Impacted
- Reach Break
- Geona Creek
- Other watercourse
- Tote Road/Proposed Access Road
- Proposed Mine Road
- Diversion Ditch
- Pipeline
- Location of Proposed Mine Infrastructure
- Geona and Fault Creek Catchments

Reach characteristics from field observations or from 2015 LiDAR data analysis (with the exception of for reach 1, for which LiDAR data was not available and so lenghts and heights taken from CANVEC data (50k)
Datum: NAD 83; Projection: UTM Zone 9N

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KUDZ ZE KAYAH PROJECT
FISHERIES OFFSETTING PLAN

FIGURE 6-1

FISH HABITAT AFFECTED BY PROPOSED MINE DEVELOPMENT

JANUARY 2017

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6.1.2 CHANGES IN HYDROLOGY

Figure 6-2 illustrates the predicted change in flow in Geona Creek at KZ-37 as a result of project activity influences throughout the Project phases (construction, operations, closure) and under three precipitation scenarios (Mean, 1/50 wet year, 1/10 dry year).

Figure 6-2: Predicted Percent Change in Runoff Relative to Baseline in Geona Creek (KZ-37) Throughout Project Phases Under Three Precipitation Scenarios

Lower Geona Creek (downstream of the mine site) is an erosional system that is very responsive to rainfall events resulting in relatively high flows during and immediately subsequent to these events. As a result, flows are highly variable and during open water months' flows can vary upwards of 150% or more over a short period of time. At freshet baseline flows have reached as high as 1.6 m^3/s or over 6 times a mean open water flow in the range of 0.25-0.30 m^3/s at KZ-37 (Hydrometeorology Baseline Report - Appendix D-2). High flows will remain within the natural variability of the system. Therefore, the higher flows expected in Geona Creek during construction should not affect the system in a substantial way. The higher flows that occur naturally in the system at freshet and during rainfall events will be tempered or evened out by the upper Geona Creek water diversions and through water management. Some additional erosion of the creek channel and banks can be expected in lower Geona Creek during construction phase as a result of the consistently higher flows but this is not anticipated to be substantial and will be short-lived as Geona Creek discharges will be lowered during the operations phase.

During operations the lower flows (in the 45% range) predicted for lower Geona Creek will be adequate to sustain the small Arctic grayling population in Geona Creek and other aquatic resources during the open water months. The lowest flows will occur during late winter during the operational phase. During this phase, the water management strategy involves sending a portion of water from the water management ponds directly to Finlayson Creek. The distribution of water can be adjusted if it is determined that flows have fallen too low and place the grayling in Geona Creek at risk.

At closure (active and transition) flows are predicted to be lower than baseline in Geona Creek by about 20% (Figure 6-2). At the onset of closure, Fault Creek and the upper Geona Creek watershed diversion will be re-directed to the Geona Creek watershed however this water will report to the ABM open pit and not contribute to flows in lower Geona Creek. Geona Creek however will experience higher flows then during the operations phase as water will no longer be discharged directly to Finlayson Creek. At post-closure flows are predicted to return close to baseline but up to 5% higher due to the anticipated change to hydrogeology in upper Geona Creek as a result of the development of the open pit. As for the operations phase, flows in Geona during all three closure periods will be adequate to support the existing aquatic resources of the system.

6.1.3 CHANGES IN SURFACE WATER QUALITY

Water quality objectives have been established for Geona Creek for constituents of potential interest based on the baseline surface and groundwater monitoring programs, and geochemical characterization of waste rock and tailings. These water quality objectives were established at levels to ensure there will be no significant effects on aquatic life, including fish, benthic invertebrates and aquatic plants. The site water quality objectives were generated using generic guidelines from both the Canadian Council of Ministers of the Environment (CCME) and the British Columbia Ministry of Environment (BCMOE), and the background procedure for parameters where the baseline is currently greater then generic guideline. A site specific water quality objective was developed for selenium in Geona Creek due to elevated baseline concentrations (Chapter 8 of Project Proposal). An aquatic effects assessment for the proposed mine development has been conducted and is available for review (Chapter 10 of Project Proposal). This chapter provides more specific detail on Parameters of Potential Concern (POPC) in the system and the predicted concentrations in the receiving environments once mining activities are triggered.

It was determined that water quality in Geona Creek will be affected by mine development and operations, but those affects have been predicted to be within the water quality objectives established and therefore will not impact or present a risk to the aquatic resources of the creek (Chapter 10).

6.2 EFFECTS TO SOUTH CREEK

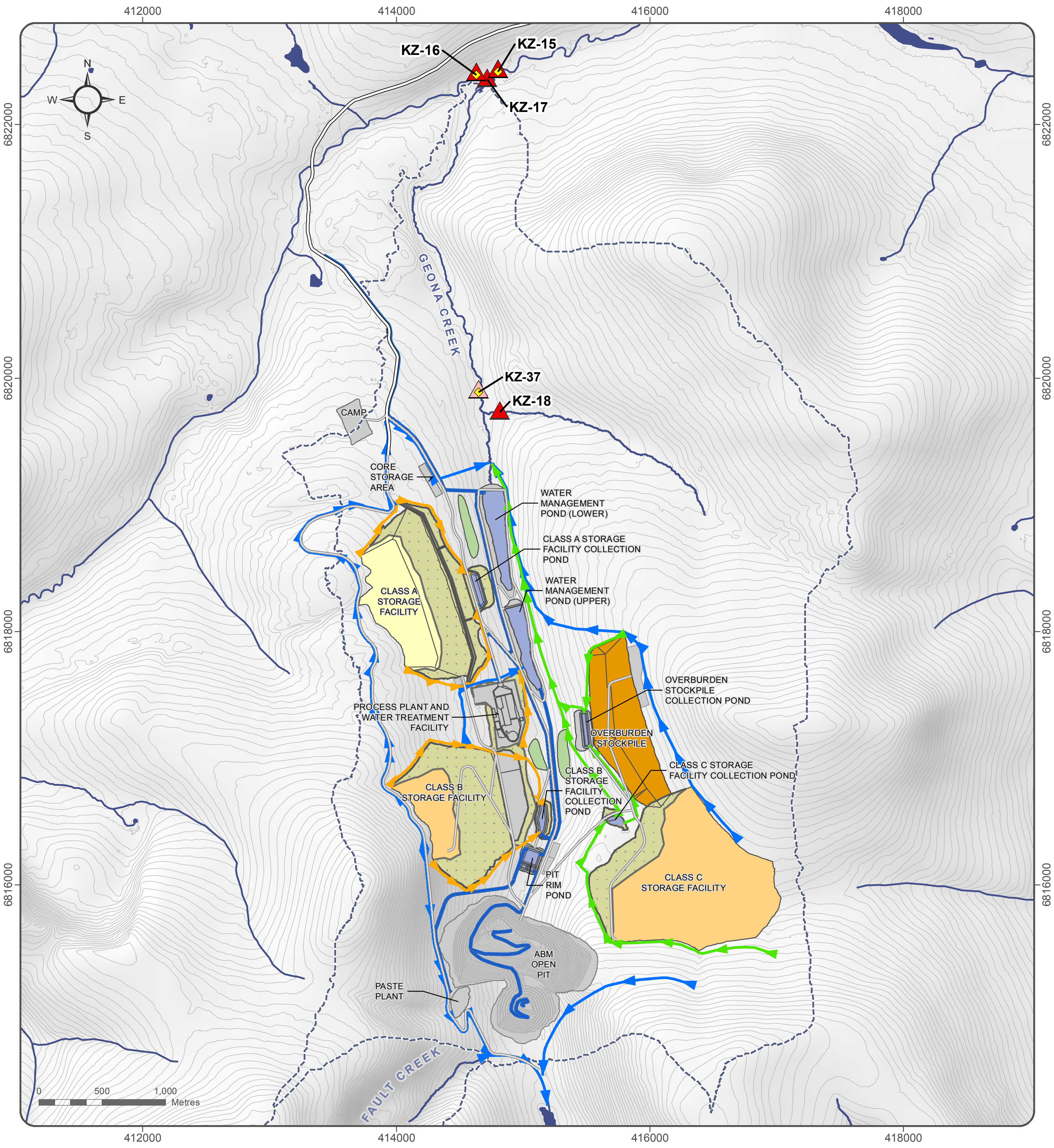
6.2.1 CHANGES IN HABITAT AVAILABILITY, DISTRIBUTION AND CONNECTIVITY

Fault Creek is not fish bearing, likely because it is a high gradient system with limited holding areas and natural barriers to fish passage. The Fault Creek/Geona Creek confluence is located near the height of land which divides the Geona Creek watershed from the South Lakes drainage, which will allow for relatively easy re-direction. Fish habitat investigations conducted in 1995 indicate there is a channel that is currently dry that likely connected these ponds to the South Lakes system in the past. Aerial reconnaissance over the area in 2016 indicates that evidence of the channel is still present. Fault Creek will be re-directed down this channel in order to reduce water handling requirements, erosion issues, and sediment mobilisation in the system downstream. In addition to the flow from Fault Creek a portion of the upper Geona Creek watershed will also be diverted into the South Creek watershed. This includes the South and South-west diversions which will deflect non-contact water from draining into the ABM open pit (see Figure 6-3).

Fault Creek will be diverted back to the Geona Creek watershed at closure. A barrier (e.g., cascade/plunge) will be established at the bottom end of the diverted stream (just upstream of the South Lakes) that will prevent fish from moving into this temporary diversion. Low numbers of fish were captured in the South Lake system during the investigations in 1995 and 2015. Captured species include Arctic grayling, slimy sculpin and burbot.

Increased flows into South Creek and South Lakes may cause some degradation of existing non-active beaver dams or structures (located below the lakes and upstream of the North River) and possibly some additional erosion in the system. However, this should be short-lived following diversion of the system and mitigated by diverting the water during a low flow period. It is not certain how the increased flow in the system will impact fish habitat; however, it is expected it may slightly enhance the habitat with additional food (drift invertebrates) being distributed into the lakes and possibly increase the overwintering habitat potential in the lakes. During overwintering habitat investigations conducted in 2016, dissolved oxygen levels were at 3.0 mg/L indicating that overwintering potential in the lakes is currently marginal at best.

At closure, once Fault Creek is re-directed into the Geona Creek watershed, it is predicted that flows will be slightly lower than baseline. This may result in lower water levels in the two lakes in upper South Creek as hydrogeological work has hypothesized that these lakes may only exist due to the presence of the shallow aquifer in the area that will be drawn down as a result of pit dewatering. This in turn could slightly reduce the amount of fish habitat available in the lakes, although they do support only low numbers of fish, based on investigations to date.



Class A Storage Facility
Class B and C Storage Facility
Overburden Stockpile
Topsoil Stockpile
Progressive Reclamation
Pond/Water
Non Contact Diversion
Contact Class A & B Diversion
Contact Class C Diversion
Pipeline
Tote Road/Proposed Access Road
Proposed Mine Road
Contour (10 m)
Water Quality and Hydrometric Station
Water Quality Sampling Location
Proposed Water Quality and Hydrometric Station
Geona and Fault Creek Catchments

KUDZ ZE KAYAH PROJECT FISHERIES OFFSETTING PLAN

FIGURE 6-3

PROPOSED PROJECT WATER DIVERSIONS

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Datum: NAD 83; Projection: UTM Zone 9N

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Recieving

6.2.2 CHANGES IN HYDROLOGY

Figure 6-4 illustrates the predicted change in flow in South Creek at KZ-13 as a result of project activity influences throughout the Project phases (construction, operations, closure) and under three precipitation scenarios (Mean, 1/50 wet year, 1/10 dry year).

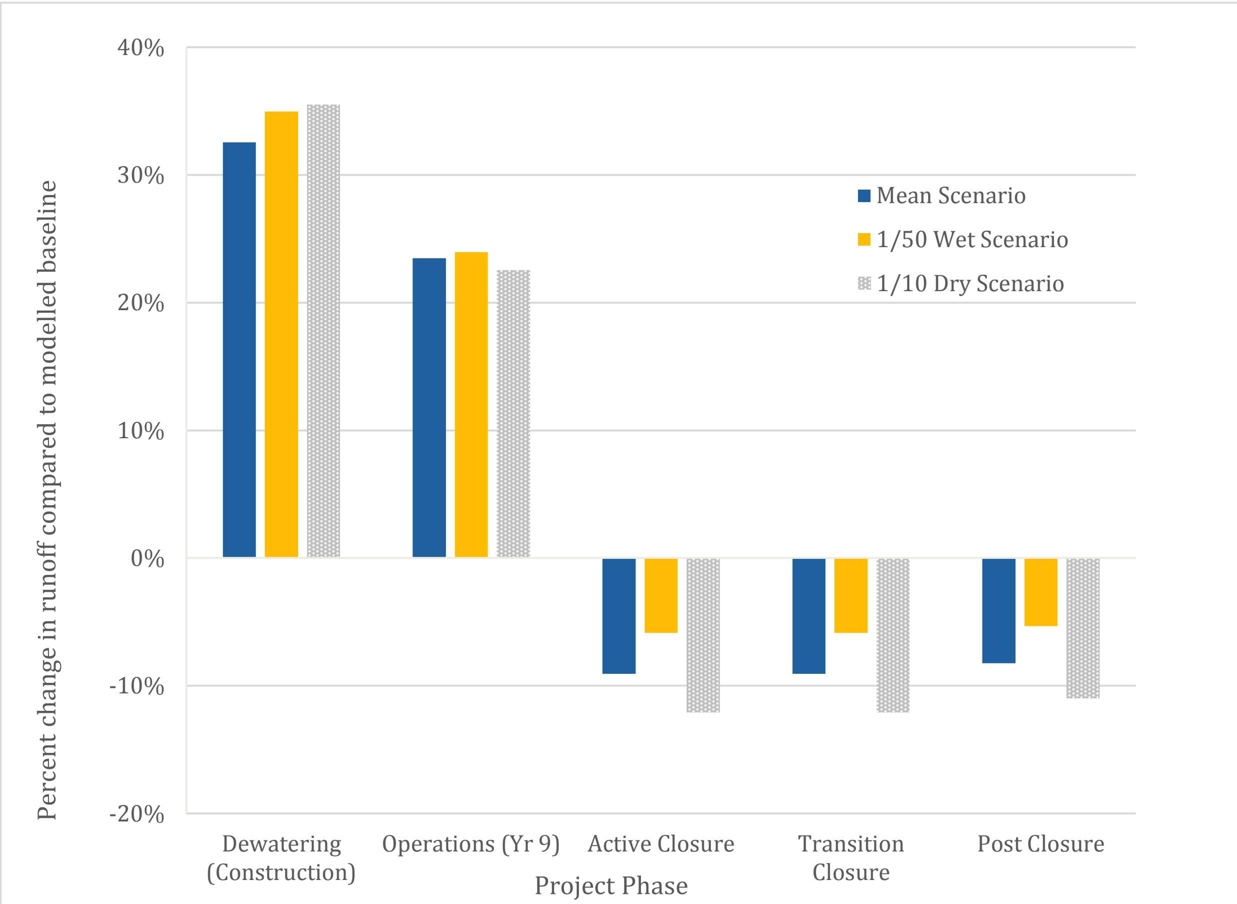


Figure 6-4: Predicted Percent Change in Runoff Relative to Baseline in South Creek (KZ-13) Throughout Project Phases Under Three Precipitation Scenarios

As described above, Fault Creek, a tributary of Geona Creek, and a portion of the upper Geona Creek watershed (south diversion) will be re-directed to South Creek watershed to accommodate the development of the open pit. This diversion will increase surface flow substantially into that system. The predicted increase in flow during Project construction is in the 35% range.

Based on the Groundwater Quality and Flow effects assessment (Chapter 9 of Project Proposal), baseline flow in South Creek is sustained in part as a result of groundwater inputs. Once dewatering of the ABM open pit is initiated groundwater baseline flow into South Creek will be reduced thus tempering the additional flow added to the system via the diversions.

During the operational phase flows in South Creek becomes more reliant on flow from Fault Creek as the groundwater aquifer will no longer feed as much flow into South Creek. As a result, the increase in flow in South Creek decreases to under 25% (Figure 6-4).

At closure, Fault Creek will be re-directed back to the Geona Creek watershed. The resultant flows in South Creek (KZ-13) are predicted to be 5 to 12% lower than baseline flows (Figure 6-4) during the active and transition closure phases. At closure the dewatering of the ABM open pit will cease and all of the flow from Fault Creek will report to the pit slowly increasing the hydraulic head in the surrounding aquifer. Once the pit is filled at post-closure and the groundwater hydraulic head increases in the watershed the resultant flow in South Creek is predicted to increase but will still remain 5 to 11% lower than baseline (see Chapter 8 of the Project Proposal – Surface Water Quality and Quantity) as a result of the influence on local hydrogeology from the ABM pit development (Appendix D-4of Project Proposal).

Similar to Geona Creek, South Creek is responsive to rainfall events and subject to relatively high extreme flows at freshet. Therefore, the increased flows during the construction and operation phases are not expected to have a substantial impact on the system. The slightly lower flows expected at closure are also not expected to significantly impact the aquatic habitat of South Creek or its resources. South Lake may shrink slightly but is expected to still be able to support the low numbers of fish in the system.

6.2.3 CHANGES IN SURFACE WATER QUALITY

The diversion of Fault Creek and a portion of the upper Geona Creek watershed, introduces water from Geona Creek catchment into South Creek. Fault Creek water contains elevated cadmium, selenium and zinc compared to South Creek, but the water quality modelling (Appendix D-7 of Project Proposal) shows that these parameters after mixing will be within generic guidelines or the range of documented baseline water quality concentrations (Chapter 8 of Project Proposal). Therefore, no impacts to the aquatic resources are expected due to water quality.

6.3 EFFECTS TO FINLAYSON CREEK

6.3.1 CHANGES IN HABITAT AVAILABILITY, DISTRIBUTION AND CONNECTIVITY

There will be no negative changes to habitat availability and connectivity in Finlayson Creek as a result of Proposed Project developments. The existing mine access road (tote road) which follows the Finlayson Creek alignment from the Robert Campbell highway, will be upgraded but will not encroach on Finlayson Creek. A clear-span bridge currently situated on the Creek is adequate to meet transport requirements. The Tote Road crosses a number of small tributaries of Finlayson Creek but they are not considered fish habitat, however care will be taken when upgrading any of the culverts on these tributaries to prevent mobilisation of sediments into Finlayson Creek.

6.3.2 CHANGES IN HYDROLOGY

Total catchment of Finlayson Creek above KZ-26 is 215 km^2. Geona Creek catchment is approximately 25 km^2 or about 11.6% of the watershed above KZ-26. The Finlayson catchment basin above Geona Creek is 41 km^2 and if Geona Creek is included, the basin in the upper Finlayson catchment is 66 km^2. Geona Creek contributes about 38% of the flow in Finlayson Creek where it enters the creek (KZ-15).

Figure 6-5 and Figure 6-6 illustrates the predicted change in flow in Finlayson Creek at KZ-15 (immediately downstream of the Geona Creek confluence) and at KZ-26 (lower Finlayson Creek), respectively, as a result of project activity influences identified above throughout the Project phases and under three precipitation scenarios (Mean, 1/50 wet year, 1/10 dry year). Further details are available in Chapter 8 (Surface Water) of the Project Proposal.

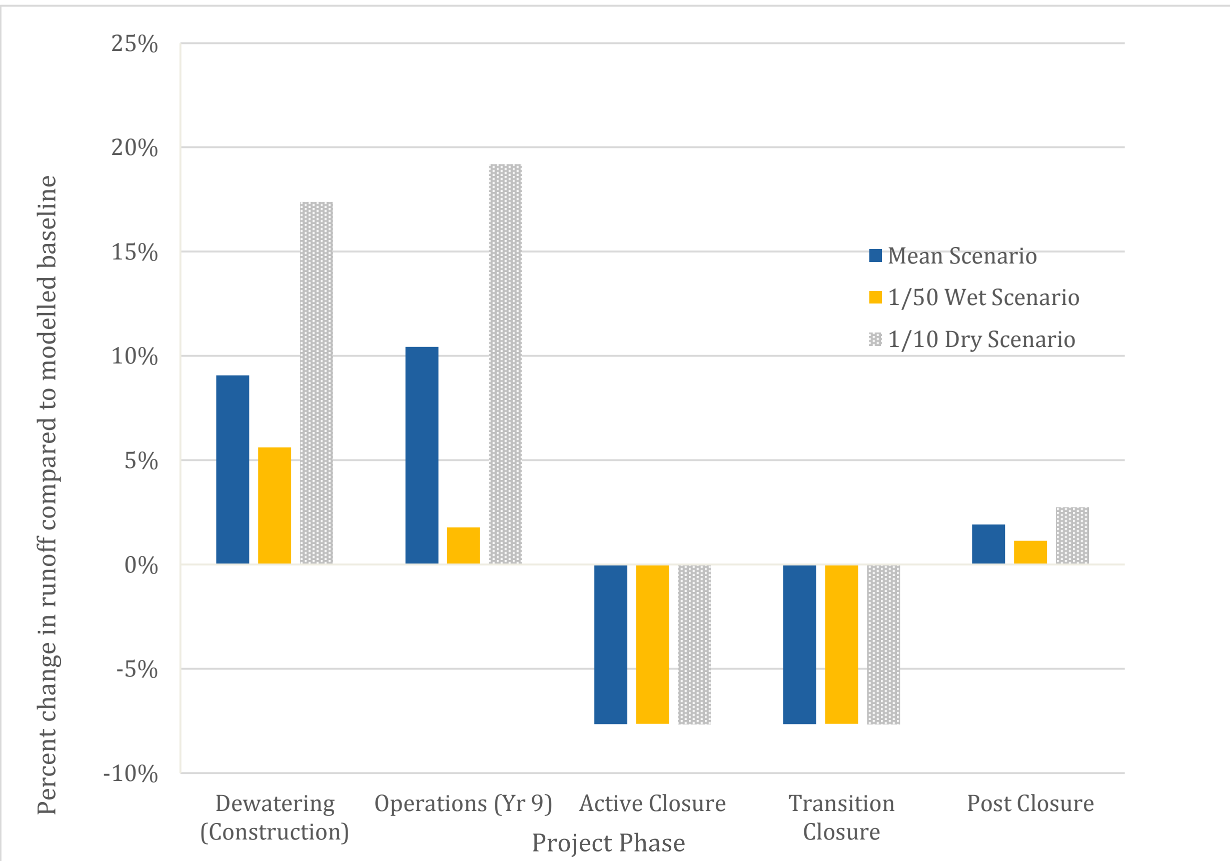


Figure 6-5: Predicted Percent Change in Runoff Relative to Baseline in Finlayson Creek (KZ-15) Throughout Project Phases Under Three Precipitation Scenarios

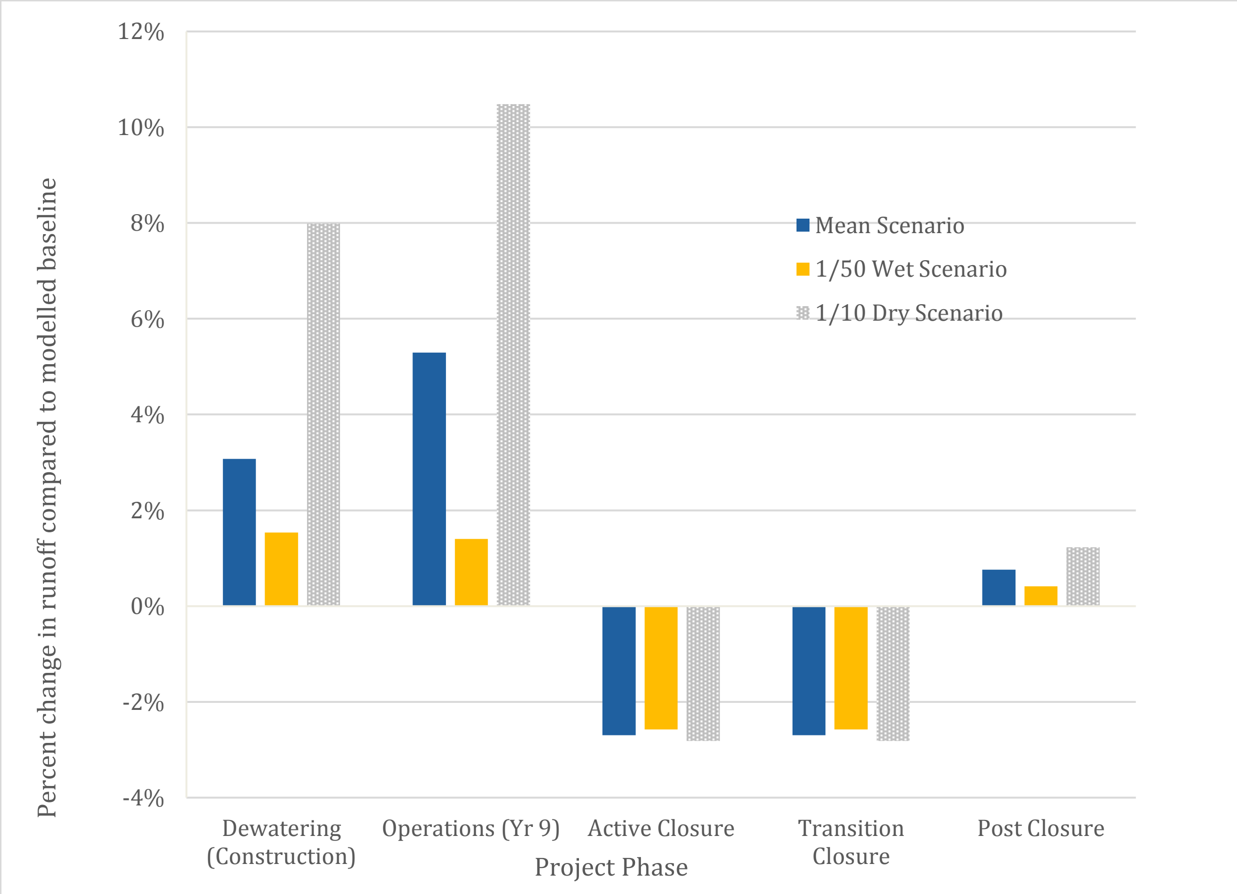


Figure 6-6: Predicted Percent Change in Runoff Relative to Baseline in Finlayson Creek (KZ-26) Throughout Project Phases Under Three Precipitation Scenarios

During construction flows in Finlayson Creek at KZ-15 are predicted to increase by between 5.5 – 17.5% in response to increased flows in Geona Creek during this phase. The increase at KZ-15 is less pronounced in lower Finlayson (KZ-26) where flows are only predicted to increase between 1.5 and 8.0% are less than half the influence at KZ-15.

During operations, flows in Finlayson Creek at KZ-15 and KZ-26 will generally be higher. During a mean precipitation year flows are predicted to increase by 5% on average with some variation throughout the year, 14% at KZ-15 (Figure 6-5) and between 2 to 8% at KZ-26 (Figure 6-6). The increase in flow is more pronounced during a dry scenario year and less during a wet year. The increase in flow in Finlayson Creek during operations is in contrast to a decrease in Geona Creek because of the water management strategy that will release a portion of compliant water from the water management ponds directly into Finlayson Creek above KZ-15, circumventing lower Geona Creek.

During active closure flows in Finlayson Creek are predicted to decrease from baseline in the range of 8.0% at KZ-15 and 3% at KZ-26 due to cessation of pit dewatering. Once the pit is filled (i.e., after the closure transition phase) flows in Finlayson will be slightly elevated above baseline conditions (Figure 6-5 and Figure 6-6). The predicted post-closure increase in baseline flow in Geona Creek, due to hydrogeological influences from development of the ABM open pit, will translate into slightly elevated flows in Finlayson Creek.

The marginal increase or decrease of flows in Finlayson Creek are not anticipated to have any effects on the fish or fish habitat in the system. Finlayson Creek is very responsive to rainfall events and freshet resulting in very large natural fluctuations in flow rates over short periods of time (Appendix D-2 of Project Proposal). The increase in flow during winter due to mining development is much more pronounced but this also aligns with when flow rates are substantially lower overall. The water management strategy will provide a more stable flow regime throughout the year that could be beneficial to the biota in the system by potentially providing more overwintering habitat.

6.3.3 CHANGES IN SURFACE WATER QUALITY

Water quality in Finlayson Creek will only be marginally affected by the Project development and operations, through discharge from the Lower Water Management Pond via a pipeline into Finlayson Creek (at a ratio greater than 2:1) and discharges conveyed via Geona Creek (at a ratio greater than 3:1). Water quality in Finlayson Creek at KZ-15 (just below Geona Creek confluence and below the pipeline from the Lower Water Management Pond) has been predicted to be within generic guidelines or remain within the range of documented baseline water quality concentrations (Chapter 10 of Project Proposal). Therefore, no impacts on aquatic resources, resulting from water quality changes predicted are anticipated for Finlayson Creek.

7 OFFSETTING MEASURES

Even though the avoidance and mitigation measures described in Section 5 are extensive, there will still be a residual impact to the fish and fish habitat of Geona Creek (as described in Section 6). Therefore, three major offsetting measures are proposed in this plan to compensate for these impacts and to maintain or enhance the productive capacity of the system for Arctic grayling. These offsetting measures include:

- Development of pond habitat in lower Geona Creek to replace and offset loss of pond habitat in upper Geona Creek;
- Development of Arctic grayling spawning habitat at the heads of the created ponds to replace and offset loss of grayling spawning habitat in upper Geona Creek; and
- Reconnect fish habitat in Finlayson Creek by enhancing fish passage through the culverts at the Robert Campbell Highway that are currently acting as a barrier to fish passage in lower Finlayson Creek.

The offsetting measures presented will require development and construction within fish habitat and will therefore have the potential to add impacts from mine development. However, these impacts will be short-lived and mitigations to minimise their potential effects are presented following the description of each respective offsetting measure.

7.1 FISH HABITAT REPLACEMENT

7.1.1 POND AND POOL HABITAT

Ponds and pools are valuable habitat for Arctic grayling and can provide optimal habitat under good conditions. Pools provide both resting and feeding areas for fry, juveniles, and adults. The fish do not have to exert as much energy to maintain themselves in a pool as they do in direct stream flow. Ponds and pools also trap invertebrates drifting downstream, adding to the food supply that is produced in the pond (Craig & Poulin, 1975).

Therefore, constructed ponds will be established to replace lost or isolated pond habitat upstream. The location of the constructed ponds will be downstream of the mine infrastructure and below a small tributary that flows into Geona Creek from the east, immediately downstream of KZ-9 (Figure 7-1). At this location there is a small beaver pond that receives flow from Geona and the tributary. This pond would be left intact and can serve as an additional sediment settling chamber, reducing bedload into the constructed ponds.

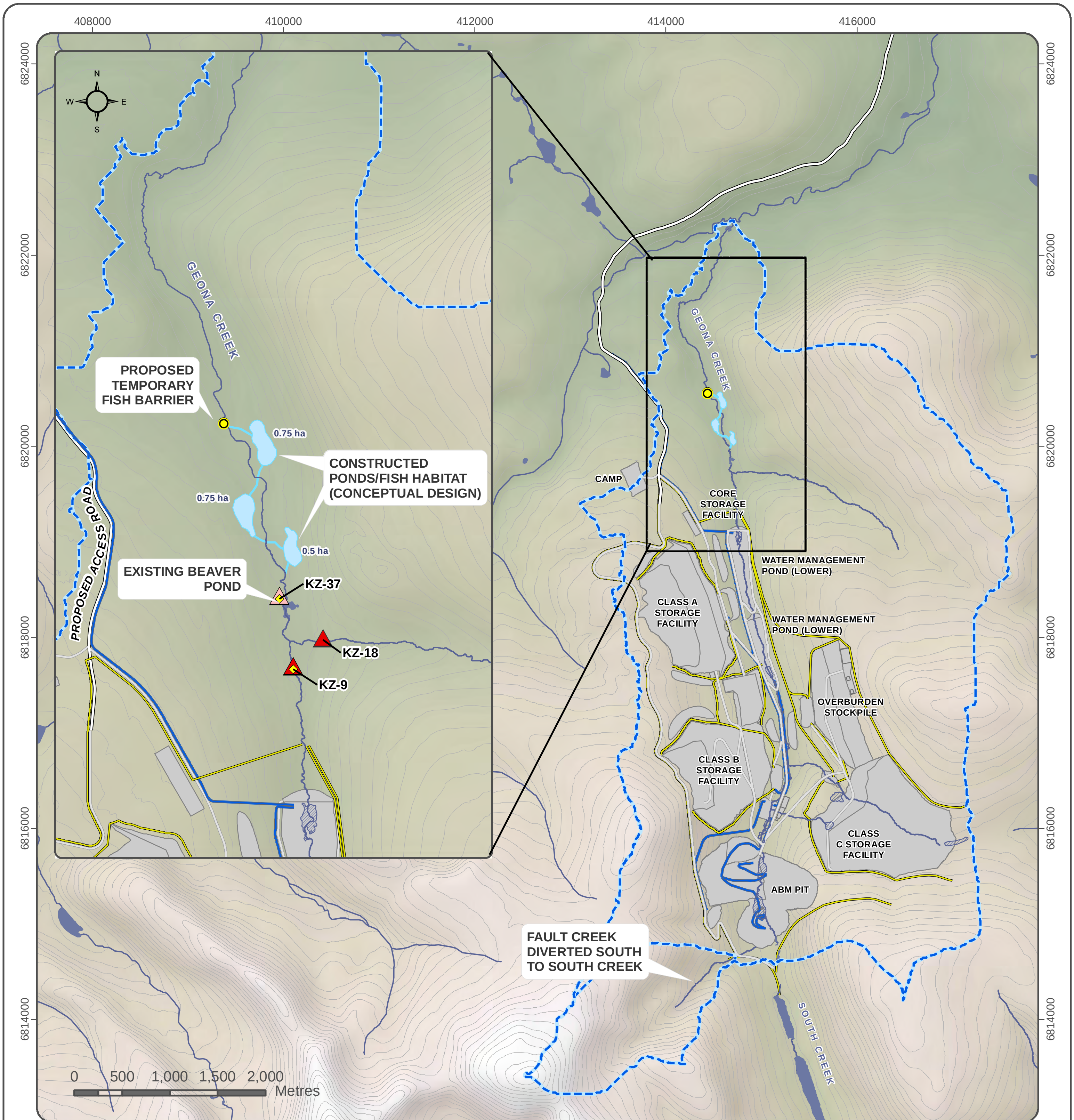
The ponds currently existing in the upper watershed are shallow, provide little to no cover, and have limited structure, thus providing less than optimal grayling habitat. The ponds planned for habitat replacement will not provide as much surface area as the existing ones, but will be developed to provide more volume (overwintering habitat) and habitat diversity.

The three ponds will be about 0.5 to 1.0 ha in surface area for a total of 2.0 ha of pond area. According to Alt and Furniss (1976) and Krueger (1981), grayling pool habitat should be 1.4 m in depth or greater to be of high suitability. Deeper ponds will additionally have the potential to provide overwintering habitat. The ponds will be excavated to an average depth of 2.0 m varying from 1.5 to 2.5 m. They will be an irregular oval shape, with the actual shape dictated by the topography. Soils excavated from construction of the ponds will be stored nearby and will provide valuable material for reclamation purposes (i.e., cover material).

The ponds will have a tendency to fill in over time with sediment and organic material but establishing a series of three ponds should increase their longevity with the first pond in the series acting as a sediment trap. Further, much of the flow into the ponds will come from the constructed sediment/polishing located just upstream. This flow including additional flow from the east side tributary will also first flow through an existing beaver pond beaver reaching the first constructed pond.

The pond structure will be established such that during periods of high flow (i.e., freshet, high rainfall events, high quantity discharge from water management ponds) a portion of the water will be able to flow down the existing creek channel circumventing the ponds. This will help maintain the integrity of the ponds over the mine's life.

The ponds will be constructed such that there are areas of cover, which will be created by placement of large woody debris – such as root wads or boulder clusters. A boulder cluster will be placed strategically near pond inlets to deflect the current and minimize flow from short-circuiting through the pond. Additional boulder clusters and large woody debris will be distributed throughout the ponds and where required to stabilise pond walls. This additional structure will also encourage the production of invertebrates, adding to the food supply in the system.



- Location of Proposed Fish Barrier
- Tote Road/Proposed Access Road
- Proposed Mine Road
- Diversion Ditch
- Pipeline
- Proposed Replacement Pond Channel
- Proposed Replacement Ponds
- Waterbodies Impacted by Development
- Geona and Fault Creek Catchments
- Location of Proposed Mine Infrastructure

KUDZ ZE KAYAH PROJECT

FISHERIES OFFSETTING PLAN

FIGURE 7-1

HABITAT REPLACEMENT CONCEPTUAL DESIGN

JANUARY 2017

Datum: NAD 83; Projection: UTM Zone 9N

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7.1.2 FLOWING /SPAWNING HABITAT

Current mine plans will result in a loss or isolation of approximately 5.4 km of Geona Creek. As described in Section 6, the watershed will be divided to accommodate construction of mine and waste storage facilities, and the conveyance of clean (non-contact) water downstream of mining operations. Thus diversion channels will be constructed on the east and west sides of Geona Creek, converging at a sediment/polishing pond. Division of the watershed and diversion of Fault Creek and additional upper catchments flows in the diversion channels will be relatively low compared to current flows in Geona. This along with gradient issues and the sediment/polishing pond situated at the downstream end of the channels exclude developing the channels as usable fish habitat. The channels will be built to accommodate peak flows during freshet, and will be lined with cobble/boulder substrate and/or rip-rap, which can help disperse flow energy and provide suitable surface area for aquatic invertebrates to colonize but will not be suitable fish habitat.

Flowing habitat is important to grayling as it connects ponds/pools and allows access to spawning and rearing areas. The transition zone where a creek flows into the pond (i.e. at the head of the pond) can provide ideal spawning habitat, provided the substrate is suitable spawning material (see Table 4-2). Therefore, pond inlets for the constructed ponds will be designed and built to provide spawning habitat to the extent possible. A riffle with good gravel and cobble substrate upstream of the constructed ponds can provide attractive spawning zones. Limited spawning habitat was identified in upper Geona Creek. Spawning habitat developed at the creek-pond transition zone will replace this habitat, and likely provide more attractive habitat than is currently in place. Options for developing riffle habitat are well described in Whyte et. al., 1997. In addition to providing suitable spawning habitat, the riffle sections established at the head of the ponds will also provide suitable substrate for aquatic invertebrates to colonize. This should provide additional food resources to the grayling, in particular those in the rearing ponds.

As mentioned in Section 7.1.1 the existing creek channel where the ponds will be developed will serve to convey a portion of Geona Creek flow downstream during high discharge events. This will help maintain the integrity of both the ponds and developed spawning habitat.

There are limited opportunities to replace additional flowing habitat due to the land constraints in the Geona Creek watershed. Therefore, BMC also intends to reconnect a significant area of potential grayling habitat in Finlayson Creek that has been isolated from use by culverts that are a barrier to fish passage. This is discussed in more detail in Section 7.2.

7.1.3 MITIGATIONS FOR PROPOSED POND AND SPAWNING HABITAT DEVELOPMENT IN GEONA CREEK

The following are mitigations that will be implemented when developing the proposed fish habitat replacement structures in Geona Creek:

- Prior to initiating construction of the ponds, the fish in Geona Creek will be isolated from the section of the creek where the ponds will be developed. Fish will be isolated by the placement of a barrier downstream of the construction zone (see Section 5.2);
- According to Allan and Lowe (1997), development of pool habitat that will have a reasonable life-span can be challenging if there is excessive bedload deposition in the system. This will largely be mitigated by the fact that the majority of the flow entering the ponds will pass through a settling pond immediately upstream (i.e., sediment /polishing pond). This should ensure that the ponds will not fill-in quickly. Furthermore, it will be a series of two to three ponds, which will allow additional sediment capture in the first pond should it be necessary;
- Ponds will be developed adjacent to Geona Creek, so much of the construction will occur on dry land;
- Work will be scheduled and conducted during low flow periods and just after freeze-up, which will give excavators improved access to the pond sites and minimise ground disturbance on adjacent land;
- Hydrologic connectivity of the ponds to Geona Creek will occur gradually to avoid cutting off flow to the creek as the ponds fill. This will also help control mobilisation of sediments as the ponds fill and connect to Geona Creek on the downstream end of the last pond;
- Sediment and erosion issues will follow protocols outlined in BMC's Sediment and Erosion Control Plan (Chapter 18 – Section 18.6 of Project Proposal);
- Boulders from the surrounding area will be used to stabilise creek or pond banks and provide structure in the ponds. If it is necessary to use rip-rap type rock, it will be screened for acid rock drainage/metal leaching issues prior to being used. Only rock that meets the non-acid rock drainage/metal leaching criteria will be used; and
- All heavy equipment to be used for creek modifications will be inspected for hydraulic fluid or oil leaks prior to entering or approaching aquatic habitat.

7.2 FINLAYSON CREEK – FISH HABITAT RECONNECTION

Finlayson Creek receives flow from Geona Creek and other tributaries within the vicinity of the KZK Project. Finlayson Creek is approximately 40 km in length from its headwaters to its confluence with the Finlayson River (Figure 4-1). Finlayson Creek flows under the Robert Campbell highway through two standard CSP culverts installed by Yukon Government Department of Highways at km 229.6. The culverts are approximately 2.4 m and slopes of 2.57% for the south culvert and 1.76% for the north culvert. It has been noted from fisheries studies conducted over the last two decades that few Arctic grayling occur upstream of the culvert, although the habitat is suitable. In contrast, many grayling have been captured downstream of the culverts during biennial sampling since 2004 Table 7-1). Other species caught in Finlayson Creek include slimy sculpin and burbot (one captured downstream of the culvert in 2012 – Table 7-1).

Table 7-1: Finlayson Creek Fish Sampling Results Summary 2002-2016

Month and Year	KZ-15 (Upstream of culverts)			KZ-16 (upstream of culverts)			KZ-26 (upstream of culvert)			KZ-26 (downstream of culvert)		
	Effort *	AG Catch **	Other species**	Effort *	AG Catch **	Other species**	Effort *	AG Catch **	Other species**	Effort *	AG Catch **	Other species**
Aug-2002	n/a	0	5 SS	n/a	0	18 SS	MT = 33 trap-hours EF = approx. 662 sec.***	1	-	MT = 16.5 trap-hours EF = approx. 662 sec.***	4	5 SS
Aug-2004	n/a	0	20 SS	n/a	0	31 SS	MT = 85 trap-hours EF = 1024 sec.	30	11 SS	MT = 42 trap-hours EF = 787 sec.	18	19 SS
Aug-2006	MT = 72 trap-hours EF = 888 sec.	0	4 SS	MT = 48 trap-hours EF = 1040 sec.	0	14 SS	MT = 41 trap-hours EF = 403 sec.	0	12 SS	MT = 126 trap-hours EF = 797 sec. ANG = 10 min.	3	17 SS
Aug-2008	MT = 72 trap-hours EF = 838 sec.	0	9 SS	MT = 51 trap-hours EF = 1215 sec.	0	6 SS	MT = 48 trap-hours EF = 431 sec.	2	20 SS	MT = 72 trap-hours EF = 1133 sec. ANG = 5 min.	16	8 SS
Aug-2010	MT = 54 trap-hours EF = 615 sec.	0	25 SS	MT = 48 trap-hours EF = 681 sec.	0	15 SS	MT = 78 trap-hours EF = 412 sec.	6	17 SS	MT = 117 trap-hours EF = 1097 sec. ANG = 5 min.	10	15 SS
Aug-2012	MT = 63 trap-hours EF = 747 sec.	1	13 SS	MT = 54 trap-hours EF = 674 sec.	0	12 SS	MT = 24 trap-hours EF = 480 sec.	0	18 SS	MT = 72 trap-hours EF = 991 sec. ANG = 10 min.	20	9 SS 1 BB
Aug-2014	MT = 61.5 trap-hours EF = 643 sec.	0	10 SS	MT = 63 trap-hours EF = 894 sec.	0	19 SS	MT = 39 trap-hours EF = 356 sec.	0	5 SS	MT = 117 trap-hours EF = 894 sec. ANG = 10 min.	8	20 SS
Jun-2016	MT = 44.4 trap-hours EF = 135 sec.	0	5 SS	MT = 44.4 trap-hours EF = 106 sec.	0	1 SS	-	-	-	-	-	-
Jul-2016	MT = 60.4 trap-hours EF = 705 sec.	0	6 SS	MT = 30.7 trap-hours EF = 679 sec.	0	24 SS	MT = 98.7 trap-hours EF = 168 sec.	0	8 SS	MT = 97.6 trap-hours EF = 163 sec.	6	7 SS
Oct-2016	MT = 86.7 trap-hours EF = 369 s.	0	1 SS	MT = 71.2 trap-hours EF = 529 s.	0	22 SS	MT = 74.5 trap-hours EF = 329 s.	0	5 SS	MT = 74.4 trap-hours EF = 347 s.	1	6 SS

* *MT = Minnow trapping, EF = Electrofishing, ANG = Angling*

** *AG = Arctic Grayling, SS = Slimy Sculpin, BB = Burbot*

**** EF effort not delineated between upstream and downstream of culvert – therefore approximated*

Inspection of the culverts in 2016 indicated that the culverts are likely a barrier to fish passage at certain times of the year, if not throughout the entire year. Both culverts discharge onto concrete platforms and then sheet off into the creek. Plate 7-1 below shows the perched platforms and resulting plunge (culvert on left side is referred to the south culvert and the one on right the north culvert). Erosion and scouring at the edges of the platforms have resulted in water plunges up to 35 cm or more (Table 7-2). This combined with relatively shallow water levels on the platforms and flow velocities of 2.5 to 3.0 m/s (Yukon Government 2014) are likely preventing certain life stages (if not all) of Arctic grayling from migrating upstream. According to Katopodis 1992, there would be no fish passage through a 20 m long culvert at the velocities detected during the 2016 assessments. A 30 cm long subcarangia form swimming fish (grayling), would only have the burst speed required to cover a distance of approximately 1.0 m at those velocities (Katopodis 1992). In order to satisfy most fish passage requirements a culvert should meet a fish passage velocity (usually 1.2 m/s or less) and minimum water depth criteria (usually 0.2 m at inlet, barrel, and outlet).

Although the velocity through the culverts could not be safely assessed during the 2016 assessments the discharge over the 2.0 m long exit platform alone was in access of 2.0 m/s and therefore it is safe to assume that the culvert is a complete barrier to passage of grayling and other species from accessing the upper watershed.

Plate 7-1: Downstream aerial view of Finlayson Creek Culverts at the Robert Campbell Highway June 17, 2016

Table 7-2: Description and Flow at Finlayson Creek Culverts (Km 229.6 on the Robert Campbell Highway)

Parameter		Left (south) culvert	Right (north) culvert
Total length (m)		20.3	20.1
Diameter (m)		2.4	2.4
Culvert slope (%)		2.57	1.76
Concrete slab length (m)		3.11	3.45
Concrete slab width (m)		4.5	4.3
Water depth on concrete slab (m)	Min	0.04	0.04
	Mean	0.09	0.08
	Max	0.18	0.15
Water velocity on concrete slab (m/s)	Min	0.850	0.590
	Mean	2.261	1.840
	Max	3.327	2.592
Height of concrete slab above water surface (m)		0.364	0.34

The culverts at this location were installed in 1974. At the time of installation, the culverts may have allowed for fish passage; however, scouring over the years at the downstream side have resulted in perched discharges of over 30 cm. Perched discharges combined with velocities and shallow water depths on the slabs are likely impeding the passage of most, if not all life stages of fish.

It is possible to modify the creek on the discharge side of the culvert to create a backflood with a series of stepped pools. Establishing a series of weirs would back up the water downstream of the crossing, and serve to eliminate the plunge off the concrete slabs at the culvert discharge while increasing water levels on the inside of the culvert and reducing flow velocities to allow fish to pass through the culvert.

A second less preferable option is to convert a smaller overflow culvert, located on the north side of the highway, into a fish passage system. The upstream side of this culvert, which is 1.4 m in diameter, is situated at approximately the same elevation as the upstream creek channel. A man-made berm is currently in place which prevents flow through the culvert except during extreme flood conditions when the creek may flow over the berm. An armoured channel on the downstream side of the culvert is already in place but would require development of a stepped pool or fish ladder structure to allow fish passage. This second bypass channel/fish ladder option is less preferable due to the ongoing maintenance caused by debris that would be required, and the fact that some fish species that may have historically accessed habitat upstream of the crossing (i.e. Whitefish (sp.), Northern Pike) are not as well adapted to navigate a fish ladder.

An initial review of the site by a qualified hydrological/hydraulic engineer experienced with developing fish passage systems indicates that either option is feasible. Preliminary conceptual engineering design of the two options is currently underway. Final engineering design of the preferred option will rely on information regarding swimming and jumping capabilities of Arctic grayling (Whyte et al. 1997) and fish passage models that are available such as that developed by Katapodis (1992). Final engineering design will proceed following “approval in principal” from the relevant territorial and federal agencies.

Allowing passage of fish through the culvert(s) will allow Arctic grayling and possibly other species to access a significant amount of diverse fish habitat upstream. Finlayson Creek is mainly a swift flowing, high gradient system, but also includes numerous small pools, eddies and small tributaries, some of which have ponds associated with them. Aerial reconnaissance conducted over the watershed in June 2016 did not reveal any barriers along its alignment that would limit fish passage upstream. In total above the culvert, Finlayson Creek encompasses a 210 km^2 catchment including 36 km of creek (linear), and a number of tributaries (not including Geona Creek) that add an additional 40 km of potential fish habitat. Some of the tributary habitat access however is limited by beaver dams (e.g., upper East creek).

Finlayson Creek is not entirely devoid of grayling above the culvert, as they have been captured upstream and are present in Geona Creek and have been noted in East Creek (Norecol, Dames & Moore. 1996). However, it is possible that as the culvert at the Robert Campbell Highway became less passable (from scouring at the downstream entrance), in the years following its placement, the populations in upper Finlayson Creek subsequently decreased. Overwintering habitat is very limited in the watershed and most grayling retreat down to the Finlayson River towards late summer and early fall (Figure 4-1) (Hubert et al. 1995). Reconnecting the Finlayson Creek watercourse will allow grayling to migrate between Finlayson River, Finlayson Lake, and Finlayson Creek. Finlayson Lake, and likely the river, provide suitable over-wintering habitat, while Finlayson Creek provides potential spawning and rearing habitat. Connecting these watercourses will allow passage of recruits between them, enhancing the sustainability and productivity of the Arctic grayling population in that watershed.

As indicated by the hydrology information presented in Chapter 8 of the Project Proposal, flows of Finlayson Creek vary significantly throughout the year. There is limited water storage (major ponds or lakes) upstream and thus the creek is very responsive to rainfall events and will typically have a peak flow period during spring freshet. Culvert flow modification will focus on lower flow periods as it will be unlikely to modify the culvert to allow passage during peak flows and will be designed based on the 1:10 year, 3 day delay discharge, which assumes that a 3 day delay for fish passage is acceptable once every ten years.

It is noted that during the first community engagement meeting that BMC held in Ross River (April 8, 2015), one of the Ross River Dene Council citizens raised the concern that the culverts were a fish barrier. nei

7.2.1 FINLAYSON CREEK CULVERT FISH PASSAGE RATIONAL AND SUPPORT

There are limited opportunities to provide fish habitat compensation for the Project in the upper reaches of Geona Creek, given the physical attributes of the system, as previously discussed. After exhausting potential habitat enhancement opportunities at the Project site, BMC investigated potential opportunities downstream of the Project. It has been well documented that there is an obvious lack of migratory fish in the catchment upstream of the Robert Campbell Highway on Finlayson Creek, although the habitat would appear to support such populations. Baseline fisheries assessments over the last 20 years have captured or observed very few migratory species in Finlayson Creek, and only suspected landlocked grayling have been captured in Geona Creek. Studies have shown that the main cause of decline of migratory species in watersheds has been the construction of obstructions preventing free upstream passage. The negative effects of these obstructions on migratory species have largely eclipsed the influence of water pollution, overfishing or habitat destruction (Jungwirth et.al. 1998). Given concerns noted by the Ross River Dena Council during public meetings, regarding the lack of fish passage on Finlayson Creek at the Robert Campbell Highway, BMC investigated the crossing in the summer of 2016, and identified that the culverts appeared to be a complete barrier to fish passage under current conditions. As such, as part of the KZK FOP, it is suggested that providing fish passage by the way of a culvert backflood or bypass channel at the highway would allow migratory fish to once again access fish habitat in the Finlayson Creek watershed, including Geona Creek. A similar project completed by the NWT Department of Transportation on Hwy 3 over Baker Creek, was successful at providing fish passage to upstream habitats, immediately upon completion of the culvert backflood (MacNeill and Schmidt, 2009).

Discussions with several staff with the Government of the Yukon, Highways and Public Works (HPW), during the summer of 2016 indicated that they would be in favor of an endeavor to provide fish passage through the culvert to allow migratory species to access fish habitat upstream of the highway, as they were aware that the culverts were a barrier to fish passage (A. McCoy 2016. Manager Environmental Affairs HPW, pers. comm. 23 August). Approvals however, would be dependent on review from the Highway Engineering department, but HPW identified an opportunity to collaborate with BMC as there were no plans to replace the culverts for at least the next 10 years.

Additional discussion were also held with Fisheries and Oceans Canada during the summer of 2016, regarding the KZK FOP inclusion of the potential of providing fish passage at the Finlayson crossing on the Robert Campbell Highway and the rational for the proposed work. Although DFO stated that they prefer compensation is provided as close to the Project site as possible, they would potentially support the fish passage option since all compensation opportunities at the project were exhausted, and the fact that the fish bypass would provide fish access to all upstream areas including Geona Creek at the Project site (D. Derochers 2016. DFO. pers. comm. 29 August).

Initial discussions have indicated support from all concerned parties including the Ross River Dena Council, Yukon HPW and DFO to justify the further investigation in the provision of migratory fish access to Finlayson Creek upstream of the Robert Campbell Highway as part of the KZK FOP.

7.2.2 MITIGATIONS TO PREVENT IMPACTS TO FISH AND FISH HABITAT DURING CULVERT FLOW MODIFICATION WORK

The following outlines mitigations in general that will be used to minimise impacts resulting from activities related to modifying fish passage through the culverts on Finlayson Creek. The final strategy for this offset still needs to be confirmed and once it is further mitigations may be developed specific to the strategy to be undertaken:

- Work will be conducted "in the dry" to the extent possible. This will require conducting construction activities during low flow periods in the summer. If only one culvert (or its downstream flow) is to be modified, it may be possible to divert and deflect much of the flow temporarily through the other culvert;
- Sediment and erosion issues will be mitigated following best management practices and as outlined in BMC's Sediment and Erosion Control Plan (Chapter 18 – Section 18.6 of Project Proposal);
- If an area of creek needs to be isolated for construction purposes, that area will be salvaged for any fish present. Fish captured during salvage operations will be returned to the creek downstream of the construction activities;
- All heavy equipment to be used for creek modifications will be inspected for hydraulic fluid or oil leaks prior to entering or approaching aquatic habitat; and
- Boulders from the surrounding area will be used to stabilise creek banks and to construct pools, however it may be necessary to use rip-rap type rock as well. Any rip-rap rock to be used will be screened for acid rock drainage/metal leaching issues prior to being placed in the waterway. Only rock meeting the non-acid rock drainage/metal leaching criteria will be used.

7.3 MONITORING SUCCESS OF OFFSETTING MEASURES

BMC has developed an Aquatic Resource Monitoring Plan (ARMP) (Chapter 19 – Section 19-8 of Project Proposal) as a component of its submission for assessment under YESAA and to the Yukon Water Board as a component of its application for a Water Use Licence. The ARMP has been developed to monitor impacts from mining development and operations on aquatic biota in the receiving environment. Considerable baseline data has been collected over the last two decades in the vicinity of the KZK mine with a more intensive program undertaken in 2015 and 2016. Therefore, impacts from mining development and operation activities on aquatic biota and habitat will be measurable. Additional monitoring to specifically determine the efficacy of offsetting measures will also be implemented following their development.

In general, a semi-quantitative fish sampling program will be conducted on an annual basis to monitor fish use in Geona, Finlayson, and South Creeks as has been done in previous years (Appendix E-3 of Project

Proposal). Additional sampling will be conducted in the developed pond habitat in Geona Creek once they are constructed and at the Finlayson Creek culverts located at the Robert Campbell Highway. Sampling will be conducted in the spring, summer and fall and winter (overwintering determination). Fish sampling methods will include electrofishing, minnow trapping, beach seining, angling, and visual observations. Overwintering sampling may only include minnow trapping and visual observation which may be aided by the use of an underwater camera. All fish captured will be identified and enumerated, measured for fork length (mm) or total length, weighed, observed for abnormalities, and released at the location of capture. Results will be reported as of Catch per Unit Effort (CPUE) to enable spatial and temporal comparisons as well as to provide a semi-quantitative assessment. Additional supporting information that will be collected includes: physical description and photo documentation of sampling locations, in situ water parameters (temperature, dissolved oxygen, conductivity) as well as weather conditions at time of sampling. A scientific collection licence that allows for fish sampling will be obtained from the DFO prior to sampling and a final report will be prepared and submitted to DFO at the termination of the assessment period as will be required as a condition of the permit.

Arctic grayling spawning surveys in Geona and Finlayson Creek will be conducted on ground and/or via aerial reconnaissance. Surveys will focus on habitat most likely to support grayling spawning based on knowledge gleaned from 2015 to 2016 habitat investigations (Appendix E-3 of Project Proposal) and will also focus, once constructed, on grayling spawning habitat developed as part of the offsetting measures. Surveys will occur post-freshet (i.e., mid-May – early June) and once water temperatures are increasing and in the 4°C range (low temp range that will trigger grayling to spawn) or higher.

Overwintering potential of the proposed constructed ponds will be investigated during winter months. Investigations will include determining volume of liquid water available in the ponds, winter flow through the ponds and dissolved oxygen content.

In addition to the fish monitoring identified above, BMC will develop and undertake a mark/recapture study to determine the success of the proposed fish passage system at the Robert Campbell Highway. Fish captured downstream will be marked (e.g., adipose fin clip or polymer tag) and released downstream. Fish captured upstream as part of the routine sampling program described above will be observed for marks. Marking effort will occur when fish are moving upstream during the spring/early summer period. Adult and juveniles will be targeted. In addition to the mark/recapture study visual observations of the fish passage system combined with physical measurements of flow (velocities, discharge, depth) will be conducted throughout the open water season to determine if the passage system is working as designed or if modifications are required.

Federal effluent regulations for the metal mining industry (Metal Mining Effluent Regulations (MMER) of the *Fisheries Act*) came into effect in June 2002 and were last updated in May 2016. These regulations, administered under the federal *Fisheries Act*, apply to mining and milling operations that discharge effluent(s) at a rate greater than 50 m^3/day. The MMER outline requirements for routine effluent monitoring, acute lethality testing, and Environmental Effects Monitoring (EEM). The objective of EEM is to determine whether mining activity is causing an effect on fish, benthic invertebrate communities and/or the use of fisheries resources (based on mercury accumulation in fish tissues). Once the Project becomes subject to the MMER (i.e., when the operation begins discharging effluent at more than 50 m^3/day) BMC must submit a study design for undertaken an EEM program within one year. The study design must also be submitted at least 6 months prior to conducting the program. The study design will follow guidance provided by the "Metal Mining Technical Guidance for EEM" (Government of Canada, 2014). With respect to aquatic resource monitoring BMC will be required to undertake studies every 3 years to monitor effects from mining operations on the fish and benthic invertebrate communities downstream of its effluent discharge point. The annual fish monitoring program described above will serve to support the requirements under EEM but an EEM specific study on fish will have to be developed for each 3 year cycle. In addition to monitoring the fish and benthic communities every three years the EEM program also requires undertaking an effluent characterization program and sub-lethal toxicity testing on two plant species, an invertebrate, and fish embryos throughout each year of operation.

8 SUMMARY/CONCLUSION

BMC is proposing to develop a mining operation within the Finlayson Creek watershed in Yukon Territory. The Project requires the development and placement of mine infrastructure within Geona Creek, a small tributary of Finlayson Creek. The upper half of Geona Creek has been identified as fish habitat which will be permanently altered as a result of mining development; as such a Fisheries Offsetting Plan is required to procure a *Fisheries Act* Authorization (FAA). An FAA was previously obtained for this Project in 1997.

Extensive historical and more recent fishery investigations have determined that Geona Creek only supports a small population of Arctic grayling but it does provide habitat for all life history requirements for the species (spawning, rearing, and overwintering). The fishery investigations also characterised Finlayson Creek and South Creek. Finlayson Creek supports Arctic grayling and slimy sculpins and a small number of burbot as does South Creek (small watershed on South side of the Project area). No commercial or aboriginal fisheries are established in these watersheds. There is some opportunity however for recreational fishing for grayling in lower Finlayson Creek.

Finlayson Creek will receive treated water water via Geona Creek and directly through a pipeline from the water management ponds that will be established on site. Mine influence on South Creek involves the diversion of Fault Creek, a headwater tributary of Geona, into South Creek. Additionally, dewatering of the mine pit and dewatering of underground workings will result in additional discharge into Geona Creek and reduce groundwater input into South Creek. Hydrological impacts of the various water diversions and water management strategy was examined in this plan for its effect on Geona, South and Finlayson Creeks and it was determined that the changes to hydrology will not significantly impact the aquatic resources in the various systems.

Historical and recent water quality investigations combined with geochemical characterization work have allowed for the development of water quality predictions for mine development. An Aquatic Ecosystem Resource effects assessment was undertaken which demonstrates that mining construction, operations and closure can be advanced, with active and passive water treatment, and avoid contaminants of potential interest exceeding the water quality objectives for the receiving environment that were developed to be protective to aquatic biota in the system.

BMC has developed a substantial number of avoidance and mitigative measures to reduce the impact of its planned development on aquatic resources in the region. BMC however cannot avoid removing and isolating fish habitat in the upper half of Geona Creek. This will result in the loss of spawning, rearing and possibly overwintering habitat for grayling. Therefore, this FOP has proposed offsetting measures to compensate for this loss of habitat. The offsetting measures includes replacement of spawning and pond habitat in lower Geona and reconnecting fish habitat in Finlayson Creek that has been isolated by perched culverts situated in the lower section of the system.

In conclusion the mining operation proposed by BMC will not discharge contaminants into the receiving environments at a level that will place the aquatic resources in those environments at risk. Mitigative measures combined with active and passive water treatment will ensure the quality of the water discharged during construction, operation and closure of the mine. The offsetting measures presented for Geona Creek should sustain or enhance the grayling population in the system while reconnecting of habitat in lower Finlayson will allow large numbers of grayling and other fish to access a significant area of habitat (up to 75 km of creek) currently isolated in the system and thereby increasing the productive capacity of the system. Post construction monitoring of the offsetting measures will allow for determination of its success and for additional modifications as may be required to achieve the desired result.

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Appendix A
Physical Fish Habitat Metrics and Criteria Optimal for Arctic Grayling

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PHYSICAL FISH HABITAT METRICS AND CRITERIA OPTIMAL FOR ARCTIC GRAYLING

Additional details on physical creek metrics important to consider for developing suitable habitat for Arctic grayling are presented below. A summary table of these metrics as they apply to various life history stages of the grayling is presented at the end of this section.

Gradient

The average gradient in Geona Creek is 2-3%. The maximum gradient within fish bearing habitat is upwards of 12%. Therefore, it can be assumed that grayling can negotiate past this gradient as they are found in the upper reaches of the system. Various species of salmonids can be found in high gradient systems, even upwards of 18% (FPC/BC 1998) however as gradients increase certain life stages of fish (i.e., fry/juveniles) may be isolated from moving upstream. A diversity of gradients can create habitat diversity. Higher gradient sections of streams are associated with riffle and cascading habitats (2-5%) and lower gradients associated with glides (< 2%). Higher gradient sections tend to expose more gravel cobble habitat which is valuable for aquatic invertebrate production (feed for fish) but does not provide great rearing/holding habitat as does lower gradient sections, although good small pool habitat can sometimes reside within the riffle/cascading sections of a stream.

For the constructed channels gradients for the most part will be dictated by topography. Some meanders could be designed into the channels to minimise gradients but as discussed above useable fish habitat will be limited to the lower sections of the channels. To the extent possible gradients in the 2-5% range (or that will provide flow velocity in the 0.5-1.0 m/s range) should be provided in the channels just upstream of ponds as this combined with appropriate substrate material should provide attractive spawning habitat.

With respect to the Fault Creek diversion (Figure 6-3) the average gradient between the upper ponds to the first of the South lakes that would be encountered is 3.3%. The gradient appears relatively consistent along its of approximate 400 m of length with the highest gradient along its alignment at about 4.5%. This should provide riffle/cascading type habitat that will not impede movement of fish upstream. If certain sections do result in flow velocities that may impede fish passage these velocities could be tempered through placement of boulders (discussed further on in substrate section below).

Flow Velocity

Flow velocity is highly correlated to gradient. According to Hubert et al. (1985), velocities of 1.0 m/s or less will not impact grayling's use of specific habitat. As velocities increase above this number habitat suitability decreases. Velocities greater than 1.5 m/s could exclude use of certain habitat acting as barrier to their movement upstream. Velocities in higher gradient sections can be influenced by the type of substrate present. Large substrate material such as cobble and boulders can help dissipate energy and reduce velocities in certain situations while providing possible resting zone on the downstream side through the formation of eddies.

For spawning areas (i.e., at transition zone from stream to pond) velocities should be less than 150 cm/s to encourage successful spawning (Stewart et al. 2007) yet should be high enough (e.g., 0.5 m/s) to keep substrate clean and to ensure in gravel flows.

Substrate

A variety of substrates is typically found in grayling habitat and are classified as shown in Table A-1. Certain substrate types however are important for different life history stage of the fish and/or for food production. For instance, loose gravels provide the best substrate for spawning whereas cobble and boulder habitat provide good substrate for production of food invertebrates. Boulders in flowing water can provide resting refuge on downstream side (if large enough to form eddies) and cover protection. In ponds the substrate will typically be sands, fines and/or organics that have settled. Large woody debris (fallen trees, root wads etc.) can provide good cover habitat and possible resting areas as can boulder clusters placed in ponds.

Table A-1: Substrate classification and relative size description

Class	Size (cm)	Description
Fines	<0.2	Smaller than ladybug size
Gravels	0.2 - 6.4	Ladybug to tennis ball size
Cobbles	6.4 - 25.6	Tennis ball to basketball size
Boulders	>25.6	Larger than a basketball
Rock	>400	Includes boulders and blocks larger than 4m, and bedrock

For spawning habitat ideally, the substrate available should be mainly gravels. This is the preferred habitat for spawning by grayling but in its absence grayling are known to make use of a variety of substrates. Cobble habitat will also be valuable throughout the habitat including upstream of fish accessible areas as cobble provides good substrate for benthic invertebrates to colonise.

Fines are neither great for spawning habitat or food production. Therefore, fines should be limited in areas that may be designated for this these types of uses. Fines will likely accumulate naturally at the inlet of ponds as flow velocity falls and the capacity of the moving water to carry fines drops.

Dissolved Oxygen

Dissolved Oxygen (D.O) is not typically an issue in flowing systems like Geona Creek during open water season. In winter however ponds can have its oxygen supply depleted when oxygen consumption from degradation of organic matter exceeds oxygen input from inflow. Under winter conditions ice cover prevents direct transfer of oxygen from the atmosphere and primary production which can directly add oxygen to water, is not occurring. Therefore, oxygen supply is reliant almost exclusively on inflow water.

If much of the inflow water is ground-sourced (spring-water) this water can have very low D.O. and may not necessarily supply the level of D.O. required to sustain fish under ice.

Arctic grayling are able to withstand relatively low D.O. conditions. A level at or above 3.0 mg/l is considered suitable to sustain them throughout the winter when their metabolic rates (temperature related) and thus oxygen consumption rates are low (Hubert et al. 1985).

Water Temperature

The maximum water temperature that grayling can withstand is approximately 25°C. Beyond this temperature growth will likely be suspended and much higher than this grayling would succumb and possibly perish. Based on temperature logger data collected in 2015 Geona Creek (KZ-9) from June to October water temperature did not exceed 15 °C and only slightly exceeded this temperature in Finlayson Creek (KZ-15 and KZ-16) (see Table A-2). This temperature is well within an acceptable range for grayling rearing in the system. Constructed diversion channels should not result in a significant increase in temperature. Likely the removal of pond habitat in the upper reaches will result and lower water temperatures.

Table A-2: Maximum Water Temperature (°C) recorded in Geona Creek and upper Finlayson Creek from May to November 2015

Month	Site			
	KZ-2	KZ-9	KZ-15	KZ-16
May	5.576	9.313	10.095	10.823
June	8.625	14.107	12.592	14.133
July	10.441	14.404	13.551	15.25
August	10.029	13.757	12.802	14.401
September	5.18	8.887	7.483	8.399
October	1.692	2.642	2.261	2.472
November	0.554	0.385	0.471	0.324

Spawning typically is not initiated until temperatures reach approximately 4 °C or higher. This mean temperature likely occurred towards the end of May/early (Table A-3). As such is grayling were spawning in the system this is the time frame it was likely occurring.

Table A-3: Mean monthly water temperature (°C) recorded in Geona Creek in upper Finlayson Creek from May to November 2015

Month	Site			
	KZ-2	KZ-9	KZ-15	KZ-16
May	2.008	3.541	3.789	3.676
June	4.27	8.115	7.96	8.172
July	6.486	10.07	9.897	10.47
August	5.679	8.36	8.419	8.776
September	2.454	3.601	3.736	3.71
October	0.65	0.848	0.876	0.709
November	0.461	0.351	0.377	0.292

Overwintering Habitat

Grayling need ponds/pools to overwinter and these pools need to be of a depth that they do not freeze solid. Typically, they need to be at least 1.2 m deep or greater. If there is sufficient continuous winter flow in the system a pond of 1.2 m may be able to remain open at depth throughout the winter. If flows are low or non-existent then much greater depth, likely 1.5 m or more is required in order to ensure there is unfrozen water for the fish. If there is zero inflow in the pond throughout the winter ponds that are less than 3.0 m in depth, the pond is likely to become devoid of oxygen as its consumed through metabolic processes involved in the degradation of organic matter. Pond habitat in Geona Creek are fairly shallow (1.5 m or less for the most part) and therefore if there is no winter flow they are likely not suitable for overwintering fish. It still has to be fully ascertained if overwintering habitat is currently available in the Geona Creek system. Investigations to date indicate if there is overwintering habitat that it is marginal and very limited.